BOOKLET

FMS 2024

國立陽明交通大學

THE 7th INTERNATIONAL SYMPOSIUM ON FRONTIERS IN MATERIALS SCIENCE

National Yang Ming Chiao Tung University, Hsinchu City, Taiwan
January 21 - 24, 2024

NSTC 國家科學及技術委員會 National Science and Technology Council

TPS TAIWAN

NSRRC 國家同步輻射研究中心 National Synchrotron Radiation Research Center

https://fms2024.conf.nycu.edu.tw

Department of Electrophysics
National Yang Ming Chiao Tung University

The Department of Electrophysics was established in 1964. It is one of the two earliest departments established by the National Chiao Tung University. Its long history has led to the department's leading role in the semiconductor and optoelectronic industry in Taiwan. Many alumni have strong influence in the scientific and technological fields at the international level, and our department has the largest and most active alumni association in Taiwan. It is worth mentioning that our department has more than 30 distinguished alumni so far. Now the department has 33 full time faculty members. Several professors have won distinguished teaching awards and outstanding research awards. Four professors are international scholars.

The courses offered by our department are interdisciplinary: in addition to subjects such as fundamental physics, quantum nanotechnology, electrical engineering, optoelectronics, and quantum information, we also focus on cross-field related courses. With solid fundamental physics training, close connection with the industry, and cooperation with international large-scale scientific projects, the course structure is adequate for our students to cope with and grasp the future trend of science and technology.

Our educational goals are to cultivate industry leaders and pioneers with strong leadership, creativity, professionalism, and the ability to collaborate and communicate effectively. The equal emphasis on fundamental science as well as modern technology is the core value of our department, which enhances students' horizons and cultivates high-tech and cutting-edge scientific research talents with a solid academic foundation. The research of our faculties focuses on forward-looking physics and technology research fields such as lasers and optoelectronics, nanomaterials, next-generation semiconductor devices, quantum materials and quantum information. Our research is fully in line with the world's most advanced research and technology and we aim to boost the new generation in high-tech industries.

The alumni of the Department of Electrophysics spans all walks of life including academic researchers (professors or researchers at world-renowned universities or research institutes), high school physics or mathematics teacher, Engineers, R&D talents, and managers or founders of high-tech enterprises (TSMC, MediaTek, Hermes, Foxconn, ESMT, Macroblock), Founders (Hanmin, ESMT, Macroblock), etc.

The Department welcomes applications from international students for admission. Admitted students have opportunities for fellowships and tuition waiver. Most of the students serve as teaching assistants (the stipend is around 200-830 US dollars per month) or research assistants (the stipend is around 300-1300 US dollars per month). Our PhD students have fellowship opportunities for publishing excellent journal papers (the stipend is around 6,000 US dollars a year).

FMS 2024

The 7th International Symposium on Frontiers in Materials Science

National Yang Ming Chiao Tung University, Hsinchu City, Taiwan

January 21-24, 2024

BOOKLET

Supervisors: Prof. Wu-Ching Chou, Prof. Michael Lang, Prof. Tomoyuki Yamamoto, Prof. Yoon-Hwae Hwang, and Prof. Nam Nhat Hoang

Editors: Nhu Quynh Diep, Bich Tuyen Huynh Thi, Quynh Trang Tran, Ssu-Kuan Wu, and Hong-Jyun Wang

Acknowledgment

My dear distinguished attendees:

Since the first International Symposium on Frontiers in Materials Sciences (FMS) in 2013, with the efforts of many professors from the European Union, Japan, Vietnam, Korea, and other countries, the previous FMS meetings have been successfully held and have led to outstanding paper publications and research cooperation results. Without the support and assistance of all distinguished participants, it would have been impossible to hold the 7th FMS in Hsinchu, Taiwan. I would also like to acknowledge the National Science and Technology Council (NSTC), National Yang Ming Chiao Tung University (NYCU), and the National Synchrotron Radiation Research Center (NSRRC) for their financial support. Special thanks to the co-chairs, Prof. Michael Lang, Prof. Tomoyuki Yamamoto, Prof. Nam Nhat Hoang, and Prof. Yoon-Hwae Hwang, for their assistance from the beginning of the preparatory stage, including recommending committee members, assisting in inviting speakers, planning the agenda, and deciding on the journals to publish papers. I sincerely acknowledge the assistance of Prof. Huan Tran for the symposium publication in Journal of Electronic Materials.

In addition, I would also like to thank all the members of the committees for their assistance, especially the help of Department Chair Shun-Jen Cheng, Professor Shiuan-Huei Lin, Professor Shih-Ying Hsu, Professor Chih-Wei Luo, Professor Chien-Te Wu, and colleagues Mable, Vera, Hedy and Chin-Chuan of the Department of Electrophysics. Students in my lab, such as Nhu Quynh, Ssu-Kuan, Hong-Jyun, Quynh Trang, and Bich Tuyen, also spent a lot of their valuable time on helping to organize the event.

I very much appreciate the international VIPs, who came to Taiwan to participate in the 2024 FMS including more than 50 professors and students from more than 10 countries including Bulgaria, Canada, the Czech Republic, Serbia, Germany, India, Japan, Korea, the Netherlands, Poland, the United States, and Vietnam, and more than 100 Taiwanese professors and students participated in the oral and poster presentations. Without your contributions, it would have been impossible to hold the successful 2024 FMS in Taiwan. We look forward to your presentation, discussion and planning of future research collaborations. During the symposium, we hope that all international guests will enjoy experiencing Taiwan's local culture and food.

Best wishes to all of you.

2024 FMS Chair, Prof. Wu-Ching Chou

Department of Electrophysics,

National Yang Ming Chiao Tung University,

Hsin Chu 300093, Taiwan

Contents

GENERAL INFORMATION

The 7th International Symposium on Frontiers in Materials Science (FMS 2024) will be held at National Yang Ming Chiao Tung University, Hsinchu City, Taiwan, January 21-24, 2024. This event continues on the success of the six previous FMSs from 2013 to 2022 in Vietnam, Germany, and Japan.

The FMS 2024 is co-organized by National Yang Ming Chiao Tung University **(NYCU, Taiwan)**, National Synchrotron Radiation Research Center **(NSRRC, Taiwan)**, The Physical Society of Taiwan **(TPS)**, Goethe University **(Germany)**, Waseda University **(Japan)**, Crystal Defect Cores **(Japan)**, Pusan National University **(Korea)**, University of Engineering and Technology and University of Science **(Vietnam National University)**, Hanoi National University of Education, **(HNUE, Vietnam)**, and Scientific Gear Service **(Taiwan)**. The FMS 2024 welcomes hundreds of participants from more than ten countries in over the world, including Bulgaria, Canada, the Czech Republic, Serbia, Germany, India, Japan, Korea, the Netherlands, Poland, the United States, and Vietnam.

Besides, the Symposium is sponsored by Taiwan National Science and Technology Council (NSTC, Taiwan), National Yang Ming Chiao Tung University (NYCU), National Synchrotron Radiation Research Center (NSRRC), Scientific Gear Service (Taiwan), AST Instrument Corporation (AST, Taiwan), 科宇系統有限公司 (Attolight, Taiwan), 俊尚科技股份有限公司 (JST, Taiwan), Quantum Design (Taiwan)

The FMS 2024 expects to bring together professionals and experts from either industrial or academic fields to exchange knowledge and discuss emerging trends in material science, either fundamental or applied fields. The conference offers the chance to cultivate ideas, experiences, and research results while promoting international cooperation in education and research in several fields: Material for green energy and environment (EE), Multiferroics and magnetic materials (MM), Photonics and nanostructured hybrid materials (PH), Spintronic & topological materials (ST), Theoretical and computation materials science (TC), THz materials and devices (TD), and Two-dimensional materials and related applications (2D). Especially, there is also a special section from professors and researchers from Taiwan's National Synchrotron Radiation Center (NSRRC): Synchrotron X-ray Science & Applications.

With diverse speakers, interactive parallel sessions, and networking opportunities, the conference promises to be a valuable platform for professional development.

Venue: Department of Electrophysics (Science Building III), College of Science, National Yang Ming Chiao Tung University (Guangfu Campus), No. 1001, Daxue Road, East District, Hsinchu City 300, Taiwan. Website: https://ep.nycu.edu.tw/en/

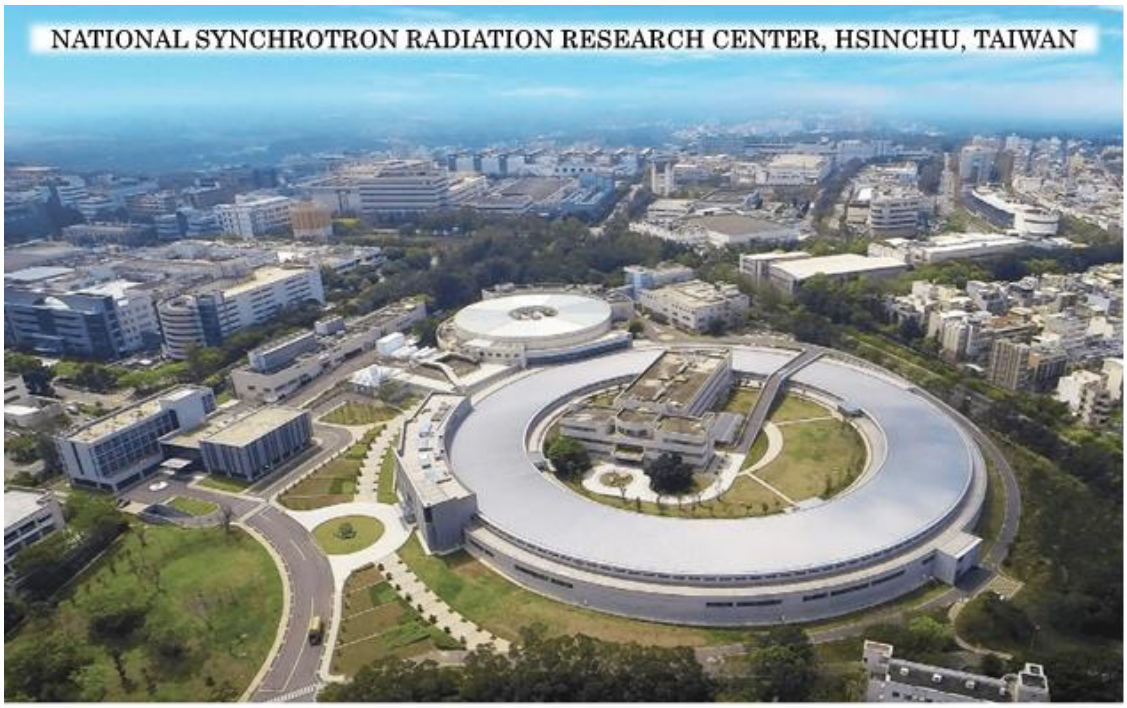
Manuscript submission and publications

Selected contributions from the symposiums have been subjected to a regular review process, and the accepted manuscripts have been published in the SCI journals, such as IEEE Transaction on Magnetics, Physica B, Optical Materials, Materials Transaction, and Journal of Applied Physics.

In FMS 2024, the participants are invited to submit their manuscripts to the Journal of Electronic Materials (JEM)_IF: 2.1 (2022). The due date for the manuscript submission is May 31, 2024. Manuscripts need to be submitted via the submission system website at http://www.editorialmanager.com/jems/default.aspx. Submitted manuscripts will be evaluated according to the same high standards as would be applied to any article published in the journal. The detailed instructions for manuscript submission will be updated later on the FMS 2024 website.

Facilities: The necessary facilities such as exhibition equipment (pins, poster frame, etc.), materials, and FMS booklets will be supported as a part of the Symposium. For any further information, please contact the FMS Secretary via email: 2024fms@gmail.com

FMS 2024 ORGANIZERS



Evolution of Synchrotron Light Sources

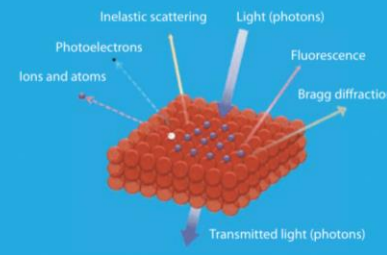
Synchrotrons have been used primarily by high-energy physicists since the mid twentieth century as indispensable tools to search for fundamental particles and to explore the essence of the cosmos. After the discovery and confirmation of electromagnetic radiation generated by synchrotrons, physicists and chemists began to apply this radiation in their scientific experiments during the hiatus of high-energy research. Such light sources were subsequently described as first-generation synchrotron light sources.

In the 1970s, scientists gradually became appreciative of the advantages of synchrotron light sources. One after another, many developed countries began to build synchrotrons specifically to generate electromagnetic radiation. Such facilities were called second-generation synchrotron light sources.

In the 1980s, new and innovative concepts were proposed by scientists to install insertion devices, such as wigglers and undulators, in a storage ring to deflect electrons multiple times instead of just once in a segment of the storage ring. Such an improvement has increased the brightness of synchrotron light more than a thousand times. In addition, the brightness of the photon beam increases as electrons in the circulating electron beam become more compact in space, their momentum vectors more parallel, and the spread of the momentum magnitudes narrower. Such a spread of electron position and momentum is termed the emittance of the storage ring, which is dictated by the layout of the magnets of the storage ring. A synchrotron designed with a small emittance and an emphasis on insertion devices to provide photon beams of great brightness is known as a third-generation synchrotron light source.

At present, there are nearly 50 operational synchrotron light sources for scientific research around the world. The third-generation synchrotron light sources among these began to open to user experiments in 1994. The Taiwan Light Source of the NSRRC began to be commissioned in 1993, and became the third third-generation soft X-ray synchrotron light source in the world to come on line for user experiments in April, 1994. As the demand for even brighter synchrotron X-rays for advanced research increases, Taiwan has begun to construct a second synchrotron light source, the Taiwan Photon Source (TPS). The project was approved by the government in 2007, and construction began in 2010. On its completion, the TPS is expected to be one of the world's brightest synchrotron light sources.

Synchrotron light source – the best sharp tool for scientific experiments



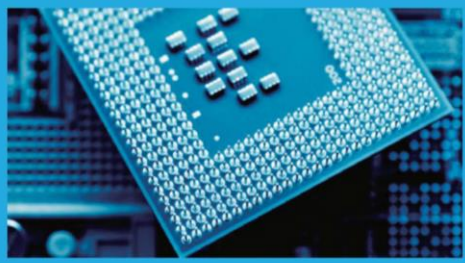
Varied phenomena, such as emission of photoelectrons; desorption or ablation of ions or atoms; absorption, scattering or diffraction of photons; and fluorescence, occur when matter is irradiated with light from a synchrotron. Each such phenomenon is closely related to the physical or chemical characteristics of the material. Studying a material with light from a synchrotron thus enables a precise exploration of the inner structure of a material, and the electron-electron interactions therein. The synchrotron light source is an indispensably sharp experimental tool for cutting-edge research in basic science, biomedical technology and industrial applications in the twenty-first century. It is applied broadly to diverse fields such as material science, biology, medicine, physics, chemistry, chemical engineering, geology, archeology, environmental protection, energy science, electronics, micromachining and nanotechnology.

Applications of the Synchrotron Light Source

Discovery of novel materials

Inspecting the microstructures of materials with synchrotron light of small wavelength and great brightness is an important way to reveal the properties of materials and to innovate in material applications. Synchrotron light coupled with advanced microscopic and spectroscopic techniques is an important experimental method to discover novel materials and to study structures on a nanometer, or even smaller, scale.

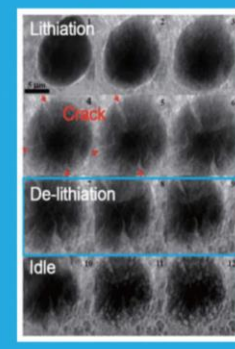
Taking research on high-T_c superconductors as an example, physicists can apply synchrotron light to explore the mechanism of superconductivity, or to search for new superconductors with zero electrical resistance even at room temperature. Taking electronic fabrication as another example, when the sizes of electronic storage devices are shrunk gradually down to a nanometer scale, the characteristics of the surface atoms become increasingly important. Research using synchrotron light is capable of revealing significant information such as nanoscale electronic and atomic structures of matter to facilitate the discovery of superior materials. This work aids tremendously to increase the storage capacities and the processing speeds of electronic components.



Development of green energy

In recent years, man-made chemicals and air pollution produced by human activities have seriously altered the condition of the terrestrial atmosphere. In particular, the anthropogenic greenhouse effect of carbon dioxide, emitted by burning fossil fuels, has resulted in global warming and climate change. Mother Nature, ecology, human health, economy, as well as the human society are faced with unprecedented severest challenges ever.

Scientists have been searching actively for highly efficient and clean energy sources. A lithium-ion battery, a rechargeable battery, is one green energy product with little pollution, in which lithium ions move between the anode and the cathode, during which chemical energy is converted to electrical energy. Using a transmission X-ray microscope with spatial resolution 50 nm at the NSRRC, researchers monitored the microscopic images of the electrodes, and investigated the changes of particles of tin, nickel, manganese or other materials of the cathode in real time during the charge-discharge cycle (migration of lithium ions in and out), so as to learn the sizes, shapes and distributions of internal grain structures in the process. This work will help scientists to discover novel materials with increased efficiencies and prolonged service lives for a lithium-ion battery in the future.



Kagami Memorial Research Institute for Materials Science and Technology, Waseda University, Tokyo, JAPAN

早稲田大学 各務記念材料技術研究所

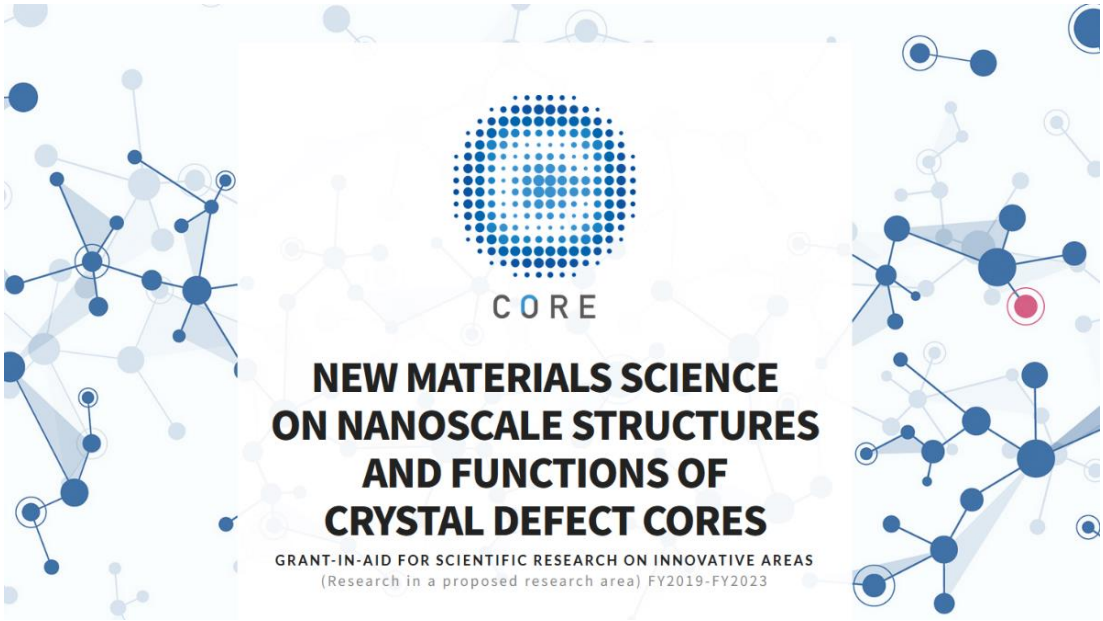
On October 21, 1938, Kagami Memorial Research Institute for Materials Science and Technology was established as the Casting Research Laboratory—the first laboratory attached to private universities in Japan—by a donation from the prominent business leader, Koichiro Kagami and his son, Yoshiyuki. Until 1980s, the laboratory played an important role both in academic and industrial circles as a unique institute focusing on metal processing such as casting, forging, welding and surface treatment. However, the laboratory had expanded its research field to cover a wider range of materials and in 1988, on the 50th anniversary of its founding, the Casting Research Laboratory was renamed Kagami Memorial Research Institute for Materials Science and Technology (ZAIKEN, which is the abbreviation of its Japanese name).

Since then, researchers studying structural materials and processes, functional materials, material properties, and material design and evaluation have joined ZAIKEN and have enhanced the quality and quantity of the research. Based on the research funding from outside the university, many professors and researchers are conducting various research projects.

ZAIKEN has been (1) acting as a leading academic research hub for fundamental technologies on a wide range of materials; (2) managing a joint use of the equipment for cutting-edge analysis and sample preparation and (3) sharing information and know-how with researchers and engineers in a wide range of material fields and constructing networks. Recently, a variety of global-scale environmental and energy problems have emerged, and solving these problems are advocated in the United Nations' Sustainable Development Goals and the Society 5.0 framework of the Japanese government. We believed that ZAIKEN can substantially contribute to solving these problems through fundamental materials technology, and accordingly, ZAIKEN applied to the program of "Joint Usage/Research Center" by MEXT, Japan, and was accepted and started in April 2018 the "Joint Research Center for Environmentally Conscious Technologies in Materials and Science".

The objectives of the Joint Research Center for Environmentally Conscious Technologies in Materials and Science are: (a) to develop fundamental technology for environmentally conscious materials, to establish scientific principles of environmentally conscious materials, to create innovative environmentally conscious materials, and to incorporate them into society. (b) to promote joint research and joint use for researchers in a variety of research fields and to contribute to the development of the material technologies in Japan by providing them with facilities, equipment, and know-how at ZAIKEN. (c) to provide researchers in a variety of research fields with academic interaction with other researchers and to promote the fusion of different fields of material technologies.

Open for the international and the domestic collaboration researches
https://www.waseda.jp/fsci/zaiken/



Project Leader: K. Matsunaga
(Professor, Nagoya Univ. Japan)

Since emergence of the human civilization, epoch-making innovations in fields of environmental conservation, energy development and information technology have been realized by emergence of novel and advanced materials of metals, ceramics, and semiconductors. In this regard, it is not too much to say that materials science has played an essential role for them in history of mankind. In the current complicated, diversified and globalized modern societies, however, timely development of unprecedented materials is indispensable and highly desired. Therefore, it is necessary to conduct materials development based on a new concept in materials science.

In this project, we firmly conduct fundamental and scientific research on the structure property relationships in crystal defects of materials at the nanometer scale. This is because crystal defects such as grain boundaries, interfaces and dislocations are found to become physical origins of distinct properties in recent advanced materials. Moreover, scientific attempts are now being done in advanced-material development by designing and controlling physical properties of crystal defects at the nanometer scale. If we know how to maximize potentials of physical properties of crystal defects, such knowledge should provide us with breakthroughs in materials science. Then, it should be an indispensable step to systematically reveal nature of specific electronic and atomic structures at crystal defects, especially at their core regions.

Here we refer to specific electronic and atomic structures localized at crystal defects as “crystal defect cores”, and try to establish the new materials science. For this purpose, researchers specializing in theoretical calculations, nanoscale characterization and advanced materials processing conduct collaborative studies. Establishment of new scientific principles based on the concept of “crystal defect core” will make it possible to explore novel materials with excellent properties due to crystal defects.

For further details, please visit the website which can be easily found by searching with the keyword “Crystal Defect Cores.

Goethe University, Germany

The Johann Wolfgang Goethe University Frankfurt am Main is one of the largest universities in Germany with around 44,000 students and with about 5,700 employees. Founded in 1914 by Frankfurt citizens and since 2008 once again proud of its foundation status, Goethe University possesses a high degree of autonomy, modernity and professional diversity. As a comprehensive university, the Goethe University offers a total of 16 departments on five campuses and 154 degree programs along with an outstanding research reputation. Furthermore, the Goethe University is part of the Group of Rhine-Main-Universities (RMU).

2023 Pusan National University, Korea

Pusan National University (PNU), founded in May, 1946 with donations and love from citizens, marks the 77th anniversary of its proud opening in 2023.

PNU was launched through the efforts of In-Ku Yun, the first president of PNU, who was then chief of academic affairs for South Gyeongsang Province, and funded by community contributions.

PNU has become the No. 1 national university in research and educational competency, and its tradition and ability are estimated highly. More than 260,000 PNU alumni have taken responsibility for the development of their communities and the country, and about 35,000 students, 1,200 professors, and 750 faculty members are working as one to develop PNU, an institution based on the principles of truth, freedom, and service.

Shining with tradition and history, PNU has surpassed 20 million won in educational funding per student for the first time among national universities in the country. It ranks first among national universities and 11th in universities nationwide, recording the top rank in the nation on the level of major private universities in the Seoul metropolitan area.

Thirty-six educational research groups and teams were selected for the 4th stage of the BK21 project, which measures the university's educational and research capabilities. PNU achieved second place among all universities nationwide.

PNU has joined the Association of Pacific Rim Universities (APRU) in 2021, one of only 61 member universities in the world. PNU is the 6th member among domestic universities. PNU is further strengthening exchanges and cooperation with excellent universities at home and abroad.

PNU has signed agreements with nearly 534 universities and institutions from 58 countries and regions around the world and has been actively engaged in exchange activities. Many PNU students are having overseas experiences through interacting with nearly 60 foreign professors, taking foreign language courses among more than 1,200 provided annually, participating in study abroad programs and overseas volunteer programs, as they become international experts and leading global intellectuals.

In addition, PNU declared a carbon-neutral eco-friendly campus and created a 'Path of Thought' on campus, boasting a beautiful campus environment located close to beautiful Mount Geumjeong and natural valleys. In line with the trends of the 4th industrial revolution, PNU is promoting the reorganization of the academic unit structure and innovation of the curriculum, while establishing the optimal foundation for student admission, education, and employment, and establishing and expanding various scholarships so that professors and students can focus more on research and education.

Furthermore, PNU, as the eldest brother of national universities in Korea, is actively leading changes in university policies such as the enactment of the National University Act and the expansion and revision of the compulsory recruitment system for public institutions. PNU will lead an era of shared growth between the country, region and universities by fulfilling its roles and responsibilities as 'The University: Changing Universities'

With the power of bold intellect leading a new era, as a central university in the southeastern megacity, the second most-populous region of Korea, and as one of the Korean Flagship National Universities, PNU will do its best to nurture outstanding talents who will lead regional and balanced national development.

We hope for your interest and support.

Faculty of Engineering Physics and Nanotechnology
University of Engineering and Technology
Vietnam National University, Hanoi

History

1999-2004:

Starting from Dept. Engineering Physics of the Faculty of Technology, Vietnam National University (VNU) in Hanoi.

September 9, 2004:

Faculty of Engineering Physics and Nanotechnology (FEPN) was officially established under the University of Engineering and Technology (UET).

***Locations**: 144 Xuan Thuy St., Cau Giay Dist., Hanoi, Vietnam*

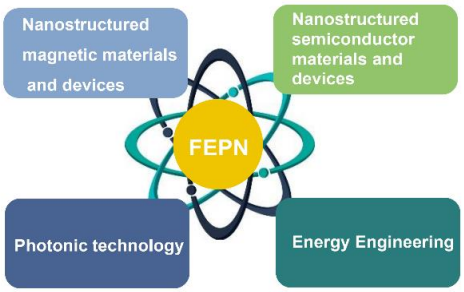
Website: http://fepn.uet.vnu.edu.vn/

Phone: (024) 3754 9429

Fax: (024) 3754 9429

Organization

Departments



Staffs

- 21 faculties and supporting staffs: 2 full professors, 5 assistant professors, 11 PhD, 5 masters
- 10 adjunct professors from partner institutions. *(Institute of Materials Science, Institute of Physics, Institute of Chemistry, Institute of Biotechnology, VAST)*

Program

Undergraduate program

Bachelor in Engineering Physics
(4 years): ~ 220 students.
Engineer in Energy Engineering
(4.5 years): ~ 220 students.

Graduate program

Master in Nanomaterials and devices
(2 years): ~ 10 students / year
PhD in Nanomaterials and devices
(4 year): ~ 10 students (in total)

Main topics

- Micro-nanostructured magnetic materials and devices.
- Micro-nanostructured semiconductor materials and devices.
- Catalysis materials
- Advanced optoelectronic materials and devices
- Physics of low dimensional systems, computational materials science.
- Photonics and lasers

Hanoi National University of Education, Vietnam

Founded on October 11, 1951, through Decree No. 276 by the Ministry of National Education, Hanoi National University of Education (HNUE) is an esteemed institution within Vietnam's educational realm. Initially recognized as a pivotal national pedagogical university in October 1975, it further advanced to become one of Vietnam's six key tertiary institutions by March 1977. Over the years, its evolution has been exceptional. By the onset of the millennium, HNUE underwent a significant transformation into a central pedagogical university with a focused mission: to cultivate outstanding educators and pursue pioneering scientific inquiry. This dedication aimed to propel the development of the pedagogical system and K-12 education within the nation.

Presently, the university comprises approximately 700 educators, including nearly 200 esteemed full and associate professors, along with over 300 doctorate holders. Its academic infrastructure spans across 23 faculties, one department, and 14 distinguished research centers. Additionally, five affiliated schools have earned national recognition within Vietnam's K-12 educational framework. Across its illustrious 70-year journey, HNUE has shaped countless schoolteachers, university lecturers, and researchers committed to the nation's advancement. Each year, the university welcomes over 4,000 undergraduate and 1,000 postgraduate students, nurturing and empowering the next generation of educators and scholars.

Aligned with its dedication to scholarly excellence, HNUE has showcased prolific scholarly output. From 2022 to 2023, the university made substantial contributions to the global academic discourse with a total of 313 international scientific articles published across esteemed platforms such as ISI, Scopus, and other international repositories. Domestically, the university has fostered intellectual dialogue with 1,034 articles, hosted three international seminars, facilitated 191 domestic workshops, and authored 537 textbooks.

Moreover, HNUE has been entrusted with a comprehensive array of projects spanning various levels, reinforcing its pivotal role in educational development. With its robust legacy and continuous contributions to academia, Hanoi National University of Education remains an unwavering bastion of learning, innovation, and academic distinction, propelling Vietnam's educational landscape forward.. Ranked 8th in Vietnam and 139th in the Asian University Rankings - Southeastern Asia 2024, Hanoi National University of Education stands as one of the premier public universities in Hanoi, Vietnam.

FMS 2024 SPONSORS

THE SYMPOSIUM CHAIRS

- **Honorary chair**

Chi-Hung Lin	President, National Yang Ming Chiao Tung University, **Taiwan**	

- **Chair**

Wu-Ching Chou *(wcchou957@nycu.edu.tw)*	National Yang Ming Chiao Tung University, **Taiwan**	

- **Co-chairs**

Michael Lang	Goethe University	**Germany**
Tomoyuki Yamamoto	Waseda University	**Japan**
Yoon-Hwae Hwang	Pusan National University	**Korea**
Nam Nhat Hoang	VNU - University of Engineering and Technology	**Vietnam**

- **Plenary Chairs**

Masato Yoshiya	Osaka University	**Japan**
Si-Young Choi	Pohang University of Science and Technology	**Korea**
An Bang Ngac	VNU - University of Science	**Vietnam**

THE SYMPOSIUM SPEAKERS

- **Plenary Speakers**

Ryo Ishikawa	University of Tokyo	**Japan**
Ho Won Jang	Seoul National University	**Korea**
Huan Tran	Georgia Institute of Technology	**USA**

- **Invited Speakers**

Vera Marinova	Institute of Optical Materials and Technologies, Sofia, **Bulgaria**
Dimitre Z. Dimitrov	Institute of Optical Materials and Technologies, Sofia, **Bulgaria**
Gabriella Tessitore	Université Laval, **Canada**
Mgr. Maksym Buryi	The Czech Academy of Sciences, **Czech Republic**
Mikhail Brik	University of Tartu, **Estonia**
Stefan Süllow	Technical University of Braunschweig, **Germany**
Jakob Walowski	University of Greifswald, **Germany**
Indrajit Shown	Hindustan Institute of Technology and Science, **India**
Masashi Akabori	Japan Advanced Institute of Science and Technology**, Japan**
Harald O. Jeschke	Okayama University, **Japan**
Takashi Kimura	Kyushu University, **Japan**
Keiichi Koyama	Kagoshima University, **Japan**
Takuji Ohigashi	High Energy Accelerator Research Organization (KEK), **Japan**
Masahiko Okumura	Japan Atomic Energy Agency (JAEA), **Japan**
Masato Yoshiya	Osaka University, **Japan**
Kazuhito Tsukagoshi	National Institue for Material Science (NIMS), **Japan**
Si-Young Choi	Pohang University of Science and Technology, **Korea**
Soo Young Kim	Korea University, **Korea**
Jae Beom Lee	Chungnam National University, **Korea**
Ekkes Brueck	Delft University of Technology, **Netherlands**
Michal Piasecki	Jan Dlugosz University**, Poland**
Candy C. Mercado	University of Philipines, **Philipines**
Wen-Hao Chang	National Yang Ming Chiao Tung University, **Taiwan**
Chia-Hao Chen	National Synchrotron Radiation Research Center, **Taiwan**
Jeng-Lung Chen	National Synchrotron Radiation Research Center, **Taiwan**

Jin-Ming Chen	National Synchrotron Radiation Research Center, **Taiwan**
Shao-Yu Chen	National Taiwan University, **Taiwan**
Shun-Jen Cheng	National Yang Ming Chiao Tung University, **Taiwan**
Cheng-Maw Cheng	National Synchrotron Radiation Research Center, **Taiwan**
Chin-Hau Chia	National University of Kaohsiung, **Taiwan**
Ying-Hao Chu	National Tsing Hua University, **Taiwan**
Chin-Han Chung	National Yang Ming Chiao Tung University, **Taiwan**
Chung-Li Dong	Tamkang University, **Taiwan**
Ray-Hua Horng	National Yang Ming Chiao Tung University, **Taiwan**
Wen-Bin Jian	National Yang Ming Chiao Tung University, **Taiwan**
Jenh-Yih Juang	National Yang Ming Chiao Tung University, **Taiwan**
Kimitoshi Kono	National Yang Ming Chiao Tung University, **Taiwan**
Wen-Cheng Ke	National Taiwan University of Science and Technology, **Taiwan**
Huu Phuoc Le	Ming Chi University of Technology, **Taiwan**
Der-Hsien Lien	National Yang Ming Chiao Tung University, **Taiwan**
Yen-Fu Lin	National Chung Hsing University, **Taiwan**
Yan-Gu Lin	National Synchrotron Radiation Research Center, **Taiwan**
Shiuan-Huei Lin	National Yang Ming Chiao Tung University, **Taiwan**
Ping-Hui Lin	National Synchrotron Radiation Research Center, **Taiwan**
Chun-Liang Lin	National Yang Ming Chiao Tung University, **Taiwan**
Jiunn-Yuan Lin	National Yang Ming Chiao Tung University, **Taiwan**
Chin-Shan Lue	National Cheng Kung University, **Taiwan**
Chih-Wei Luo	National Yang Ming Chiao Tung University, **Taiwan**
Ying-Rui Lu	National Synchrotron Radiation Research Center, **Taiwan**
Hsin-Fei Meng	National Yang Ming Chiao Tung University, **Taiwan**
Way-Faung Pong	Tamkang University, **Taiwan**
Hung-Wei Shiu	National Synchrotron Radiation Research Center, **Taiwan**
Shih-Chang Weng	National Synchrotron Radiation Research Center, **Taiwan**
Chien-Te Wu	National Yang Ming Chiao Tung University, **Taiwan**
Atsushi Yabushita	National Yang Ming Chiao Tung University, **Taiwan**
Chu-Shou Yang	Tatung University, **Taiwan**
Thanh Cong Bach	VNU - University of Science, **Vietnam**
Van Hao Bui	Phenikaa University, **Vietnam**
Danh Bich Do	Hanoi National University of Education, **Vietnam**
Viet Cuong Le	VNU - University of Engineering and Technology, **Vietnam**
Huy Hoang Luc	Hanoi National University of Education, **Vietnam**
An Bang Ngac	VNU - University of Science, **Vietnam**
Nang Dinh Nguyen	VNU - University of Engineering and Technology, **Vietnam**
The Toan Nguyen	VNU - University of Science, **Vietnam**
Duy Thien Nguyen	VNU - University of Science, **Vietnam**
Huy Tiep Nguyen	VNU - University of Engineering and Technology, **Vietnam**
Thanh Tra Vu	Can Tho University, **Vietnam**

THE SYMPOSIUM COMMITTEES

- **International Advisory Board (45)**

Vera Marinova	Institute of Optical Materials and Technologies, Sofia, **Bulgaria**
Mikhail Brik	University of Tartu, **Estonia**
Andreas Honecker	CY Cergy Paris Université, **France**
Michael Lang	Goethe University, **Germany**
Markus Münzenberg	Greifswald University, **Germany**
KazuhitoTsukagoshi	WPI-MANA, NIMS, **Japan**
Tomoyuki Yamamoto	Waseda University, **Japan**
Masato Yoshiya	Osaka University, **Japan**
Yoon-Hwae Hwang	Pusan National University, **Korea**
Dong Hyun Kim	Chungbuk National University, **Korea**
Hyung-Kook Kim	Pusan National University, **Korea**
Jae Beom Lee	Chungnam National University, **Korea**
Yee Hui Robin Chang	Universiti Teknologi MARA, **Malaysia**
Ekkes Brueck	Delft University of Technology, **Netherlands**
Vinh Hung Tran	Institute of Low Temperature and Structural Research, **Poland**
Wen-Hao Chang	National Yang Ming Chiao Tung University, **Taiwan**
Edward Yi Chang	National Yang Ming Chiao Tung University, **Taiwan**
Chia-Hao Chen	National Synchrotron Radiation Research Center, **Taiwan**
Shun-Jen Cheng	National Yang Ming Chiao Tung University, **Taiwan**
Ying-Hao Chu	National Tsing Hua University, **Taiwan**
Shangjr Gwo	National Tsing Hua University, **Taiwan**
Ray-Hua Horng	National Yang Ming Chiao Tung University, **Taiwan**
Di-Jing Huang	National Synchrotron Radiation Research Center, **Taiwan**
Wen-Bin Jian	National Yang Ming Chiao Tung University, **Taiwan**
Jenh-Yih Juang	National Yang Ming Chiao Tung University, **Taiwan**
Kimitoshi Kono	National Yang Ming Chiao Tung University, **Taiwan**
Shiuan-Huei Lin	National Yang Ming Chiao Tung University, **Taiwan**
Chih-Ming Lin	National Tsing Hua University, **Taiwan**
Jiunn-Yuan Lin	National Yang Ming Chiao Tung University, **Taiwan**
Chin-Shan Lue	National Cheng Kung University, **Taiwan**
Hsin-Fei Meng	National Yang Ming Chiao Tung University, **Taiwan**
Chung-Yu Mou	National Tsing Hua University, **Taiwan**
Way-Faung Pong	Tamkang University, **Taiwan**
Ji-Lin Shen	Chung Yuan Christian University, **Taiwan**
Meng-Jiy Wang	National Taiwan University of Science and Technology, **Taiwan**
Manh Thuong Nguyen	Pacific Northwest National Laboratory, **USA**
Thanh Cong Bach	VNU - University of Science, **Vietnam**
Nam Nhat Hoang	VNU - University of Engineering and Technology, **Vietnam**
Huy Hoang Luc	Hanoi National University of Education, **Vietnam**
An Bang Ngac	VNU - University of Science, **Vietnam**
Nang Dinh Nguyen	VNU - University of Engineering and Technology, **Vietnam**
Bach Thang Phan	VNU - Ho Chi Minh University of Science, **Vietnam**
Dinh Lam Vu	Vietnam Academy of Science and Technology, **Vietnam**
Thanh Tra Vu	Can Tho University, **Vietnam**
Ngoc Tuoc Vu	Hanoi University of Science and Technology, **Vietnam**

- **Executive Committee (12)**

Shun-Jen Cheng	National Yang Ming Chiao Tung University, **Taiwan**
Wu-Ching Chou	National Yang Ming Chiao Tung University, **Taiwan**
Shih-Ying Hsu	National Yang Ming Chiao Tung University, **Taiwan**
Wen-Bin Jian	National Yang Ming Chiao Tung University, **Taiwan**

Der-Hsien Lien	National Yang Ming Chiao Tung University, **Taiwan**
Chun-Liang Lin	National Yang Ming Chiao Tung University, **Taiwan**
Chih-Wei Luo	National Yang Ming Chiao Tung University, **Taiwan**
Chien-Te Wu	National Yang Ming Chiao Tung University, **Taiwan**
Nam Nhat Hoang	VNU - University of Engineering and Technology, **Vietnam**
Huy Hoang Luc	Hanoi National University of Education, **Vietnam**
Huan Tran	Georgia Institute of Technology, **USA**
Manh Thuong Nguyen	Pacific Northwest National Laboratory, **USA**

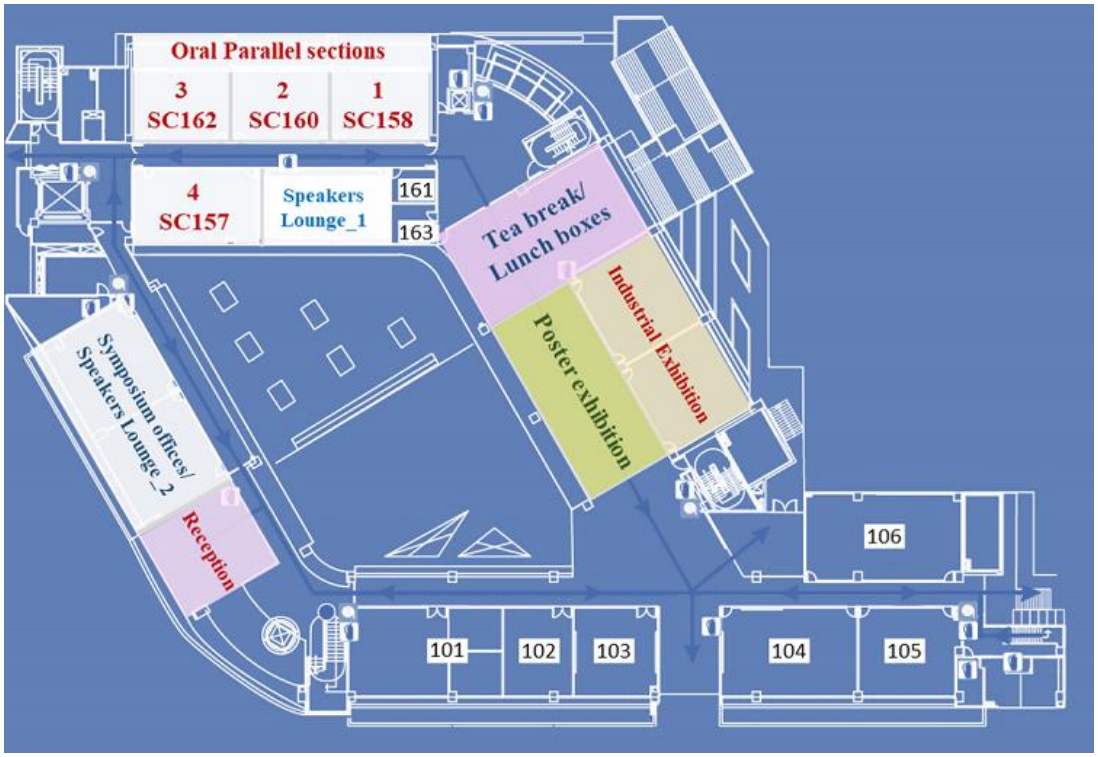
- **Program Committee (18)**

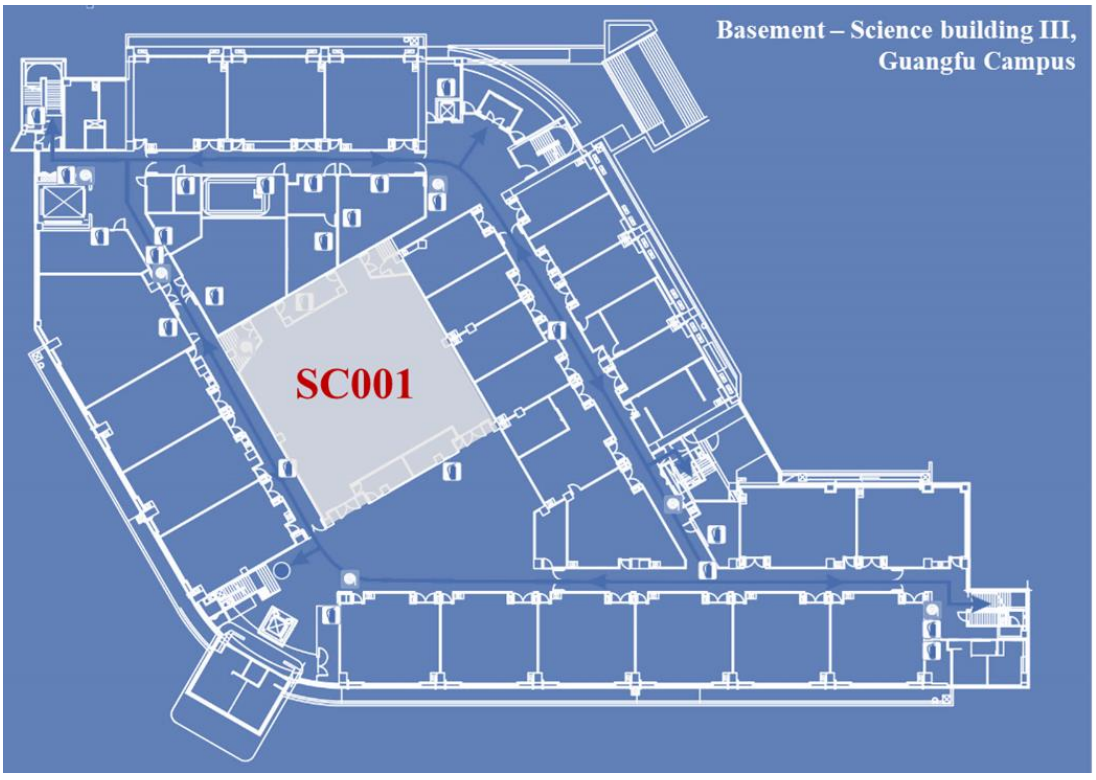
Chin-Hau Chia	National Kaohsiung University, **Taiwan**
Ching-Yu Chiang	National Synchrotron Radiation Research Center, **Taiwan**
Chung-Li Dong	Tamkang University, **Taiwan**
Wen-Cheng Ke	National Taiwan University of Science and Technology, **Taiwan**
Yen-Fu Lin	National Chung Hsing University, **Taiwan**
Shiuan-Huei Lin	National Yang Ming Chiao Tung University, **Taiwan**
Chun-Liang Lin	National Yang Ming Chiao Tung University, **Taiwan**
Ying-Rui Lu	National Synchrotron Radiation Research Center, **Taiwan**
Chih-Wei Luo	National Yang Ming Chiao Tung University, **Taiwan**
Atsushi Yabushita	National Yang Ming Chiao Tung University, **Taiwan**
Chu-Shou Yang	Tatung University, **Taiwan**
Chi-Tsu Yuan	Chung Yuan Christian University, **Taiwan**
Danh Bich Do	Hanoi National University of Education, **Vietnam**
Dinh Tu Bui	VNU - University of Engineering and Technology, **Vietnam**
Dinh Lam Nguyen	VNU - University of Engineering and Technology, **Vietnam**
The Toan Nguyen	VNU - University of Science, **Vietnam**
Van Hai Pham	Hanoi National University of Education, **Vietnam**
Huan Tran	Georgia Institute of Technology, **USA**

- **Local Organizing Committee (14)**

Cheng-Maw Cheng	National Synchrotron Radiation Research Center, **Taiwan**
Chin-Han Chung	National Yang Ming Chiao Tung University, **Taiwan**
Chung-Li Dong	Tamkang University, **Taiwan**
Shih-Ying Hsu	National Yang Ming Chiao Tung University, **Taiwan**
Ching-Shun Ku	Scientific Gear Service, **Taiwan**
Der-Hsien Lien	National Yang Ming Chiao Tung University, **Taiwan**
Yan-Gu Lin	National Synchrotron Radiation Research Center, **Taiwan**
Chun-Liang Lin	National Yang Ming Chiao Tung University, **Taiwan**
Chih-Wei Luo	National Yang Ming Chiao Tung University, **Taiwan**
Atsushi Yabushita	National Yang Ming Chiao Tung University, **Taiwan**
Chu-Shou Yang	Tatung University, **Taiwan**
Chi-Tsu Yuan	Chung Yuan Christian University, **Taiwan**
Dinh Tu Bui	VNU - University of Engineering and Technology, **Vietnam**
Dinh Lam Nguyen	VNU - University of Engineering and Technology, **Vietnam**

SYMPOSIUM VENUE





GENERAL PROGRAM SCHEDULE

<table>
<tr><th colspan="2">Jan. 21, 2024
Sunday</th><th colspan="2">Jan. 22, 2024
Monday</th><th colspan="2">Jan. 23, 2024
Tuesday</th><th colspan="2">Jan. 24, 2024
Wednesday</th></tr>
<tr><th>Time</th><th>Event</th><th>Time</th><th>Event</th><th>Time</th><th>Event</th><th>Time</th><th>Event</th></tr>
<tr><td rowspan="5"></td><td rowspan="5"></td><td>8:30 – 10:00</td><td>Welcome & Registration</td><td rowspan="2">08:30 - 10:50</td><td rowspan="2">Oral 3: 2 parallel sections (14 talks)
Location: SC158-160</td><td rowspan="2">08:30 - 10:50</td><td rowspan="2">Oral 4 (21 talks)
Location:
SC158-160-162</td></tr>
<tr><td>10:00-11:00</td><td>Opening Ceremony
Location: SC001</td></tr>
<tr><td>11:00-11:20</td><td>Tea break</td><td>10:50 – 11:00</td><td>Tea break</td><td>10:50 – 11:10</td><td>Tea break</td></tr>
<tr><td rowspan="2">11:20-11:50</td><td rowspan="2">Plenary Talk 1
Prof. Ryo Ishikawa
Location: SC001</td><td rowspan="2">11:00 - 12:30</td><td>Group 1:
Poster exhibition
First floor corridors</td><td>11:10 - 11:40</td><td>Plenary talk 2
Prof. Ho Won Jang
Location: SC001</td></tr>
<tr><td>Group 2:
NSRRC tour</td><td>11:40 – 12:10</td><td>Plenary talk 3
Dr. Huan Tran
Location: SC001</td></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td>12:00-13:00</td><td>Lunch time</td><td rowspan="5">12:30 -20:30</td><td rowspan="5">Excursion</td><td rowspan="2">12:10 - 12:40</td><td rowspan="2">Closing remark & Awards
Location: SC001</td></tr>
<tr><td rowspan="2">13:00-15:00</td><td rowspan="2">Oral 1: 3 parallel sections (18 talks)
Location: SC158-160-162</td></tr>
<tr><td>14:00</td><td rowspan="2">Arrival & Registration</td><td>15:00-15:15</td><td>Tea break</td><td rowspan="4">12:40</td><td rowspan="4">Farewell</td></tr>
<tr><td rowspan="2">16:00-18:00</td><td rowspan="2">Steering Committee Meeting</td><td>15:15-16:35</td><td>Oral 2: 4 parallel sections (16 talks)
Location: SC157-158-160-162</td></tr>
<tr><td>16:45-17:30</td><td>Leaving for banquet</td></tr>
<tr><td>18:00</td><td>Poster Preparation & Reception Dinner</td><td>17:30-20:00</td><td>Banquet</td></tr>
</table>

FMS 2024_DAILY PROGRAM SCHEDULE

Time	Event	
Jan. 21, 2024 Sunday	**Welcome to FMS 2024**	
14:00-16:00	Arrivals & Registrations	
16:00-18:00	Steering Committee Meeting	
18:00-20:00	Reception Dinner SC353	Poster Preparation 1st floor, Science Building III
Jan. 22, 2024 Monday	**Conference (1/3)**	
8:30 – 10:00	Welcome & Registrations	
10:00-11:00	**Opening Ceremony** Location: SC001 **Chair: Prof. Wu-Ching Chou**	**10:00-10:05: Opening remark** **Chi-Hung Lin,** NYCU president **10:05-10:10: Sponsor remarks** **Minn-Tsong Lin**, Deputy Minister of Taiwan National Science and Technology Council (NSTC) **10:10-10:15: Sponsor remarks** **Meng-Fan Luo**, Director General, Department of Natural Science and Sustainable Development, NSTC **10:15-10:35: Co-organizer remarks: Scientific Opportunities @ the NSRRC** **Chia-Hung Hsu**, Director of National Synchrotron Radiation Research Center (NSRRC), Taiwan **10:35-11:00**: Taking group photos
11:00-11:20	**Tea break**	
11:20-11:50	**Plenary Talk 1** Location: SC001 **Section Chair: Prof. Masato Yoshiya**	**Prof. Ryo Ishikawa**, University of Tokyo, Japan Atomistic defect analysis by atomic-resolution electron microscopy
12:00-13:00	**Lunch time**	

13:00-15:00	**Oral 1:18 talks**			
	Oral 1_Section 1: SC158 **Chair: Chih-Wei Luo** **Two-dimensional materials and related applications (2D_I)**	**Oral 1_Section 2: SC160** **Chair: Mikhail Brik** **Materials for green energy and environment (EE_I)**	**Oral 1_Section 3: SC162** **Chair: Thanh Cong Bach** **Multiferroics and magnetic materials (MM)**	
13:00-13:20	2D_T01 (Shun-Jen Cheng)	EE_T01 (Chung-Li Dong)	MM_T01 (Way-Faung Pong)	
13:20-13:40	2D_T02 (Ying-Hao Chu)	EE_T02 (Shiuan-Huei Lin)	MM_T02 (Ekkes Brueck)	
13:40-14:00	2D_T03 (Shao-Yu Chen)	EE_T03 (Soo Young Kim)	MM_T03 (Harald O. Jeschke)	
14:00-14:20	2D_T04 (Yen-Fu Lin)	EE_T04 (Mgr. Maksym Buryi)	MM_T04 (Jakob Walowski)	
14:20-14:40	2D_T05 (Wen-Cheng Ke)	EE_T05 (Michal Piasecki)	MM_T05 (Keiichi Koyama)	
14:40-15:00	2D_T06 (Vera Marinova)	EE_T06 (Chin-Hau Chia)	MM_T06 (Stefan Süllow)	
15:00-15:15	**Tea break**			
15:15-16:35	**Oral 2: 16 talks**			
	Oral 2_Section 1: SC158 **Chair: Shao-Yu Chen** **Two-dimensional materials and related applications (2D_II)**	**Oral 2_Section 2: SC160** **Chair: The Toan Nguyen** **Materials for green energy and environment (EE_II)**	**Oral 2_Section 3: SC162** **Chair: Yen-Fu Lin** **Two-dimensional materials and related applications (2D_III)**	**Oral 2_Section 4: SC157** **Chair: Keiichi Koyama** **Spintronic & topological materials (ST)**
15:15-15:35	2D_T07 (Chih-Wei Luo)	EE_T07 (Jae Beom Lee)	2D_T11 (Wen-Hao Chang)	ST_T01 (Chin-Shan Lue)
15:35-15:55	2D_T08 (Dimitre Z. Dimitrov)	EE_T08 (Van Hao Bui)	2D_T12 (Thanh Cong Bach)	ST_T02 (Masashi Akabori)
15:55-16:15	2D_T09 (Chun-Liang Lin)	EE_T18 (Kazuhito Tsukagoshi)	2D_T13 (Takuji Ohigashi)	ST_T03 (Takashi Kimura)
16:15-16:35	2D_T10 (Chu-Shou Yang)	EE_T10 (Nang Dinh Nguyen)	2D_T14 (Huy Tiep Nguyen)	ST_T05 (Jiunn-Yuan Lin)
16:45-17:30	Leaving for banquet			
17:30-20:00	**Banquet**			

Jan. 23, 2024 Tuesday	Conference (2/3)	
8:30 - 10:50	**Oral 3: 13 talks**	
	Oral 3_Section 1: SC158 **Chair: Cheng-Maw Cheng/ Yan-Gu Lin** **Synchrotron X-Ray Science & Applications (NSRRC)**	**Oral 3_Section 2: SC160** **Chair: Takashi Kimura** **THz materials and devices (TD)**
8:30-8:50	Opening remarks (Chia-Hao Chen)	TD_T01 (Hsin-Fei Meng)
8:50-9:10	NSRRC_T01 (Hung-Wei Shiu)	TD_T02 (Atsushi Yabushita)
9:10-9:30	NSRRC_T02 (Ping-Hui Lin)	TD_T03 (Chin-Han Chung)
9:30-9:50	NSRRC_T04 (Yan-Gu Lin)	TD_T04 (Der-Hsien Lien)
9:50-10:10	NSRRC_T05 (Cheng-Maw Cheng)	MM_T07 (Jenh-Yih Juang)
10:10-10:30	NSRRC_T06 (Ying-Rui Lu)	MM_T08 (Chien-Te Wu)
10:30-10:50		MM_T09 (Huu Phuoc Le)
10:50 – 11:00	**Tea break**	
11:00 - 12:30	**Poster exhibition** First floor corridors	**NSRRC tour**: **10:50 – 11:00**: NYCU – to – NSRRC **11:00 – 12:30**: TPS Site Tour (09A, 27A, 30A)
12:30 -20:30	**Excursion**	
	Bus A: Taipei National Palace Museum-Jiufen Old Street **12:30-13:45**: To Taipei National Palace Museum **13:45-14:15**: Tour guidance (tickets, audio guides) **14:15-15:15**: Visit gallery at 3rd floor → 2nd floor → 1st floor **15:15-15:45**: Free time for guest **15:50-17:00**: To Jiufen old street **17:00-18:00**: Walking around the old street **18:00-19:30**: Dinner & Tea **19:30-20:30**: Back to NYCU	**Bus B: Sun Moon Lake** **12:30-14:45**: To Sun Moon Lake **14:45-15:00**: Tour guidance **15:00-15:45:** Xiangshan Visitor Center/ Xiangshan Scenic outlook **15:45-16:30**: Visit Shuishe port **17:00-18:30**: Dinner & Tea **18:30-20:30**: Back to NYCU

Jan. 24, 2024 Wednesday	Conference (3/3)			
08:30 - 10:50	Oral 4 :21 talks			
	Oral 4_Section 1: SC158 **Chair: Nang Dinh Nguyen** **Photonics and nanostructured hybrid materials (PH)**	**Oral 4_Section 2: SC160** **Chair: Jenh Yih Jhuang** **Materials for green energy and environment (EE_III)**	**Oral 4_Section 3: SC162** **Chair: Huan Tran** **Theoretical and computational materials science (TC)**	
8:30-8:50	PH_T01 (Gabriella Tessitore)	EE_T11 (Wen-Bin Jian)	TC_T01 (Mikhail Brik)	
8:50-9:10	PH_T02 (An Bang Ngac)	EE_T12 (Jeng-Lung Chen)	TC_T03 (Masahiko Okumura)	
9:10-9:30	PH_T03 (Viet Cuong Le)	EE_T13 (Duy Thien Nguyen)	TC_T04 (The Toan Nguyen)	
9:30-9:50	EE_T15 (Ray-Hua Horng)	EE_T14 (Danh Bich Do)	TC_T05 (Masato Yoshiya)	
9:50-10:10	EE_T16 (Candy C. Mercado)	ST_T06 (Kimitoshi Kono)	TC_T06 (Si-Young Choi)	
10:10-10:30	EE_T17 (Indrajit Shown)	ST_T07 (Jin-Ming Chen)	TC_T07 (Thanh Tra Vu)	
10:30-10:50	2D_T15 (Sonia Sharma)	ST_T08 (Ying-Kuan Ko)	TC_T08 (Khuong Dien Vo)	
10:50 – 11:10	Tea break			
11:10 - 11:40	**Plenary talk 2** Location: SC001 **Section Chair**: **Prof. Si-Young Choi**	**Prof. Ho Won Jang**, Seoul National University, Korea Halide Perovskites for Data Storage and Neuromorphic Computing		
11:40 – 12:10	**Plenary talk 3** Location: SC001 **Section Chair**: **Prof. An Bang Ngac**	**Dr. Huan Tran**, Georgia Institute of Technology, USA Materials Informatics: Accelerating Materials Research with Artificial Intelligence		
12:10 - 12:40	**Closing remark & Awards** Location: SC001			
12:40	Farewell			

INSTRUCTION FOR CHAIRS, INVITED SPEAKERS, AND POSTER PRESENTERS

For Session Chairs:

- Chairs are recommended to be at the meeting room at least 15 minutes before the session starts.
- Please precisely control the starting time for each talk according to the conference program to ensure the smooth proceeding of each session.

For Plenary Speakers and Invited Speakers

Session Type	Time slots
Plenary talk	30 min. presentation, including Q & A
Invited talk	20 min. presentation, including Q & A

Preparations for presentations:

- Please prepare your backup copy on a USB. Kindly test and check your presentation slides at least 30 minutes prior to your presentation session at the Oral room.
- The meeting room will be equipped with a Notebook and projector. All speakers are recommended to use the Notebook provided to prevent the problem of connectivity and save time for installation.
- Please arrive at your session meeting room at least 15 minutes before your session starts to discuss with the Session Chairs and have your presentation ready.

Speaker Lounge

- Venue: Room SC151 - SC159
- Service Hours:
  - 7:30 – 18:00 Monday, 22 January to Tuesday, 23 January 2024
  - 7:30 – 13:00 Wednesday, 24 January 2024

Instruction for Poster Presenters

- Poster presentation will be held on the 1st floor, Science Building III of National Yang Ming Chiao Tung University.
- At least one of the authors is required to be in attendance during the Poster Exhibition time.
- Presenting authors are required to set up their posters at designated hours according to the program schedule.
- Mounting and Removal
  - Adhesive staples will be provided onsite.
  - Authors hang their posters and remove them after the exhibition.

TABLE OF CONTENTS_INVITED TALKS

EE_T12	Oral 4_Section 2	Jeng-Lung Chen	Application of X-ray absorption spectroscopy at TPS 44A beamline to decipher the active site in energy material	44
EE_T13		Duy Thien Nguyen	Ag-Coated Si nanowire arrays: A new route for the precise detection of carbendazim in pomelo by surface enhanced Raman scattering	45
EE_T14		Danh Bich Do	Photothermal Natural-Inspired Materials For Highly Efficient Solar Steam Generation	46
EE_T15	Oral 4-Section 1	Ray-Hua Horng	Study on P-type Ga_2O_3 epilayers using phosphorus-ion implantation technology	47
EE_T16		Candy C. Mercado	Enhancement of Dye Degradation in Piezo-Photocatalytic ZnO-MoS_2 Heterostructures	48
EE_T17		Indrajit Shown	Advancing Metal Sulphide Photocatalysts in Artificial Photosynthesis for Sustainable Energy Solutions	49
EE_T18	Oral 2_Section2	Kazuhito Tsukagoshi	Electromechanical Switching of a C_{60} nanochain	50
Multiferroics and magnetic materials (MM)				
MM_T01	Oral 1_Section 3	Way-Faung Pong	Coupling between spin and lattice in an XY-like spin-glass $(Ni_{0.40}Mn_{0.60})TiO_3$	51
MM_T02		Ekkes Brück	Materials for efficient conversion of low temperature waste heat	52
MM_T03		Harald O. Jeschke	Progress in frustrated magnetism from density functional theory based energy mapping	53
MM_T04		Jakob Walowski	Exploring the impact of the inverse Faraday-effect on all-optical helicity-dependent magnetization switching	54
MM_T05		Keiichi Koyama	Synthesis of some ferromagnetic materials in a magnetic field	55
MM_T06		Stefan Süllow	Competing magnetic phases of frustrated quantum magnets: Field-induced quantum criticality and dimensional reduction in the quantum sawtooth chain atacamite	56
MM_T07	Oral 3_Section 2	Jenh-Yih Juang	Coexistence of the E-type and cycloidal magnetic phases in multiferroic $YMnO_3$ thin films unveiled by the wasp-waisted magnetic hysteresis loops	57
MM_T08		Chien-Te Wu	BCS-BEC crossover in two-band superconductors—A GG0 T-matrix approach	58
MM_T09		Huu Phuoc Le	Partial superconductivity and anomalous magnetoresistance in SnTe thin films	59
Photonics and nanostructured hybrid materials (PH)				
PH_T01		Gabriella Tessitore	Luminescence Dynamics in Lanthanide-Doped Nanomaterials	60

PH_T02	Oral 4_Section 1	An Bang Ngac	Unraveling the mechanism of photo-induced surface enhanced Raman scattering on ZnO/Au nanostructures	61
PH_T03		Viet Cuong Le	Non-conventional Surface Plasmon Resonance Sensors	62
Spintronic & topological materials (ST)				
ST_T01	Oral 2_Section 4	Chin Shan Lue	Single crystal growth of quantum and functional materials at NCKU	63
ST_T02		Masashi Akabori	Growth and characterization of MnSb and InSb on GaAs (111)B using molecular beam epitaxy for spin-FET application	64
ST_T03		Takashi Kimura	Spin transport and spin thermo-electric properties of 2D vdW FeGaTe film	65
ST_T04 (canceled)		Sungkyun Park	Study on the spin-flop transition in epitaxial α-Fe_2O_3 films	66
ST_T05		Jiunn-Yuan Lin	Ultrafast dynamics in critical topological materials	67
ST_T06	Oral 4_Section 2	Kimitoshi Kono	Anomalous Hall Effect in Superfluid 3He-A	68
ST_T07		Jin-Ming Chen	High-pressure induced spin state transition and intermetallic charge transfer in $PbCoO_3$	69
ST_T08		Ying-Kuan Ko	Terahertz Emission from Topological Material $SrCd_2Sb_2$ single crystals	70
Theoretical and computational materials science				
TC_T01	Oral 4_Section 3	Mikhail G. Brik	First-principles and crystal field calculations of optical properties of phosphor materials	71
TC_T02 (canceled)		Hidekazu Ikeno	Catalytic properties of perovskite-type related oxides for oxygen evolution reactions based on density functional calculations	72
TC_T03		Masahiko Okumura	Machine learning molecular dynamics simulations of materials with complex structures	73
TC_T04		The Toan Nguyen	Comparing receptor binding properties of SARS-CoV-2 and of SARS-CoV virus by using unsupervised machine learning models	74
TC_T05		Masato Yoshiya	Factors governing disparities of electrons and phonons transports in quasi-ternary sulphides for thermoelectric applications	75
TC_T06		Si-Young Choi	Ferroelectricity by phonon-decoupled oxygen tetrahedra in brownmillerite oxides	76
TC_T07		Thanh Tra Vu	The influences of external fields on the optical absorption spectra of zigzag buckling silicene nanoribbons without and with divacancies	77

TC_T08		Khuong Dien Vo	Correlation between Orbital Hybridizations, Phonon Spectra, and Thermal Properties of Graphene, Germanene, and Plumbene	78
THz materials and devices				
TD_T01	Oral 3_Section 2	Hsin-Fei Meng	The development and application of organic solar panels and ammonia sensors	79
TD_T02		Atsushi Yabushita	Ultrafast electronic and vibrational dynamics in carbon nanotubes dependent on chirality and alkylation	80
TD_T03		Chin-Han Chung	Impact of Proton Irradiation on Quaternary InAlGaN/AlN/GaN Epitaxial Structure for LEO Satellite Applications	81
TD_T04		Der-Hsien Lien	Manipulating 2D Carrier Density in Atomically-Thin In_2O_3	82
Two-dimensional materials and related applications				
2D_T01	Oral 1_Section 1	Shun-Jen Cheng	Optical Access of Finite Momentum Excitons in Transition-metal Dichalcogenide Monolayers Using Twisted Lights	83
2D_T02		Ying-Hao Chu	Epitaxial Growth, Characterizations, and Integration of Bi_2O_2X Semiconductors	84
2D_T03		Shao-Yu Chen	Toward Artificial 2D Hybrid Quantum Materials	85
2D_T04		Yen-Fu Lin	Ambipolar 2D Transistor: Potentially Pioneering the Next Wave of Device Applications	86
2D_T05		Wen-Cheng Ke	InGaN-Based Light-Emitting Diodes Grown on Various Layer Numbers of Graphene Interlayers/Patterned Sapphire Substrate	87
2D_T06		Vera Marinova	Two-dimensional nanomaterials toward photonic applications	88
2D_T07	Oral 2_Section 1	Chih-Wei Luo	Nematicity in SnS single crystals probed by ultrafast spectroscopy	89
2D_T08		Dimitre Dimitrov	WTe_2: synthesis, properties and applications	90
2D_T09		Chun-Liang Lin	Superconductivity in Plumbene-Au Kagome Superstructure	91
2D_T10		Chu-Shou Yang	Characteristic of 2D to 3D Heterostructures Grown by Molecular Beam Epitaxy	92
2D_T11	Oral 2_Section 3	Wen-Hao Chang	Wafer-Scale Single-Crystal Growth of 2D Semiconductors for Practical Applications	93
2D_T12		Thanh Cong Bach	First Order Magnetic Transitions in 2D Blume- Capel Spin 1 Model	94

2D_T13		Takuji Ohigashi	Development of soft X-ray microscopic analysis and its perspective	95
2D_T14		Huy Tiep Nguyen	Multiferroic properties in 2D layered organic-inorganic perovskite single crystals	96
2D_T15	Oral 4_Section 1	Sonia Sharma	Highly fluorescent MoS2 Qauntum dots as a photoluminecsence sensing platform for Fe3+ ion detection	97
Special talks: Synchrotron X-Ray Science & Applications				
NSRRC_T01	Oral 3_Section 1	Hung-Wei Shiu	Advancements in Spectromicroscopy: The STXM End-Station at TPS 27A	98
NSRRC_T02		Ping-Hui Lin	Unveiling Electron Dynamics: Time-Resolved Angle-Resolved Photoemission Spectroscopy in NSRRC	99
NSRRC_T04		Yan-Gu Lin	Characterizing Catalysts in Action through Synchrotron Radiation	100
NSRRC_T05		Cheng-Maw Cheng	Unveiling Surface Electron Accumulation in Transition Metal Dichalcogenides: Insights and Applications in MoS_2, $MoSe_2$, and ReS_2	101
NSRRC_T06		Ying Rui Lu	Tender X-ray Absorption Spectroscopy (XAS) Beamline in Taiwan Photon Source	102

Plenary Talks

Plenary Talk 1: Prof. Ryo Ishikawa

University of Tokyo, Japan

Location: SC001
Section Chair: Prof. Masato Yoshiya

Atomistic defect analysis by atomic-resolution electron microscopy

Ryo Ishikawa*

[1]*Institute of Engineering Innovation, University of Tokyo, 2-11-16, Yayoi, Bunkyo, Tokyo 113-8656, Japan.*

* Corresponding e-mail: *sishikawa@sigma.t.u-tokyo.ac.jp*

Following the development of modern aberration correction in electron microscopy, it has been routinely available sub-Ångstrom spatial resolution in inorganic materials. The currently achievable spatial resolution is less than half an Ångstrom [1], which seems sufficiently high enough to analyze local atomic structures. However, such high spatial resolution is only valid in the lateral two dimensions, and the last remaining depth resolution along the axial direction is still no better than 5 – 10 nm in scanning transmission electron microscopy (STEM). Since the physical limit of the depth resolution is dominated by the illumination angle (α) in STEM [2,3], we therefore have newly developed a Delta-type corrector that can correct up to 6^{th}-fold astigmatism and installed the corrector into our ARM300CF at the University of Tokyo. The flat region in Ronchigram is remarkably improved up to 70 mrad at 300 kV. By utilizing such large α, we have systematically investigated the depth resolution by using single Ce dopants embedded in cubic boron nitride (*c*-BN) [4], where we obtained 2.1 nm depth resolution with the illumination angle of 63 mrad at 300 kV [5]. Furthermore, by combining statistical analysis with STEM depth sectioning, we also achieved 3D atomic resolution at the oxide surface [6].

The other critical issue in STEM is the low temporal resolution because of the slow scanning of the electron probe [7]. We, therefore, developed a new scanning probe system. By implementing this sub-scanning probe system into our microscope, we achieved 25 fps (frame per second) with a 512 × 512 pixels image size at an atomic resolution corresponding to 40 milliseconds per frame [8]. We will also discuss our new scanning probe system, tracking the Pt single atomic motion and the dynamics of Pt nanoparticles on TiO_2 (110) at high temperatures [9].

Keywords: atomic-resolution STEM, depth sectioning, differential phase contrast

References:

[1] R. Ishikawa et al., Microscopy **72** 78-96 (2023).
[2] R. Ishikawa et al., Ultramicroscopy **151** 122 (2015).
[3] R. Ishikawa et al., Appl. Phys. Lett. **109** 163102 (2016).
[4] R. Ishikawa et al., Phys. Rev. Lett. **110** 065504 (2013).
[5] R. Ishikawa et al., Phys. Rev. Appl. **13** 034064 (2020).
[6] R. Ishikawa et al., ACS Nano **15** 9186 (2021).
[7] R. Ishikawa et al., Phys. Rev. Lett. **113** 155501 (2014).
[8] R. Ishikawa et al., Microscopy **69** 240 (2020).
[9] R. Ishikawa et al., Nano Lett. **22** 4161 (2022).

Presenting author Email address: sishikawa@sigma.t.u-tokyo.ac.jp

Plenary Talk 2: Prof. Ho Won Jang

Seoul National University, Korea

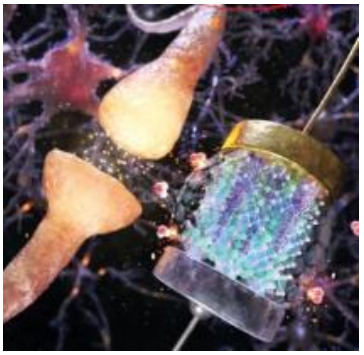
Location: SC001
Section Chair: Prof. Si-Young Choi

Halide Perovskites for Data Storage and Neuromorphic Computing

Ho Won Jang[1*]

[1] *Department of Materials Science and Engineering, Seoul National University, Republic of Korea*

[*] Corresponding e-mail: *hwjang@snu.ac.kr*



Halide perovskites have been noted for their exotic properties such as fast ion migration, tunable composition, facile synthetic routes, and flexibility in addition to large light absorption coefficients, long carrier diffusion lengths, and high defect tolerance. These properties have made halide perovskites promising materials for memristors. Applications in the field of resistive switching memory devices and artificial synapses for neuromorphic computing are especially noteworthy. This Perspective covers state-of-the-art perovskite-based memristive devices. Moreover, the fundamental mechanisms and characteristics of perovskite-based memristors are elucidated. Interesting opportunities to improve the performance of perovskite-based memristors for commercialization are provided, including improving film uniformity and air stability, controlling the stoichiometry, finding new all-inorganic and lead-free halide perovskites, and making perovskites into single crystals or quantum dots. We expect our Perspective to be the foundation of realizing next-generation halide perovskite-based memristors.

Keywords: Memristors, Halide Perovskites, Random Acess Momory, Resitive Switching, Neuromorphic

References:

[1] Advanced Materials 2016, 28 (31), 6562–6567.
[2] Journal of Physical Chemstry Letters 2021, 12 (37), 8999–9010.
[3] Nano Letters 2022, 22 (14), 6010–6017.
[4] Materials Today 2022, 52, 19–30.

Presenting author Email address: hwjang@snu.ac.kr

Plenary Talk 3: Dr. Huan Tran

Georgia Institute of Technology, USA

Location: SC001
Section Chair: Prof. An Bang Ngac

Materials Informatics: Accelerating Materials Research with Artificial Intelligence

Huan Tran

School of Materials Science & Engineering, Georgia Institute of Technology, 771 Ferst Dr. NW, Atlanta, GA 30332, USA
Matmerize, Inc., Atlanta, GA 30332, USA

* Corresponding e-mail: *huan.tran@mse.gatech.edu*

In the last decade or so, Materials Informatics has been emerging as a new subfield of Materials Science & Engineering, focusing on developing suitable machine-learning (ML), and in a broader view, artificial-intelligence (AI) approaches, to advance the fundamental understanding and to accelerate the discovery/design of new functional materials. Two primary factors that initiate and promote the development of Materials Informatics are the recent maturity of past data, typically curated/generated from experiments and (empirical- and first principles-based) simulations, and the advance of modern ML/AI infrastructures, e.g., hardware and algorithms. This highly-interdisciplinary research and development field is now blossoming globally with numerous game-changing approaches and toolkits that were developed and, ultimately, new functional materials with targeted, application-specific properties/performances that were discovered and/or designed. In this talk, I will outline the development of Materials Informatics, the current central problems and results, the critical challenges, and the next steps that can be envisioned for the near future.

Presenting author Email address: huan.tran@mse.gatech.edu

Invited Talks

EE_T01

Emerging X-ray spectroscopy for energy materials

Chung-Li Dong[1*]

[1]*Department of Physics, Tamkang University, Tamsui 25137, Taiwan*

[*] Corresponding e-mail: *cldong@mail.tku.edu.tw*

Materials scientists play a crucial role in addressing the issues of increasing global demand for sustainable and clean energy. To pave the way for a zero-emission future, developing advanced renewable energy materials holds significant importance, and thus we must tackle these challenges from multiple perspectives, with a specific emphasis on the materials that enhance energy conversion, storage, and conservation efficiencies. Improving the efficiency of existing energy materials is straightforward but presents technically challenges. The physical and chemical properties of materials are closely correlated with their atomic and electronic structures. Gaining a deep understanding of these fundamental characteristics, particularly their behavior at work, is essential for effective engineering and practical application. Synchrotron x-ray spectroscopies, including x-ray absorption and x-ray emission spectroscopies, serve as powerful tools for investigating the atomic and electronic structures of energy materials. By employing in situ techniques, the dynamic changes in the atomic and electronic structures during operation can be monitored. The emerging scanning transmission x-ray microscopy offers spatially resolved x-ray spectroscopy, holding great potential for exploring energy science. This presentation aims to underscore the significance of x-ray spectroscopies in characterizing the atomic and electronic structures of energy material systems, such as artificial photosynthesis materials, advanced nanocatalysts, and smart materials. It will also encompass recent advancements in in-situ techniques. Tamkang University TKU-NSRRC end-stations at the Taiwan Photon Source (TPS) 45A & 27A beamlines, which are specifically dedicated to energy science research will be also introduced.

Keywords: X-ray spectroscopy, atomic structure, electronic structure, energy materials

Presenting author Email address: cldong@mail.tku.edu.tw

Atomic layer deposited Al-doped ZnO thin films for liquid crystal devices

Shiuan Huei Lin[1*], Stefan Petrov[1], Vera Marinov[2*], Dimitrina Petrova[3] and Dimitre Dimitrov[2]

[1]*Department of Electrophysics, National Chiao Tung University, Hsinchu 30010, Taiwan*
[2]*Institute of Optical Materials and Technologies, Bulgarian Academy of Sciences, 1113 Sofia, Bulgaria*
[3]*Faculty of Engineering, South-West University "Neofit Rilski", 2700 Blagoevgrad, Bulgaria*

[*] Corresponding e-mail: *lin@nycu.edu.tw; vmarinova@iomt.bas.bg*

The integration of high uniformity, conformal and compact transparent conductive layers into next generation indium tin oxide (ITO)-free optoelectronics including wearable and bendable structures is a huge challenge [1-2]. In this talk, we demonstrate transparent and conductive functionality of Aluminum-doped zinc oxide (AZO) thin films deposited on glass as well as on Polyethylene terephthalate (PET) flexible substrates by using atomic layer deposition (ALD) technique. AZO thin films possess high optical transmittance at visible and near-infrared spectral range and electrical properties competitive to commercial ITO layers. AZO layers deposited on flexible PET substrate demonstrate very stable sheet resistance over 1000 bending cycles. Based on the performed optical and electrical characterizations several applications of ALD AZO as transparent conductive layer are shown: AZO/Glass supported Liquid Crystal (LC) display as well as AZO/PET based flexible Polymer Dispersed Liquid Crystal (PDLC) devices [3-4]. In addition, we demonstrate for the first time to the best of our knowledge a vertical orientation of the LC director achieved by controlling the crystallographic orientation of the AZO films, further enhanced by formation of nanogrooves on the films surface by the mechanical rubbing. The electro-optical characteristics of the AZO based LC phase retarder were demonstrated. Presented results show the superior potential of AZO for integration in next-generation indium-free LC devices.

Keywords: Al-doped ZnO, ALD technique, transparent conductive layers, LC display, flexible PDLC devices.

References:

[1] K. Elmer, Past achievements and future challenges in the development of optically transparent electrodes, Nature Photon 6, (2012), 809–817.
[2] M. Morales-Masis, S. Wolf, R. Woods-Robinson, J. Ager, C. Ballif, Transparent Electrodes for Efficient Optoelectronics, Adv. Electron. Mater. 3, (2017), 1600529.
[3] D. Dimitrov, C. L. Tsai, S. Petrov, V. Marinova, D. Petrova, B. Napoleonov, B. Blagoev, B. Strijkova, K. Y. Hsu, S. H. Lin, "Atomic layer deposited Al-doped ZnO thin films for display applications" Coatings 10 (6), (2020), 539.
[4] D. Z. Dimitrov, Z. F. Chen, V. Marinova, D. Petrova, C. Y. Ho, B. A. Napoleonov, B. Blagoev, V. Strijkova, K. Y. Hsu, S. H. Lin, J. Y. Juang, ALD deposited ZnO:Al films on mica for flexible PDLC devices, Nanomaterials 11, (2021), 1011

Presenting author Email address: lin@nycu.edu.tw

MOF-based efficient catalysts for CO_2 electrochemical conversion

Soo Young Kim [1*]

[1] *Department of Materials Science and Engineering, Korea University, Republic of Korea*

[*] Corresponding e-mail: sooyoungkim@korea.ac.kr

The pursuit of a circular carbon economy and the need to surmount the constraints of CO_2 electroreduction technology has prompted the development of single-atom catalysts (SACs) for electrocatalysts. SACs consist of isolated metal atoms dispersed on a support material. First, zeolitic imidazolate framework (ZIF)-8 containing various transition metal ions—Ni, Fe, and Cu—at varying concentrations upon doping were fabricated for the electrocatalytic CO_2 reduction reaction (CO2RR) to CO without further processing. The electron-rich sp_2 C atoms of optimized copper doping on ZIF-8, leading to a local effect between the Zn–N_4 and Cu–N_4 moieties, achieve a maximum Faradaic efficiency for CO_2 to CO of 88.5% at -1.0 V (vs. RHE) with a stability over 6 h.[1] Second, compared to nanoparticles, single atom catalysts (SACs) have been shown to significantly enhance the efficiency of metal atom utilization by nearly 100%, which results in a higher concentration of active sites, leading to outstanding catalytic activity, excellent product selectivity, and stability. Among the diverse support materials, the ZIFs, a sub-class of metal-organic frameworks (MOFs) with high nitrogen content, have been widely used to prepare metal-nitrogen-doped carbon (M-N-C) SACs with dense active sites. Herein, we utilized an eco-friendly approach to produce two-dimensional ZIF-8 nanosheets (ZIF-8-NS) as an optimal support material for SACs. Additionally, we introduced Ni precursor into the synthesis process of Ni-ZIF-8-NS, which was then subjected to pyrolysis at 950 °C under a N_2 atmosphere to yield the final product, Ni-NC-NS. Ni-NC-NS demonstrated an outstanding CO_2RR performance by exhibiting excellent Faradaic efficiency (FE) toward CO of ~100% both in the H-cell and flow-cell reactors as well as a remarkable turnover frequency (TOF) of 23,699 h^{-1} [2]

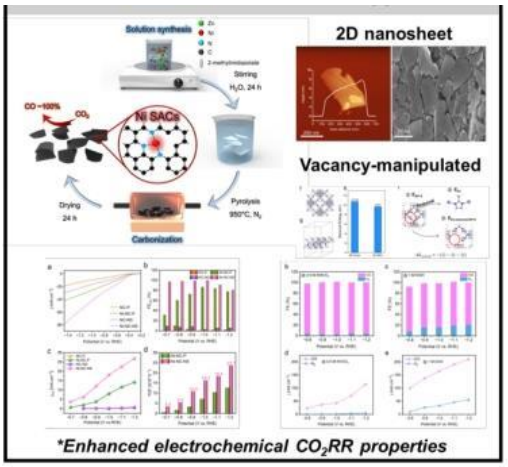


Figure 1. 2D MOF nanosheet as SAC support

Keywords: carbon dioxide reduction, 2-dimensional material, metal-organic frameworks, single-atom catalyst, vacancy sites

References:

[1] J. H. Cho, S. H. Hong, C. Lee, S. Back, M.-g. Seo, M. Lee, H.-K. Min, Y. Choi, Y. J. Jang, S. H. Ahn*, H. W. Jang*, S. Y. Kim*, "Transition metal ions doping on ZIF-8 for enhancing the electrochemical CO2 reduction reaction", ***Advanced Materials***, vol. 35, p.2208224 (1-9) (2023)

[2] J. H. Cho+, J. Ma+, C. Lee+, J. W. Lim, Y. Kim, H. Y. Jang, J. Kim, M.-g. Seo, Y. Choi, Y. J. Jang, S. H. Ahn, H. W. Jang, S. Back*, J.-L. Lee*, S. Y. Kim*, "Crystallographically vacancy-induced MOF nanosheet as rational single-atom support for accelerating CO2 electroreduction to CO", on-line published at ***Carbon Energy***

Presenting author Email address: sooyoungkim@korea.ac.kr

The potential of plasma chemical technologies in the new materials synthesis

Maksym Buryi[1*], Jafar Fathi[1], Alan Mašláni[1], David John[2,3,4], Vladimir Babin[2], Zdeněk Remeš[2]

[1]*Institute of Plasma Physics of the Czech Academy of Sciences, U Slovanky 2525/1a, 182 00, Prague, Czechia*
[2] *FZU - Institute of Physics of the Czech Academy of Sciences, Na Slovance 1999/2, 18200 Prague, Czechia*
[3] *Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Břehová 7, 11519 Prague, Czechia*
[4] *Nuclear Physics Institute of the Czech Academy of Sciences, Na Truhlářce 39/64, 18000 Prague, Czechia*

[*] Corresponding e-mail: *buryi@ipp.cas.cz*

Single crystalline bodies in most cases are highly efficient materials with the given properties which find application in many branches of science, industry and everyday life of the human society. However, the single crystal production is expensive and, therefore, neverending search for the cheaper but as much effective compounds is conducted worldwide. As the alternatives, especially, in optoelectronics, glasses or glass ceramics are proposed. Their fabrication is easier and cost effective in this case but still the efficiency is not enough as compared to the single crystals. At the same time, downscaling the size of the crystalline and amorphous compounds, i.e., growth of the nanoparticles can lead to the improved demanding characteristics due to the enhanced surface and increased surface to volume ratio. This effect is known in e.g., zinc oxide.

ZnO, cesium lead bromide ($CsPbBr_3$, CPB) or silicon have pronounced photovoltaic effect [1] which can be used not only in the solar cells but also for the environmental protection, in particular, for water purification [2]. There are several commonly known conventional chemical methods of the nanoparticles synthesis like sol-gel, hot injection, growth from liquid and others. Plasma torch can also be used for the nanoparticles synthesis [3,4]. Moreover, it has the advantage of using, in fact, any kind of precursor. Moreover, plasma itself treats the input materials resulting in the improved properties of the output nanoparticles. As an example, thermal plasma synthesis of Si/SiC nanoparticles from silicon and activated carbon powders can be mentioned [3,4]. Plasma can also be used for the post-growth treatment of the produced nanomaterials. This can result in the improvement of the conductivity and luminescence properties as was reported for Er doped ZnO nanorods exposed to cold inductively coupled Ar + H_2 plasma [5]. As one can see, indeed, plasma chemical technologies are of great importance and, therefore, the aim of the present work was to demonstrate their potential for the carbon-based nanoparticles synthesis.

Keywords: plasma torch, plasma reactor, carbon-based nanoparticles, luminescence, electron paramagnetic resonance

References:

[1] M. Verma, S. Gautam, Journal of Magnetism and Magnetic Materials. 588 (2023) 171436.
[2] O. Al-Hashimi, K. Hashim, E. Loffill, I. Nakouti, A.A.H. Faisal, T.M. Čebašek, Sci Rep. 13 (2023) 13148.
[3] Y.-T. Yu, G.K. Naik, Y.-B. Lim, J.-M. Yoon, Nanoscale Res Lett. 12 (2017) 606.
[4] C.-H. Lee, P. Rai, S.-Y. Moon, Y.-T. Yu, Ceramics International. 42 (2016) 16469–16473.
[5] M. Buryi, Z. Remeš, V. Babin, A. Artemenko, S. Chertopalov, J. Mičová, J. Alloys Compd. 895 (2022).

Presenting author Email address: buryi@ipp.cas.cz

Insights from Experiment and Theory on Peculiarities of the Electronic Structure and Optical Properties of the $Tl_2Hg(Sn,Ge)Se_4$ Crystals

O.Y. Khyzhun [1], TuanV.Vu [2, 3], G.L. Myronchuk [4], A.O. Fedorchuk [5], M. Piasecki [6, 7*]

[1] [a]*Frantsevych Institute for Problems of Materials Science, National Academy of Sciences of Ukraine, 3 Krzhyzhanovsky Street, 03142 Kyiv, Ukraine*
[2]*Laboratory for Computational Physics, Institute for Computational Science and Artificial Intelligence, Van Lang University, Ho Chi Minh City, Vietnam*
[3]*Faculty of Mechanical - Electrical and Computer Engineering, School of Technology, Van Lang University, Ho Chi Minh City, Vietnam*
[4]*Department of Experimental Physics and Information-Measuring Technology, Lesya Ukrainka Volyn National University, 13 Voli Avenue, 43025 Lutsk, Ukraine*
[5]*Department of Inorganic and Organic Chemistry, Lviv National University of Veterinary Medicine and Biotechnologies, 50 Pekarska Street, 79010 Lviv, Ukraine*
[6]*Jan Dlugosz University Częstochowa, Armii Krajowej 13/15, 42-217 Częstochowa, Poland*
[7]*Inorganic Chemistry Department, Uzhhorod National University, 46 Pidhirna, UA-88000, Uzhhorod, Ukraine*

Quaternary chalcogenides $A^I_2B^{II}D^{IV}Q_4$ (A^I presents Cu or Ag; B^{II} denotes Zn, Cd, and Hg; D^{IV} stands for Si, Ge and Sn; whereas Q indicates S and Se) attract over recent two decades a tremendous attention from technological and scientific viewpoints because of their numerous feasible practical applications (see Fig.1). A number of the $A^I_2B^{II}D^{IV}Q_4$ sulfides and selenides manifest a direct energy band gap being in the 1.0–1.5 eV range, high absorption coefficients (at least bigger than 10^4 cm^{-1}), electrical conductivity of p-type, high conversion powers, etc. These properties are very attractive for application of the $A^I_2B^{II}D^{IV}Q_4$ compounds, especially tin-bearing sulfides and selenides, as efficient materials of thin-film solar cell absorbers [1], thermoelectric and photovoltaic semiconductors [2], photocatalytic convertors of water splitting to hydrogen gas, promising materials for nonlinear optics and luminescence applications. Many physicochemical properties of the $A^I_2B^{II}SnQ_4$ sulfides and selenides can be changed effectively via the formation of solid solutions and doping with other chemical elements, decreasing crystal dimensions to nanosizes, formation of special vacancies on peculiar crystallography sites or intrinsic defects to reach the desirable technological parameters. Because of the relative novelty of $Tl_2Hg(Sn,Ge)Se_4$ selenides, as the literature data feature, peculiarities of its electronic band structure and optical constants, to the best of our knowledge, have not yet been investigated, both theoretically and experimentally. To overcome this lack, we have made experimental as well as theoretical studies of the electronic and optical properties of the titled selenides.

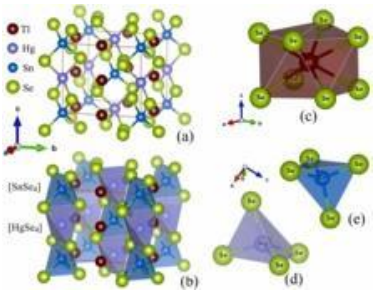


Figure 1. The arrangement of the constituting atoms

Keywords: Crystal structure, Crystals, Mercury, Selenides, X-ray photoelectron spectroscopy, photovoltaics

References:

[1] O.Y. Khyzhun, Tuan V. Vu, G.L. Myronchuk, M. Denysyuk, L.V. Piskach, A.O. Selezen, A.A. Lavrentyev, B.V. Gabrelian, A.O. Fedorchuk, V.A. Tkach, S.S. Petrovska, M. Piasecki, J. Alloys Compd., 952, 2023,170093.
[2] Tuan V. Vu, Oleg Khyzhun, Galyna L. Myronchuk, Mariana Denysyuk, Lyudmyla Piskach, Andrij O. Selezen, Ilona Radkowska, Anatolii O. Fedorchuk, Svitlana S. Petrovska, Vira A. Tkach and Michał Piasecki, Inorganic Chemistry 2023 62 (41), 16691-16709

Presenting author Email address: m.piasecki@ujd.edu.pl

Photoluminescence characteristics of post-annealed Cu_2O thin films

Chin-Hau Chia[1*], Shih-Hao Su[1], Yu-Min Hu[1], Jau-Wen Chiou[1], Chin-Chung Yu[1] and Sheng-Rui Jian[2]

[1]*Department of Applied Physics, National University of Kaohsiung, Kaohsiung 81148, Taiwan*
[2]*Department of Materials Science and Engineering, I-Shou University, Kaohsiung 84001, Taiwan*

[*] Corresponding e-mail: *chchia@nuk.edu.tw*

Cuprous oxide (Cu_2O) acquires considerbly attentions due to its potential use in photovoltaic device in recent years [1]. The Cu_2O films can be successfully fabricated by various techniques, using either the following processes: oxidation of Cu, reduction of CuO into Cu_2O, and direct deposition of Cu_2O. Among them, an appropiate annealig process is required to obtain high-quality films. However, the annealing process may need caution to avoid over-oxidation or over-reduction of film.

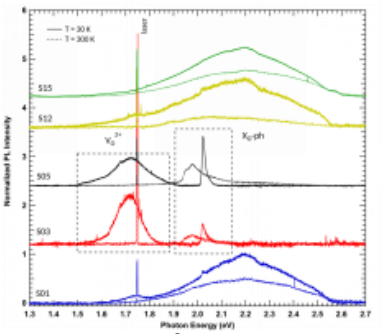


Figure 1. Low-and Room Temperature PL speactra of Cu_2O films

Photoluminescence (PL) measurement is a convenient and nondestructive technique to evaluate the quality of semiconductor thin films. Since the optical dipole transitions of lowest-energy exciton is forbidden in Cu_2O [2], the emission band from Cu_2O film is hardly detected and systematic PL studies on the films are still relatively rare.

In this study, we grew a series of Cu_2O films by rf-magnetron sputtering method. By controlling the post-annealing atmosphere, oxygen-riched to oxygen-deficient films are obtained. XRD and PL are used to study the structural and optical properties of these films. Fig. 1 shows the PL spectra of post-annealed films from oxygen-riched to oxygen-deficient (top to bottom), measured at 30 K and 300 K. The spectra are characterized by a broad visible band at around 2.2 eV, a near-infrared band at 1.75 eV, and phonon-assisted transitions of ortho-exciton at about 2.0 eV. Temperature-dependent PL measurement was also performed to investigate the 1.75 eV-band and excitonic band. The line-shape of phonon-sideband is well modeled by a Maxwell-Boltzmann function and thermal shrinkage of band-gap obtained from the fitting is comparable to those reported [3]. It can be found that the most appropriate oxygen partial pressure for annealing the as-grown Cu_2O thin films is about 2.5-5.3 mTorr at growth-temperature about 700 ^oC. In addition, by comparing the results of XRD and PL, the presence broad luminescence in the visible light spectral-region largely depends on the existence of structural defects in the films.

Keywords: Cu_2O, photoluminesce, post-annealing

References:

[1] Stefan T. Omelchenko *et al.*, '*Excitonic in Emerging Photovoltaic Materials: A Case Study in Cu_2O*', ACS Energy Lett. 2017, **2**, p431-437

[2] Mitsuyoshi Takahata and Nobuko Naka, '*Photoluminescence properties of the entire excitonic series in Cu_2O*', Phys. Rev. B, 2018, **98**, p195205

[3] D. W. Snoke *et al.*, '*Phonon-absorption recombination luminescence of room-temperature excitons in Cu_2O*', Phys. Rev. B, 1992, **45**, p11693

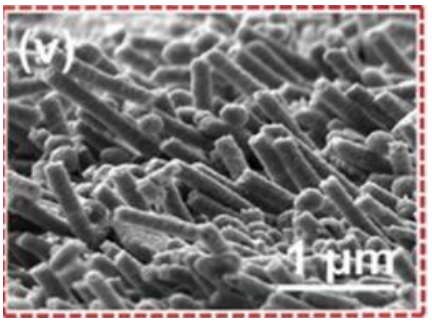
Presenting author Email address: chchia@nuk.edu.tw

Rugged Forest Morphology of Magnetoplasmonic Nanorods that Collect Maximum Light for Photoelectrochemical Water Splitting

Hyung Kook Kim[1], Mahendra Goddati[2], Huu-Quang Nguyen[2], Jaebeom Lee[2]

[1]*Structural Relaxations in Nanosysyems Lab. Department of Nanoenergy Engineering, Pusan National University, Busan, Republic of Korea*
[2]*Department of Chemistry, Chemical Engineering and Applied Chemistry, Chungnam National University, Daejeon, Republic of Korea*

* Corresponding e-mail: *nanoleelab@cnu.ac.kr*



A feasible nanoscale framework of heterogeneous plasmonic materials and proper surface engineering can enhance photoelectrochemical (PEC) water-splitting performance owing to increased light absorbance, efficient bulk carrier transport, and interfacial charge transfer. This article introduces a new magnetoplasmonic (MagPlas) Ni-doped Au@FexOy nanorods (NRs) based material as a novel photoanode for PEC water-splitting. A two stage procedure produces core-shell Ni/Au@FexOy MagPlas NRs. The first-step is a one-pot solvothermal synthesis of Au@FexOy. The hollow FexOy nanotubes (NTs) are a hybrid of Fe2O3 and Fe3O4, and the second-step is a sequential hydrothermal treatment for Ni doping. Then, a transverse magnetic field-induced assembly is adopted to decorate Ni/Au@FexOy on FTO glass to be an artificially roughened morphologic surface called a rugged forest, allowing more light absorption and active electrochemical sites. Then, to characterize its optical and surface properties, COMSOL Multiphysics simulations are carried out. The core–shell Ni/Au@FexOy MagPlas NRs increase photoanode interface charge transfer to 2.73 mAcm−2 at 1.23 V RHE. This improvement is made possible by the rugged morphology of the NRs, which provide more active sites and oxygen vacancies as the hole transfer medium. The recent finding may provide light on plasmonic photocatalytic hybrids and surface morphology for effective PEC photoanodes.

Keywords: Magnetoplasmonic, Photoelectrochemical, Water Splitting, Morphology

References:

[1] Small, Volume19, Issue 43, October 25, 2023, 2302980

Presenting author Email address: nanoleelab@cnu.ac.kr

Advanced Pt-based catalyst synthesis by atomic layer deposition

Hao Van Bui*

Faculty of Materials Science and Engineering, Phenikaa University, Yen Nghia Ward, Ha Dong District, Hanoi 12116, Vietnam

* Corresponding e-mail: hao.buivan@phenikaa-uni.edu.vn

Platinum-based catalysts are widely used in many important chemical processes and electrocatalytic systems for energy conversion, storage and utilization.[1] However, the scarcity and high cost of Pt are the main issues that hinder the practical applications of these catalysts.[2] The search for cheap and abundant alternatives to replace Pt has resulted in the development of many novel catalysts.[3] Although the discoveries of promising catalysts are often reported, none can compete with Pt in the intrinsic activity.[4] Therefore, maximizing the catalytic performance while minimizing the Pt loading has become a more practical and efficient route for addressing the cost-related issues of Pt.[5] This requires a highly controllable method for the fabrication of Pt nanostructures. To this end, atomic layer deposition (ALD) has become an excellent candidate that offers the controllability at the single-atom precision.[5,6] In my presentation, I will talk about our recent achievements on ALD of Pt on high-surface-area substrates, i.e., graphene and TiO_2 nanopowders, which is carried out in a fluidized bed reactor.[7–9] Our approach provides the capability of controlling the nucleation and growth of Pt at the atomic level, enabling the fabrication of advanced catalysts based on Pt nanoparticles and Pt single atoms.

Keywords: Atomic layer deposition, fluidized bed reactor, platinum-based catalysts, single-atom catalysts

References:

[1] Chen and P. Holt-Hindle, Chem. Rev., 2010, 110, 3767–3804.
[2] M. Li, K. Duanmu, C. Wan, T. Cheng, L. Zhang, S. Dai, W. Chen, Z. Zhao, P. Li, H. Fei, Y. Zhu, R. Yu, J. Luo, K. Zang, Z. Lin, M. Ding, J. Huang, H. Sun, J. Guo, X. Pan, W. A. Goddard, P. Sautet, Y. Huang and X. Duan, Nat Catal, 2019, 2, 495–503.
[3] L. D. de Almeida, H. Wang, K. Junge, X. Cui and M. Beller, Angewandte Chemie International Edition, 2021, 60, 550–565.
[4] J. N. Hansen, H. Prats, K. K. Toudahl, N. Mørch Secher, K. Chan, J. Kibsgaard and I. Chorkendorff, ACS Energy Lett., 2021, 6, 1175–1180.
[5] N. Cheng, S. Stambula, D. Wang, M. N. Banis, J. Liu, A. Riese, B. Xiao, R. Li, T.-K. Sham, L.-M. Liu, G. A. Botton and X. Sun, Nat Commun, 2016, 7, 13638.
[6] D. Liu, X. Li, S. Chen, H. Yan, C. Wang, C. Wu, Y. A. Haleem, S. Duan, J. Lu, B. Ge, P. M. Ajayan, Y. Luo, J. Jiang and L. Song, Nat Energy, 2019, 4, 512–518.
[7] H. Van Bui, F. Grillo, S. Sharath Kulkarni, R. Bevaart, N. V. Thang, B. van der Linden, J. A. Moulijn, M. Makkee, M. T. Kreutzer and J. R. van Ommen, Nanoscale, 2017, 9, 10802–10810.
[8] F. Grillo, H. Van Bui, D. La Zara, A. A. I. Aarnink, A. Y. Kovalgin, P. Kooyman, M. T. Kreutzer and J. R. van Ommen, Small, 2018, 14, 1800765.
[9] F. Grillo, H. Van Bui, J. A. Moulijn, M. T. Kreutzer and J. R. van Ommen, J. Phys. Chem. Lett., 2017, 8, 975–983.

Presenting author Email address: hao.buivan@phenikaa-uni.edu.vn

Enhancing Photocatalytic Activity in Bi_2WO_6 Photocatalyst through Controlled Oxygen Vacancy Formation

Vu Quoc Trung[1], Nguyen Dang Phu[1], Pham Van Hai[1], Ta Thi Thuy Nga[2], Chong Li Dong[2], Wu Ching Chou[3], Nguyen Thi Ngoc Hue[4], Pham Thi Hue[4], Luu Anh Tuyen[4]
Nguyen Quang Hung[5] and Luc Huy Hoang[1*]

[1]*Faculty of Physics, Hanoi National University of Education, Hanoi, Vietnam*
[2]*Department of physics, Tamkang University, New Taipei City, Taiwan*
[3]*Department of Electrophysics, National Yang Ming Chiao Tung University, Taiwan*
[4]*Center for Nuclear Technologies, Vietnam Atomic Energy Institute, Ho Chi Minh, Vietnam*
[5]*Institute of Fundamental and Applied Sciences, Duy tan University, Ho Chi Minh, Vietnam*

[*] Corresponding e-mail*:* *hoanglhsp@hnue.edu.vn*

In this study, we fabricated nano-thin Bi_2WO_6 layers using hydrothermal methods and introduced controlled oxygen vacancies through microwave-assisted alkali etching. We comprehensively characterized the resultant oxygen vacancy sites within the Bi_2WO_6 material using a combination of Raman spectroscopy, X-ray absorption spectroscopy (XAS), Transmission Electron Microscopy (TEM), X-ray photoelectron spectroscopy (XPS), and Positron Annihilation Spectroscopy. We explored the influence of oxygen vacancies at various surface and crystal structure sites on the photocatalytic performance of Bi_2WO_6. Our results reveal that a deliberate introduction of 5 out of 6 possible oxygen vacancies in the Bi_2WO_6 structure significantly enhances light absorption and facilitates the efficient separation of photogenerated charge carriers. Consequently, these vacancies lead to a substantial improvement in the photocatalytic activity of Bi_2WO_6. This research introduces an innovative approach to tailor oxygen vacancies on the surface of Bi_2WO_6 catalysts, thereby advancing their potential for applications in photocatalytic processes targeted at environmental pollution degradation.

Presenting author Email address: hoanglhsp@hnue.edu.vn

Effective approach for large-scale production of nitrogen-doped TiO2 nanoparticles by a combination of ultrasonic irradiation and electrochemistry

Nguyen Thi Khanh Van[1], Dang Van Thanh[2], Hoang Nam Nhat[1], and Nguyen Nang Dinh [1,*]

[1]*University of Engineering and Technology, Vietnam National University in Hanoi, Vietnam*
[2]*Faculty of Basic Sciences, TNU-University of Medicine and Pharmacy, Vietnam*

[*] Corresponding e-mail: *dinh158@gmail.com*

We report a facile and effective approach for large-scale production of N-doped TiO_2 nanoparticles (UNTs) by using ultrasonic irradiation and electro-chemistry. NH_4NO_3 electrolyte as the nitrogen source has been used. Ten electrodes were made of high purity titanium metal with a purity of 99.7%, length of 150 mm, and diameter of 6.35 mm. They were placed parallel in a glass tank containing 2 l of 0.5 M NH_4NO_3 solution. The DC power source connected to two electrodes has a voltage in the range of 20–25 V, corresponding to a current of 8.0–9.5 A. The electrochemical system was placed in a large capacity ultrasonic bath (40 kHz, 400 W). After 45 min of a batch experiment, the solution was collected and filtered through a polyvinylidene fluoride (PVDF) membrane with a vacuum filter. The filtered solid powder was then washed with double-distilled water and subsequently dried at 100 °C in a vacuum oven for 24 h. Finally, the material was finely ground using an agate mortar and annealed at 450 °C in an oven under the atmospheric condition for 1 h. As-prepared UNTs were characterized by x-ray diffraction, Raman spectroscopy, x-ray photoelectron spectroscopy, scanning electron microscopy, transmission electron microscopy, and UV–visible diffuse reflectance spectroscopy. The results indicated that the nitrogen content of UNTs reached 9.3% and bandgap energy of 2.62 eV. The photocatalytic activities of the materials were evaluated by the decoloration of synthetic wastewater containing methylene blue under visible light irradiation supplied by a 400 W xenon lamp. Light filters were used to remove the short wavelengths of $\lambda < 420$ nm. The distance from the lamp to the MB solution was set at 15 cm. To limit the influence of outside light, the entire experimental system was placed in a dark chamber. At first, the mixture (50 mg of photocatalytic material and 100 ml of 10 mg l-1 MB solution in a 250 ml double-layer jacketed beaker) was stirred in the dark for 60 min to reach the adsorption–desorption equilibrium and then irradiated with visible light for 120 min. During the reaction, 1.5 ml of water sample was collected every 15 min and sent for MB concentration analysis. In addition, the efficiencies of photolysis and photocatalysis were also compared by performing another similar experiment in the absence of the TiO_2 catalyst. Characterization of the UNTs gave the high photocatalytic degradation of methylene blue (MB) under visible light irradiation. The mechanism for the formation of UNTs by ultrasonic-assisted electrochemical approach has been also discussed.

Keywords: Electrochemical, ultrasonic-assisted, N-doped, TiO2, visible light.

Presenting author Email address: dinh158@gmail.com

Piled-Up Energy Storage Capability of Nanoparticulate WO_3/MoO_3 Films

Chia-Chun Wei,[1] Jun-Wei Huang,[1] Wen-Bin Jian[*,1], Kazuhito Tsukagoshi[1,2]
[1]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 30010, Taiwan*
[2] *International Center for Materials Nanoarchitectonics (WPI-MANA), National Institute for Materials Science (NIMS), Tsukuba, Ibaraki 305-0044, Japan*

[*] Corresponding e-mail: *wbjian@nycu.edu.tw*

Sustainable developments to improve energy consumption in buildings and energy storages are essential issues that can be solved by using green technologies. In this talk, we present electro-exploding wire and spray coating techniques for the synthesis of nanoparticulate films of WO_3-MoO_3 composite films. The nanoparticulate films are used to assemble electrochromic devices for the transmittance and energy storage measurements. The nanoparticulate WO_3-MoO_3 films exhibit high electrochromic performances with a diffusion coefficient of deintercalation of $3.39X10^{-10}$ cm^2/s, a charge density of 28.5 mC/cm^2, the coloration efficiency of 40.9 cm^2/C at the light wavelength of 430 nm, and the transmittance variations of about 17% and 44% at wavelengths of 430 and 635 nm [1,2].

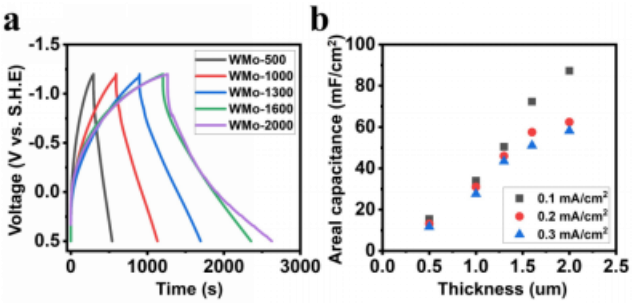


Figure 1. (a) Galvanostatic charge-discharge (GCD) curves at a current density of 0.1 mA/cm^2 for Samples WMo-500-Wmo-2000. The charge-discharge operation voltage is set in the range between -1.2 and +0.5 V. (b) Calculated areal capacitance from GCD curves as a function of film thickness. The black squares, red dots, and blue triangles represent areal capacitance measured at current densities of 0.1, 0.2, and 0.3 mA/cm^2.

The nanoparticulate WO_3-MoO_3 films not only display good electrochromic performances but also energy storage capabilities. These films exhibit a high porosity that is beneficial for ion diffusions in electrolyte and for increasing the efficiency of oxidations and reductions. In particular, the porous nanoparticulate WO_3-MoO_3 films can be stacked to increase the thickness and to enhance the energy storage capability.

Keywords: Electrochromic Device, Energy Storage, Nanoporous Materials, Supercapacitor, Tungsten Trioxides

References:

[1] C. C. Wei et al., Electrochimica Acta, 2023, 442, 141897.
[2] C. M. Chang et al., Sol. Energy Mater. Sol. Cells, 2021, 223, 110960.

Presenting author Email address: wbjian@nycu.edu.tw

Application of X-ray absorption spectroscopy at TPS 44A beamline to decipher the active site in energy material

Jeng-Lung Chen[1*], Chih-Wen Pao[1], Chun-Hong Kuo[2,3], Luning Chen[4], Ji Su[4,5]

[1]*National Synchrotron Radiation Research Center, Science-Based Industrial Park Hsinchu 300092, Taiwan.*
[2]*Department of Applied Chemistry, National Yang Ming Chiao Tung University, Hsinchu 300093, Taiwan.*
[3] *Center for Emergent Functional Matter Science, National Yang Ming Chiao Tung University, Hsinchu 300093, Taiwan.*
[4] *Chemical Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720, United States.*
[5] *Energy Storage and Distributed Resources Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, United States.*

[*] Corresponding e-mail: *chen.jl@nsrrc.org.tw*

X-ray absorption spectroscopy (XAS), which includes X-ray absorption near edge structure (XANES) and extended X-ray absorption fine structure (EXAFS), is a powerful tool at synchrotron radiation facilities. The XANES region of XAS provides the electronic structure and local geometric information, and the EXAFS region is used to obtain the detailed local atomic structure around the absorbing atoms, such as the nearest neighbor atomic type, the number of atoms in a specific coordination shell, the interatomic distance, and the structural disorder. Generally, one full spectrum which includes EXAFS region needs to spend 15 to 40 minutes collecting. Unfortunately, most chemical reactions happened in a few seconds. Therefore, it is urgent to collect one full spectrum in a few seconds. Here, a quick-scanning X-ray absorption spectroscopy beamline (TPS 44A) at the Taiwan Photon Source, is presented. The beamline is equipped with a quick-scanning monochromator (Q-mono), which can provide conventional step-by-step scans and on-the-fly scans for a full spectrum [1].

Fossil fuels are the most commonly used fuels for energy in our daily lives. However, the concentration of carbon dioxide in the atmosphere has increased year by year due to the excessive use of fossil fuels. In turn, it has caused extreme changes in the global climate. Therefore, finding low-carbon emissions and clean renewable energy is the goal of all countries in the world. Hydrogen is regarded as an ideal alternative clean fuel because it can be effectively converted into energy without producing harmful substances or greenhouse gases. It can be produced by thermally cracking hydrocarbons to produce hydrogen or using photocatalytic or electrocatalytic ways for water splitting. These catalytic reactions are extremely dependent on the activity of metal catalysts. Therefore, it is very important to understand the working pathways of the catalyst. Here, i*n-situ*/*operando* electrocatalyst characterization [2] and methane pyrolysis reactions [3] were presented by the XAS technique.

Keywords: *Time-resolved XAS, HER, OER, Methane pyrolysis*

References:

[1] C.-W. Pao, J.-L. Chen, J.-F. Lee, M.-C. Tsai, C.-Y. Huang, C.-C. Chiu, C.-Y. Chang, L.-C. Chiang, and Y.-S. Huang "The new X-ray absorption fine-structure beamline with sub-second time resolution at the Taiwan Photon Source," *J. Synchrotron Radiat.*, 28, 930-938, 2021.

[2] C.-W. Liao, S.-Y. Chen, L.-C. Hsu, C.-W. Lin, J.-L. Chen*, C.-H. Kuo*, and Y.-H. Chang* "Insights into electrocatalytic oxygen evolution over hierarchical $FeCo_2S_4$ nanospheres," *ACS Sustainable Chem. Eng.*, 10, 431-440, 2022.

[3] L. Chen†, Z. Song†, S. Zhang†, C.-K. Chang, Y.-C. Chuang, X. Peng, C. Dun, J. J. Urban, J. Guo, J.-L. Chen*, D. Prendergast, M. Salmeron, G. A. Somorjai*, and J. Su* "Ternary NiMo-Bi liquid alloy catalyst for efficient hydrogen production from methane pyrolysis," Science, 381, 857-861, 2023.

Presenting author Email address: chen.jl@nsrrc.org.tw

Ag-Coated Si nanowire arrays: A new route for the precise detection of carbendazim in pomelo by surface enhanced Raman scattering

Nguyen Duy Thien[1], Le Van Vu[1], Nguyen Quang Hoa[1], Sai Cong Doanh[1], Vuong Van Hiep[1], Nguyen Ngoc Dinh[1], Pham Nguyen Hai[1], Le Quang Thao[1], Nguyen Nang Dinh[1], Le Viet Cuong[2], Nam Nhat Hoang [2,*]

[1]*Faculty of Physics, VNU-University of Science, 334 Nguyen Trai, Thanh Xuan, Ha Noi, 100000, Viet Nam*
[2]*Faculty of Engineering Physics and Nanotechnology, VNU-University of Engineering and Technology, 144 Xuan Thuy, Cau Giay, Ha Noi, 100000, Viet Nam*

[*] Corresponding e-mail: *namnhat@gmail.com*

In this study, we present an efficient method based on vertically oriented silicon nanowire arrays coated with silver nanoparticles to achieve significantly surface enhanced Raman scattering (SERS) signals. The method is applicable for the accurate detection of fungicides and related compounds. The substrates were obtained by a two-step process consisting of the growth of Si nanowire arrays on a silicon wafer by metal-assisted chemical etching and subsequent coating with Ag nanoparticles by the sputtering method. The effect of sputtering time on the growth of nanowires, their morphology and enhancement factor of the signals obtained from the SERS sensor were studied in detail. The final enhancement factor of Raman shift is 1.1 × 10^7, allowing the limit of trace detection for carbendazim in acetone to be as low as 0.1 ppm, with a relative standard deviation of less than 2.07%. And then, the SERS sensor were used to detect carbenzadim (CBZ) residue in pomelo with CBZ concentration as low as 1 ppm. This result opens up the potential for direct application of prepared substrates in ultra-fast chemical analysis.

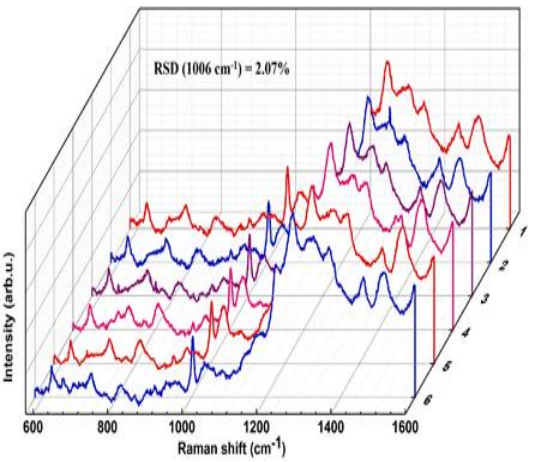


Figure 1. Raman spectra of 10 ppm CBZ on Si/Ag50 substrate masured at different points.

Keywords: Raman, Surface enhanced, Sputtering Si NWs, Carbendazim

References:

[1] K. Hering, D. Cialla, K. Ackermann, T. Dorfer, R. Moller, H. Schneidewind, R. Mattheis, W. Fritzsche, P. Rosch, J. Popp, SERS: a versatile tool in chemical and biochemical diagnostics, Anal. Bioanal. Chem. 390 (2008) 113–124.
[2] H.B. Abdulrahman, J. Krajczewski, D. Aleksandrowska, A. Kudelski, Silicaprotected hollow silver and gold nanoparticles: new material for Raman analysis of surfaces, J. Phys. Chem. C 119 (2015) 20030–20038.

Presenting author Email address: lvcuong1985@gmail.com

Photothermal Natural-Inspired Materials For Highly Efficient Solar Steam Generation

Danh Bich Do [1, *], Pham Tien Thanh [1, 2]

[1]*Faculty of Physics, Hanoi National University of Education, 136 Xuan Thuy Road, Cau Giay District, Hanoi 100000, Vietnam*
[2]*VNU Vietnam Japan University, Vietnam National University Hanoi (VNU), Luu Huu Phuoc Street, Nam Tu Liem District, Hanoi 100000, Vietnam*

[*] Corresponding e-mail: *dodanhbich@hnue.edu.vn*

Solar steam generation (SSG) is an emerging area in energy harvest and sustainable technologies. The nano-structured photothermal materials can harvest energy from the entire solar spectrum and convert it to heat with high efficiency. This work investigates the fabrication of novel natural-inspired photothermal materials such as the leaf, coconut husk, and green tea for application in SSG systems. It is observed that the light absorbance of fabricated materials exceeds 92% in the wavelength region of 300-250nm. The developed SSG systems result in a water evaporation rate up to 1.92kgm^{-2}h^{-1} under 1 sun illumination. The high water evaporation performance of SSG based on fabricated materials highlights the promising application toward sustainable seawater desalination.

Keywords: solar stream generation (SSG), photothermal materials, plasmonics, water vapor generation

Presenting author Email address: dodanhbich@hnue.edu.vn

Study on P-type Ga_2O_3 epilayers using phosphorus-ion implantation technology

Ray Hua Horng*, Xin-Ying Tsai and Fu-Gow Tarntair

Institute of Electronics, National Yang Ming Chiao Tung University, Hsinchu 30010, Taiwan, ROC

* Corresponding e-mail: rayhua@nycu.edu.tw

Among the ultra-wide bandgap materials under consideration for power devices applications, gallium oxide (Ga_2O_3) is an promising candidate, due to a wide bandgap of 4.9 eV, a high breakdown electrical field strength of 8 MV/cm, and remarkable thermal stability [1-3]. Even though, there exists a challenge about p-type Ga_2O_3, which limits the power devices applications.

In this study, we investigate the electrical properties of unintentionally doped (UID) β-Ga2O3 epilayers and epilayer implanted phosphorous with low, medium, and high doses. These epilayers were grown on sapphire substrates by metalorganic chemical vapor deposition.

Specifically, the low-dose implantation involved phosphorus ions at concentrations of $1.6Í10^{13}$, $1Í10^{12}$ and $2.5Í10^{12}$ atoms/cm^2, administered at implantation energies of 100, 50, and 40 keV, respectively. The medium-dose implantation utilized phosphorus ions at concentrations of $1.6Í10^{14}$, $1Í10^{13}$ and $2.5Í10^{13}$ atoms/cm^2, at same implantation energies. Finally, the high-dose implantation employed phosphorus ions at concentrations of $1.6Í10^{15}$, $1Í10^{14}$ and $2.5Í10^{14}$ atoms/cm^2, with implantation energies of 100, 50, and 40 keV, respectively. The implantation parameters were also simulated using the Stopping and Range of Ions in Matter software, while the actual concentration of phosphorus ions was measured via secondary ion mass spectrometry. Subsequently, Ni and Au were deposited on the annealed phosphorus-implanted β-Ga_2O_3 epilayers, followed by rapid thermal annealing at 600°C in a nitrogen environment for one minute, for Hall measurement. The electrical properties of the phosphorus-implanted β-Ga_2O_3 epilayers were assessed through Hall measurements. Notably, the β-Ga_2O_3 epilayers implanted with middle and high doses displayed p-type behavior. The resistivity of the p-type β-Ga_2O_3 epilayers with middle and high doses measured 9.699 and 6.439 Ω.cm, respectively, as determined by Hall measurements. Additionally, the hole carrier concentrations for these doses were measured as 1.612×10^{18} and 6.428×10^{17}, respectively. Consequently, the phosphorus ion implantations using middle and high doses were proven effective in obtaining p-type Ga_2O_3. To further explore the defect formation energies and Fermi energies of substitutional phosphorus defects within the β-Ga_2O_3 lattices, first-principles density-functional simulations were employed.

Keywords: ultra-wide bandgap materials, gallium oxide (Ga_2O_3), implantation

References:

[1] S. J. Pearton et al., A review of Ga_2O_3 materials, processing, and devices, Appl. Phys. Rev. 5 (2018) 011301, DOI: 10.1063/1.5006941.

[2] M. Higashiwaki et al., Recent progress in Ga_2O_3 power devices, Semicond Sci Technol 31 (2016) 034001, DOI: 10.1088/0268-1242/31/3/034001.

[3] J. Lee et al., High Thermal Stability of κ- Ga_2O_3 Grown by MOCVD, Crystals 11 (2021) 446, DOI: 10.3390/cryst11040446.

Presenting author Email address: rayhua@nycu.edu.tw

Enhancement of Dye Degradation in Piezo-Photocatalytic ZnO-MoS_2 Heterostructures

James Albert B. Narvaez, C. Mercado*

Department of Mining, Metallurgical, and Materials Engineering, University of the Philippines Diliman, Quezon City 1100, Philippines

* Corresponding e-mail: *ccmercado1@up.edu.ph*

Photocatalysis is a novel approach to degrade hazardous compounds, frequently employed in environmental remediation such as eliminating methyl orange (MO) dye from wastewater. However, low efficient usage of visible light due to the large band gap of photocatalysts and its high rate of recombination limit the process. To address this issue, piezo-phototronics is utilized to improve the efficacy of catalytic degradation. Specifically for this study, the piezo-photocatalytic efficiency of ZnO-MoS_2 heterostructures is realized using solar and mechanical energy in degrading MO dye. One-dimensional heterostructures with an average length of 3.34 μm and an average diameter of 872.6 nm compactly aligned on glass substrates was synthesized through a two-step hydrothermal process. Under simulated solar illumination and ultrasonic vibration, the ZnO-MoS_2 effectively degraded MO improving the degradation efficiency from 55% to 84% by introducing piezopotential in ZnO. Ultrasonication aided photocatalysis through field-assisted separation of the photogenerated electrons and holes, reducing recombination. Coupled liquid chromatography and mass spectrometry confirmed the degradation of MO into its smaller metabolites. The catalyst films have achieved 61% degradation even after 3x reuse.

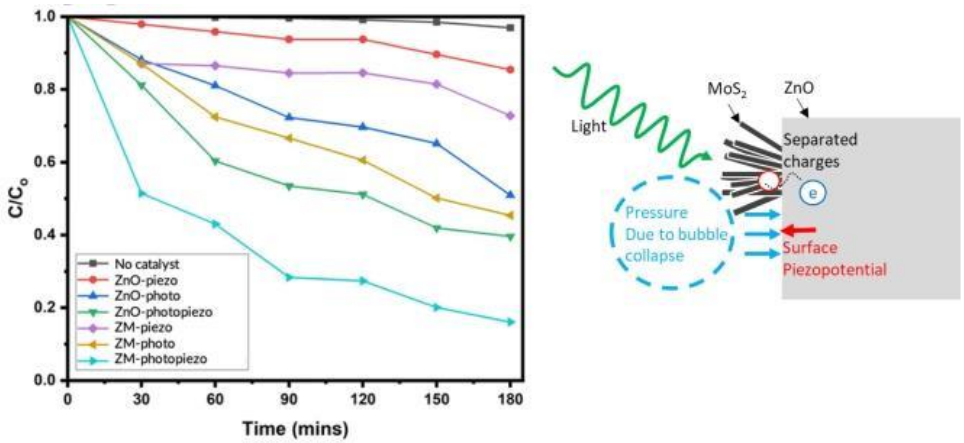


Figure 1. Degradation efficiencies of ZnO and MoS_2 combinations with ultrasonic agitation and visible light illumination

Keywords: Piezophotocatalysis, photocatalytic degradation, zinc oxide, molybdenum disulfide

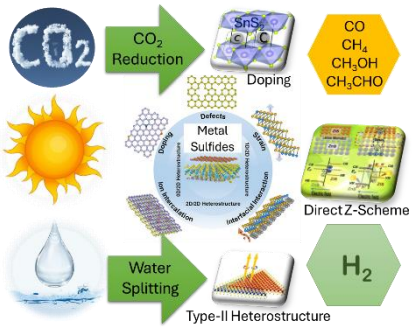
Presenting author Email address: ccmercado1@up.edu.ph

Advancing Metal Sulphide Photocatalysts in Artificial Photosynthesis for Sustainable Energy Solutions

Indrajit Shown[1*], Ranjith Ravi[1], Amr Sabbah[2], Kuei-Hsien Chen[3], Li-Chyong Chen[2]

[1]*Department of Chemistry, Hindustan Institute of Technology and Sciences, Chennai, India*
[2]*Center for Condensed Matter Sciences, National Taiwan University, Taipei, Taiwan*
[3]*Institute of Atomic and Molecular Sciences, Academia Sinica, Taipei, Taiwan*

[*] Corresponding e-mail : *shownindrajit@gmail.com*



In recent years, the pursuit of sustainable energy sources has intensified, with an increasing focus on harnessing solar energy to meet our ever-growing energy demands. Artificial photosynthesis and photochemical CO_2 reduction have emerged as a promising path in this effort, aiming to mimic the remarkable efficiency of natural photosynthetic processes in converting sunlight into chemical energy. To unravel the secrets of photo-induced light-matter interactions and propel the field of artificial photosynthesis forward, this talk will delve into cutting-edge research, innovative approaches, and potential applications.

This talk delves into the intricate realm of artificial photosynthesis, specifically exploring advancements in the modulation of two-dimentional metal sulfide based heterostructure photocatalysts for the simultaneous processes of photochemical CO_2 reduction and photochemical water-splitting. Harnessing sunlight for sustainable energy solutions is at the forefront of scientific innovation, and this presentation sheds light on recent developments in tailoring advanced photocatalysts. By intricately manipulating heterostructures, our aim to optimize the efficiency of both CO_2 reduction and water splitting, crucial components of the artificial photosynthetic process. This talk will provide insights into the several two dimentional metal sulfide based photocatalyst systems and their potential performances towards photochemical CO_2 reduction and watersplitting which propelling us toward a more sustainable future by converting solar energy into valuable chemical fuels.

Keywords: Artificial photosynthesis, Photocatalysis, water-splitting, heterostructure, CO_2 reduction

References:

[1] Nature Communications, 2022, 13(1), 1-8
[2] Nano Energy, 2022, 93, 106809
[3] Small, 2021, 18, 2105076
[4] Nano Energy, 2020, 72, 104717
[5] Nanoscale, 2020, 12, 23301
[6] ACS Applied Materials & Interfaces, 2019, 11, 28, 25186.
[7] Nature Communications, 2018, 9, 169Publication reference

Presenting author Email address: shownindrajit@gmail.com, indrajits@hindustanuniv.ac.in

Electromechanical Switching of a C_{60} nanochain

Kazuhito Tsukagoshi

Research Center for Materials Nanoarchitectonics (MANA),
National Institute for Materials Science (NIMS), Japan

E-mail: *TSUKAGOSHI.Kazuhito@nims.go.jp*

Electromechanical switching in fullerene C_{60} nanochains, introduced in the device as a C_{60} pyrrolidine tris-acid film, was realized in nanogap electrodes with ~20-nm separation, where negative differential resistance and binary resistance switching were reproducibly observed. In the nanogap electrodes, an initial conductive C_{60} chain spontaneously formed only through a direct current injection from the electrode without any preset process of electron beam irradiation on the C_{60} channel film, which was always needed for microscale C_{60} channels. The nanoscale C_{60} chain in the nanogap allowed us to evaluate the single junction resistance in the switching cycle. From the switching voltage and current values, the switching energy for the C_{60} chain in the nanogap was estimated to be approximately several milliwatts, most probably caused by the polymerization and depolymerization of the conductive C_{60} chain. These novel results provide significant advantages for electron device development over the commonly used STM tool.

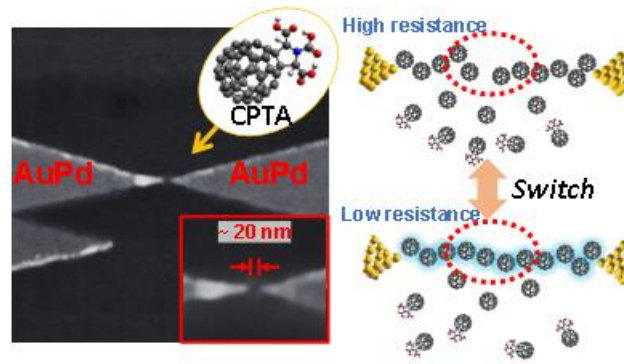


Figure 1. Using nanogap electrodes with ~20 nm separation, electrical conduction of fullerence C_{60} chain channel was characterized

References

[1] Umeta. Y, Suga, H, Tsukagoshi. K, et al., "C_{60}-Nanowire Two-State Resistance Switching Based on Fullerene Polymerization/Depolymerization", ACS Appl. Nano Mater, 4, 820−825 (2021).
[2] Takeuchi. M, Suga. H, Tsukagoshi. K, et al., "Fullerene Nanostructure-Coated Channels Activated by Electron Beam Lithography for Resistance Switching", ACS Appl. Nano Mater, 5, 6430−6437 (2022).
[3] Takei. M, Suga. H, Tsukagoshi. K, et al., "Electromechanical Switching of a C_{60} Chain in a Nanogap", ACS Appl. Electron. Mater, 5, 3184−3189 (2023).

Presenting author Email address: TSUKAGOSHI.Kazuhito@nims.go.jp

Coupling between spin and lattice in an XY-like spin-glass $(Ni_{0.40}Mn_{0.60})TiO_3$

Way-Faung Pong

Department of Physics, Tamkang University, New Taipei City, Taiwam

* Corresponding e-mail: *wfpong@mail.tku.edu.tw*

Synchrotron-based resonant inelastic X-ray scattering (RIXS) and X-ray absorption spectroscopy (XAS) experiments were performed to probe the nature of XY-like spin-glass (SG) focusing on the spin-flip (magnon) excitation and lattice distortion in single-crystal Ni0.4Mn0.6TiO3 (NMTO) close to the spin-glass temperature (TSG). RIXS provides clear evidence of crystal field (d-d) excitations at the Ni and Mn L3-edge, but the magnon is observed mainly at the Ni L3-edge RIXS at the scattering of NMTO close to TSG. Temperature-dependent extended X-ray absorption fine structure (EXAFS) measurement further reveals a large increase of the Ni-O bond length along the c-axis and phonon softening that is caused by the large static disorder of Ni sites near TSG, suggesting that the spin-lattice coupling that is associated with the anti-symmetric Dzyaloshinskii–Moriya (DM) interaction involved magnetic exchange interaction in NMTO. Ni L3,2-edge X-ray magnetic circular dichroism (XMCD) measurement revealed the ferromagnetic/ferrimagnetic ordering of Ni+2 ions in NMTO near TSG. This phenomenon is consistent with the measured magnetic hysteresis (H-M) curve, which exhibits the ferromagnetism/ferrimagnetism that is probably caused by a non-collinear or canted-type spin orientation of Ni2+ ions in the ab-plane of NMTO.

Keywords: RIXS, XAS, EXAFS, XMCD, spin-glass.

Presenting author Email address: wfpong@mail.tku.edu.tw

Materials for efficient conversion of low temperature waste heat

Ekkes Brück[*1], Hamutu[1], Anika Kiecana[1], Qi Shen[1], Ivan Batashev[2], Gilles de Wijs[2], Niels van Dijk[1]

1Delft University of Technology, Faculty of Applied Sciences, Department of Radiation Science and Technology, Mekelweg 15, 2629 JB Delft, The Netherlands
2Radboud Universiteit, Faculty of Science, Institute for Molecules and Materials, Heyendaalseweg 135, 6525 AJ Nijmegen, The Netherlands

[*] Corresponding e-mail: *e.h.bruck@tudelft.nl*

The production and use of energy account for more than 75% of the EU's greenhouse gas emissions. Decarbonising the EU's energy system is therefore critical to reach our 2030 climate objectives and the EU's long-term strategy of achieving carbon neutrality by 2050. At the same time, we will generate vast amounts of low-grade heat in e.g. datacenters, food, pulp and paper industries that is available 24/7. Efficient machines or devices to convert this low-grade heat in an economically sound way are however lacking. Upgrading only a small percentage, as dictated by laws of thermodynamics, of this otherwise wasted heat into electricity, can already be significant due to the sheer amount of heat in the temperature range below 390 K. As the heat is available and often needs to be downgraded before it can be safely released into the environment, we have similar to PV and offshore wind mainly to consider the cost of investment to determine the economic framework of such a generator. The existing prototypes [1, 2] are essentially proofs of principle but have demonstrated where we can gain efficiency by improving designs and by tailoring materials properties. Promissing materials have to fulfill a few requirements [3]: Low and adjustable Curie temperature for low-grade heat, low remnant magnetization (Mr), which is generally fulfilled as one operates near or at the critical temperature. Significant and steep magnetization change at the Curie temperature as the figure of merrit of this type of materials is proportional to the change in magnetization, and inversly proportional to the heat input required to induce this change in magnetization. A high thermal conductivity to facilitate a rapid temperature change, and last but not least low-costs, which implies the preferred use of earth-abundant elements. A few of these materials requirements are very similar to the requirements for magnetocaloric materials. However, e.g. latent heat that helps for magnetocaloric applications is detrimental to thermomagnetic applications, as it implies more heat is needed to induce a change in temperature. We will discuss current state of the art devices and review developments in tailoring the performance of novel magnetic materials for efficient energy conversion.

Keywords: Energy conversion, magnetic materials, thermomagnetic devices, energy efficiency

References:

[1] T. Christiaanse, E. Brück, Met. Mat Trans. E 1, 36-40 (2014)
[2] A. Waske, D. Dzekan, K Sellschopp, D. Berger, A. Stork, K. Nielsch, S. Fähler, Nat. Energy 4, 68-74 (2019).
[3] D. Dzekan, A. Waske, K. Nielsch, S. Fähler, APL Materials 9, 011105 (2021)

Presenting author Email address: e.h.bruck@tudelft.nl

Progress in frustrated magnetism from density functional theory based energy mapping

Harald O. Jeschke[1*]

[1]*Research Institute for Interdisciplinary Science, Okayama University, Okayama 700-8530, Japan*

[*]Corresponding e-mail: *jeschke@okayama-u.ac.jp*

Recent years have ushered in enormous advances in frustrated and complex magnetism. Progress in sample growing and in experimental techniques have changed the focus from perfecting material realizations of single or few parameter kagome or triangular lattice model Hamiltonians to a wealth of materials with low symmetry, lattice distortions and complex threedimensional networks. Simple fits to experimental data are often not enough to determine the magnetic Hamiltonian of such materials. However, an accurate density functional theory based energy mapping technique with statistical safeguards promises to be a step forward, allowing unbiased determination of completely non-intuitive hierarchies of exchange interactions. A number of recent examples will be discussed. In the search for quantum spin liquids, there are new fascinating possibilities to realize them in three dimensions: From five exchange couplings of equal rank in $K_2Ni_2(SO_4)_3$, energy mapping shows that two trillium lattices are in competition with a strong bipartite lattice coupling and puts the material on the verge of a 3D quantum spin liquid (QSL) of nickel S=1 spins [1,2]. The DFT based method also identifies a highly frustrated hyperkagome network in $PbCuTe_2O_6$ that explains the experimental QSL signatures [3]. In $BaCoSiO_4$, energy mapping identifies the cause for a complex magnetic order where the magnetic cobalt sites are partitioned into three entwined networks; together with tiny frustration and anisotropic interactions, this leads to a magnetic field control of toroidal moments [4]. For the distorted lattice of Y-kapellasite, energy mapping identifies a three parameter kagome lattice Hamiltonian with a very interesting phase diagram [5].

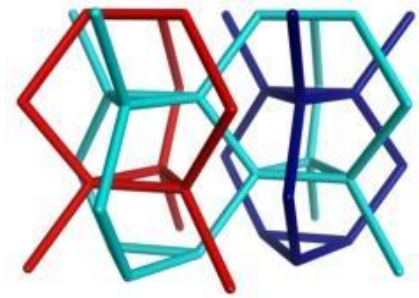


Figure 1. Three intertwined sublattices identified by DFT energy mapping in $BaCoSiO_4$.

Acknowledgment : Work done in collaboration with Yasir Iqbal, Johannes Reuther, Ivica Živković, Henrik Ronnow, Bella Lake, Igor I. Mazin, Ronny Thomale, Huibo Cao and many others.

Keywords: quantum spin liquid, toroidal moment, trillium lattice, hyperkagome lattice

References:

[1] I. Živković, V. Favre, C. Salazar Mejía, *et al.*, Phys. Rev. Lett. **127**, 157204 (2021).
[2] M. G. Gonzalez, V. Noculak, A. Sharma, *et al.*, arXiv:2308.11746v1.
[3] S. Chillal, Y. Iqbal, H. O. Jeschke, *et al.*, Nature Commun. **11**, 2348 (2020).
[4] L. Ding, X. Xu, H. O. Jeschke, *et al.*, Nature Commun. **12**, 5339 (2021).
[5] M. Hering, F. Ferrari, A. Razpopov, *et al.*, npj Comput. Mater. **8**, 10 (2022).

Presenting author Email address: *jeschke@okayama-u.ac.jp*

Exploring the impact of the inverse Faraday-effect on all-optical helicity-dependent magnetization switching

Jakob Walowski[1*]

[1]*Institute of Physics, Greifswald University, Germany*

* Corresponding e-mail: *jakob.walowski@uni-greifswald.de*

All-optical helicity-dependent magnetization switching (AO-HDS) is a fast and deterministic technique for data storage applications that solely uses the helicity of ultrashort laser pulses for magnetization reversal, see Figure 1. Developed for heat-assisted magnetic recording, granular high-density magnetic storage media are ideal for investigating magnetization switching effects. In the latest perception, we identify two effects, the magnetic circular dichroism (MCD) and the inverse Faraday effect (IFE), as the forces driving the switching process. During photon absorption, the magnetization quenching is caused by a rapid temperature rise due to helicity-dependent absorption, which ensures two distinct electron temperatures. This effect already holds a nonvanishing probability for magnetization switching. Simultaneously, the IFE induces a magnetic moment in the material, thereby enhancing the probability of a switching event. In my talk, I will present AO HDS experiments using ultrashort laser pulses (≤ 200 fs) in the near-infrared range from 800 nm to 1500 nm. The data indicates a strong dependence of the switching efficiency on the absorbed energy density, bringing the electron temperature close to the Curie Temperature, allowing for the IFE to take full effect, inducing a magnetic moment for deterministic switching in the quenched magnetization state. Supported by multiscale simulations, we conclude that the magnetic moment induced by the IFE is crucial for the switching efficiency and the distinct deterministic character of the switching process. Laser pulses with a higher absorption induce a higher magnetic moment and switch magnetization at lower fluences more efficiently, see figure 2. The IFE takes full effect, when the electron temperature rises up to the Curie point.

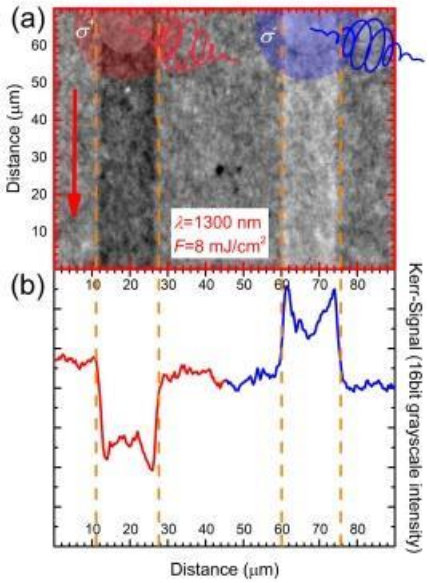


Figure 1. Experimental results, magnetization switching using helicity.

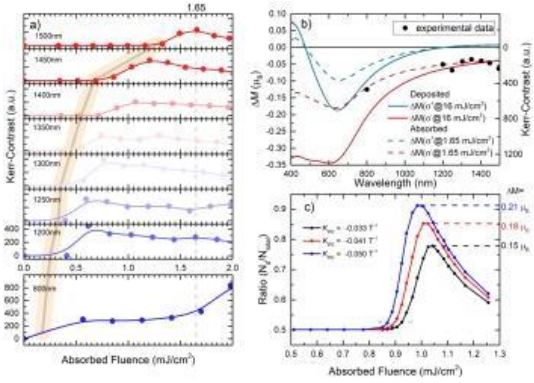


Figure 2 Switching efficiency, supported by multiscale simulations.

Keywords: FePt, AOHDS, IFE, MCD

Presenting author Email address: jakob.walowski@uni-greifsald.de

Synthesis of some ferromagnetic materials in a magnetic field

Keiichi Koyama[1*], Ryota Kobayasi[1] , Yumi Watanabe[1] , and Yoshifuru Mitsui [1]

Graduate School of Science and Engineering, Kagoshima University, Kagoshima 890-0065, Japan

* Corresponding e-mail: koyama@sci.kagoshima-u.ac.jp

Magnetic field is one of the important thermodynamic parameters such as temperature and pressure to control the condensate equilibrium [1]. In order to discover and develop new materials, research on material synthesis using magnetic fields has been attempted all over the world. Interesting magnetic field effects on magnetic phase transitions, chemical reactions, solidification, etc. have been reported using strong magnetic fields. However, it has been difficult to conduct these experiments at high temperatures and in high magnetic fields using commercially available equipment.

Generally, magnetic energy is very small compared to thermal energy. For example, the magnetic energy of an electron spin due to one Bohr magneton (μB) under a magnetic field *B* of 1 T corresponds to a temperature T of 0.67 K [1]. This is why high magnetic fields are required to investigate the effect of magnetic fields on material synthesis above room temperature. On the other hand, some ferromagnetic materials have a large magnetic moment even at temperatures above 300 K due to strong exchange interactions. When a 10T class magnetic field is applied to a ferromagnetic material with a large magnetic moment and a high Curie temperature, such as Mn-Bi, Mn-Al, Mn-Ga, Fe-Ga systems, the magnetic energy reaches approximately 10K or more. A 10T class magnetic field can also be easily generated with commercially available cryocooled superconducting magnets.

Our research group has been studying the synthesis reactions of Mn-Bi [2], Mn-Al [3], Mn-Ga [4] systems, etc. in a magnetic field through experiments and calculations. We concluded that the equilibrium state of ferromagnets in a magnetic field is dominated by the gain of magnetic energy [2]. Furthermore, we found that a magnetic field promotes the ferromagnetic synthesis reaction and a paramagnetic-ferromagnetic phase change in the Mn-Al system [3]. We have also shown that in binary systems containing many different magnetic phases, such as Mn-Ga [4], specific compounds can be grown in alloys by suppressing the diffusion of atoms using magnetic fields.
In this presentation, I would like to report on the recent magneto-science research of our Kagoshima University group, focusing on the experimental result of Mn/Ga diffusion couple experiment.

Keywords: ferromagnetic materials, magnetic field, synthesis

References:

[1] M. Yamaguchi and Y. Tanimoto, Magneto-Science, (Kodansha-Springer, Japan, 2006).
[2] Y. Mitsui et al., J. Alloys & Compounds 577 (2013) 315.
[3] R. Kobayashi et al., Mater. Trans. 58 (2017) 1511.
[4] Y. Watanabe et al., J. Alloys & Compounds 887 (2021) 161310.

Presenting author Email address: koyama@sci.kagoshima-u.ac.jp

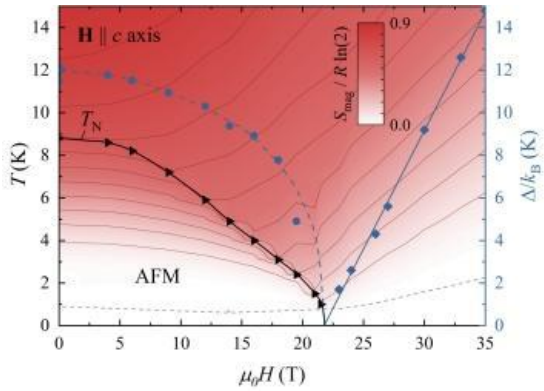
Competing magnetic phases of frustrated quantum magnets: Field-induced quantum criticality and dimensional reduction in the quantum sawtooth chain atacamite

S. Süllow[1], L. Heinze[1], T. Kotte[2], S. Luther[2], H. Kühne[2], A. Demuer[3], K. C. Rule[4], A. U. B. Wolter[5]

[1]*Technische Universität Braunschweig, Braunschweig, Germany*
[2]*Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany*
[3]*Laboratoire national des champs magnétiques intenses, Grenoble, France*
[4]*Australian Nuclear Science and Technology Organization, Lucas Heights, Australia*
[5]*Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden, Dresden, Germany*

* Corresponding e-mail: *s.suellow@tu-braunschweig.de*

Frustrated low-dimensional quantum spin systems offer a unique opportunity to study complex quantum systems. In this field of research, a multitude of models such as the kagome lattice or the diamond chain are studied with respect to novel and exotic ground and field-induced states such as spin liquids or magnetization plateaus. Correspondingly, on the experimental side the task is to identify model compounds to test and verify these concepts.



The natural mineral atacamite $Cu_2Cl(OH)_3$ is one such material, featuring a coupling scheme of a non-uniform quantum sawtooth chain with J = 336K along the basal sites of the chain and J' = 102K within the sawteeth [1]. The magnetization of this frustrated material is plateau-like with M ~ $M_{sat}/2$ in high magnetic fields, but which is unrelated to the 1/2-plateau of the sawtooth chain [1]. Starting from our studies of the magnetic phase diagram, we present high-field heat capacity data in the field range of the plateau-like magnetization. We find evidence for a field-induced quantum critical point in atacamite which separates the antiferromagnetic phase in lower magnetic fields from a field region without long-range magnetic order in higher magnetic fields. This behavior is very distinct from that of classical frustrated triangular lattice systems and thus appears to be an unusual quantum phenomenon.

Keywords: sawtooth chain, high magnetic fields

References:

[1] L. Heinze et al., Phys. Rev. Lett. **126**, 207201 (2021).

Presenting author Email address: s.suellow@tu-braunschweig.de

Coexistence of the E-type and cycloidal magnetic phases in multiferroic $YMnO_3$ thin films unveiled by the wasp-waisted magnetic hysteresis loops

My Ngoc Duong[1], Yu-Xun Chen[1,2], Shang-Hsien Hsieh[2], Kuang-Hung Chen[3], Tahta Amrillah[4], Kuang-Hsiung Wu[1], Jeng-Lung Chen[2], Juiin-Yuan Lin[5], Jin-Ming Chen[1,2] and Jenh-Yih Juang[1 *]

[1] *Department of Electrophysics, National Yang Ming Chiao Tung University, Taiwan*
[2] *National Synchrotron Radiation Research Center, Hsichu, Taiwan*
[3] *Department of Physics, Tamkang University, New Taipei City, Taiwan*
[4] *Department of Nanotechnology, Faculty of Advanced Technology and Multidiscipline, Universitas Airlangga, Indonesia*
[5] *Institute of Physics, National Yang Ming Chiao Tung University, Hsinchu, Taiwan*

* Corresponding e-mail: jyjuang@nycu.edu.tw

The cycloidal (or sinusoidal) and the colinear *E*-type antiferromagnetic orders are the two primary magnetic ground states being identified to give rise to the magnetism-induced ferroelectric polarization unique to the multiferroic manganites. In the former the electric polarization is driven by the $\vec{S_i} \cdot \vec{S_j}$ - type Dzyaloshinskii-Moriya interaction, while in the latter the polarization arises through the type $\vec{S_i} \cdot \vec{S_j}$ magnetostriction effect. Since the strength of the magnetism-induced polarization can vary dramatically depending on the magnetic ordering ground state, identifying or even manipulating the magnetic order by controlling available external parameters, thus, have been of extensive research interests from both fundamental and application points of view. In this study, we successfully fabricate single crystalline multiferroic orthorhombic YMnO3 (o-YMO) thin films on SrTiO3(110) substrates using the pulsed laser deposition. The high crystalline quality of the obtained o-YMO films, as being confirmed by X-ray scattering and reciprocal space mapping, allows us to probe the magnetic properties by applying the magnetic field along the respective crystallographic orientations. In particular, the temperature dependence of the magnetic hysteresis loops not only exhibit substantial anisotropy but also display characteristics of wasp-waisted M-H loops, signifying that there might be two or even more magnetic phases coexisting at temperatures well below the commonly recognized Neél temperature. The detailed analyses on how these coexisting magnetic phases evolves with the lowering temperature along the respective crystallographic axis will be presented and discussed.

Keywords: Multiferroic manganites thin film; Wasp-waisted magnetic hysteresis loops; Cycloidal and collinear antiferromagnetic ordering

Presenting author Email address: jyjuang@nycu.edu.tw

BCS-BEC crossover in two-band superconductors—A GG0 T-matrix approach

Chien-Te Wu[1*], Ming-Yan Li[1], Jian-Lin Li[1], and Wei Lu[1]

[1]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu, Taiwan*

[*] Corresponding e-mail: *chientewu@nycu.edu.tw*

Given the recent noteworthy outcomes in experiments involving FeSe multi-band superconductors, we undertake a theoretical examination of the impacts of pairing fluctuation within a two-band superconductor. Our investigation encompasses both intra- and inter-band pairing interactions. Employing a diagrammatic self-consistent *T*-matrix method with a GG_0 pair propagator, we explore the consequences of the matrix structure of the pair propagator on the Thouless criterion and self-energies. To comprehend experimental findings related to the pseudogap size, we concentrate specifically on the interplay between the strength of intra-band pairing interaction and the extent of the pseudogap region, particularly when one of the two bands is in the BCS-BEC crossover regime. In order to propose avenues for future experiments and verify the pseudogap's nature in a two-band superconductor, we also calculate various other significant physical quantities, including density-density response functions, critical temperature, and fermionic chemical potential, as functions of temperature and the strengths of intra- and inter-band interactions.

Keywords: FeSe superconductors, pseudogap

References:

[1] Mizukami, Y., Haze, M., Tanaka, O. *et al.* Unusual crossover from Bardeen-Cooper-Schrieffer to Bose-Einstein-condensate superconductivity in iron chalcogenides. *Commun Phys* **6**, 183 (2023).

Presenting author Email address: chientewu@nycu.edu.tw

Partial superconductivity and anomalous magnetoresistance in SnTe thin films

Phuoc Huu Le[1,2†], Chih-Wei Luo[3,*], Jiunn-Yuan Lin[4,*]

[1] *Center for Plasma and Thin Film Technologies, Ming Chi University of Technology, New Taipei City 24301, Taiwan*
[2] *Department of Physics and Biophysics, Faculty of Basic Sciences, Can Tho University of Medicine and Pharmacy, 179 Nguyen Van Cu Street, Can Tho City, Vietnam*
[3] *Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 30010 Taiwan*
[4] *Institute of Physics, National Yang Ming Chiao Tung University, Hsinchu 300, Taiwan*

[*] Corresponding e-mail: *cwluoep@nycu.edu.tw; ago@nycu.edu.tw*

SnTe is a narrow band-gap topological crystalline insulator and a thermoelectric material working in a high-temperature regime. In this study, SnTe thin films with various thicknesses from 127 to 462nm were grown on Al_2O_3 (0001) substrates at 300°C and helium ambient pressure of 200 mTorr using pulsed laser deposition. The films exhibited cubic crystal structure of SnTe with space group $Fm\underline{3}m$ (a = 6.327Å) and (2 0 0)-preferred orientation, and they had granular surface morphology. Interestingly, magnetotransport measurements at low temperatures (below 5 K) on the SnTe films reveal partial superconductivity with $T_c^{onset} \sim 3.83$ K, and various types of anomalous magnetoresistance (MR) curves. The SnTe films possessed Sn-rich compositions that could create Sn precipitates inside the films, and consequently, Sn precipitates induced the partial superconductivity and anomalous MR phenomena. Two superconducting transitions were observed for a 462 nm-thick SnTe film, which is likely due to the proximity effect, suggesting the formation of superconducting regions at the Sn/SnTe interfaces.

***Keywords*:** SnTe thin films; superconductivity; anomalous magnetoresistance; pulsed laser deposition.

Presenting author Email address: cwluoep@nycu.edu.tw

Luminescence Dynamics in Lanthanide-Doped Nanomaterials

Gabriella Tessitore[1]*

[1]*Deparment of Chemistry, Center for Optics, Photonics and Lasers (COPL), Advanced Materials Research Center (CERMA), Université Laval, 1045 avenue de la Médicine, G1V 0A9, Québec, QC, Canada*

* Corresponding e-mail: *gabriella.tessitore@chm.ulaval.ca*

Luminescence decay times are a key indicator of the extent of non-radiative phenomena influencing the luminescence response of an optical material.[1-2] The complex nature of the light-matter interactions at the nanoscale represents sometimes a barrier to uniquely correlating a certain trend in the measured decay times to a specific luminescence mechanism. Power dependencies, stronger for non-linear luminescence mechanisms, are often undervalued,[2-3] contributing to the broad spectrum of decay time values provided in the literature for a certain emitter. The plethora of available synthesis protocols and resulting geometries of the produced nanosystems, each influencing the luminescence response, further complicates the analysis of decay time curves.

The combination of different spectroscopic techniques and mathematical modeling of the luminescence mechanisms represent unsubstitutable tools to unravel the luminescence mechanisms at the nanoscale,[2] enabling novel applications of luminescent nanomaterials.[3] The dependency of the decay time curves on several parameters is reported for linear and non-linear luminescence mechanisms involving lanthanide ions, considering their wel-characterized spectroscopic footprint and broad application fields.[4] The presented spectroscopic and mathematical tools could further promote the desirable definition of an analysis routine to characterize the luminescence dynamics in nanomaterials, potentially mitigating the discrepancies in the data provided in the literature.

Keywords: Luminescence, nanomaterials, decay times, energy transfer

References:

[1] Tessitore, Gabriella; Mandl, Gabrielle A; Brik, Mikhail G; Park, Wounjhang; Capobianco, John A. (2019). Recent insights into upconverting nanoparticles: spectroscopy, modeling, and routes to improved luminescence. Nanoscale. 11(25): 12015-12029.

[2] Tessitore, Gabriella; Maurizio, Steven L; Sabri, Tarek; Capobianco, John A. (2019). Intrinsic Time-Tunable Emissions in Core-Shell Upconverting Nanoparticle Systems. Angewandte Chemie International Edition. 58(29): 9742-9751.

[3] Tessitore, Gabriella; Maurizio, Steven L; Sabri, Tarek; Skinner, Cameron D; Capobianco, John A. (2020). The Key Role of Intrinsic Lifetime Dynamics from Upconverting Nanosystems in Multiemission Particle Velocimetry. Advanced Materials. 32(42): 2002266.

[4] Tessitore, Gabriella; Mandl, Gabrielle A; Maurizio, Steven L; Kaur, Mannu; Capobianco, John A. (2023). The role of lanthanide luminescence in advancing technology. RSC Advances. 13(26): 17787-17811.

Presenting author Email address: gabriella.tessitore@chm.ulaval.ca

Unraveling the mechanism of photo-induced surface enhanced Raman scattering on ZnO/Au nanostructures

An Bang Ngac[1*], Viet Tuyen Nguyen, Nguyen Hai Pham[1]

[1]*Vietnam National University, University of Science, 334 Nguyen Trai, Thanh Xuan, Hanoi*

[*] Corresponding e-mail: ngacanbang@hus.edu.vn

Surface-enhanced Raman scattering (SERS) is a powerful technique for detecting pollutants. Recent studies have shown that the sensitivity of SERS can be further improved by using appropriate light excitation before or during Raman measurements, a phenomenon known as photo-induced enhanced Raman scattering (PIERS). However, the underlying mechanism of PIERS is still under debate.

In this research, sensitive SERS platforms based on ZnO/Au nanorods and ZnO/Au thin films were prepared by hydrothermal and sputtering processes. The study showed that an in situ UV excitation helped to enhance Raman signal efficiently up to 30.1 times compared with traditional SERS measurement under the same measurement condition. The enhancement process showed a reversible nature where a quick relaxation of Raman intensity to the initial level after shutting down UV excitation was observed. Experiment and simulation were performed to reveal the nature of photo induced enhancement process. The mechanism of PIERS effect is attributed to the generation of electron – hole pairs and charge transfer between ZnO and Au nanostructures.

Keywords: ZnO; Au nanoparticles; sputtering; surface enhanced Raman scattering (SERS); UV excitation

References:

[1] J. Zhao, Z. Wang, J. Lan, I. Khan, X. Ye, J. Wan, Y. Fei, S. Huang, S. Li, J. Kang, Recent advances and perspectives in photo-induced enhanced Raman spectroscopy, Nanoscale. 13 (2021) 8707–8721. https://doi.org/10.1039/D1NR01255J.

[2] V.T. Tran, T.H. Tran, M.P. Le, N.H. Pham, V.T. Nguyen, D.B. Do, X.T. Nguyen, B.N.Q. Trinh, T.T. Van Nguyen, V.T. Pham, M.Q. Luu, A.B. Ngac, Highly efficient photo-induced surface enhanced Raman spectroscopy from ZnO/Au nanorods, Opt Mater (Amst). 134 (2022) 113069. https://doi.org/10.1016/J.OPTMAT.2022.113069.

[3] S. Cong, X. Liu, Y. Jiang, W. Zhang, Z. Zhao, Surface Enhanced Raman Scattering Revealed by Interfacial Charge-Transfer Transitions, The Innovation. 1 (2020) 100051. https://doi.org/10.1016/J.XINN.2020.100051.

Presenting author Email address: ngacanbang@hus.edu.vn

Non-conventional Surface Plasmon Resonance Sensors

Viet Cuong Le, Hoang Hung Nguyen, Duc Hieu Nguyen, Chi Thanh Tran, Nam Nhat Hoang,

Huy Tiep Nguyen*

[1]*Faculty of Engineering Physics and Nanotechnology, VNU University of Engineering and Technology, No. 144, Xuan Thuy Road, Dich Vong Hau Ward, Cau Giay District, Hanoi 100000, Vietnam*

* Corresponding e-mail: *tiepnh@vnu.edu.vn*

Surface plasmon resonance (SPR) is an optical phenomenon that occurs when a p-polarized incident light is directed at a metal surface and stimulates the electrons of the metal to oscillate collectively. The oscillation generates surface electromagnetic waves called evanescent waves. SPR sensors can exploit these waves to measure tiny changes in the refractive index (RI) of the medium near the metal surface. The changes in the RI can be due to biomolecular interactions, chemical reactions, substance concentrations, etc. The SPR sensors have been developed and become the standard tool for characterizing and quantifying in real-time applications, including biological studies, biointeractions, clinical diagnosis, medical diagnosis, food safety, environment monitoring, etc. However, conventional SPR sensors rely on an outside photoreceiver and a complex mechanical system to measure the changes in the RI by detecting the reflected light's position and intensity. This is the most significant disadvantage of the conventional SPR sensors. This paper exhibits a photodiode-integrated SPR sensor to get over this main problem. Furthermore, the working principle and factors affecting the sensitivity of our SPR sensors are also outlined.

Keywords: surface plasmon resonance, SPR sensor, evanescent wave sensor, refractive index sensor.

Presenting author Email address: cuonglv@vnu.edu.vn

Single crystal growth of quantum and functional materials at NCKU

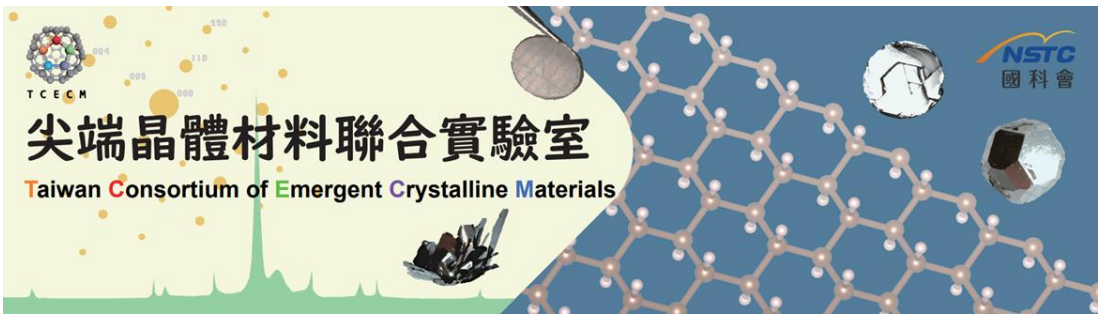
Chia Nung Kuo and Chin Shan Lue

Department of Physics, National Cheng Kung University, Tainan 70101, Taiwan
Taiwan Consortium of Emergent Crystalline Materials, National Science and Technology Council, Taipei 10601, Taiwan
Program on Key Materials, Academy of Innovative Semiconductor and Sustainable Manufacturing, National Cheng Kung University, Tainan 70101, Taiwan

*Corresponding author e-mail: *cslue@mail.ncku.edu.tw*

I will introduce to the crystal growth laboratory at National Cheng Kung University (NCKU) and various investigations of these crystals via academic collaborations. Up to now, we have synthesized more than one hundred kinds of single crystalline compounds by using the flux growth, chemical vapor transport, and Bridgman methods. Such an achievement is not ubiquitous among the worldwide crystal growth laboratories. These crystals cover a wide range of material systems from novel superconductors, charge-density-wave compounds, emergent topological materials, layered magnetic systems, and multifunctional 2D materials. From the fundamental and applied research, we have a fruitful publication with more than seventy papers in recent five years. The papers published on top journals include Nature Electronics, Nature Communications, Science Advances, Physical Review Letters, Physical Review B, Applied Physics Letters, Advanced Materials, Advanced Functional Materials, Small, 2D Materials, ACS Nano, ACS Catalysis, Journal of Materials Chemistry A, etc.

Presenting author Email address: cslue@mail.ncku.edu.tw



Growth and characterization of MnSb and InSb on GaAs (111)B using molecular beam epitaxy for spin-FET application

Md. Faysal Kabir, Masashi Akabori*

Center for Nano Materials and Technology (CNMT), Japan Advanced Institute of Science and Technology (JAIST)1-1 Asahidai, Nomi, Ishikawa 923-1292, Japan

* Corresponding e-mail: akabori@jaist.ac.jp

Ferromagnetic metal/semiconductor (FM/SC) hybrid structures are anticipated to lead a new era in spintronic device fabrication, particularly in spin field-effect transistors (spin-FETs) [1]. Hexagonal MnSb, a ferromagnetic metal, exhibits compatibility with III-V compounds such as GaAs and InSb [2,3], and InSb, a narrow gap semiconductor, exhibits strong spin-orbit coupling. Therefore, MnSb/InSb hybrid structure emerges as an appealing FM/SC hybrid structure for spin-FET application. Additionally, (111)B surfaces of III-V compounds are attractive due to their crystallographic compatibility with hexagonal FM structures [4,5]. Despite this potential, there is no significant work on the growth of MnSb/InSb hybrid structures on GaAs (111)B substrates. In this study, we report our recent MnSb and InSb growth on GaAs (111)B using molecular beam epitaxy (MBE) and their characterization. For MnSb growth on GaAs (111)B, we varied growth temperature from 300 °C to 600 °C. By scanning electron microscopy (SEM), energy dispersive x-ray spectroscopy (EDS) and x-ray diffraction (XRD), we found that not only MnSb but also other compounds were deposited at 300 °C, and only Mn was deposited at 600 °C. Therefore, we found that the optimum growth temperature for MnSb is between 400 °C and 500 °C in our study. Then, we varied Sb/Mn beam equivalent pressure (BEP) ratio from 1 to 6 at 400 °C. By SEM and XRD, we found the optimum BEP is between 3 and 6. Moreover, we measured magnetization curves by superconducting quantum interface device (SQUID) magnetometer as shown in Figure 1. We found a good property of the sample with BEP of 3. Similarly for InSb growth on GaAs (111)B, we varied growth temperature from 400 °C to 500 °C. By Hall measurement with van der Pauw geometry, we obtained room temperature electron mobility of 5000 $cm^2/V\text{-}s$ with electron concentration of 1.6×10^{17} cm^{-3} in the sample grown at 400 °C. Through a comprehensive analysis of growth and characterization, superior MnSb and InSb samples were identified for the prospective InSb/MnSb hybrid structure on GaAs (111)B substrate. This hybrid structure holds promise as a high-performance spin-FET device, with magnetically improved MnSb acting as source/drain and conductive InSb with spin-orbit coupling acting as channel.

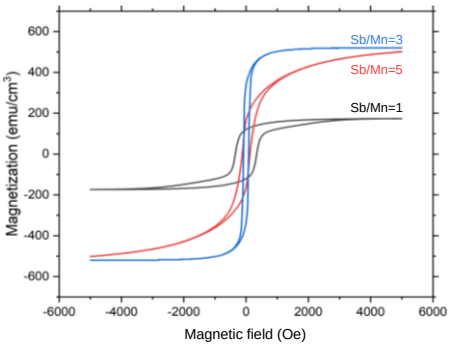


Figure 1 Magnetization curves.

Keywords: Spin-FET, MnSb/InSb, MBE

References

[1] S. Datta and B. Das, Appl. Phys. Lett. **56**, 665 (1990).
[2] H. Akinaga et al., Appl. Phys. Lett. **70**, 2472 (1997).
[3] A. Kochura et al., EPJ Web of Conferences **185**, 06003 (2018).
[4] Y. Morishita et al., Jpn. J. Appl. Phys. **36**, L1100 (1997).
[5] Md. E. Islam and M. Akabori, J. Crystal Growth **463**, 86 (2017).

Presenting author Email address: akabori@jaist.ac.jp

Spin transport and spin thermo-electric properties of 2D vdW FeGaTe film

Takashi Kimura[1]

[1]*Department of Physics, Kyushu University, 744 Motooka, Fukuoka, 819-0395, Japan*

[*] Corresponding e-mail: *t-kimu@phys.kyushu-u.ac.jp*

Recent progress of two-dimensional (2D) van der Waals (vdW) materials provides much research attention owing to their fascinating features with intriguing quantum mechanisms. These characteristics open high potential applications in future advanced nano-electronic devices but also the investigation of novel quantum phenomena. Particularly, 2D vdW magnetic materials have attracted a great deal of interest for developing low-dimensional magnetic and spintronic devices as well as exploring novel spin-related quantum phenomena The advantage of 2d vdW magnets over the conventional non-VdW magnets is that the physical properties of these magnets can be effectively modulated by varying the external parameters, such as the charge carrier doping, thickness effect, pressure and strain. In addition, the efficient spin-heat conversion processes have been demonstrated by using the 2d vdW magnets. These enables us to realize the pioneering applications in spintronics, spin-caloritronics, spin-sensing and quantum spin computation based on additional modulation functions. However, despite significant advancements for 2D vdW FMs, in most cases, their Curie temperatures remain below room temperature. In addition, the miniaturization of the ferromagnet and the perpendicular magnetic anisotropy (PMA) are crucial roles for the efficient operation and ultra-small device fabrication for spin-related devices. Here, we show that the vdW FeGaTe films shows an excellent spin-thero-electric property with the robust large room-temperature PMA. Moreover, we show that the magnetic ansitropy is effectively modulated by the pressure application.

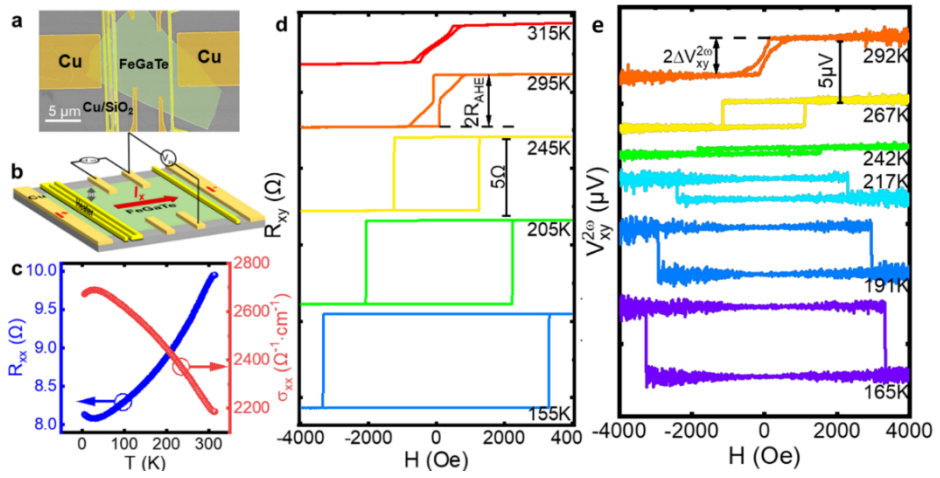


Figure 1. (a) Scanning electron microscope image of the fabricated FeGaTe film device and (b) its schematic illustration. (c) Temperature dependence of electrical resistance an longitudinal electrical conductivity (d) Anomalous Hall resistance curves for various temperatures (e) Anomalous Nernst signal under the perpendicular magnetic field for various temperatures.

Keywords: 2D materials, Perpendicular magnetic anisotropy, Anomalous Nernst effect, Pressure effect,

Presenting author Email address: t-kimu@phys.kyushu-u.ac.jp

Study on the spin-flop transition in epitaxial α-Fe_2O_3 films

Hyunkyung Lee[1], Sehwan Song[2], Youngjun Son1, Minjae Kim[1], Jong Mok Ok[1] and Sungkyun Park[1,3,*]

[1]*Department of Physics, Pusan National University, Busan, 46241, Republic of Korea*
[2]*Quantum Spin Team, Korea Research Institute of Standard & Science, Daejeon, 34113, Republic of Korea*
[3]*Nuclear Science Research Institute, Pusan National University, Busan, 46241, Republic of Korea*

[*]Corresponding e-mail: psk@pusan.ac.kr

In recent years, antiferromagnetic material has garnered significant attention to replace ferromagnets, particularly in spintronics [1]. They have attractive functionalities like spin colossal magnetoresistance, ultra-fast dynamics, high domain-wall propagation velocities, etc. Despite all these advantages, they have thus far only served in support roles as pinning or exchange bias layers in thin-film spintronic devices because their magnetic ordering is challenging to detect and control. Previously, α-Fe_2O_3 exhibits a spin-flop transition known as the Morin transition near the 263 K [2]. It has weak ferromagnetism between 263 K and 960 K, with the antiferromagnetically ordered spins slightly canted in *ab* plane. Below the Morin transition temperature (T_M), the spins align parallel to the *c*-axis, forming a collinear antiferromagnetic order. This transition is attributed to the competition between magnetic dipole (K_{DM}) and single-ion anisotropy (K_{SI}) energies [3]. Therefore, it can be tuned by controlling the magnetic anisotropy energy.

Here, we explored the correlation between the scaling and Morin transition in epitaxial α-Fe_2O_3 films. The various thicknesses of α-Fe_2O_3 films were grown on an α-Al_2O_3 substrate using pulsed laser deposition. As a result, the different spin-flop transition characteristics were observed with film thickness from magnetization and X-ray linear dichroism measurements. Further structural analysis confirmed the presence of the strained-thin layers at the interface and local distortion. These structural distortions triggered variation of the electronic structure and the single-ion anisotropy (K_{SI}), suggesting the possibility of controlling the spin-flop transition without chemical defects.

Keywords: α-Fe_2O_3, Morin transition, Strain, Single-ion anisotropy

References:

[1] T. Jungwirth *et al*., Antiferromagnetic spintronics, *Nat. Nanotechnol.* **11**, 231 (2016)
[2] F. J. Morin, Magnetic susceptibility of α-Fe_2O_3 and α-Fe_2O_3 with added titanium, *Phys. Rev.* **78**, 819 (1950)
[3] H. Jani *et al*., Reversible hydrogen control of antiferromagnetic anisotropy in α-Fe_2O_3, Nat. Commun **12**, 1668 (2021)

Presenting author Email address: psk@pusan.ac.kr

Ultrafast dynamics in critical topological materials

Jiunn-Yuan Lin

Institute of Physics, National Yang Ming Chiao Tung University

*Corresponding e-mail: *ago@nycu.edu.tw*

Topological materials exhibiting symmetry-protected surface states have recently attracted attention due to its unique physical properties and potential novel applications. In this talk, the present the study of the ultrafast dynamics on AB_2X_2 type (i) $SrCd_2Sb_2$ and $SrCd_2As_2$ single crystals; (ii) $EuCd_2Sb_2$ single crystals.

Case (i): Helicity-dependent THz emission measurements have been performed on both SrCd2Sb2 and SrCd2As2 single crystals. This technique provides a contact-free method to study spin-polarized photocurrent from topological surface states due to circular hotogalvanic effect (CPGE). Our results agree with theoretical calculations and indicate a chemical pressure-induced topological phase existing in $SrCd_2Sb_2$.

Case (ii): Ultrafast optical pump-probe (OP-OP) spectroscopy, both at low temperature and in magnetic fields, was employed to investigate the presumed magnetic topological $EuCd_2Sb_2$. A detailed analysis on the OP-OP spectra will provide deeper understanding on the underlying physics of the electronic and magnetic structure of $EuCd_2Sb_2$ single crystals. The relation between magnetic and topological orders will be discussed.

Keywords: Topological materials, magnetic topological materials, Dirac semimetals, Weyl semimetals.

Presenting author Email address: ago@nycu.edu.tw

Anomalous Hall Effect in Superfluid ^{3}He-A

Kimitoshi Kono

International College of Semiconductor Technology, NYCU, Taiwan

*Corresponding e-mail: kkono@nycu.edu.tw

Superfluid helium is one of the most standard broken-symmetry states in condensed matter systems, manifesting topological properties. In particular, in superfluid ^{3}He, relevant symmetry operations are described by U(1), $SO(3)^L$ for orbital, and $SO(3)^S$ for spin degrees of freedom. Here, U(1) denotes a guage rotation, which is essential to exhibit superfluidity, and SO(3) denotes 3D rotation. In superfluid ^{3}He, in addition to U(1), both $SO(3)^L$ and $SO(3)^S$ are broken, so that the order parameter of superfluid ^{3}He may have a very rich structure as shown in FIG. 1. This is because the Cooper pair in seperfluid ^{3}He has the orbital angular momentum, L=1, and the spin angular momentum, S=1 (p-wave). Note that space and time inversion are applicable as well.

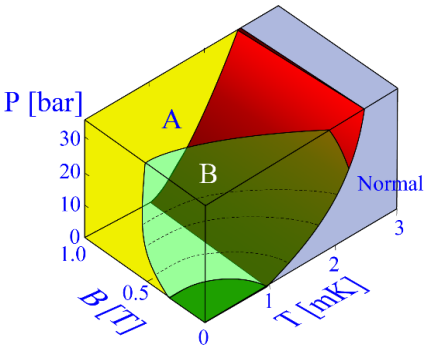


Figure 1. Phase diagram of Superfluid ^{3}He in temperature (T), magnetic field (B), and pressure (P) space. The B-phase (green) occupies a corner near origin. The A-Phase (yellow) is preferred under finite magnetic fields and pressures.

After the symmetry breaking, the order parameter of superfluid ^{3}He, which is essentially the wavefunction of Cooper pair, remains invariant under certain symmetry operations involved in the original SO(3). Such a remaining symmetry property can be specified by assigning the eigenstates of Cooper pair. The B-phase corresponds to J=0 eigenstate, and invariant under the simultaneous rotation of the orbital and spin space, where J is the total angular momentum, J=L+S. The B-phase is invariant under time inversion as well.

The A-phase is described by the eigenstate corresponding to L_z=1 and S_z=0, that is, the A-phase is invariant under spin rotation about the z-axis, and orbital rotations about the z-axis by an arbitrary angle q accompanied by simultaneous gauge rotation by the angle q/2. L_z=1 implies that the orbital angular momentum aligns along z-axis in momentum space and in real space. The macroscopic alignment of Cooper pair angular momentum results broken time reversal symmetry and the A-phase is chiral. This axial anisotropy follows that a moving small object perpendicular to angular momentum vector experiences asymmetric (skew) scattering off by thermally excited quasiparticles in the direction perpendicular to both moving direction and angular momentum of Cooper pair. Thus, an anomalous Hall effect is produced in superfluid ^{3}He-A. This effect is observed by measuring the ion transport trapped under the free surface of superfluid ^{3}He-A [1,2], which is in good agreement with the theory [3].

Keywords: superfluid ^{3}He, A-phase, chiral, broken symmetry, topological

References:

[1] H. Ikegami, Y. Tsutsumi, and K. Kono: Science **341**, 59 (2013).
[2] H. Ikegami, Y. Tsutsumi, and K. Kono: J. Phys. Soc. Jpn. **84**, 044602 (2015).
[3] O. Shevtsov and J. A. Sauls: Phys. Rev. B **94**, 064511 (2016).

Presenting author Email address: kkono@nycu.edu.tw

High-pressure induced spin state transition and intermetallic charge transfer in $PbCoO_3$

Zhehong Liu[1,2], Shu-Chih Haw[3], Hirofumi Ishii[3], Zhiwei Hu[4], J. Paul Attfield[5], Masaki Azuma[6], Youwen Long[1,2], Jin-Ming Chen[3,*],

[1]*Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China*
[2]*School of Physics, University of Chinese Academy of Sciences, Beijing 100049, China*
[3]*National Synchrotron Radiation Research Center, 101 Hsin-Ann Road, Hsinchu 30076, Taiwan*
[4]*Max-Planck Institute for Chemical Physics of Solids, NöthnitzerStraße 40, 01187 Dresden, Germany*
[5]*Centre for Science at Extreme Conditions and School of Chemistry, University of Edinburgh, Mayfield Road, Edinburgh EH9 3JZ, United Kingdom*
[6]*Laboratory for Materials and Structures, Tokyo Institute of Technology, 4259 Nagatsuta, Midori, Yokohama 226-8503, Japan*

*Corresponding email: *jmchen@nsrrc.org.tw*

Spin state transition and intermetallic charge transfer can both essentially change the *d*-electronic configurations without introducing any doping element, giving rise to drastic variations for materials structures and physical properties. However, these two effects are never found to occur together in a specific material. Here we report that pressure can sequentially induce the spin state transition and intermetallic charge transfer in $PbCoO_3$ perovskite which possesses a very rare A- and B-site ordered charge format $Pb^{2+}Pb^{4+}{}_3Co^{2+}{}_2Co^{3+}{}_2O_{12}$ at ambient conditions. With increasing pressure, the high spin Co^{2+} gradually changes to be low spin, while the $AA2_3B_2B2_2O_{12}$-type crystal structure maintains unchanged with insulating conductivity below 20 GPa. Between 20 and 30 GPa, the ordered Co^{2+}/Co^{3+}charge states are melted into a mixed $Co^{2.5+}$ at higher temperatures accompanying with metallization, but lowering temperature leads to a metal-insulator transition. Moreover, Pb^{4+}-Co^{2+} intermetallic charge transfer also takes place in this pressure region. With further compression up to 30 GPa, the charge transfer completes, and the compound most probably develops into an A-site ordered $Pb^{2+}Pb^{4+}Co^{3+}{}_2O_6$ phase. Since the B-site is fully occupied by the low spin Co^{3+}, insulating behavior emerges again in this phase.

Keywords: high pressure, spin state transition and intermetallic charge transfer

Presenting author Email address: jmchen@nsrrc.org.tw

Terahertz Emission from Topological Material $SrCd_2Sb_2$ single crystals

Ying-Kuan Ko[1], Xin-Yun Chang[1], Yan-Cheng Ko[1], Po-Wei Gong[1], Yi-Cheng Cheng[1], Pei-Tsung Yang[1], Jiun-Haw Chu[2], Cheng-Chien Chen[3], Chih-Wei Luo[1], Jiunn-Yuan Lin[4], and Chien-Ming Tu[1,5,6*]

[1]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu, 300093 Taiwan*
[2]*Department of Physics, University of Washington, Seattle, WA, 98195 USA*
[3]*Department of Physics, University of Alabama at Birmingham, Birmingham, AL, 35294 USA*
[4]*Institute of Physics, National Yang Ming Chiao Tung University, Hsinchu, 300093 Taiwan*
[5]*Undergraduate Degree Program of Systems Engineering and Technology, National Yang Ming Chiao Tung University, Hsinchu, Taiwan*
[6]*Chung Cheng Institute of Technology, National Defense University, Taoyuan, Taiwan*

[*] Corresponding e-mail: kentko78@gmail.com

Topological materials (TMs) have attracted much interests both theoretically and experimentally due to their exotic transport phenomena, and potential applications in spintronics and quantum computing. Dirac and Weyl semimetal are quantum matters which its conduction and valance bands cross each other and show linear dispersion around pairs of nodes in reciprocal space. Magnetic Weyl semimetal is bearing seeking for long time, and $EuCd_2Sb_2$ has been predicted as an ideal magnetic Weyl semimetal in the spin-polarized ferromagnetic state by applying external magnetic field [1]. $SrCd_2Sb_2$ ($SrCd_2As_xSb_{2-x}$, x = 0), the non-magnetic analogue of $EuCd_2Sb_2$, has also been predicted to show non-trivial topological phase in room temperature. Besides, THz emission spectroscopy is a powerful contact-free tool to detect the dynamics of photocurrents in topological materials through circular photogalvanic effect [2, 3]. The photocurrent can be described by the equation (1). By transient current radiation, the photocurrents are able to emit electromagnetic wave in THz frequency range i.e. $E_{THz} \propto \frac{\partial J_{THz}}{\partial t}$. In this study, we report on terahertz emission spectroscopy of topological material $SrCd_2As_xSb_{2-x}$ single crystals. For $SrCd_2Sb_2$ single crystal, at the oblique incidence case (θ = 45°), a significant nonzero CPGE term of terahertz emission were extracted by time-domain decomposition and recombination, and however, at the normal incident case ($\theta \sim 0°$), the CPGE value is almost zero. This phenomenon agrees with the characteristics of nontrival topological surface state on the surface of a topological Dirac semimetal $SrCd_2Sb_2$ single crystal.

$$\boldsymbol{J_{THz}(\alpha, t) \propto C(t)sin(2\alpha) + L_1(t)sin(4\alpha) + L_2cos(4\alpha) + D(t)} \quad \textbf{(1)}$$

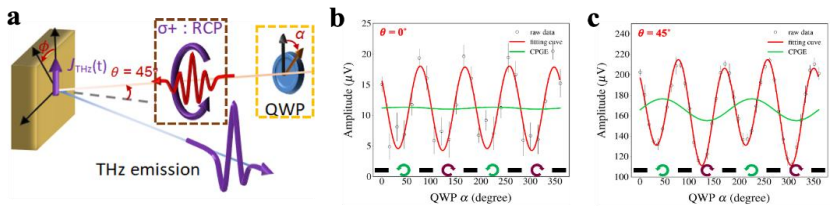


Figure 1. a, circularly polarized optical pulses illuminated a $SrCd_2Sb_2$ single crystal at an oblique angle θ = 45° of incidence to generate photocurrents (J_{THz}) with direction perpendicular to the plane of incidence. In b-c, the figures show the emitted THz radiation at different incident angle of $\theta \sim 0°$ and 45° respectively. α : the phase angle of the quarter-wave plate (QWP).

Keywords: Terahertz emission, Topological materials, Spintronics.

References:

[1] J.-R. Soh, *et al*., Phys. Rev. B **98**, 064419 (2018).
[2] N. Sirica, *et al*., Phys. Rev. Lett. **22**, 197401 (2019).
[3] L. Luo, *et al*., Nat. Mat. **20**, 329-334, (2021).

Presenting author Email address: kentko78@gmail.com

First-principles and crystal field calculations of optical properties of phosphor materials

M.G. Brik[1,2,3,4,5,*], M. Piasecki[4], A.M. Srivastava[6,]

[1]*College of Sciences & CQUPT-BUL Innovation Institute, Chongqing University of Posts and Telecommunications, Chongqing 400065, People's Republic of China*
[2]*Centre of Excellence for Photoconversion, Vinča Institute of Nuclear Sciences - National Institute of the Republic of Serbia, University of Belgrade, Belgrade, Serbia*
[3]*Institute of Physics, University of Tartu, W. Ostwald Str. 1, Tartu 50411, Estonia*
[4]*Faculty of Science and Technology, Jan Długosz University, 42200 Częstochowa, Poland*
[5]*Academy of Romanian Scientists, 050044 Bucharest, Romania*
[6]*Current Chemicals, 1099 Ivanhoe Road, Cleveland, OH, 44110, USA*

[*] Corresponding author e-mail: *mikhail.brik@ut.ee*

Combination of complementary calculation techniques – first-principles and crystal field calculations – is a powerful tool for getting a deeper understanding of complicated interrelations between the structural and electronic properties of a host material, on one side, and energy levels of a dopant, on the other side. The first-principles calculations allow for calculating the electronic band structure of solids, whereas the crystal field models give a possibility of calculating the crystal field splittings of the multielectron energy levels of impurities. Such calculations, if performed for large groups of isostructural materials or isoelectronic impurities, can help in revealing certain correlations, sometimes not obvious, between local structure and optical properties. Numerous examples focused on the Mn^{4+}-, Eu^{2+}- and Cr^{3+}-doped phosphor materials for lighting and thermometry will be discussed in detail, with an emphasis on tunabilty of the spectral positions of the emission peaks and their intensity by varying host's chemical composition [1-5].

Keywords: phosphor materials; transition metal ions; rare earth ions; electronic properties.

References:

[1] M.G. Brik, C.-G. Ma, A.M. Srivastava, M. Piasecki, Chin. J. Lumin. 41 (2020) 1011-1029.
[2] M.G. Brik, V. Jarý, L. Havlák, J. Bárta, M. Nikl, Chem. Eng. J. 418 (2021) 129380.
[3] M. Subhoni, U. Zafari, A.M. Srivastava, W.W. Beers, W. Cohen, M.G. Brik, T. Yamamoto, Opt. Mater. 115 (2021) 110986.
[4] N.Mironova-Ulmane, M.G. Brik, J. Grube, G. Krieke, M. Kemere, A. Antuzevics, E. Gabrusenoks, V. Skvortsova, E. Elsts, A. Sarakovskis, M. Piasecki, A.I. Popov, Opt. Mater. 132 (2022 112859.
[5] M. G. Brik, M.S. Kurboniyon, C.-G. Ma, Chin. J. Lumin. 43 (2022) 1459-1468.

Presenting author Email address: mikhail.brik@ut.ee

Catalytic properties of perovskite-type related oxides for oxygen evolution reactions based on density functional calculations

Hidekazu Ikeno[1,*]

[1] *Department of Materials Science, Graduate School of Engineering, Osaka Metropolitan University*

[*] Corresponding e-mail: *h-ikeno@omu.ac.jp*

The oxygen evolution reaction (OER) is a crucial electrochemical reaction utilized in the electrolysis of water, industrial electrolytic anodes, and metal-air secondary batteries. Various transition metal composite oxides are currently being studied as non-precious metal catalysts to reduce the overpotential of OER. Among them, perovskite oxides represented by the formula ABO_3 are extensively researched. There are mainly two approaches for material design: one is to optimize the catalytic activity by altering the chemical composition by mixing different elements at the A and B sites. The other approach is to maximize catalytic activity by changing the crystal structure. For example, quadruple perovskite oxides show improved OER activity compared to simple perovskite oxides with the same constituent elements. However, understanding how these approaches enhance OER catalytic activity at the atomic level is essential for developing novel OER catalysts.

This study investigated the OER catalytic activity in perovskite-related oxides using density functional theory calculations. Upon systematically examining the relationship between the bulk electronic state and the OER activity of perovskite oxides, we found that the charge transfer energy Δ, defined as the difference between the occupied oxygen 2p band center and the unoccupied cation 3d band center, serves as a good descriptor for OER activity. Additionally, we performed theoretical overpotential calculations using slab models to understand the differences in OER activity due to crystal structures. In quadruple perovskite oxides, it was clarified that OER overpotential decreases when adsorbing at bridge sites spanning two cation sites on the (220) surface (see Figure 1). In the presentation, we will also discuss how catalytic activity is improved by mixing multiple cations.

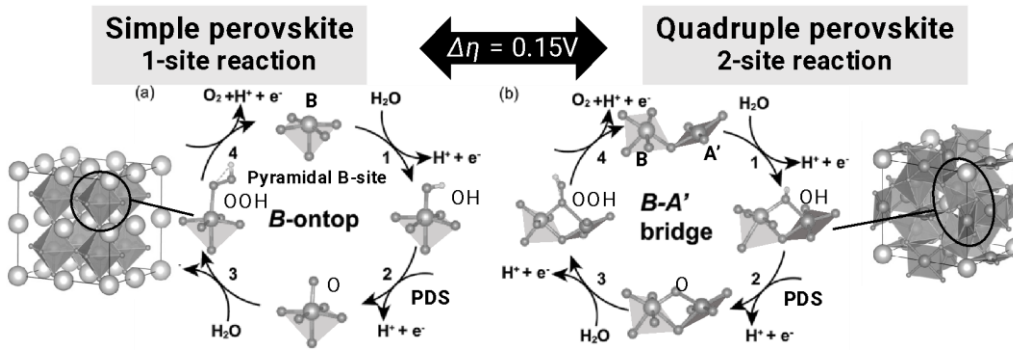


Figure 1. OER reaction mechanism in simple and quadruple perovskite oxides

Keywords: Electrocatalysis; First-principles calculations; Quadruple-perovskite;

References:

[1] Yamada et al., J. Phys. Chem. C **122,** 27885 (2018).
[2] Takamatsu *et al.,* J. Phys. Chem. C **121,** 28403 (2017).
[3] Okazaki et al., RSC Adv. **12,** 5094 (2022).

Presenting author Email address: h-ikeno@omu.ac.jp

Machine learning molecular dynamics simulations of materials with complex structures

Masahiko Okumura[1*]

[1]*Center for Computational Science and e-Systems, Japan Atomic Energy Agency, Kashiwa, Chiba 277-0871, Japan*

[*] Corresponding e-mail: okumura.masahiko@jaea.go.jp

Machine learning molecular dynamics (MLMD) is a promising method for large-scale simulations with first-principles (FP) accuracy. This method employs artificial neural networks (ANNs) trained with many FP calculation results. The calculation speed of the ANN is much faster than that of the FP calculations. The input and output of the ANNs are a configuration of atoms and the total energy corresponding to the configuration, respectively; the ANNs mimic the potential energy surface (PES) of the FP calculations. In general, the MLMD simulations of materials with complex structures have complex PES. Therefore, the MLMD simulations of the materials with simple structures are easier than those with complex structures, e.g., the PES of crystalline materials can be reproduced by the ANNs easier than those of amorphous materials due to the complexity of the PES. The presentation will show our recent MLMD simulation results of three different complex structured materials.

First, the MLMD simulation result of kaolinite, a layered clay mineral, will be shown. Clay minerals are ubiquitous natural materials, and they can be synthesized artificially. Kaolinite is used as a raw material for ceramics, cosmetics, and papermaking. Kaolinite has a larger unit cell than simple materials, e.g., the bcc or fcc metals. In addition, they contain hydroxy groups (OH), which do not have rigid structures. The finite temperature phonon spectra of such a soft structure are not easy to obtain. Our MLMD simulation gave the phonon spectrum of the hydroxy group consistent with an experimental result, which classical molecular dynamics simulation failed to reproduce it.

The second one is thorium dioxide (ThO_2), which has a simple fluorite-type crystalline structure. However, this material shows the superionic phase transition, i.e., the oxygen moves like liquid above the transition temperature although thorium maintains the frame of the solid. This coexistence of liquid-like and solid-like materials is challenging for MLMD simulations because the PES drastically changes before and after the transition. Our MLMD simulation captured the phase transition, and the evaluated transition temperature is consistent with the experimental result.

The final one is silica glass, a popular amorphous material. Even in the quartz glass, one can find some clear structures, although amorphous is considered a material without order. For example, the tetrahedra structure of SiO_2 can be easily identified by the second peak of the total structure factor observed by the X-ray diffraction. The first peak of the spectrum called the first sharp diffraction peak (FSDP), is an issue; the origin of the FSDP has been debated for a long time. To tackle this issue, we focused on the FSDPs of two types of compressed quartz glasses: permanently compressed silica glasses made by cold and hot compressions. Our MLMD simulation revealed that the structural origin of the middle range order corresponds to the FSDP.

Keywords: machine learning, molecular dynamics, clay minerals, superionic transition, glass

References:

[1] K. Kobayashi *et al*., Appl. Clay Sci. **228**, 106596 (2022).
[2] K. Kobayashi *et al*., Sci. Rep. **22**, 9808 (2022).
[3] K. Kobayashi *et al.*, Sci. Rep. **13**, 18721 (2023).

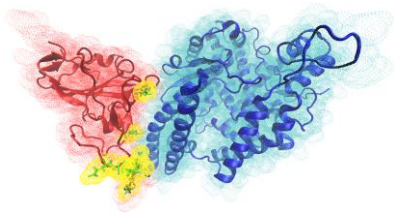
Presenting author Email address: okumura.masahiko@jaea.go.jp

Comparing receptor binding properties of SARS-CoV-2 and of SARS-CoV virus by using unsupervised machine learning models

Cao Phuong Cong[1,2], Hien T. T. Lai[1], Ly H., Nguyen[1,3], Agata Kranjc[4,5,6,1], Duc Nguyen-Manh[7], Carloni Paolo[4,7,1], and Toan T. Nguyen[1,2,*]

[1]*Key Laboratory for Multiscale Simulations of Complex Systems, University of Science, Vietnam National University, 334 Nguyen Trai Street, Thanh Xuan, Hanoi 11400, VIETNAM*
[2]*Faculty of Physics, University of Science, Vietnam National University, 334 Nguyen Trai Street, Thanh Xuan, Hanoi 11400, VIETNAM*
[3]*Digital Materials Science laboratory (VinUniversity, Hanoi 100000, Vietnam)*
[4]*Institute for Neuroscience and Medicine (INM-9), Forschungszentrum Jülich, Jülich, 52425, Germany*
[5]*Laboratoire de Biochimie Théorique, UPR 9080 CNRS, Université de Paris, 13 rue Pierre et Marie Curie, F-75005, Paris, France*
[6]*Institut de Biologie Physico-Chimique-Fondation Edmond de Rotschild, SL Research University, 75005, Paris, France*
[7]*JARA-Brain Institute Molecular Neuroscience and Neuroimaging, Research Center Jülich GmbH, Jülich, 52425, and RWTH Aachen University, Aachen, 52056, Germany*
[8]*CCFE, United Kingdom Atomic Energy Authority, OX14 3DB, Abingdon, UK*

[*] Corresponding e-mail: toannt@hus.edu.vn



This work continues our recently molecular dynamics investigation of the three systems of the human ACE2 receptor interacting with the viral RBDs of SARS-CoV virus and two variants of SARS-CoV-2 viruses. The simulations are extended and analysed using unsupervised machine learning models to give complementary descriptions of hidden features of the viral binding mechanism. Specifically, the principle component analysis (PCA) and the variational autoendoder (VAE) models are employed, both are classified as dimenstionality reduction approaches with different focuses. The results support the molecular dynamics results that the two variants of SARS-CoV-2 bind stronger and more stable to the human ACE2 receptor than SARS-CoV virus does. Moreover, stronger bindings also affects the structure of the human receptor, making it fluctuate more, a sensitive feature which is hard to detect using standard analyses. Importantly, is is found that the VAE model interestingly can learn and arrange randomly shuffled protein structures obtained from molecular dynamics in time order in the latent space represetation. This result potentially has promissing application in compotional biomolecules. One could use this VAE model to jump forward in time during a molecular dynamics simulation, and to enhance the sampling of protein configuration space. Nevertheless, our results are reportedly preliminary, more rigorous investigation to optimize parameters and hyperparameters of the model are needed in the future.

Keywords: Coronaviruses, human ACE2, variational autoencoder, enhanced sampling, molecular dynamics

Presenting author Email address: toannt@hus.edu.vn

Factors governing disparities of electrons and phonons transports in quasi-ternary sulphides for thermoelectric applications

M. Yoshiya[1,2,3], K. Funai[2], C.-H. Kim[1], K. Yoshizawa[1], R. Akitake[1], H. Nakao[1], S. Fujii[1,2,3]

[1]*Department of Adaptive Machine Systems, Graduate School of Engineering, Osaka University, Japan*
[2]*Division of Materials and Manufacturing Science, Graduate School of Engineering, Osaka University, Japan*
[3]*Nanostructures Research Laboratory, Japan Fine Ceramics Center, Japan*

* Corresponding e-mail: yoshiya@mat.eng.osaka-u.ac.jp

High electronic conductivity and low phonon thermal conductivity must be simultaneously achieved for thermoelectric applications, despite those transport properties obviously have a positive correlation [1], instead of negative which is desired for the applications, in terms of relationship in terms of quantum-waves or their scattering, on the text-book level. Extensive experimental studies have demonstrated the deviation of it, exhibiting high thermoelectric performance through high electronic and low phonon thermal conducitivies. Peculiar crystal structures is one of the reasons which are used upon phenomenologically elucidating underlying mechanisms behind the disparity. Lattice defects, such as grain boundaries, point defects and dislocations, are known to be responsible for the deviation, through atomic coodination environments deviated from those in perfect crytals. Yet another elucidation includes explotation the difference in mean free paths of electrons and phonons. However, less attnetion has been paid to ones of the most fundamental factors, i.e., chemical bonding among constituent atoms and ground states of electrons and phonons before their scattering upon travelling through crystals.

A series of a quasi-ternary sulphide system, Cu-Zn-Sn-S exhibits mosaic-like patterns of ordered phases and disorderd phases on the meso-scale between nanometer and micrometer dimensions. It has been found that the mosaic patterns substantially contribute to lowering phonon thermal conductivity by a simple set of model calculations by some of the authors [2]. However, detailed mechanism behind the transport properties remain uncertain, unconvering of which would pave the way for further materials designing for the applications.

In this study, we have done first principles calculations for electronic structures and their transport properties and molecular dynamics calculations for phonon structures and their transport properties, to uncover the underlying mechanisms behind the transport properties. These calculations assumes nothing of the conventional theories for the transport properties and thus would enable us to further explor the mechanisms beyond the conventional theories. It is found that, while disordered atomic arrangements of the disoder phase supposedly triggers scattering of electrons and phonons, thereby lowering both electronic conductivity and phonon thermal conductivity, modifications of ground states of electrons and phonons acommpanies something more than simple scattering of electrons and phonons, respectively. This leads to the modification in electronic and phonon thermal conductivity beyond what the conventional theories would predict based on scatting theories, providing further rooms to selectrively optimize the two transport properties separately.

Keywords: electronic conductivity, thermal conductivity, lattice defects, *ab initio* calculations, molecular dynamics

References:

[1] J. M. Ziman, “Electrons and Phonons”, Clarendon Press, Oxford, UK, 1960.
[2] C. Li, Y. Shen, R. Huang, A. Kumamoto, S. Chen, C. Dai, M. Yoshiya, S. Fujii, K. Funai, C. A. J. Fisher, Y. Wang, R. Qi, C.-G. Duan, L. Pan, J. Chu, T. Hirayama, Y. Ikuhara, "Hierarchically Structured Thermoelectric Materials in Quaternary System Cu-Zn-Sn-S Featuring a Mosaic-type Nanostructure", ACS Appl. Nano Mater., 1, 6, (2018) 2579-2588.

Presenting author Email address: yoshiya@mat.eng.osaka-u.ac.jp

Ferroelectricity by phonon-decoupled oxygen tetrahedra in brownmillerite oxides

Si-Young Choi

Department of Materials Science and Engineering, POSTECH, Republic of Korea
Department of Semiconductor Engineering, POSTECH, Republic of Korea
Center for van der Waals Quantum Solids, Institute of Basic Science, Republic of Korea

* Corresponding e-mail: youngchoi@postech.ac.kr

Ferroelectricity is an intriguing phenomenon essential for non-volatile memory device applications with the advantages of high operation speed and low power consumption, which store information by spontaneous electric polarization. An innate property of ferroelectricity is that the spontaneous polarization can be switched under the application of an electric field. Singly-oriented polarization is electrostatically unstable because of the uncompensated charge at the surface, and a domain is formed to minimize the free energy. The domain size or pattern of conventional ferroelectrics is mostly determined by mechanical boundary conditions, such as interfacial strain and electrical boundary conditions. In this regard, there have been lots of efforts to reduce the ferroelectric domains; *i.e.*, an ultrafine ferroelectric domain structure with an approximate width of 10 nm has been reported in conventional perovskites, $Pb(Zr,Ti)O_3$ thin films, and the critical size of ferroelectric domains in a $BaTiO_3$ nanocrystal is limited to approximately 5–10 nm scale.

Ferroelectric HfO_2 has been considered as an appropriate candidate owing to its ultimately fine domains and half-unit cell width.[1] The orthorhombic phase of HfO_2 can be switched to zero-width domain walls contrary to the case in $PbTiO_3$ having diffused domain walls. Freestanding membrane $CsBiNb_2O_7$ has also been known to have unit cell wide ferroelectric domains;[2] however, there is insufficient understanding of the application of these materials to actual devices. In this talk, I do introduce a controllable unit cell-scale domain in the brownmillerite oxides.[3] The first-principles phonon calculations show that the phonon modes related with oxygen-octahedra are fully decoupled from those with oxygen-tetrahedra, and the strongly localized oxygen-tetrahedral phonons enable site-selective control of the unit cell-wide domain. By combining atomic-scale imaging and in situ transmission electron microscopy, we visualized unit cell-wide ferroelectricity separated by electrically neutral unit cell-wide walls and its switchable characteristics. Our findings provide inspiration for designing high-density memory devices at the quantum limit.

References:

[1] H.-J. Lee, M. Lee, K. Lee, et al, Scale-free ferroelectricity induced by flat phonon bands in HfO_2. Science 369, 1343-1347 (2020).
[2] Y. Guo, B. Goodge, L. Zhang, et al, Unit-cell-thick domain in free-standing quasi-two-dimensional ferroelectric material. Phys. Rev. Mater. 5, 044403 (2021).
[3] Jinhyuck Jang, Yeongrok Jin, Heung-Sik Park, et al, Circumscribed ferroelectricity by phonon-decoupled oxygen tetrahedra in brownmillerite oxides. doi.org/10.21203/rs.3.rs-3343923/v1.

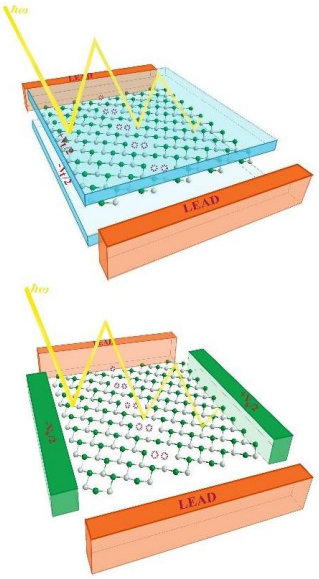
Presenting author Email address: youngchoi@postech.ac.kr

The influences of external fields on the optical absorption spectra of zigzag buckling silicene nanoribbons without and with divacancies

Lam-Thuy-Duong Nguyen[1], Van-Chinh Ngo[1,2], Thi-Thu-Tram Nguyen[3], Thi-Kim-Quyen Nguyen[1], Van-Truong Tran[4], Thanh-Tra Vu[5,6,*] and Thi-Kim-Loan Phan[5]

[1]*School of Graduate, College of Natural Sciences, Can Tho University, Can Tho, Vietnam*
[2]*Ho Thi Ky High School, Ca Mau, Vietnam*
[3]*Can Tho University of Medicine and Pharmacy, Can Tho, Vietnam*
[4]*Centre de Nanosciences et de Nanotechnologies, Université Paris-Saclay, 91120 Palaiseau, France*
[5]*Department of Physics, School of Education, Can Tho University, Can Tho, Vietnam*
[6]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu, Taiwan*

[*] Corresponding e-mail: *vttra@ctu.edu.vn*



In this study, by combining the tight-binding description with the gradient approximation [1], we have provided an overall picture of the impact of the external stimuli on the optical characteristics of the zigzag edge of buckling silicene nanoribbons (BSiNRs). In which, we will, in turn, utilize the perpendicular and parallel electric potentials to regulate the variation of the spectral peak structure of this material in two cases without and with the effect of divacancies (DVs). Our results have shown that for a perfect model, at the same magnitude of the voltage, the perpendicular electric field causes the powerful shifting to the higher frequency in the peak structure; meanwhile, the parallel electric field is responsible for the increment of the intensity of the excitation channels obeying the selection rule $\otimes J$ = even. In particular, applying the potentials in a suitable range can improve the optical absorption efficiency at a certain frequency (in the former field) or widen the threshold absorption intensity from J^v = -1 to J^c = 1 (in the latter field). Besides, the absorption spectrum in the defective BSiNRs will have a richer peak structure than in the perfect structure with the appearance of new optical excitations due to the transitions between the concave downward and upward subbands around the Fermi level. Consequently, the obtained results have offered suggestions for using the appropriate type of stimulants for different purposes and have driven the material's applications in optoelectronic and photovoltaic devices [2,3].

Keywords: optical properties, tight-binding method, divacancies, perpendicular electric field, parallel electric field

References:

[1] A. Cresti, G. Grosso, G.P. Parravicini, Valley-valve effect and even-odd chain parity in p−n graphene junctions, Phys. Rev. B 77 (2008) 233402.
[2] M. Noshin, A.I. Khan, R. Chakraborty, S. Subrina, Modeling and computation of thermal and optical properties in silicene supported honeycomb bilayer and heterobilayer nanostructures, Mater. Sci. Semi. Process. 129 (2021) 105776.
[3] Y. Hou, C. Jiang, Optical properties of silicene-dielectric interfaces from IR to far UV, Int. J. Mod. Phys. B 35, 2150235 (2021).

Presenting author Email address: duongp1919001@gstudent.ctu.edu.vn

Correlation between Orbital Hybridizations, Phonon Spectra, and Thermal Properties of Graphene, Germanene, and Plumbene

Vo Khuong Dien[1], Nguyen Thi Han[2], Wei Bang-Li[3], and Ming-Fa Lin[4]

[1]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 300, Taiwan*
[2] *Faculty of Materials Science and Engineering, Phenikaa University, Hanoi 12116, Vietnam*
[3] *Department of Physics, National Cheng Kung University, 701 Tainan, Taiwan*

[*] Corresponding e-mail*:* *vokhuongdien@nycu.edu.tw*

Based on first-principles calculations within the harmonic approximation, the phonon properties and specific heat capacities of 2D honeycomb lattices are investigated. Graphene, germanene, and plumbene manifest interesting phonon properties. The similarities and differences in their nature, for example, the total phonon bandwidth, low-frequency phonon dispersion, and phonon bandgap mostly arise from the significant orbital interactions. These features are reflected in the phonon branch-dependent specific heat capacity. The information obtained in this work about the relative contributions of distinct phonons to different temperature ranges is crucial for energy storage and heat management applications.

Keywords: group IV monolayer, orbital hybridizations, phonon branch-dependent heat capacity, phonon gaps

References:

[1] Vo Khuong Dien, et al. “Correlation between orbital hybridizations, phonon spectra, and thermal properties of graphene, germanene, and plumbene.” physica status solidi (RRL) - Rapid Research Letters 17.5 (2023): 2200469.

Presenting author Email address: vokhuongdien@nycu.edu.tw

The development and application of organic solar panels and ammonia sensors

Hsin-Fei Meng[1 *], Ngoc Khanh Tran Ho[1], Hsiao-Wen Zan[2], Yu-Chiang Chao[3]

[1]*Institute of Physics, National Yang Ming Chiao Tung University, Hsinchu, 300, Taiwan*
[2]*Department of Photonics and Institute of Electro-Optical Engineering, National Yang Ming Chiao Tung University, Hsinchu, 300, Taiwan*
[3]*Department of Physics, National Taiwan Normal University, Taipei 106, Taiwan*

*Corresponding author : meng@nycu.edu.tw

In this presentation I will introduce two topics on organic semiconductor devices: the solar panels and the gas sensor. We have developed a simple and reliable fabrication method for large-area organic photovoltaic (OPV) panels on A4 glass substrate with active area of 216 cm ^{2}. Using the non-fullerene active materials the certificated efficiency is over 10%. The key step is the blade coating of the active and interface layers with high precision over the A4 area. The sunlight lifetime is improved by ternary (three-component) active layer to prevent the molecular aggregations under ultraviolet irradiation. The small-area sunlight half-lifetime is over 1700 hours, and over 4000 hours when a UV filter is introduced. The module stability is shown to be close to small device stability. The stability is maintained when the think opaque metal electrode is replaced by the thin transparent electrode of 15 nm. The semi-transparent OPV panels are applied in a greenhouse to study the vegetable growth in the potentially self-powered greenhouse. For the gas sensor, we have developed a sensitive and reliable ammonia sensor with vertical electrical channel. The sensor is applied to detect the breath ammonia level of over 120 patients in the hospital. It is shown that the breath ammonia level of 0.9 ppm can be used as a standard to screen kidney diseases.

Keywords: gas sensor, solar cell, breath

References:

[1] Sol. RRL 2022, 2101076
[2] Sol. RRL 2022, 2200712
[3] ACS Appl. Mater. Interfaces 2023, 15, 7911
[4] Biomedicines 2020, 8, 468

Presenting author Email address: meng@nycu.edu.tw

Ultrafast electronic and vibrational dynamics in carbon nanotubes dependent on chirality and alkylation

Atsushi Yabushita[1,2], Shih-Wen Kai[1], Chia-Hung Lin[1], Hsuan-Yu Ou[1], Ying-Kuan Ko[1], Yutaka Maeda[3], Takayoshi Kobayashi[1]

[1] *Department of Electrophysics, National Yang Ming Chiao Tung University, 1001, Ta-Hsueh Road Hsinchu 300, Taiwan, R.O.C.*

[2] *Research Institute for Engineering, Kanagawa University, 3-27-1, Rokkaku-bashi, Kanagawa-ku Yokohama-shi Kanagawa 221-8686, Japan*

[3]*Department of Chemistry, Tokyo Gakugei University, 4-1-1, Nukuikita-machi, Koganei-shi, Tokyo 184-8501, Japan.*

*Corresponding author *: yabushita@nycu.edu.tw*

Carbon nanotubes (CNT) have been widely studied because of their specific characters like tensile strength, high thermal conductivity, and adjustable electrical conductivity dependent on its structure. The structure of CNT can be described using (n, m) notation. CNT has metallic (semiconductor-like) character when the difference of n and m is (not) integer multiple of three. Chemical modification on CNT was also reported to enhance photoluminescence.

To elucidate the mechanism of this enhancement, we have performed transient absorption (TA) spectroscopy for original sample, alkylated sample (attaching both ends of C_4H_8 on side surface of SWCNT), and the alkylated sample annealed at 350 ºC to remove excess chemical modification. The result has indicated that the intraband relaxation of ~100 fs time scale is delayed by the excess modification but this relaxation rate recovers in annealed alkylated sample to be the same as that of original sample.

In all of these three samples, radial breathing mode (RBM) was found to be well coupled with the electronic excitation showing frequency shift after photoexcitation. Different chirality gives different diameter resulting in difference of RBM frequency. Thus, the observed frequency shift of RBM is thought to be reflecting the vibrational energy transfer between CNTs with different chiralities. TA spectroscopy was performed for two samples of CNT whose chiralities are purified to be (6,5) and not purified as mixed one. The result shows that RBM frequency shift is only observed in the mixed sample, which certifies the assignment discussed above.

Recently, we became able to purify chirality of CNT even for samples with chemical modification. Thus, we have performed TA spectroscopy of (6,5) CNT samples with and without chemical modification to clarify how their relaxation dynamics could be controlled by the modification.

Presenting author Email address: yabushita@nycu.edu.tw

Impact of Proton Irradiation on Quaternary InAlGaN/AlN/GaN Epitaxial Structure for LEO Satellite Applications

Shao-Kuan Li[1*], Chin-Han Chung[1], You-Chen Weng[2], Chih-Yi Yang[1], Edward-Yi Chang[1,3],

[1]*International College of Semiconductor Technology, National Yang Ming Chiao Tung University, Hsinchu 30010, Taiwan*
[2]*College of Photonics, National Yang Ming Chiao Tung University, Tainan 71150, Taiwan*
[3]*Department of Materials Science and Engineering, National Yang Ming Chiao Tung University, Hsinchu 30010, Taiwan*

[*]Corresponding e-mail: king@nycu.edu.tw

In space, electronic devices must endure energetic particles capable of inducing signal disruptions and permanent degradations. In the low earth orbit (LEO), protons with energy up to several hundreds MeV are the main source of radiation-induced reliability issues, and testing electronic devices using high-energy protons is crucial to ensuring a safe and reliable operation. Compared to Si-based devices, GaN high electron mobility transistors (HEMTs) are considered more resilient against ionizing damage from radiation due to the wide bandgap of GaN. [1]-[3]. This, combined with the inherent advantages of GaN to operate under high power and high frequency, makes GaN HEMTs especially appealing for LEO satellite applications. For next-generation GaN technology, the quaternary InAlGaN/GaN structure provides improved device performance over the traditional AlGaN/GaN [4]. Besides ionizing damage, displacement damage (DD) resulting from the collisions between energetic particles and the atoms in the lattice can also degrade the device. These radiation-induced defects impact the epitaxial structure the most by creating trapping sites and interfering with the carriers in the 2DEG. To fully investigate the potential of the GaN HEMT adopting the InAlGaN/GaN structure aiming for LEO satellite applications, proton irradiation tests are necessary.

In this study, the degradation of quaternary InAlGaN/AlN/GaN epitaxial structure under proton irradiation was recorded. The structure being studied started with a GaN cap on a Si substrate, utilizing a GaN:C back-barrier (BB) and an AlGaN/AlN superlattice (SL) buffer layer. The irradiation tests were conducted using protons with energy of 230 MeV at a fixed fluence level of $1 \times 10^{11}\ cm^{-2}$. Significant changes were observed for all samples following proton irradiation in sheet resistance (R_{SH}), carrier mobility (μ_n) and the sheet carrier density (n_s) determined by a Hall measurement system. Additionally, the forward vertical breakdown characteristics of the irradiated samples were also recorded. These results provide insight to the understanding of device degradation expected for LEO satellite applications and valuable clues to the optimization of the technology.

Keywords: InAlGaN, Proton, Displacement damage (DD)

References:

[1] Kim, Hong-Yeol, et al. "Effects of proton irradiation energies on degradation of AlGaN/GaN high electron mobility transistors." *Journal of Vacuum Science & Technology B* 30.1 (2012).
[2] Fleetwood, Daniel M., et al. "Radiation effects in algan/gan hemts." *IEEE Transactions on Nuclear Science* 69.5 (2022): 1105-1119.
[3] Li, Qicong, Haijun Lou, and Linli Zhu. "Strain effect on the performance of proton-irradiated GaN-based HEMT." *Applied Physics A* 129.5 (2023): 374.
[4] Weng, You-Chen, et al. "High Current Density and Low Ron Quaternary InAlGaN MIS-HEMT on Si for Power Applications." *ECS Journal of Solid State Science and Technology* 12.7 (2023): 075003.

Presenting author Email address: danielairlon2.c@nycu.edu.tw

Manipulating 2D Carrier Density in Atomically-Thin In_2O_3

Der-Hsien Lien

Institute of Electronics
Department of Electrophysics
National Yang Ming Chiao Tung University

This talk presents recent advances in carrier density modulation and characterization in atomically-thin In_2O_3 semiconductors, offering insights that hold significant promise for next-generation electronics. The requirement for miniaturization in semiconductor devices has led to the exploration of two-dimensional (2D) [1] and quasi-2D semiconductors [2]. We introduce the methods for precise carrier density control, including optical-thermal modulation, charge transfer doping using viologen, and a counter-degenerate n-doping scheme in atomically-thin In_2O_3, and show that all of which are entirely reversible. We also show that the carrier density can be tuned by viologen based on the charge transfer scheme previously employed in 2D semiconductors. Additionally, we employ a field-effect Hall device to elucidate the intricate relationship between charge carrier density and mobility in atomically-thin In_2O_3, revealing quantum confinement effect with respect to the percolation transport characteristics. These findings pave the way for advancements in semiconductor technology and the development of next-generation electronic applications.

Reference:

[1] D. H. Lien *et al*., *Science*, **364**, 468 (2019).
[2] R. Tseng *et al*., *Nature Communications*, **14**, 5423 (2023).
[3] S. T. Wang *et al*., *ACS Appl. Mater. Interfaces* (2024).

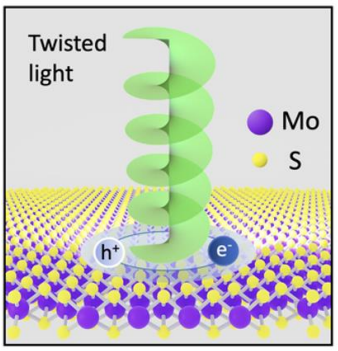
Presenting author Email address: dhlien@nycu.edu.tw

Optical Access of Finite Momentum Excitons in Transition-metal Dichalcogenide Monolayers Using Twisted Lights

Shun-Jen Cheng[1], Guan-Hao Peng[1], Ping-Yuan Lo[1], Wei-Hua Li[1], Oscar J. G. Sanchez[1], Jhen-Dong Lin[1], Shao-Yu Chen[2], Ting-Hua Lu[3], and Yann-Wen Lan[3]

[1]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 300, Taiwan*
[2]*Center of Condensed Matter Sciences, National Taiwan University, Taipei 106, Taiwan*
[3]*Department of Physics, National Taiwan Normal University, Taipei 11677, Taiwan*

* Corresponding e-mail: *sjcheng@nycu.edu.tw*



In this work, we present a comprehensive theoretical investigation of the full excitonic fine structures of transition-metal dichalcogenide monolayers (TMD-MLs) by solving the density-functional-theory (DFT)-based Bethe-Salpeter equation (BSE) with the full consideration of both electron-hole direct and exchange Coulomb interactions.[1] Because of enhanced Coulomb interactions in low dimensionality, the excitonic spectra of TMD-MLs are featured with especially complex fine structures, spectrally well resolving the states of bright exciton (BX), spin-forbidden (SF) and various finite momentum (MF) excitons as well. The finite momentum excitons have drawn a great deal of attention because of their essential involvement in exciton transport, but are usually hardly observed and identified. By means of the DFT-based methodology, we revealed the optical signatures of the optically inactive MF-DX in temperature-dependent photo-luminescence, in excellent agreement with the existing experimental data.[1] Further, we for the first time pointed out that the application of twisted light enable the optical access of the finite momentum exciton states of TMD-MLs, leading to spatially localized exciton wave packets with the OAM- and SAM-encoded geometrical patterns.[2,3] Those findings shed light on the prospect of the twisted-light-based photonics in 2D materials.

Keywords: twisted light, exciton, ransition-metal dichalcogenides

References:

[1] G. H. Peng et al., Nano Lett. 19, 2299 (2019).
[2] K. Bryan et al., ACS Nano 15, 3481 (2021).
[3] G. H. Peng et al., Phys. Rev. B. 16, 155304 (2022) …

Presenting author Email address: sjcheng@nycu.edu.tw

Epitaxial Growth, Characterizations, and Integration of Bi_2O_2X Semiconductors

Ying-Hao Chu[1,2,3*]

[1]*Department of Materials Science & Engineering, National Tsing Hua University, Hsinchu, Taiwan*
[2] *Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu, Taiwan*
[3]*Institute of Physics, Academia Sinica, Taipei, Taiwan*

[*] Corresponding e-mail: *yhchu@mx.nthu.edu.tw*

The search for 2D semiconductors with excellent electronic performance and stability in the ambient environment is urgent. Bi_2O_2X (X=S, Se, Te), a series of air-stable layered oxides, have emerged as promising new semiconductors with excellent electronic and optoelectronic properties. Studies demonstrate that its layered nature makes it ideal for fabricating electronic devices down to a few atomic layers. Currently, these materials are synthesized by either chemical solution or vapor methods. It remains a great chance to have control of thickness and uniformity. In this study, the physical vapor deposition method is adopted for depositing these materials on various oxide substrates. A pathway to integrate with Si will also be demonstrated. For practical applications, electronic devices such as thin film transistors and optoelectronic devices such as solar cells and photodetectors will be delivered with optimized performances.

Keywords: 2D, epitaxy, semiconductor, oxides, high mobility

Presenting author Email address: yhchu@mx.nthu.edu.tw

Toward Artificial 2D Hybrid Quantum Materials

Chuan-Yu Chang[1], Chi-Tai Chang[2], Min-Jia Chang[2], Yu-Ming Chang[3, 4], *Shao-Yu Chen[3, 4]

[1]*Department of Physics, National Taiwan University, Taiwan*
[2]*Department of Physics, National Taiwan Normal University, Taiwan*
[3]*Center of Atomic Initiative for New Materials, National Taiwan University, Taiwan*
[4]*Center for Condensed Matter Sciences, National Taiwan University, Taiwan*

* Corresponding e-mail: *shaoyuchen@ntu.edu.tw*

The advent of atomically thin materials brings out innovative paradigms, examining the intricate relationships among charge, spin, lattice, valley, and photons. Particularly striking are the quantum effects observed when layering two-dimensional (2D) materials. A notable example is the pioneering study demonstrating that two graphene layers twisted at specific "magic" angles can exhibit insulating or superconductivity. This approach paves the way to developing artificial 2D hybrid quantum materials that merge various 2D materials deliberately, unlocking groundbreaking functions and expanding the horizon of quantum materials. In my talk, I will share our latest advances in crafting artificial 2D hybrid materials with meticulous control over twist angles and strain. We integrate the 2D materials stacking technologies with a handful of optical spectroscopy, including second harmonic generation, absorption, photoluminescence, and Raman spectroscopy. Our homemade system can facilitate in-situ monitoring and precisely controls strain and twist-angle. Our research is a stepping stone toward realizing the full potential of 2D materials, potentially leading to breakthroughs in quantum computing, exciton physics, and other emergent fields.

Keywords: artificial hybrid 2D quantum materials, dark excitons, straintronics, twistronics

Presenting author Email address: shaoyuchen@ntu.edu.tw

Ambipolar 2D Transistor: Potentially Pioneering the Next Wave of Device Applications

Yen-Fu Lin*

Department of Physics and Institute of Nanoscience, National Chung Hsing University, Taichung 40227, Taiwan

* Corresponding e-mail: yenfulin@nchu.edu.tw

The surge in van der Waals layered materials has ushered in new realms of physics and processing techniques, opening doors to innovation in electronic and optoelectronic devices. Among these, ambipolar 2D semiconductors stand out for their exceptional gate-controlled capability and unique physical traits, enabling the dynamic and reversible tuning of major charge carriers between holes and electrons via an electrostatic field. Nevertheless, the ambiguous and high off-state current hampers their broader applications in logic circuits. In this presentation, I will delve into the transport mechanism of ambipolar-based transistors, with a focus on $MoTe_2$ and $ReSe_2$. Additionally, I'll present methods for effectively manipulating their ambipolar properties. Finally, I will explore how these ambipolar transistors could potentially serve as alternatives to achieve flash memory, simplify circuits, and address the computational bottlenecks associated with von Neumann architectures. [1-8].

Keywords: ambipolar charge transport, transistors, van der Waals electronics, logic circuits, artificial synapses

References:

[1] Adv. Mater. 26, 3263 (2014)
[2] Adv. Mater. 30, 1706995 (2018)
[3] Adv. Funct. Mater. 31, 1809011 (2019)
[4] Nano Energy 66, 104107 (2019)
[5] Adv. Funct. Mater. 31, 2105345 (2021)
[6] Adv. Sci. 9, 2106016 (2022)
[7] Nat. Electron. 6, 755 (2023)
[8] Sci. Adv. In press (2023)

Presenting author Email address: yenfulin@nchu.edu.tw

InGaN-Based Light-Emitting Diodes Grown on Various Layer Numbers of Graphene Interlayers/Patterned Sapphire Substrate

Wen-Cheng Ke[1*] and Isaac Chen[2]

[1]*Department of Materials Science and Engineering, National Taiwan University of Science and Technology, Taipei 106, Taiwan*
[2]*Elmore Family School of Electrical and Computer Engineering, Purdue University, West Lafayette, IN 4790, US*

[*]*Corresponding e-mail: wcke@mail.ntust.edu.tw*

In this study, various layer numbers of graphene interlayers are grown on a patterned sapphire substrate (PSS). The layer number of graphene interlayers on PSS can be controlled by adjusting epitaxy temperature. The layer number of graphene interlayer on PSS increased with increasing epitaxy temperature. In this presentation, the bi-layer graphene interlayer is grown on PSS at an epitaxy temperature of 950 ^{o}C. The relationship between the electroluminescence (EL) peak wavelength and injection current indicated that InGaN LEDs are grown on a bi-layer graphene interlayer/PSS exhibit a stable emitting wavelength in the current range of 10-100 mA. The transmission electron microscopy showed that the TDs density of InGaN LEDs on bi-layer graphene/PSS (Gr-LED) decreased significantly compared to the InGaN LED on PSS (Ref-LED). The spatially-resolved micro-Raman spectra confirmed that the compressive strain in the near-active layer of GrLED was lower than that in Ref-LED. The simulated piezoelectric fields were 1.60 and 1.16 MV/cm^{-1} for RefLED and Gr-LED, respectively [1-3]. The low piezoelectric field diminished the screen of the polarized field resulting in a stable emitting wavelength of Gr-LED in the current range of 10-100 mA. On the other hand, the rate of increase in chip temperature of Gr-LED (i.e., ~0.16 K/mA) was lower than the Ref-LED (~0.49 K/mA) (see Fig. 1). The bi-layer graphene interlayer can improve the heat accumulation behavior of Ref-LED. Thus, this study demonstrates that the bilayer graphene interlayer on PSS is a promising substrate for high-power InGaN LEDs.

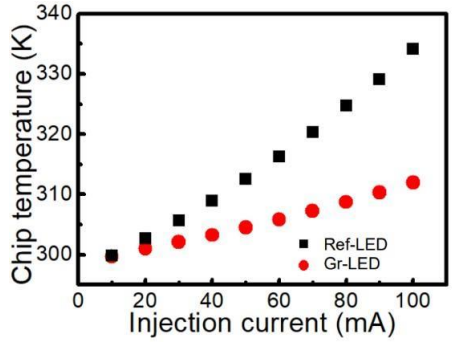


Figure 1: The relationship between chip temperature and injection current of Ref-LED and Gr-LED.

Keywords: Graphene interlayer, InGaN LEDs, Raman, electroluminescence

References:

[1] Wen-Cheng Ke *et al*., *Appl. Phys. Lett.*, **122**, 203501 (2023).
[2] Wen-Cheng Ke *et al*., *Appl. Surf. Sci.*, **494**, 644 (2019).
[3] Wen-Cheng Ke *et al*., *ACS Appl. Mater. Interfaces.*, **11**, 48086 (2019).

Presenting author Email address: wcke@mail.ntust.edu.tw

Two-dimensional nanomaterials toward photonic applications

Vera Marinova[1,2]*, Stefan Petrov[1], Chau Nguyen Hong Minh[1], Ken Yuh Hsu[3], Shiuan Huei Lin[1] and Dimitre Dimitrov[2,4]

[1] *Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 30010, Taiwan*
[2] *Institute of Optical Materials and Technologies, Bulgarian Academy of Sciences, Sofia, Bulgaria*
[3] *Department of Photonics, National Yang Ming Chiao Tung University, Hsinchu 30010, Taiwan*
[4] *Institute of Solid State Physics, Bulgarian Academy of Sciences, 1784 Sofia, Bulgaria*

* Corresponding e-mail: *vera_marinova @yahoo.com*

2D layered materials have attracted outstanding attention due to their strong in-plane covalent bonds and weak van der Waals bonds joining adjacent layers which provide extraordinary electron mobility, band gap dependence on the number of layers and extremely high anisotropic optical response. Among the emerging two-dimensional (2D) materials, transition metal dichalcogenides (TMDC) has imposed their key role.

Here, we report the detailed study of controlled synthesis and characterization of graphene and TMDCs and their intergation in photonic devices. As example, the application of graphene as transparent conductive electrode in liquid crystal (LC) display devices is demostrated. In addition, surface anchoring energy and pre-tilt angle value were determined to characterize the interfaces at the boundary and the impact on the dynamic performances of the assembled LC cells. Besides the excellent phase modulation repeatability over the large-scale area, graphene exhibits great potential for future ITO-free integrated photonic devices and bio-oriented technologies.

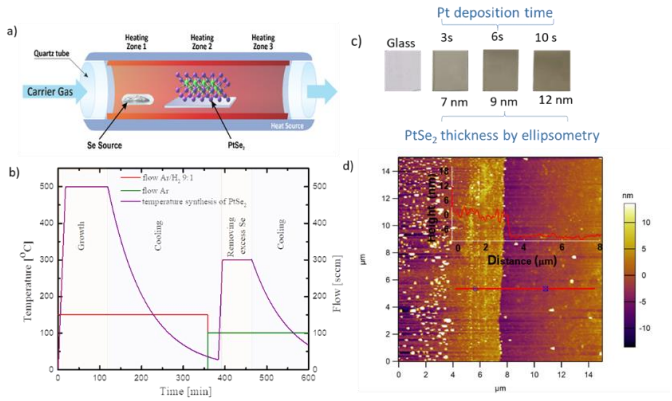


Figure 1. (a) Schematic diagram of 3 zone Atmospheric Pressure TAC system; (b) Temperature and flow diagrams of the growth process (c) Photographs of $PtSe_2$ layers on glass substrate; (d) AFM image of $PtSe_2$ (6s deposition time of Pt layer) with the height profile across the straight solid red line (the scale bar 2 μm) indicating the layer thickness ~9.5nm.

Next, we focus on synthesis details of 2D $PtSe_2$ layers on regular glass substrates by selenization of pre-deposited Pt layers using thermally assisted conversion (TAC) method at atmospheric pressure. The nanolayers were further studied by X-ray photoelectron spectroscopy (XPS), Raman analysis, transmission electron microscopy (TEM) and optical ellipsometry, revealing the thickness dependence on metal precursor sputtering time.

Keywords: 2D layers, synthesis, LC display devices

Acknowledgement: We are grateful to the financial support of Bulgarian Science Fund under the project FNI КП-06-H-68/1 and National Science and Technology Council (NSTC), Taiwan under contract number MOST 110-2221-E-A49 -098 - MY3 and NSTC 111-2221-E-A49 -055 -MY3. We are grateful to the Bilateral grant agreement between Bulgarian Academy of Sciences (BAS) and National Science and Technology Council (NSTC), Taiwan

Presenting author Email address: vera_marinova@yahoo.com

Nematicity in SnS single crystals probed by ultrafast spectroscopy

Nguyen Nhat Quyen[1], Tz-Ju Hong[1], Chin En Hsu[2], Wen-Yen Tzeng[1], Chien-Ming Tu[1], Chia-Nung Kuo[3,4], Hung Chung Hsueh[2,5], Chin-San Lue[3,4], Chih-Wei Luo[1,4,6,7*]

[1] *Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 30010, Taiwan*
[2] *Department of Physics, Tamkang University, New Taipei City 251301, Taiwan*
[3] *Department of Physics, National Cheng Kung University, Tainan 70101, Taiwan*
[4] *Taiwan Consortium of Emergent Crystalline Materials (TCECM), Ministry of Science and Technology, Taipei 10601, Taiwan*
[5] *Research Center of X-ray Science, College of Science, Tamkang University, New Taipei City 251301, Taiwan*
[6] *National Synchrotron Radiation Research Center, Hsinchu, 30076, Taiwan*
[7] *Institute of Physics and Center for Emergent Functional Matter Science, National Yang Ming Chiao Tung University, Hsinchu, 30010, Taiwan*

* Corresponding e-mail: cwluoep@nycu.edu.tw

SnS is one of the promising materials for the applications of optoelectronics and photovoltaics. This study determines the nematic dynamics of photoexcited electrons and phonons in SnS single crystals using polarization-dependent femtosecond spectroscopy at various temperatures, as shown in Fig. 1. Besides the fast relaxation of photoexcited electrons, a damped oscillation component with a frequency of 36~41 GHz is also present in transient reflectivity change ($\Delta R/R$) spectra, which is generated by the thermoelastic effect [1]. The results of this study show that electrons and coherent acoustic phonons demonstrate significant anisotropy on the ac-plane in the transition region from 330 K to 430 K, possibly because of strong electron-phonon coupling (e.g., 1.16 along a-axis at 300 K). However, this in-plane anisotropy weakens dramatically in the low temperature (< 330 K) and high-temperature (> 430 K) phases. These play an important role in anisotropic heat dissipation and charge carrier mobility in polarization-sensitive optical and optoelectronic devices.

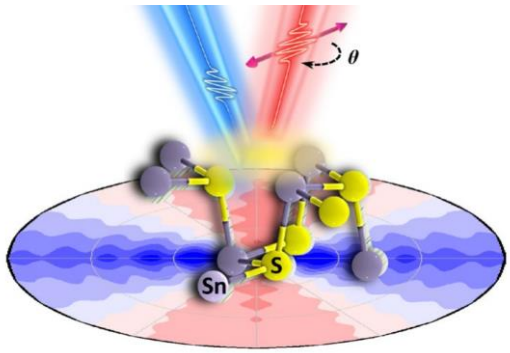


Figure 1. Crystal structure of SnS and schematics of the polarization-dependent pump probe measurements.

Keywords: nematicity, SnS, ultrafast spectroscopy

References:

[1] Nguyen Nhat Quyen et al., Applied Physics Letters 121, 172105 (2022). Featured on the cover

Presenting author Email address: cwluoep@nycu.edu.tw

WTe2: synthesis, properties and applications

Dimitre Dimitrov [1,2*], Vera Marinova[2,3], Ken Yuh Hsu[4], and Shiuan Huei Lin[3]

[1]*Institute of Solid State Physics, Bulgarian Academy of Sciences, Sofia, Bulgaria*
[2]*Institute of Optical Materials and Technologies,*
[3]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 30010, Taiwan*
[4]*Department of Photonics, National Yang Ming Chiao Tung University, Hsinchu 30010, Taiwan*

[*] Corresponding e-mail: *dzdimitrov@issp.bas.bg*

Since the discovery of a new material phase, topological quantum materials (TQMs), [1] tremendous effort has been made to explore a wide variety of novel and abundant physics appearing in topological insulators (TIs), topological superconductors (TSCs), and Weyl semimetals for creating novel electric and spintronics devices. WTe_2 belongs to the family of transition-metal dichalcogenides (TMDs) and crystallizes naturally in a non-centrosymmetric orthorhombic structure (also known as the T_d or distorted 1T phase, in which the tungsten atoms are octahedrally coordinated by the tellurium atoms) with polar space group Pmn21. The polar axis in WTe_2 is oriented along the stacking direction of layers. Unlike other TMDs, WTe_2 is a Weyl semimetal in its native crystal phase [2]. Among Weyl semimetals, T_d-type WTe_2 is a new class, a type-II Weyl semimetal, [where the Weyl points appear at the crossing of the oblique conduction and valence bands due to the broken inversion symmetry and non-saturating giant positive magnetoresistance is a manifestation of the type-II Weyl character [3]. In this presentation the current status of the research and emerging applications of WTe_2 are reviewed.

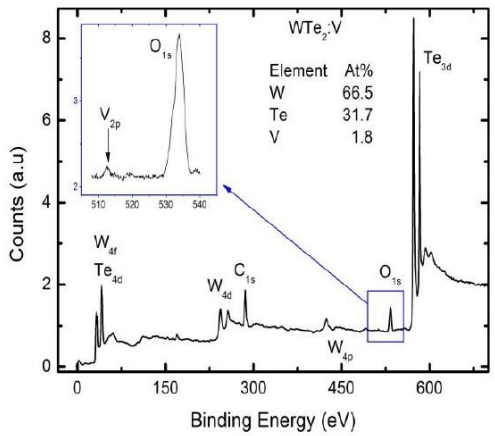


Figure1. Vanadium doping quantified by XPS. Atomic concentration of about 2% V.

Acknowledgement: D.D. and V.M. acknowledge the support of the European Union's Horizon 2020 FET-PROACTIVE project TOCHA under Grant No. 824140

Keywords: 2D materials, single crystal, WTe_2, topological insulator

References:

[1] A. A. Soluyanov, D. Gresch, Z. Wang, Q.S. Wu, M. Troyer, X. Dai & A. Bernevig, Nature 527(2015), pp.495–498
[2] D. Zhang, P. Schoenherr, P. Sharma & J. Seidel, Nature Reviews Materials 8, (2023) pp. 25–40
[3] X.-C. Pan, X. Wang, F. Song & B. Wang, Advances in Physics: X, 3, 1, (2018) pp.592-606

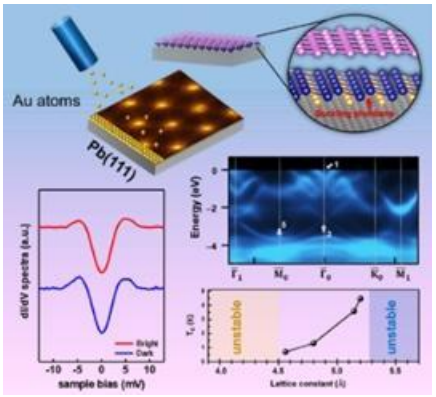
Presenting author Email address: dzdimitrov@issp.bas.bg

Superconductivity in Plumbene-Au Kagome Superstructure

Wan-Hsin Chen[1], Chin-Hsuan Chen[2], Guan-Hao Chen[1], Wei-Chuan Chen[2, 3], Fu-Xiang Rikudo Chen[1], Pei-Jung Chen[1], Chun-Kai Ku[1], Naoya Kawakami[1], Jia-Ying Li[2], Iwao Matsuda[4], Wen-Hao Chang[1], Juhn-Jong Lin[1], Chien-Te Wu[1], Chung-Yu Mou[2], Horng-Tay Jeng[2, 3], Shu-Jung Tang[2 ,3], Chun-Liang Lin[1*]

[1]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 300, Taiwan.*
[2]*Department of Physics and Astronomy, National Tsing Hua University, Hsinchu 300, Taiwan.*
[3]*Institute of Physics, Academia Sinica, Taipei 115, Taiwan.*
[4]*Institute for Solid State Physics, The University of Tokyo, Kashiwa, Chiba 277-8581, Japan*

[*] Corresponding e-mail: clin@nycu.edu.tw



Superconductivity in ultrathin film rises an issue to reconsider the pair correlation in BCS theory in two-dimensional (2D) limit. Former studies by using scanning tunneling microscopy (STM) and scanning tunneling spectroscopy (STS) have observed the superconductivity in atomic-thickness layers of Pb and In on Si substrates [1]. Besides, the current discovery of superconductivity in twist bilayer graphene drives the focus on electronic correlations in honeycomb lattices. As an element of the carbon family, lead (Pb) has also been proposed a similar structure as graphene, which is called plumbene. Theoretical predictions indicate that the tuning buckling and spin-orbit couplings in 2D honeycomb lattices may enhance the superconducting critical temperature. In the current study, a plumbene-based superstructure grown by deposition a small amount of Au on Pb(111) surface are found. By STM and temperature-dependent STS, a higher critical temperature (Tc) in plumbene-based superstructure than that of Pb substrate is observed, which is totally beyond the proximity effect. By combining angle-resolved photoemission spectroscopy with density functional theory, the monolayer Au-intercalated low-buckled plumbene sandwiched between the top Au Kagome layer and the bottom Pb(111) substrate is confirmed and the electron–phonon coupling-enhanced superconductivity is revealed [2].

Keywords: Plumbene, Kagome, Superconductivity

References:

[1] D. Roditchev et al., *Nat. Phys.* 11 332 (2015)
[2] W. H. Chen et al., *Adv. Sci.* 10, 2300845 (2023).

Presenting author Email address: clin@nycu.edu.tw

Characteristic of 2D to 3D Heterostructures Grown by Molecular Beam Epitaxy

Chu-Shou Yang[1]*, Ssu-Kuan Wu[2], Li-Ming Yeh[1], Li-Chieh[1], Lin Hao-Ning Yang[1],
Jia-Cheng Yang[1], Sheng Wei Hsiao[3], Chao-An Jong[4]

1 Institute and Department of Electrical Engineering, Tatung University, Taipei, Taiwan
2 Department of Electrophysics, National Yang-Ming Chiao-Tung University, Hsinchu, Taiwan
3 National Synchrotron Radiation Research Center, Hsinchu, Taiwan
4 National Applied Research Laboratories Taiwan Semiconductor Research Institute, Hsinchu, Taiwan

* Corresponding e-mail*:* csyang@gm.ttu.edu.tw

Because the component requirements are getting thinner, smaller, and shorter, the two-dimensional structure of van der Waals film has become an important key technology. Inevitably, the heterogeneous structure formed by the two-dimensional (2D) structure and the three-dimensional (3D) structure will become an unavoidable issue. In this study, we demonstrate the heterostructure of InSe/ZnSe, InTe/ZnTe, and GaSe/ZnSe grown by molecular beam epitaxy (MBE). Firstly, ZnSe is deposited on a lattice-matched GaAs(001) substrate. The van der Waals epitaxial (vdWE) InSe was deposited on ZnSe. The growth method of vdWE layers employed general MBE, solid phase epitaxy [1], and the indium precursor method[2]. Additionally, the growth temperature of the vdWE layer, ZnTe, and ZnSe are around 600 oC, 340 oC, and 300 oC, respectively. In figure 1 (a), the X-ray diffraction spectrum of vdWE-InSe and cubic-ZnSe was found. A similar phenomenon was observed on InTe/ZnTe system by using Raman scattering measurement, as shown in Fig. 1(b). The fundamental properties of the vdWE layer are not influenced by the ZnSe layer, although a huge lattice mismatch in heterostructure and growth temperature. Secondly, the deposition layer processes were inverse to fabricating ZnSe on GaSe. The high-temperature layer is grown first, followed by the low-temperature layer to avoid the impact of thermal damage on the previously made film. According to the reflection high-energy electron diffraction and XRD results, the crystalline of ZnSe layer exhibits Wurtzite, which is different from ZnSe deposited on GaAs (001). However, due to the easy lift-off property of GaSe, a flexible ZnSe with a few GaSe buffer layer was figured out.

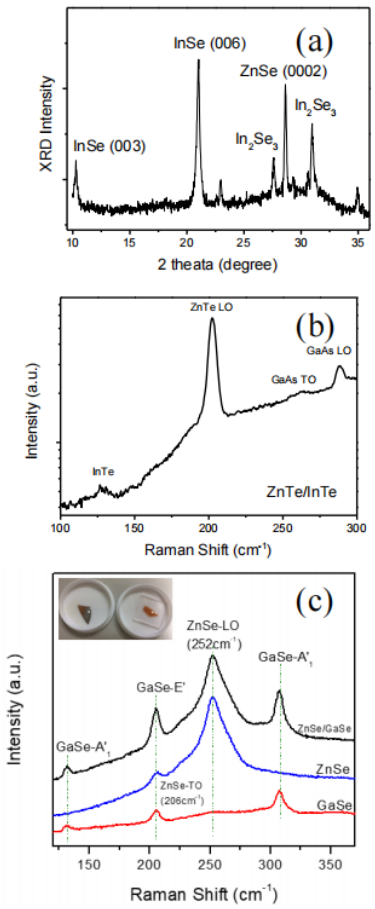


Figure 1. (a) The X-ray diffriction spectrum of InSe grown on ZnSe sample. Raman spectra of (b) InTe thin films grown on ZnTe and (c) ZnSe grown on GaSe, respectively. The insert image of fig. (c) is a lift off ZnSe/GaSe flexiable sample.

Keywords: Two-dimensional material, Heterostructure, 2D, 3D, MBE

References:

[1] Chia-Hsing Wu; Yu-Che Huang,; Yen-Teng Ho.; *et al.* Solid Phase Epitaxy of Single Phase Two-Dimensional Layered InSe Grown by MBE. Nanomaterials 2022, 12, 2435.
[2] Sheng-Wei Hsiao; Chu-Shou Yang,; Hao-Ning Yang,; *et al.* Novel Method for the Growth of Two Dimensional Layered InSe Thin Films on Amorphous Substrate by Molecular Beam Epitaxy. Front. Mater 2022.871003.

Presenting author Email address: csyang@gm.ttu.edu.tw

Wafer-Scale Single-Crystal Growth of 2D Semiconductors for Practical Applications

Wen-Hao Chang[1,2*]

[1]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 30010, Taiwan*
[2]*Research Center for Applied Sciences, Academia Sinica, Taipei 11529, Taiwan*

* Corresponding e-mail: whchang@nycu.edu.tw

Two-dimensional (2D) semiconductors, in particular transition metal dichalcogenides (TMDs), have been actively considered as channel materials in field-effect transistors (FETs) for continuing device scaling beyond the 2-nm technology node. Wafer-scale single-crystal growth of hexagonal boron nitrides[1] (hBN) and molybdenum disulfide[2,3] (MoS_2) have recently been demonstrated, representing a millstone toward scalable and industry-compatible fabrications of 2D devices. However, for practical applications of 2D FETs in very large-scale integration (VLSI) technology, multiple challenges remain. In this talk, I will present our recent efforts on the growth of wafer-scale single-crystal growth of 2D materials with low defect density, interface and layer engineering to boost carrier mobility, high-κ dielectric integration with a low equivalent oxide thickness, and improved transfer process to enable low device-to-device variation. Through collaborations with industry, our high-quality MoS_2 have also been successfully applied to nanosheet gate-all-around (GAA) devices, scaled contacted gate pitch devices, and low-operation-voltage ferroelectric FETs, demonstrating the potential of 2D FETs in future VLSI technologies.

References:

[1] T.-A. Chen et al., Wafer-scale single-crystal hexagonal boron nitride monolayers on Cu(111). Nature 579, 219–223 (2020)
[2] T. Li et al., Epitaxial growth of wafer-scale molybdenum disulfide semiconductor single crystals on sapphire. Nat. Nanotechnol. 16, 1201–1207 (2021).
[3] J.-H. Fu et al., Oriented lateral growth of two-dimensional materials on c-plane sapphire. Nat. Nanotechnol. (2023). https://doi.org/10.1038/s41565-023-01445-9

Presenting author Email address: whchang@nycu.edu.tw

First Order Magnetic Transitions in 2D Blume- Capel Spin 1 Model

Phong H. Nguyen [1], Oanh K.T. Nguyen [2] and Giang H. Bach[1], Cong T. Bach[1, *]

[1] *Computational Materials Science Lab., Faculty of Physics, VNU University of Science, 334 Nguyen Trai street, Thanh Xuan, Hanoi, Viet Nam*
[2] *Electric Power University, 235 Hoang Quoc Viet Street, Bac Tu Liem, Hanoi, Viet Nam*

[*] Corresponding e-mail: congbt@vnu.edu.vn

First-order magnetic transitions (FOMTs) play an important role in the giant low-field magnetocaloric effect [1] when the magnetization shows a step anomaly near the phase transition temperature or in the jumps of the magnetization curve with increasing field [2] (which is also called the First Order Magnetization Process, or FOMP). Understanding the microscopic mechanism of that effect is essential for the application. In this research, FOMTs are investigated using Blume- Capel spin 1 Hamiltonian with random anisotropy in the external magnetic field *h*. This model is an extension of the same model [3] without the external field

$$\mathcal{H} = -J\sum_{(i,j)} S_i S_j + \sum_j D_j S_j^2 - h\sum_j S_j .$$

Here the random anisotropy D_j follows the distribution law

$$P(D_j) = p\delta(D_j - D) + (1-p)\delta(D_j).$$

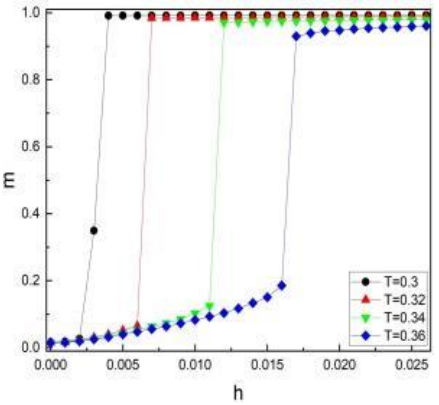


Figure 1. First order transition process in 2D square spin lattices at different temperatures. Temperature *T* and anisotropy strength *D* are given in the unit of the exchange parameter *J*. Here *D*= -2.4, *p*=0.8.

The Monte – Carlo method and the integral representation method for S=1 Callen equality are used in calculations. Both methods show similar results. It was shown that near the phase transition temperature, where the FOMT appeared [3], the FOMP due to the field occurs (see Fig. 1). The mechanism of this phenomenon is competition between different kinds of interaction: positive ferromagnetic (FM) exchange *J* with negative suitable random anisotropy and Zeeman energy.

Acknowledgement: The authors thank Project ĐTĐL.CN-27/23 for support.

Keywords: First order magnetic transitions, Blume-Capel Ising spin 1 model, Monter- Carlo method, Integral representation for Callen equality.

References:

[1] F. Guillou, A.K. Pathak, D. Paudyal, Y. Mudryk, F. Wilhelm, A. Rogalev, V. K. Percharsky, *Nature Communications* **9** (2018) 2925.
[2] Niem T. Nguyen, Giang H. Bach, Thao H. Pham, Huy D. Nguyen1, Oanh T.K. Nguyen, Cong T. Bach, *Materials Transactions* **64** (2023) 2118.
[3] E. C. Bezerra, M. Gomes da Silva, J. Ricardo de Sousa, Physica A **615** (2023)128510.

Presenting author Email address: congbt@vnu.edu.vn

Development of soft X-ray microscopic analysis and its perspective

Takuji Ohigashi

Photon Factory, High Energy Accelerator Research Organization (KEK), 1-1 Oho, Tsukuba, Ibaraki, 305-0801 Japan.

* Corresponding e-mail: *ohigashi@post.kek.jp*

A scanning transmission x-ray microscope (STXM) is a powerful tool to analyze 2-dimensional chemical state of a sample with high spatial resolution around 50 nm. Typical features of STXM are high transmittance, lower radiation dose than electron microscopy, relative long working distance and analysis of organic materials (if used in a soft X-ray region). The author formerly worked at a STXM beamline, BL4U, in UVSOR (Okazaki, Japan) and have developed special analytical techniques by using those features [1-3]. The special analytical techniques at BL4U enable researchers to explore wider scientific field.

In recent days, a new beamline, BL-12A, is under construction in Photon Factory (Tsukuba, Japan) and is due to begin its operation from 2024 spring. The conceptual design of BL-12A is shown in Fig. 1. BL-12A uses white beam from a bending magnet and has two optical paths. These paths can be selectively used by inserting/extracting a first mirror (M0S) to/from an optical axis. Each path equips with a varied line spacing plane grating (50 ~ 2,000 eV) and a double-crystal (1,700 ~ 5,000 eV) monochromators, respectively. Focal points of two paths are coincident at the end of the beamline. Therefore, in total, a wide energy range of the soft and the tender X-rays (50 ~ 5,000 eV) can be available at the focal point. Basically, BL-12A will be used for X-ray reflectometry and X-ray absorption spectroscopy. In addition, an advanced X-ray microscope for chemical analysis, instead of a general STXM, is under planning.

In this session, perspective of soft X-ray microscopic analysis and a concept of the new X-ray microscope will be reported.

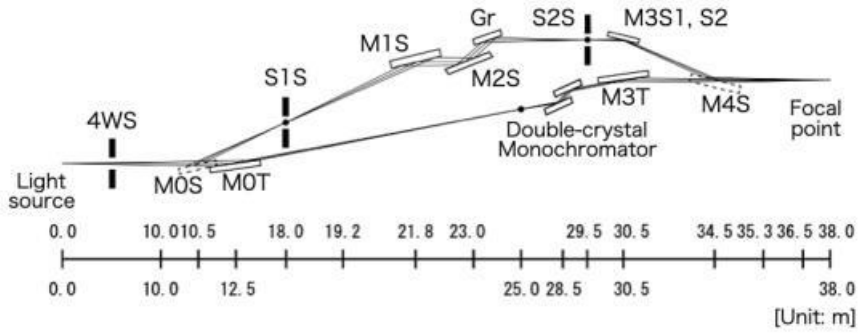


Figure 1. Conceptual design of BL-12A in Photon Factory

Keywords: X-ray microscopy, X-ray absorption spectroscopy, wide energy range beamline

References:

[1] T. Ohigashi and N. Kosugi, *J. Electron Relat. Phenom.*, **266**, (2023), 147356.
[2] T. Ohigashi, H. Yuzawa and N. Kosugi, *Rev. Sci. Instrum.*, **91**, (2020), 103110.
[3] T. Ohigashi, M. Nagasaka, T. Horigome, N. Kosugi, S. M. Rosendahl and A. P. Hitchcock, *AIP Conf. Ser.*, **1741**, (2016), 050002.

Presenting author Email address: ohigashi@post.kek.jp

Multiferroic properties in 2D layered organic-inorganic perovskite single crystals

Nguyen Huy Tiep, Nguyen Hoang Hung, Vu Quoc Thinh, Hoang Nam Nhat, Le Viet Cuong *

Faculty of Engineering Physics and Nanotechnology, VNU-University of Engineering and Technology, Hanoi, Vietnam

* Corresponding e-mail: *cuonglv@vnu.edu.vn*

Two-dimensional (2D) hybrid organic-inorganic perovskites (HOIP) have emerged as one of the most promising material candidates for photovoltaics, optoelectronic and magnetic applications. In this study, the multiferroic property of the 2D layered $(C_6H_5C_2H_4NH_3)_2MCl_4$ perovskite single crystals (M = Cu, Mn, Ni, …) has been reported. The crystals were synthesized by the anti-solvent evaporation method in a layer-by-layer mode with a relatively smooth surface that was confirmed by SEM image. The XRD patterns reveal a high crystalline quality with (n00) dominant planes (n = 2, 4, 6, …). The 180^o reproducible hysteresis phase loop, butterfly-like amplitude curve, and an effective piezoelectric coefficient of up to 327 pm/V were evaluated using Piezoelectric Force Microscopy (PFM) measurements. Particularly, the tunable magnetic properties of the materials have also been investigated by $(C_6H_5C_2H_4NH_3)_2(Ni_{1-x}Mn_x)Cl_4$ (x = 0, 0.05, 0.10. 0.20, 0.25, and 0.50) perovskite crystals. The vibrating sample magnetometer (VSM) measurements show that the magnetic anisotropy of the material can be changed from parallel to perpendicular by increasing the Mn^{2+} ratio. This study offers an opportunity to develop new multiferroics and spintronics applications based on the 2D layered hybrid perovskite single crystals.

Keywords: 2D hybrid organic-inorganic perovskite, single crystal, multiferroic property, anti-solvent evaporation method.

References:

[1] Cuong, L. V.; Hieu, N. D.; Tu, B. D.; Tiep, N. H., Multiferroic Property of 2D Hybrid Organic-Inorganic $(C_6H_5C_2H_4NH_3)_2NiCl_4$ Perovskite Single Crystals, *Materials Transactions* **2023**, 64 (9), 2168-2173.
[2] Tiep, N. H.; Ku, Z.; Fan, H. J., Recent Advances in Improving the Stability of Perovskite Solar Cells, *Advanced Energy Materials* **2016**, 6 (3), 1501420.

Presenting author Email address: tiepnh@vnu.edu.vn

Highly fluorescent MoS2 Qauntum dots as a photoluminecsence sensing platform for Fe3+ ion detection

Sonia Sharma[1], Ji-Lin Shen[1*]

[1]*Department of Physics and Center for Nanotechnology, Chung Yuan Christian University, Chung-Li, 320314, Taiwan*

[*] Corresponding e-mail: *jlshen@cycu.edu.tw*

Abstract : In this study, we successfully synthesized GSH-functionalized MoS_2 QDs. By doping of GSH, the PL of the MoS_2 QDs (GSH-functionalized MoS_2 QDs) can be increased ~9.5 times. As a passivating agent, GSH might be able to reduced the surface defects in MoS_2 QDs to enhance their fluorescence. The mechanism of fluorescence quenching was used to develop the MoS_2-QD-based metal ion sensor. Additionally, the photoluminescence of MoS_2 QDs is studied with increasing Fe^{3+} concentration. Moreover, it was discovered that the addition of Fe^{3+} ion decreased the PL intensity of the MoS_2 QDs.The quenching effect could be caused by an effective electron transfer from GSH-functioanlized MoS_2 QDs to Fe^{3+} ion. This research shows the ability of MoS_2 QDs as a luminescence sensing probe for the detection of Fe^{3+} ion.

Keywords: molybednum disulphide; quantum dots; photoluminescence quanching; iron ion.

Introduction :

Two-dimensional molybdenum disulphide (MoS_2) QDs have attracted considerable interest due to their pronounced quantum confinement and edge effects. [1] Therefore, MoS_2 QDs have drawn a lot of interest in photodynamic treatment, bioimaging, and sensing. [2] MoS_2 QDs functionalized with cysteine have been employed to the detection of Al^{3+} and Fe^{3+} metal ions.[3] In this research, we synthesized the GSH-functioanlized MoS_2 QDs using microwave-assisted method. The resulting GSH-functionalized MoS_2 QDs have strong fluorescence. Moreover, the GSH-functionalized MoS_2 QDs were developed as PL sensing platforms to determine Fe^{3+} using these QDs. As a result, as the Fe^{3+} ion concentration increased, the PL intensity of the GSH-functionalized MoS_2 QDs steadily decreased. Most likely, the quenching effect was caused by the effective electron transfer from GSH-functionalized MoS_2 QDs to the Fe^{3+} ion.

Results and discussion :

As shown in Fig. 1a the PL spectra of 50 mM GSH-functioanlized MoS_2 QDs in the presence of Fe^{3+} were also investigated. Additionally, the photoluminescence of MoS_2 QDs is studied with increasing Fe^{3+} concentration. Moreover, it was discovered that the addition of Fe^{3+} ion decreased the PL intensity of the MoS_2 QDs as shown in Fig.1a. The quenching effect could be caused by an effective electron transfer from GSH-functionalized MoS_2 QDs to Fe^{3+} ion. There is a good linear relationship between the intensity of the GSH-MoS_2 QDs in the absence and presence of Fe^{3+} in the concentration range of 0 to 7 µM, as shown in Fig. 1b

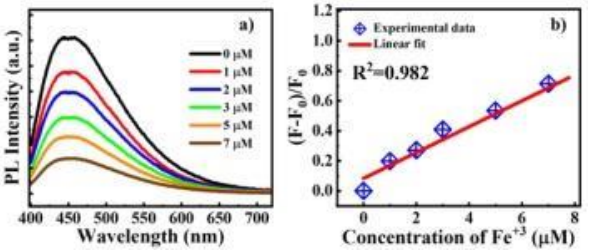


Figure 1. (a) PL emission spectra of GSH-functionalized MoS_2 QDs with different concentrations of Fe^{3+} ions (b) The relationship between [(F -F0)/F0]. F0 and F are fluorescence intensities without and with Fe^{3+} respectively.

References:

[1] Splendiani, A., et al., Emerging Photoluminescence in Monolayer MoS2. Nano Letters, 2010. **10**(4): p. 1271-1275.

[2] Xu, S.J., et al., One-Pot, Facile, and Versatile Synthesis of Monolayer MoS2/WS2 Quantum Dots as Bioimaging Probes and Efficient Electrocatalysts for Hydrogen Evolution Reaction. Advanced Functional Materials, 2015. **25**(7): p. 1127-1136.

[3] Wu, Q., et al., MoS2-QD-Based Dual-Model Photoluminescence Sensing Platform for Effective Determination of Al and Fe Simultaneously in Various Environment. Chemistryselect, 2018. **3**(8): p. 2326-2331.

Presenting author Email address: sonia.solan170295@gmail.com

Advancements in Spectromicroscopy: The STXM End-Station at TPS 27A

Hung-Wei Shiu[1]*, Hsiao-Tsu Wang[2], Yao-Jane Hsu[1], Chia-Hao Chen[1], Der-Hsin Wei[1], Chung-Li Dong[2], Cheng-Hao Chuang[2] and Way-Faung Pong[2]

[1] *National Synchrotron Radiation Research Center, 101 Hsin-Ann Road, Hsinchu Science Park, Hsinchu, Taiwan*
[2] *Department of Physics, Tamkang University, No.151, Yingzhuan Rd., Tamsui Dist., New Taipei City, Taiwan*

**Corresponding e-mail: hwshiu@nsrrc.org.tw*

In the forthcoming talk, we will unveil a novel soft X-ray imaging technology, the Scanning Transmission X-ray Microscope (STXM). Highly valued for its ability to detect reaction heterogeneity, STXM is utilized across various areas, including chemistry, magnetism, materials science, and environmental studies. This tool not only provides nanometer-scale spatial resolution but also exposes specific chemical and electronic structures at precise locations.

The STXM facility located at TPS27A spans a broad energy spectrum from 90 to 3000 eV, enabling the exploration of organic molecules, light elements, and transition metals. Typically, STXM achieves a 30 nm spatial resolution, with potential to reach below 10 nm using a lensless approach known as ptychography. Additionally, STXM is equipped with comprehensive in-situ environmental controls—ranging from temperature regulation to gas and electrochemical cells, and magnetic fields—offering observers live analysis of reactive processes. Collaborative opportunities allow users to tailor environmental cells to meet the unique demands of their specialized research. Presently, after the completion of its hardware setup, the system is starting its initial commissioning phase, awaiting the first X-ray at TPS27A.

Presenting author Email address: hwshiu@nsrrc.org.tw

Unveiling Electron Dynamics: Time-Resolved Angle-Resolved Photoemission Spectroscopy in NSRRC

Ping-Hui Lin[1*]

[1]*National Synchrotron Radiation Research Center, Hsinchu City 30010, Taiwan R.O.C*

[*] Corresponding e-mail: *lin.pinghui@nsrrc.org.tw*

Time-resolved angle-resolved photoemission spectroscopy (Tr-ARPES) offers direct insights into electron dynamics, revealing various intrinsic ultrafast behaviors within novel materials. In NSRRC, we've developed a Tr-ARPES apparatus utilizing a duo-Yb-KGW laser-based high harmonic generation (HHG) EUV system, which allows for the exploration of dynamic bandgap features, charge carrier scattering, relaxation process, and collective excitations. This technique provides comprehensive information, capturing temporal, energy, and momentum-resolved data in a single experiment.

Moreover, ongoing research at NSRRC uses high-power pulse laser sources for studying photon-induced engineering phenomena. This project aims to leverage advanced laser technology to manipulate and engineer material properties via photon-induced processes.

The development of Tr-ARPES setups combined with advanced laser technology at NSRRC offers a promising platform for delving into fundamental material properties. I will offer a brief overview of the current status and specifications of the Tr-ARPES setup as well as explore the scientific opportunities it presents.

Presenting author Email address: lin.pinghui@nsrrc.org.tw

Characterizing Catalysts in Action through Synchrotron Radiation

Yan-Gu Lin[1*]

[1]*Scientific Research Division, National Synchrotron Radiation Research Center, Hsinchu, Taiwan*

[*] Corresponding e-mail: *lin.yg@nsrrc.org.tw*

The primary goal of attaining net-zero CO_2 emissions by 2050 hinges on the ability to transform renewable energy into storable fuels. Hydrogen plays a crucial role in connecting renewable energy sources with end-users. However, achieving cost-effective, widespread hydrogen production presents a multifaceted challenge. This requires a thorough understanding of electrocatalysis for the creation of efficient catalysts. Current research in electrocatalysis primarily concentrates on grasping the alterations occurring on catalyst surfaces. To comprehend how solid-liquid interfaces impact electrochemical processes, it is imperative to scrutinize the surface chemistry where the electrode and electrolyte intersect. In this presentation, I will demonstrate how the NSRRC beamlines can furnish this essential information. Our experimental findings underscore the valuable perspectives offered by in-situ/operando X-ray characterization in unveiling the authentic mechanisms governing catalytic reactions.

Keywords: Synchrotron Radiation, X-ray, Catalyst, Hydrogen

References:

[1] Peng, C.K.; Lin, Y.C.; Chiang, C.L.; Qian, Z.; Huang, Y.C.; Dong, C.L.; Li, J.F.; Chen, C.T.; Hu, Z.; Chen, S.Y.; Lin, Y.G.; Zhang-Rice singlets state formed by two-step oxidation for triggering water oxidation under operando conditions. Nature Communications, 2023, 14, 529.

[2] Lim, S.C.; Chiang, C.L.; Peng, C.K.; Wu, W.B.; Lin, Y.C.; Lin, Y.R.; Chen, C.L.; Lin , Y.G.; Realizing the bifunctional electrocatalysis via local charge rearrangement of α-CrOOH-modulated Co@CoMoOx for overall water splitting. Chemical Engineering Journal, 2023, 452, 139715.

[3] Li, Y.; Peng, C.K.; Hu, H.; Chen, S.Y.; Choi, J.; Lin, Y.G.; Lee, J.M.; Interstitial boron-triggered electron-deficient Os aerogels for enhanced pH-universal hydrogen evolution. Nature Communications, 2022, 13, 1143.

[4] Lin, Y.C.; Peng, C.K.; Lim, S.C.; Chen, C.L.; Nguyễn, T.N.; Wang, T.T.; Lin, M.C.; Hsu, Y.J.; Chen, S.Y.; Lin, Y.G.; Tailoring the Surface Oxygen Engineering of a Carbon-Quantum-Dot-Sensitized ZnO@H-ZnO1-x Multijunction toward Efficient Charge Dynamics and Photoactivity Enhancement. Applied Catalysis B: Environmental, 2021, 285, 119846.

Presenting author Email address: lin.yg@nsrrc.org.tw

Unveiling Surface Electron Accumulation in Transition Metal Dichalcogenides: Insights and Applications in MoS_2, $MoSe_2$, and ReS_2

Cheng-Maw Cheng

National Synchrotron Radiation Research Center, Hsinchu 300092, Taiwan
Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 300, Taiwan
Department of Physics, National Sun Yat-sen University, Kaohsiung 80424, Taiwan

* Corresponding e-mail: *makalu@nsrrc.org.tw*

Transition metal dichalcogenide (TMDC) layered semiconductors exhibit great potentials in electronics, optoelectronics, and spintronic devices. Because the surface-to-volume ratio of quasi-two-dimensional materials is extremely high, understanding their surface characteristics is crucial for practically controlling their intrinsic properties and fabricating p-type and n-type layered semiconductors. A comprehensive insight into the phenomena of surface electron accumulation (SEA) and its diverse applications become crucial. Here in, the realm of three transition metal dichalcogenides (TMD) materials—specifically, molybdenum disulfide (MoS_2), molybdenum diselenide ($MoSe_2$), and rhenium disulfide (ReS_2) were carefully studied. Employing advanced experimental techniques such as scanning tunneling microscopy (STM) and angle-resolved photoemission spectroscopy (ARPES), the results exhibit preconceived notions about the inertness of van der Waals crystals, particularly MoS_2, $MoSe_2$ and ReS_2, revealing its unexpected surface behavior as a significant n-doping source. S and Se vacancies could be identified as the primary source of SEA and *n*-type conductivity, further explores the enhancement of electrochemical hydrogen evolution reaction (HER) activity, such as in MoSe2, demonstrating its potential as a stable and efficient catalyst, particularly following nitrogen plasma treatment. These collective findings shed light on the intricate surface electronic properties of TMD materials, providing valuable insights crucial for fine-tuning electronic structures and advancing the development of efficient catalysts.

Keywords: Transition metal dichalcogenide, angle-resolved photoemission spectroscopy, hydrogen evolution reaction, band structure

References:

[1] Hemanth Kumar Bangolla *et al.*, Nanoscale, DOI: 10.1039/D3NR04830F (2023).
[2] Y. S. Chang *et al.*, Nano Energy, **84**, 105922 (2021).
[3] Xixia Zhang *et al.*, Physical Chemistry Chemical Physics **22**, 21776-21783 (2020).
[4] M. D. Siao etal., Nature Communication **9**, 1442 (2018).

Presenting author Email address: makalu@nsrrc.org.tw

Tender X-ray Absorption Spectroscopy (XAS) Beamline in Taiwan Photon Source

Ying Rui Lu[1], Din Goa Liu[1], Ming Han Lee[1], Chia Feng Chang[1], Cheng Chih Liang[1], Jia Lin Tu[1], Jyh Fu Lee[1],

Chi Liang Chen[1]

[1]*Experimental Facility Division, National Synchrotron Radiation Research Center, Hsinchu, Taiwan*

The TPS 32A Beamline is a tender X-ray beamline that comes equipped with two types of water-cooled double crystal monochromators (DCMs): InSb(111) and Si(111), which can cover a photon energy range from 1.7 to 11 keV. The beamline's design allows for a focus beam size of 0.9 × 0.9 mm² (horizontal × vertical, Full Width at Half Maximum) using the Si(111) DCM at 4 keV, where the photon flux approximates ~10^{12} photons per second. This beamline is capable of measuring the elemental spectra encompassing the K-edges of elements from Silicon to Zinc, as well as the L-edges of second-row transition metals. Research at the TPS 32A beamline is anticipated to unveil valuable information on the electronic structures of an assortment of metals and ligands, which is of considerable importance to a range of scientific disciplines, including physics, chemistry, materials science, chemical engineering, geology, earth sciences, biology, and environmental science. The X-ray absorption spectroscopy (XAS) technique, a mainstay in this context, is utilized to elucidate the electronic and atomic structures of specific elements within samples. The multi-channel fluorescence silicon drift detector (SDD) employed here boasts a detection threshold that may extend to monolayer levels, or a few parts per million. Moreover, this endstation also features Hard X-ray Photoelectron Spectroscopy (HAXPES), which aids in the investigation of the electronic structures at deeper levels. Additionally, Micro-XAS, offering a spatial resolution of approximately 10 μm, will be available in the endstation. The beamline is also equipped with various heating systems, cryogenic systems, and in situ electrochemical reaction cells, allowing for adjustments to be made according to the differing environmental conditions of the samples. These comprehensive efforts are geared towards providing a diverse and user-friendly experimental milieu, thereby enhancing the scientific yield.

TABLE OF CONTENTS_POSTER PRESENTATIONS

PH_P10	Chih-Yu Hsieh	Using AI drawing software scan H&E-stained rat tissue sections and harnessing AI software objectively assess student hand drawings	127
PH_P11	Yu-Lin Zhou	Fabrication and Characterization of Implant Confined VCSEL with Dielectric DBR Mirror	128
PH_P12	Tuan Canh Nguyen	Develop Electrospray for Quantum Dot Light- Emitting Diode Fabrication	129
Spintronic & topological materials (ST)			
ST_P01	Hung-Viet Khuc	Temperature dependent ultrafast dynamics of topological material $SrCd_2Sb_2$	130
ST_P02	Riku Iimori	Pressure effect on unidirectional magnetoresistance in heavy metal/ferromagnetic bilayer	131
ST_P03	H. Hitotsukabuto	Electrical modulation of interfacial spin-charge conversion in CoFeB/Pt bilayer on PMN-Pt substrate	132
ST_P04	Surajit Ghosh	Exploring Griffith's Phase and re-entrant Spin Glass state of $CuMn_{1.8}Fe_{0.2}O_4$ Spinel: Insights from Synchrotron Spectroscopy	133
ST_P05	Xin-Yun Chang	Helicity-dependent Terahertz Emission Spectroscopy of Topological Material $EuCd_2As_2$ Single Crystals	134
Theoretical and computational materials science (TC)			
TC_P01	Ly Nguyen Hai	Computational Study of Aptamer – Botulinum Bindings for Optimization and Design of Biosensor for Detection of Botulinum Neurotoxin	135
TC_P02	Cong Thang Tran	Analysis of phonon properties in Zintl layered materials AMgBi	136
TC_P03	Nguyen Hai Chau	Uncertainty quantification for prediction of high-entropy alloy's yield strength	137
THz materials and devices (TD)			
TD_P02	Tran Ho Ngoc Khanh	Organic photovoltaic (OPV) modules with good stability under UV irradiation	138
TD_P03	Yu-Ting Chen	Measuring Electric Fields in GaN/AlGaN High Electron Mobility Transistors using Luminescence Techniques	139
TD_P04	Shih-Chieh Chen	Atomically thin impedance switches for 6G communication	140
TD_P05	Yu-Ling Liao	Electronic Synapse Memristive Switaching based on Lysine-functionalized MoS2 Quantum Dots	141
TD_P06	You-Chen Chang	Counter-Degenerate P-type Doping in Ultrathin Oxide Semiconductor	142
TD_P07	Denice Navat Feria	Surface defect passivation of ZnO Nanorod Arrays/p-GaN Heterostructure Devices by Nontoxic Bio-based Materials	143
TD_P08	Ranjan Kumar Ghadai	Comparative Analysis of Various MCDM Techniques for The Optimization of CVD Process Parameters to Deposit the SiCN Thin Film Coating	144
TD_P09	Ching-Wen Wang	Encoding information into Terahertz pulses via spectrally modulated ultrafast optical pulses	145
TD_P10	Yu-Ting Lin	Generation of circularly polarized THz dual pulses	146
TD_P11	Chien-Ming Chen	Ultrafast Dynamics of Tb_2Te_5 Single Crystal Using Optical Pump Probe Spectroscopy	147
TD_P12	Chun-Ying Lin	Generate Mid-infrared Ultrashort Pulses via Four-Wave Difference Frequency Generation for Measurements	148
TD_P13	Shih-Chi Hung	Ultrafast Electron Dynamics in 1T-$TiSe_2$ by Tr-ARPES	149
TD_P14	Zhi-Ling Chen	Pump fluence-dependent effective mass in 1T-$TiSe_2$	150

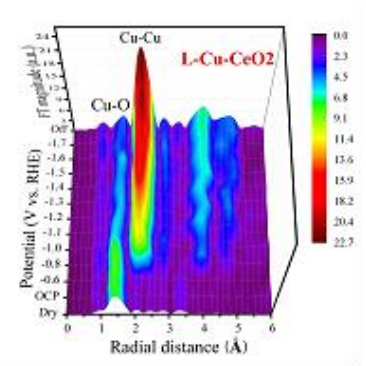
TD_P15	Wei-Hong Huang	Generation of circularly polarized ultra-broadband MIR pulses through the laser-induced filament of atmosphere	151
TD_P16	Yan-Cheng Ko	High Efficiency Terahertz Emission from Weyl Semimetal $EuCd_2Sb_2$ Single Crystals	152
TD_P17	Jia-Yuan Sun	Ultrafast Carrier Dynamics of the Grain Boundaries in LSMO Homostructure by Spatial Resolved Ultrafast Pump-Probe Spectroscopy	153
Two-dimensional materials and related applications (2D)			
2D_P01	Ngo Ngoc Uyen	Photocatalytic degradation of metronidazole by TiO_2 and Bi-Se-Te /TiO_2 nanomaterials	154
2D_P02	Yu-Hsiang Liao	Enhancing Deep Ultraviolet Light-Emitting Diodes by Graphene Transparent Conductive Layer	155
2D_P03	Ashutosh Shirsat	Preparation of Graphene Mask using Solid State Carbon Source	156
2D_P04	Po-Han Tseng	Wide-range and area-selective threshold voltage tunability in quasi-2D oxide semiconductor	157
2D_P05	Yi-Yu Pan	Abnormal short channel effect in ultrathin oxide semiconductors	158
2D_P06	Heng-An Chen	Insights into the Formation of Cu_2O Nanostructures and Ion Exchange Reactions by In-Situ X-Ray Absorption Spectroscopy	159
2D_P07	Wei-Tung Liu	Formation of Nickel After WS2 Hydrogen-Cracking Modifications	160
2D_P08	Jyun-Yu Wu	Tomography Scan of Charge Density Wave in $NbSe_2$	161
2D_P09	Po Hung Lin	Radiation and Annealing Effects on N-Channel MOSFETs	162
2D_P10	Shin-Lin Tsai	Exploring Anisotropy of Electrical and Thermoelectric Properties in Few-Layer $ReSe_2$ Field-Effect Transistors	163
2D_P11	Oscar Javier Gomez Sanchez	Photo-Excitation of Gray Excitons in a WSe_2 Monolayer with Vector Vortex Beams	164
2D_P12	Nhu Quynh Diep	Surface Morphology and Crystal Structure of Gallium Monochalcogenides Grown by Molecular Beam Epitaxy	165
2D_P13	Umeshwar Reddy Nallasani	Epitaxial Growth of 2D β-In_2Se_3/3D β-Ga2O3 Heterostructure on c-Sapphire by PA-MBE	166
2D_P14	Quynh Trang Tran	Molecular Beam Epitaxy growth and characterization of 2D GaSe-based heterostructures	167
2D_P15	Bich Tuyen Huynh Thi	Growth and Characterizations of InGaSe Ternary Alloys on c-sapphire by Molecular Beam Epitaxy	168
2D_P16	Pratyay Amrit	Tuning of unoccupied band by surface decoration	169
2D_P17	Jia-Cheng Yang	Growth and Characteristics of $InSe_{1-x}Te_x$ Ternary Compound Thin Films with an Indium Precursor Layer by Molecular Beam Epitaxy	170
2D_P18	Nguyen Nhat Quyen	Ultrafast dynamics in quasi-2D CDW systems $LaTe_3$ and $LaSeTe_2$	171
2D_P19	Hao-Ning Yang	Growth Dynamic of Pure Indium Selenide via the Indium Precursor Method by using Molecular Beam Epitaxy	172
2D_P20	Bo-Jun Lai	Energy Transfer Between Quantum Dots and Monolayer MoS_2 Studied by Ultrafast optical Pump-Probe Spectroscopy	173
2D_P21	Li-Yang Jiang	Study of the ablation thresholds of monolayer MoS_2 from femtosecond to picosecond regime	174

In-situ X-ray Absorption Spectroscopic Studies of Copper Single-Atom Incorporated on Cerium Dioxide Nanorods for Electrocatalytic Urea Synthesis

Ta Thi Thuy Nga[1,2], Xiaoxiao Wei[3], K. Thanigai Arul[2], Yu-cheng Huang[4], Cheng-Jie Yang[2], Wei-Hsiang Huang[4], Jeng-Lung Chen[4], Chi-Liang Chen[4], Zhiwei Hu[5], Shuangyin Wang[3], Chung-Li Dong[2*], and Wu-Ching Chou[1*]

[1]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 30010, Taiwan*
[2]*Research Center for X-ray Science and Department of Physics, Tamkang University, New Taipei City 25137, Taiwan*
[3]*State Key Laboratory of Chem/Bio-sensing and Chemometrics, College of Chemistry and Chemical Engineering, Hunan University, Changsha 410012, China*
[4]*National Synchrotron Radiation Research Center, Hsinchu 30010, Taiwan*
[5]*Max-Planck-Insititute for Chemical Physics of Solids, 01187 Dresden, Germany*

[*] Corresponding e-mail: *cldong@mail.tku.edu.tw*



Electrocatalytic C-N coupling between carbon dioxide and nitrate facilitates efficient urea synthesis which is one of the important amines in the field of agriculture and industry. Although single-atom materials have attracted significant interest in the catalytic field because of their high activity, the nature of active sites and the identification of electronic structure transformation remain elusive. Here, we report the catalyst of copper single atom decorated on cerium dioxide nanorods (denoted as L-Cu-CeO_2) exhibits an average urea yield rate of 53 mmol h^{-1} g_{cat}^{-1} at -1.6V versus reversible hydrogen electrode. A comprehensive investigation of *operando* X-ray absorption spectroscopy (XAS) including hard-XAS and soft-XAS for the electronic and atomic structural dynamics of L-Cu-CeO_2 during electrocatalytic reaction are presented. *Operando* XAS analytical results reveal copper single-atom is reduced to metallic copper during electrolytic conditions, indicating metallic copper is the real active site for electrocatalytic urea synthesis. Notably, when the applied potential is switched to an open-circuit potential, the reversible transformation of metallic copper to copper single-atom attains. These findings strongly declare the outstanding potential of single-atom materials as well as the superiority of *operando* XAS technique for electrocatalytic research.

Keywords: in-situ X-ray absorption spectroscopy, copper single atom, cerium dioxide, urea synthesis

Presenting author Email address: thuynga.sc10@nycu.edu.tw

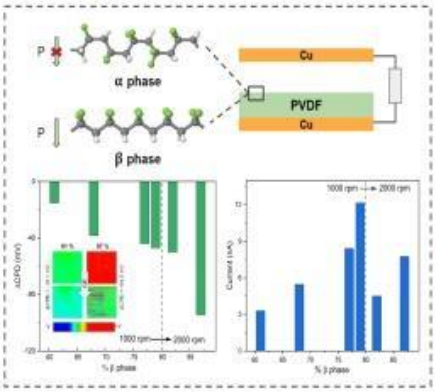
A study of contact electrification process on PVDF metal interface: Effect of β phase composition [1]

Yerkezhan Amangeldinova[1], Dong Myeong Shin[2], and Yoon-Hwae Hwang[1,3*]

[3] *Department of Nanofusion Technology, Pusan National University, Busan 46241, Republic of Korea*
[2] *Department of Mechanical Engineering, The University of Hong Kong, Pokfulam Road, Hong Kong, People Republic of China*
[3] *Department of Nanoenergy Engineering, Pusan National University, Busan 46241, Republic of Korea*

[*] Corresponding e-mail: *yhwang@pusan.ac.kr*

The Recently, triboelectric nanogenerators (TENGs) are getting considerable attention as an energy harvesting tool that can convert random mechanical energy into electricity due to the wide material selection, low cost and easy fabrication. TENGs work by contact electrification on the interface and electrostatic induction on the electrodes when two surfaces contact and separate. Herein, the study of the contact electrification process on the metal-PVDF interface is conducted focusing on the effect of β phase content on the electrical properties of the PVDF films. It was found through the EFM and KPFM surface electrical studies that a higher β phase promotes stronger electrostatic interactions and enhanced electron-cloud overlap with the metal coated cantilever tip that lead to higher amount of charge transfer. Additionally, there is overall enhancement of the TENGs electric output performance for a higher β phase containing PVDF films and the maximum electric output of 8.1 V and 12.2 nA is obtained for the TENG made with 79 % β phase PVDF film.



Keywords: Triboelectricity, Nanogenerator, contact electrification, β phase PVDF

References:

[1] Advanced Materials Interfaces (in press)

Presenting author Email address: yhwang@pusan.ac.kr

Large Stokes Shift Gold-doped Silver Nanoclusters-based Efficient Luminescent Solar Concentrators

Russel Cruz Sevilla[1,2], Ruth Jeane Soebroto[1,2], Hsiu-Ying Huang[1,2] and Chi-Tsu Yuan[1,2*]

[1]*Department of Physics, Chung Yuan Christian University, Taoyuan City, Taiwan*
[2]*Center for Semiconductor Materials and Advanced Optics, Taoyuan City, Taiwan*

[*] Corresponding e-mail: *ctyuan@cycu.edu.tw*

Reabsorption-free luminescent solar concentrators (LSCs) play a vital role in the development of photovoltaic windows [1]. Metal nanoclusters (NCs) that possess perfect atomic arrangement and exhibit a significant change in photoluminescence (PL) known as Stokes-shift, have considerable potential for utilization in luminescent solar concentrators (LSCs) [2]. In addition, photons with wavelengths ranging from 500 – 900 nm is beneficial for commercial solar cell in accordance to its external quantum efficiency [3].

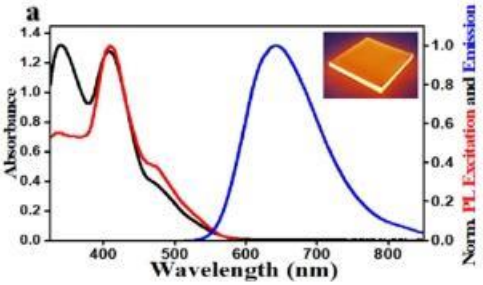


Figure 1. Absorbance PLE, and PL Spectra of Au-AgNCs@PVP

The fabricated LSC with Gold-doped Silver nanoclusters embedded in Polyvinylpyrrolidone (Au-AgNCs@PVP), with PL peak at ~ 650 nm, Stokes shift of ~ 230 nm, and high photoluminescence quantum yield (PLQY) of ~ 50%, yielded ~ 1.3% power conversion efficiency (PCE) under appropriate experimental condition. Owing to these values, the synthesized Au-AgNCs@PVP holds great potential for an efficient and eco-friendly building-integrated photovoltaics (BIPV).

Keywords: silver nanoclusters, luminescent solar concentrators, photoluminescence

References:

[1] Mazzaro, R. and A. Vomiero (2018). "The Renaissance of Luminescent Solar Concentrators: The Role of Inorganic Nanomaterials." Advanced Energy Materials **8**(33): 1801903.

[2] Sevilla, R. C., et al. (2023). "Self-Trapped, Thermally Equilibrated Delayed Fluorescence Enables Low-Reabsorption Luminescent Solar Concentrators Based on Gold-Doped Silver Nanoclusters." ACS Applied Materials & Interfaces **15**(45): 53136-53145.

[3] Farah Khaleda, M. Z., et al. (2021). Chapter 18 - Spectral response and quantum efficiency evaluation of solar cells: a review. Energy Materials. S. J. Dhoble, N. T. Kalyani, B. Vengadaesvaran and A. Kariem Arof, Elsevier**:** 525-566.

Presenting author Email address: russelcruzsevilla@gmail.com

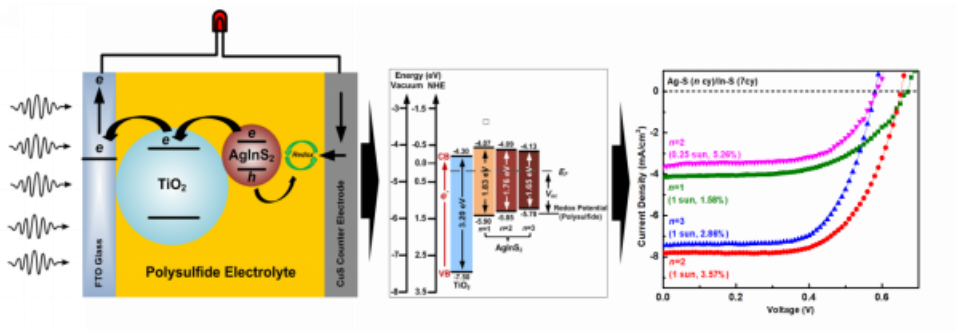
Enhanced Photovoltaic Performance of $AgInS_2$ Quantum Dot-Sensitized Solar Cells Via a Facile SILAR Method

Siti Utari Rahayu[1,2*], Yu-Rou Wang[1], and Ming-Way Lee[1]

[1]*Department of Physics and Institute of Nanoscience, National Chung Hsing University, Taichung, 402, Taiwan*
[2]*Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara, Medan 20155, Sumatera Utara, Indonesia*

[*] Corresponding e-mail: siti.utari@usu.ac.id

This study investigates the synthesis of $AgInS_2$ quantum dots (QDs) using a facile successive ionic layer adsorption and reaction (SILAR) method, exploring their application in solar cells. The $AgInS_2$ QDs were grown on mesoporous TiO_2 via a two-stage SILAR process at room temperature. The optimization of Ag-S SILAR cycles (*n*) was performed to discern the ideal conditions, while the In-S SILAR cycles were held constant at 7 cycles. X-ray diffraction (XRD) pattern analysis revealed the orthorhombic crystalline structure of the synthesized $AgInS_2$ QDs. Optical spectra analysis exhibited a decrease in the optical energy bandgap ($E_{g,op}$) of $AgInS_2$ QDs from 2.00 eV to 1.77 eV with increasing *n* from 1 to 3, corroborated by cyclic voltammetry (CV) analysis showing a similar trend albeit with slightly different values: 1.83 eV (*n*=1), 1.76 eV (*n*=2), and 1.65 eV (*n*=3). Employing $AgInS_2$ QDs, a polysulfide electrolyte, and a CuS counter electrode, liquid-junction semiconductor quantum dot-sensitized solar cells (QDSSCs) were fabricated. Optimal conditions were achieved at *n*=2, resulting in a champion power conversion efficiency (PCE) of 3.57% (J_{sc}=8.56 mA/cm^2, V_{oc}=0.64 V, *FF*=65.2%). Under reduced light intensity (0.25 sun), the PCE increased to 5.26%. The external quantum efficiency (EQE) spectrum spanned 400−700 nm, maintaining a nearly constant EQE value of ~65% within the 400−600 nm range. Remarkably, the achieved PCE surpasses previously reported liquid-junction $AgInS_2$ QDSSCs. These findings highlight the facile production of $AgInS_2$ QDs through a room-temperature SILAR method and the tunable optical properties of $AgInS_2$ QDs by controlling SILAR cycles, highlighting their potential as



an efficient solar absorber.

Keywords: silver indium sulfide, quantum dot, solar energy materials, bandgap engineering, room temperature synthesis.

References:

[1] Cai, C., Zhai, L., Ma, Y., Zou, C., Zhang, L., Yang, Y., & Huang, S. (2017). Synthesis of AgInS2 quantum dots with tunable photoluminescence for sensitized solar cells. Journal of power sources, 341, 11-18.

Presenting author's E-mail address: siti.utari@usu.ac.id

Green Synthesis of NiO Nanoporous Film for Flexible Non-Enzymatic Glucose Sensing via Electro-Exploding Wire Technique

Nadeem Ahamad[1], Soumallya Benerjee[1], Chia-Chun Wei[2], Kuan-Cheng Lu[2], Akhil Pradiprao Khedulakar[2], Chih Wei Chu[3], Hong-Cheu Lin[1]*, Wen-Bin Jian[2]*

[1] *Department of Materials Science and Engineering, National Yang Ming Chiao Tung University, Hsinchu 300, Taiwan.*

[2] *Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 300, Taiwan.*

[3] *Research Center for Applied Sciences, Academia Sinica, Taipei, 11529, Taiwan.*

*Corresponding e-mail: *wbjian@nycu.edu.tw*

Glucose, a fundamental carbohydrate and essential component in the human body, plays a critical role in maintaining physiological health. For individuals with diabetes or prediabetes, monitoring blood glucose levels is imperative to prevent complications. Modern healthcare technology enables precise real-time glucose monitoring. Their ability to improve diagnostic accuracy not only enhances healthcare services but also maintains beverage quality standards. Compared to other sensors, electrochemical sensors feature exceptional sensitivity and selectivity, making them the preferred choice for accurate and real-time glucose monitoring.

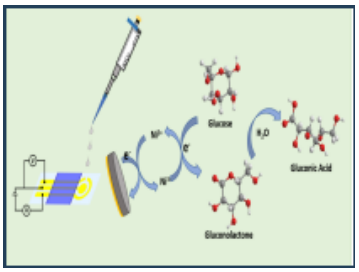


Figure 1. A schematic of the mechanism for the oxidation of glucose on the surface of NiO nanoporous film

In recent years, nickel oxide-based glucose sensors have gained attention due to their high sensitivity, selectivity, and cost-effectiveness, making them a promising choice for accurate and accessible glucose monitoring. The electro-exploding wire technique involving rapid discharge of electrical energy facilitates the controlled formation of porous nickel oxide nanoparticles, improving sensitivity and reactivity in glucose detection.

In this study, we introduce a single-step, green synthesis non-enzymatic glucose sensor: a flexible electrode coated with a NiO nanoporous film. The NiO suspension synthesized by the electro-exploding wire technique provides a large surface area with active catalytic sites which increases their efficiency in catalyzing chemical reactions. The results show an impressive linear detection range from 50 μM to 1000 μM, with a sensitivity of 1.2 (μA/μM) cm^{-2} and a remarkably low detection limit of 502 nM. In addition, NiO exhibits excellent selectivity and reliability in detecting glucose in beverages.

Keywords: Non-enzymatic Glucose sensor, NiO nanoporous film, Electrochemical interaction, Flexible electrode, electro-exploding wire technique

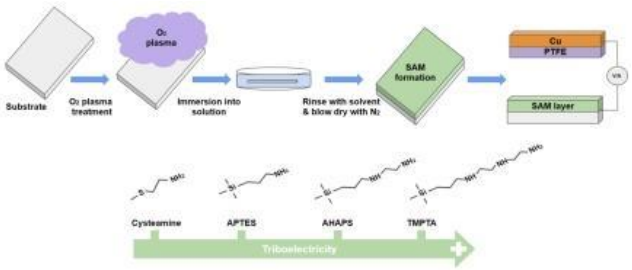
Presenting author Email address: nadeemmit93@gmail.com

The Effect of Tribo-Active Layer Surface Functionalization on Triboelectric Nanogenerator Output Performances

Dimaral Aben[1], Dong Myeong Shin[2], Hyung-Kook Kim[1,3] and Yoon-Hwae Hwang[1,3*]

[3] *Department of Nanofusion Technology, Pusan National University, Busan 46241, Republic of Korea*
[2] *Department of Mechanical Engineering, The University of Hong Kong, Pokfulam Road, Hong Kong, People Republic of China*
[3]*Department of Nanoenergy Engineering, Pusan National University, Busan 46241, Republic of Korea*

[*] Corresponding e-mail: *yhwang@pusan.ac.kr*



We studied the effect of surface functionalization of tribo-active layers on a triboelectric nanogenerator (TENG) output. First, we functionalized Au surfaces by cysteamine (Cys) to improve a TENG output performance. We found that Cys forms a monolayer on Au film and that the contact separation mode output power of the TENG with polytetrafluoroethylene (PTFE) film as a tribo-negative layer was improved from 0.11 nW/cm^2 (bare Au) to 0.37 nW/cm^2 (Cys on Au). We also studied the effect of a number of amine groups in the surface funtionalization of tribo-active surfaces by using 3-Aminopropyl triethoxysilane (APTES-1N), N-[3-(Trimethoxysilyl) propyl] ethylenediamine (AHAPS-2N), and N1-(3-Trimethoxysilylpropyl) diethylenetriamine (TMPTA-3N). We found that the amount of generated charges on the chemically functionalized surface as the amine group number increased. The amount of charges increased more than 19 times compared to that on the bare PTFE surface with increasing the number of amine groups. Therefore, the surface functionalization of the tribo-active layer seems to be an effective way of controlling the amount of tribo-generated charges and the power output of TENG [1,2].

Keywords: Triboelectricity, Nanogenerator, Surface Functionalization, Amin Group

References:

[1] Choi, Y. S., Kim, S. W., & Kar-Narayan, S. (2021). Materials-related strategies for highly efficient triboelectric energy generators. Advanced Energy Materials, 11(7), 2003802.
[2] Liu, Y., Mo, J., Fu, Q., Lu, Y., Zhang, N., Wang, S., & Nie, S. (2020). Enhancement of triboelectric charge density by chemical functionalization. Advanced Functional Materials, 30(50), 2004714.

Presenting author Email address: hkkim@pusan.ac.kr

Influence of Temperature and Oxygen Flow Rate on the Quality of Epitaxial Growth by Organometallic Chemical Vapor Deposition Method

Chih-Yang Huang[1*], Ray-Hua Horng[2]
[1] *Institute of Pioneer Semiconductor Innovation, National Yang Ming Chiao Tung University, Hsinchu, 30010, Taiwan*
[2] *Institute of Electronics, National Yang Ming Chiao Tung University, Hsinchu, 30010, Taiwan*
[*] Corresponding e-mail: *x121690@gmail.com*

As a fourth-generation compound semiconductor, gallium oxide has a wider energy gap (about 4.6~4.9eV), a higher collapse electric field (8MV/cm) and a very high Baliga FOM than third-generation semiconductors such as gallium nitride and silicon carbide. (~3444). Based on the above material characteristics, gallium oxide has greater potential than the above two compound materials to be used to prepare high-power components. In the production of components, it can also be made into ultraviolet components due to its wider energy gap. Photo sensors (UV sensors), as well as high-voltage metal-oxide semi-field effect transistors (MOSFETs) and Schottky diodes (SBDs).

There are six different crystal phases of gallium oxide, namely α, β, γ, δ, ε, and κ, among which the β type is a thermally stable monoclinic phase. In this experiment, the organometallic chemical vapor deposition method was used (MOCVD) grows beta-type gallium oxide heterojunction epitaxial crystals on an alumina substrate (Al_2O_3). Trimethylgallium (Trimethylgallium) is used as a precursor to achieve a faster growth rate, and the temperature, oxygen flow, etc. are controlled. Different conditions and various material analysis instruments were used to confirm whether the epitaxial quality of gallium oxide was improved as a result.

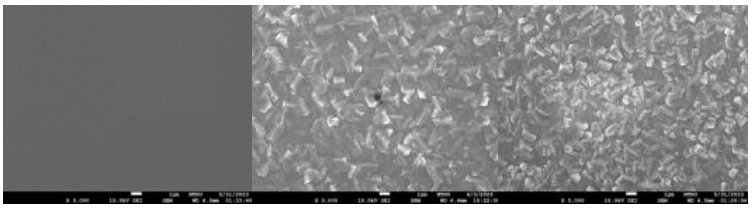


Figure 1. SEM Top-View at different temperatures (850, 875, 900°C).

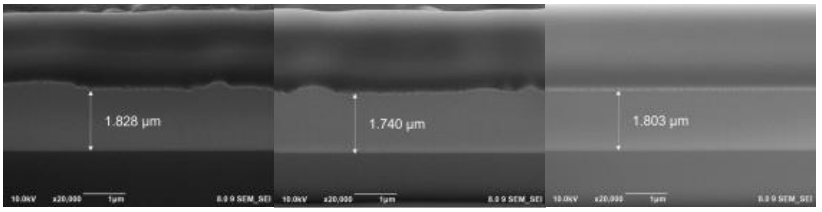


Figure 2. SEM cross-section at difference temperatures (850, 875, 900°C)

Keywords: MOCVD, gallium oxide, trimethylgallium

References:

[1] Ze-Yu Fan, Min-Ji Yang, Bo-Yu Fan, Andraž Mavrič, Nadiia Pastukhova, Matjaz Valant, Bo-Lin Li, Kuang Feng, Dong-Liang Liu, Guang-Wei Deng, Qiang Zhou, Yan-Bo Li, " Journal of Electronic Science and Technology Volume 20, Issue 4, December 2022, 100176"
[2] Yuan Qin, Li-Heng Li, Zhaoan Yu, Feihong Wu, Danian Dong, Wei Guo, Zhongfang Zhang, Jun-Hui Yuan, Kan-Hao Xue, Xiangshui Miao, Shibing Long, "Adv. Sci.2021,8, 2101106"
[3] Elham Rafie Borujeny1 and Kenneth C Cadien1," ECS Meeting Abstracts DOI 10.1149/MA2021-01362104mtgabs"
[4] Junghwan Kim, Takumi Sekiya, Norihiko Miyokawa, Naoto Watanabe, Koji Kimoto, Keisuke Ide, Yoshitake Toda, Shigenori Ueda, Naoki Ohashi, Hidenori Hiramatsu, Hideo Hosono & Toshio Kamiya, "NPG Asia Materials volume 9, pagee359 (2017)"
[5] Sanghyun Moon, Donggyu Lee, Jehwan Park, and Jihyun Kim, "ACS Appl. Mater. Interfaces 2023, 15, 31, 37687–37695"

Presenting author Email address: x121690@gmail.com

Alginate Biopolymer Stabilized Pickering Emulsion Liquid Membrane for Methylene Blue Extraction from Aqueous Solution

Jerold Manuel

Department of Biotechnology, National Institute of Technology Warangal, Warangal – 506004, Telangana, India

* Corresponding e-mail: jerold@nitw.ac.in

Membrane technology is one of the emerging technologies for the recovery of toxic elements from wastewater. Liquid membrane is gaining more importance due to its various salient features such less expensive, more permeability, higher diffusivity coefficient, one step operation. Emulsion liquid membrane (ELM) techniques is successfully used for the extraction of heavy metals or precious metals, dyes, Organic acids and other compounds. PELM is the modified version of ELM in which the emulsions are stabilized by colloidal solid particles. In PELM, the solid particles with a balance of hydrophilic and hydrophobic surface properties could strongly absorb at interfaces and stabilize emulsions have emerged in recent years. Pickering stabilization is the phenomena that solid particles employed on the interface of droplets to provide resistance to opposing coalescences, fusion and coarsening. In the present investigation, alginate biopolymer stabilized Pickering emulsion liquid membrane (PELM) was employed for the extraction of Methylene blue (MB) from aqueous solution. The novel PELM composed of aliquat 336 as a carrier, potassium hydroxide (KOH) as a stripping agent, and waste cooking oil (WCO) as the green diluent. WCO is a non-toxic organic solvent was used as substitution of petroleum based organic solvent in the preparation of PELM. The optimum conditions for the maximum removal of MB were: Emulsifier concentration – 2.3 (v/v %), Carrier concentration – 5.6 (v/v%), Treat ratio – 12, internal phase concentration – 0.92 M, initial external feed phase concentration – 100 ppm, O/A ratio – 1. The mechanism of MB extraction was also presented. At optimized condition, the maximum extraction of 98.8% was recorded. Kinetic analysis shows that the MB extraction by PELM follows first-order reaction. Furthermore, the thermodynamic analysis reveals that the extraction process was an endothermic, and spontaneous in nature.

Keywords: Emulsion Liquid Membrane Biopolymer, Dye, Alginate, Extraction,

References:

[1] Sujatha S., M. Rajasimman, Development of a green emulsion liquid membrane using waste cooking oil as diluent for the extraction of arsenic from aqueous solution – Screening, optimization, kinetics and thermodynamics studies, Journal of Water Process Engineering, Volume 41, 2021, 102055

[2] Xinyu Zhang, Hao Zhang, Pingting Chen, Meng Liu, Pan Wu, Changjun Liu, Wei Jiang, One-step dye wastewater treatment by combined adsorption, extraction, and photocatalysis using g-C3N4 pickering emulsion,Colloids and Surfaces A: Physicochemical and Engineering Aspects,Volume 644,2022

Presenting author Email address: jerold@nitw.ac.in

Investigation of ion irradiation on structure, magnetic properties and GMI effect of Co-based amorphous ribbons

Nguyen Quang Hoa[1,*], Vuong Van Hiep[1], Nguyen The Nghia[1], Nguyen Duy Thien[1], Tran Vinh Thang[1], Nguyen Ngoc Dinh[1], Bach Thanh Cong[1]

[1]*Faculty of Physics, VNU-University of Science, 334 Nguyen Trai, Thanh Xuan, Ha Noi, 100000, Viet Nam*

[*] Corresponding e-mail: *hoanq@hus.edu.vn*

In this study, the effects of ion irradiation on structure, magnetic properties and giant magnetoimpedance (GMI) have been investigated for a Co-based amorphous ribbon with various kinds of ions such as H and Ni. The structure of the samples before and after the ion irradiation was studied using X-ray diffractometer. The magnetic properties and GMI ratio were used to characterize the samples before and after the ion irradiation. The X-ray diffraction analysis shows that the samples before and after the ion irradiation are amorphous. The GMI ratio increased considerably in the ion irradiated samples and the GMI response showed a strong dependence on the irradiated ion species and driving frequencies. The observed GMI features in Co-based materials can be interpreted by adapting the skin-effect model in conjunction with the magnetic field dependence of the longitudinal permeability. This result is very beneficial for developing highly sensitive GMI sensor applications.

Keywords: Ion radiation, GMI, Co-based amorphous ribbon, magnetic properties.

References:

[1] A.T. Le, N.Q. Hoa, P.D. Tam, D.G. Park, M.H, Phan, H. Srikanth, S.C. Yu, Enhancement of the giant magnetoimpedance effect and its magnetic response in ion-irradiated magnetic amorphous ribbons, Materials Science and Engineering: B 166 (2010) 89-93.

[2] P. Sharma, A. Dhawan, S.F. Naqvi, S.K. Sharma, Effect of Ni ion irradiation on microstructure and corrosion properties of $Zr_{59}Nb_3Cu_{20}Al_{10}Ni_8$ amorphous alloy, Indian Journal of Pure and Applied Physics 56 (2018) 965–969.

Presenting author Email address: hoanq@hus.edu.vn

Magnetic field effects for activation energy of ε-τ and τ-β phase transformations on (Mn, Zn)-Al and Mn-Al-C

Ryota Kobayashi[1*], Yoshifuru Mitsui[1], Syuto Fumoto[1], Kohki Takahashi[2] and Keiichi Koyama[1]

[1] *Graduate School of Science and Engineering, Kagoshima University, Kagoshima, Kagoshima 890-0065, Japan*
[2] *Institute for Materials Research, Tohoku University, Sendai, Miyagi 980-8577, Japan*

[*] Corresponding e-mail: *k3579242@ kadai.jp*

The ferromagnetic Mn-Al (τ phase) is one of the Mn-based ferromagnetic alloy with high uniaxial magnetic anisotropy. The τ phase is metastable, so that it is difficult to obtain pure τ phase. The τ phase can be obtained from ε phase with hcp structure by annealing [1].

On the other hand, the ferromagnetic phase stabilizes by high magnetic fields. Magnetic field effects on the phase transformation of $Mn_{55}Al_{45}$, $Mn_{53}Zn_2Al_{45}$ and $Mn_{55}Al_{45}C_2$ have been evaluated [2-3]. ε-τ phase transformation of $Mn_{55}Al_{45}$ and $Mn_{53}Zn_2Al_{45}$ were promoted by magnetic fields. However, this promotion effect by the magnetic field could not be observed in $Mn_{55}Al_{45}C_2$. In addition, the τ-β phase transformation of $Mn_{55}Al_{45}$ and $Mn_{53}Zn_2Al_{45}$ were suppressed by magnetic fields.

Thus, it is necessary to clarify the kinetics more in detail because the magnetic field effect changes depending on the substituted elements.

In this study, differential thermal analysis (DTA) was performed in a magnetic field. The activation energy of ε-τ and τ-β phase transformations was determined from the obtained phase transition temperatures, and the magnetic field effect on the activation energy was evaluated.

$Mn_{53}Zn_2Al_{45}$ and $Mn_{55}Al_{45}C_2$ were prepared by reactive sintering. The obtained pellets were heat-treated at 1373 K for 48 hours and quenched in ice water. After quenching, the samples were confirmed to be single ε phase by X-ray diffraction measurement. The pellets were cut into the cubes with 2 x 2 x 2 mm. The DTA under high magnetic fields up to 10 T were carried out. The obtained peak temperatures from DTA were analyzed by using Kissinger plots to evaluate activation energies of ε-τ and τ-β phase transformations.

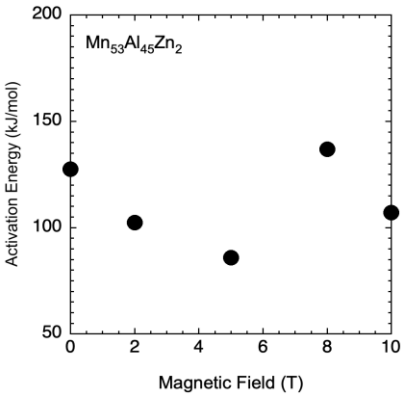


Fig.1 Magnetic field dependence of activation energy on τ-β and τ-β phase transformations at $Mn_{53}Zn_2Al_{45}$

Fig.1 shows the magnetic field dependence of activation energy of $Mn_{53}Zn_2Al_{45}$. According to Figure 1, a minimum was observed at 5 T. This is due to the DTA peaks include the ε-τ and τ-β phase transformations. Magnetic field promotes the ε-τ phase transformation and suppresses the τ-β phase transformation, resulting in an activation energy has minimum. On the other hand, the activation energy increased with magnetic field at of DTA $Mn_{55}Al_{45}C_2$. This suggests that only the suppression effect of the τ-β phase transition appeared. Thus, considering kinetics, the magnetic field effects are dependent on the substituted elements.

Keywords: *Magnetic fields, Mn-Al, Substitution, (Mn,Zn)-Al, Mn-Al-C*

References:

[1] H. Kono, J. Phys. Soc. Jpn., **13**, 1444-1451 (1958).
[2] R. Kobayashi et al., Mater. Trans., **58**, 1511-1518 (2017).
[3] Y. Mitsui et al., IEEE. Trans. Magn., **55**, 2100704 (2019).

Presenting author Email address: k3579242@kadai.jp

Crystal growth of ferromagnetic MnBi phase by in-magnetic-field liquid-solid reaction of Bi/Mn diffusion couples

Yoshifuru Mitsui[1*], Yukinari Sueyoshi[1], Ryota Kobayashi[1], and Keiichi Koyama[1]

[1]*Graduate School of Science and Engineering, Kagoshima University*

[*] Corresponding e-mail: *mitsui@sci.kagoshima-u.ac.jp*

In-magnetic-field annealing affects magnetocrystalline anisotropy of ferromagnetic phase, resulting in a unique microstructure and crystal growth. Uniaxial crystal growth and aligned structure of ferromagnetic MnBi phases were synthesized by in-magnetic-field solidification or semi-solid MnBi/Bi composite [1-3]. On the other hand, solid-phase reaction of MnBi from Mn and Bi was enhanced and uniaxial oriented MnBi phases were synthesized by magnetic field [4]. Unique crystal growth of MnBi phase is expected because in-magnetic-field affects both kinetics of reaction and microstructure. The influence of magnetic fields on the kinetics of reaction have been evaluated by diffusion couples [5]. Therefore, in this study, in-magnetic-field annealing of Bi/Mn diffusion couples were performed.

In-magnetic-field reaction of Bi/Mn was performed at 573 K for up to 48 h with or without a magnetic field of 5 T. Under this condition, liquid Bi and Mn reacted at Bi/Mn interface. First, the sample temperature was heated to 673 K for 1 h to bond Bi/Mn interface and then cooled to 573 K. The direction of applied magnetic field was perpendicular to the interface. Crystal growth behavior of ferromagnetic MnBi phase at Bi/Mn interface was observed using an electron probe micro analyzer and metallographic microscope.

Microscopic observation revealed that caves were created on the Mn surface and MnBi particles were synthesized at the Bi/Mn interface. Some MnBi grains were observed in Bi area at 0 and 5 T. It is suggested that the synthesized MnBi grain separated from Bi/Mn interface during annealing and flew in Bi liquid. When a magnetic field of 5 T was applied, the elongated MnBi grains were observed at Bi/Mn interface, and the number of caves increased, resulting the rough surface of Mn phase. Consequently, it was found that the in-magnetic-field reaction in Bi/Mn diffusion couple enhanced nucleation site and subsequent uniaxial crystal growth of MnBi phase.

Acknowledgment: This work is partly supported by KAKENHI grant no. 21K18833.

Keywords: magnetic field, diffusion couple, liquid-solid reaction, anisotropic growth

References:

[1] H. Morikawa *et al.*, Mater. Trans. 39 (1998) 814.
[2] Y. Liu *et al.*, Solid State Commun. 138 (2006) 104
[3] C. Lou *et al.*, J. Alloys Compd. 505 (2010) 96.
[4] Y. Mitsui *et al.*, J. Alloys Compd. 615 (2014) 131.
[5] X. Ren, *et al.*, J. Alloys Compd 472 (2009) 525.

Presenting author Email address: mitsui@sci.kagoshima-u.ac.jp

Dynamic response of multilayered multiferroic structures

Sonal Nirwal*[1], Ernian Pan*[1, 2], Chih-Ping Lin[1, 2], and Tran Quoc Kinh[1]

[1]*Department of Civil Engineering, National Yang Ming Chiao Tung University, 1001 Daxue Rd., Hsinchu 300, Taiwan*
[2]*Disaster Prevention and Water Environment Research Center, National Yang Ming Chiao Tung University, 1001 Daxue Rd., Hsinchu 300, Taiwan*

* Corresponding e-mail: *sonal.iitism@gmail.com*

Magneto-electro-elastic (MEE) materials are a specific class of advanced smart materials that simultaneously manifest the co-existence of electric and magnetic fields. This unique combination of properties allows MEE materials to respond to mechanical, electrical, and magnetic stimuli, making them versatile for various applications. In this problem, the response of a three dimensional (3D) multilayered transversally isotropic linear MEE layered half-space induced by dynamic and static deformation (which has been applied horizontally and vertically) is investigated. The Green's function corresponding to the time-harmonic deformations (mechanical and electrical) on the surface of the multilayered structure are derived by using a new and novel Fourier Bessel series (FBS) system of vector function. By the virtue of FBS method, two set of first order ordinary differential equation (i.e., N-type and LM type) are obtained, where these extension coefficient being Love number. In addition, the dual variable and position method (DVP) is taken into account to deal with the multilayered system. Some numerical examples are shown to discuss the influence of load types on the dynamic and static response of the structure.

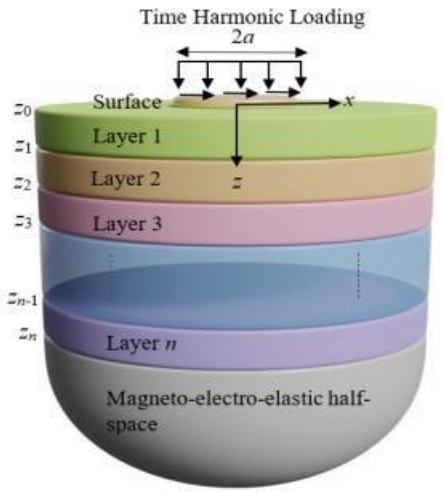


Figure 1. A TI-MEE layered half-space under time-harmonic loads

Keywords: Multiferroics, Multilayers, Love numbers, FBS vectors, DVP method, Dynamics

References:

[1] Wang, H. M., Pan, E., Sangghaleh, A., Wang, R. & Han, X., 2012. Circular loadings on the surface of an anisotropic and magneto-electro-elastic half-space. *Smart Materials and Structures*, **21**(7), 075003….
[2] Guo, J., Chen, J. & Pan, E., 2018. A three-dimensional size-dependent layered model for simply-supported and functionally graded magneto-electro-elastic plates. *Acta Mechanica Solida Sinica*, **31**, 652-671.

Presenting author Email address: sonal.iitism@gmail.com

Up-conversion Photoluminescence in Carbon-based Nanomaterials

Ruth Jeane Soebroto[1,2], Chia-Tse Chang[1], Hung-Yu Pan[1], Hsiu-Ying Huang[1,2] and Chi-Tsu Yuan[1,2*]

[1]*Department of Physics, Chung Yuan Christian University, Taoyuan City, Taiwan*
[2]*Research Center of Semiconductor Materials and Advanced Optics, Taoyuan City, Taiwan*

[*] Corresponding e-mail: *ctyuan@cycu.edu.tw*

Up-conversion photoluminescence (UCPL) is a phenomenon where a material was excited using lower energy photons and emit higher energy photons which is beneficial for various applications in optoelectronics, bioimaging, and optical refrigeration [1]. This phenomenon is commonly found in semiconductor materials and few are found in organic materials. This study will focus in reporting the occurrence of UCPL in carbon-based nanomaterials, mainly focused in graphene quantum dots. The results showed bright orange emission of graphene quantum dots when it was excited using higher energy photons. Moreover, UCPL was detected with anti-Stokes shift of more than 200 milli-electronvolts. This study provides the evidence of UCPL phenomenon in carbon-based nanomaterials.

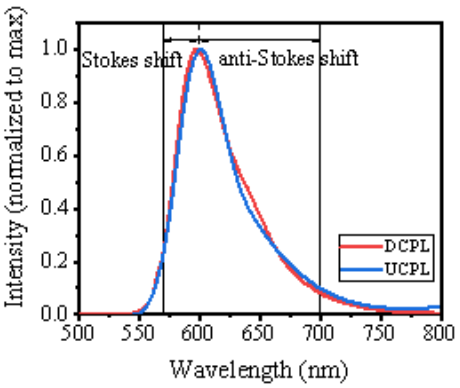


Figure 1. DCPL and UCPL in graphene quantum dots

Keywords: up-conversion photoluminescence, graphene quantum dots

References:

[1] Kohata S, Nakanotani H, Chitose Y, Yasuda T, Tsuchiya Y, Adachi C. Anti-Stokes Luminescence in Multi-Resonance-Type Thermally-Activated Delayed Fluorescence Molecules. Angew Chem Int Ed Engl. 2023 Oct 26;62(44):e202312326. doi: 10.1002/anie.202312326. Epub 2023 Sep 26. PMID: 37726257.

Presenting author Email address: jeane_ruth@yahoo.com

Photo-aligned PAZO Liquid crystal cell writing Geometric phase

Chau Nguyen Hong Minh[1*], Stefan Petrov[1], Vera Marinova[1,2] and Shiuan Huei Lin[1**]

[1] *Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 30010, Taiwan*
[2] *Institute of Optical Materials and Technologies, Bulgarian Academy of Sciences, Sofia, Bulgaria*

* Corresponding e-mail: * krys.ep10@nycu.edu.tw; **lin@nycu.edu.tw

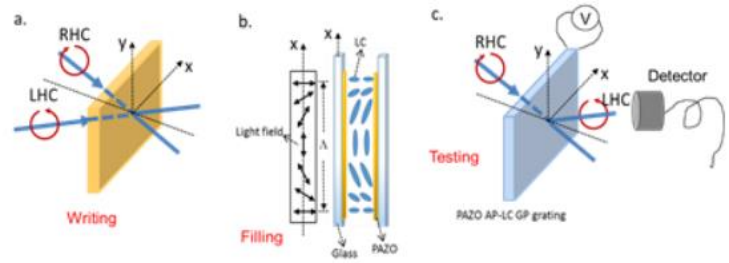


Figure 1. The experimental febrication of LC-beased GP device and testing setup

Optical components like lenses, prisms, and wave plates traditionally alter light fields within dielectric materials, yet their compactness is hindered by size and weight. The recent alternative is the "Geometric Phase (GP)" approach, which utilizes the relationship between phase change and polarization conversion in anisotropic mediums [1-3]. The "geometric phase" is tied to the optical axis orientation angle, making related components flat, physically thin, and resistant to manufacturing tolerances. This innovation, often termed a "diffractive waveplate," enables simultaneous conversion of polarization state and wavefront, presenting diverse photonic applications. The GP effect can be achieved by imposing subwavelength structures on artificial materials like metasurfaces or in naturally birefringent materials. Liquid crystal (LC) materials, with significant natural birefringence, are commonly used in GP optical elements. Photo-aligned LC cells, exhibiting geometric phase proportional to the local optic axis orientation, offer advantages in large-scale fabrication without requiring nanoscale lithography. Leveraging established technologies in the flat-panel display industry, polarization holography emerges as a powerful method for generating diffractive GP LC waveplates. This study shows the implementation of diffractive GP devices on an NLC cell, with the photoinduced polymer using poly [1- [4-(3-carboxy-4-hydroxyphenylazo) benzenesulfonamido]-1,2-ethanediyl, sodium salt] azo-polymer (PAZO) [4], outlining the design, production, and evaluation of GP grating and lens components.

Keywords: Geometric Phase, Polarization holography, Liquid crystal cell, Photoinduced polymer

References:

[1] L. Garza-Soto, …etc. "Wave description of geometric phase," J. Opt. Soc. Am. A 40, 388-396 (2023).
[2] Galvez, Enrique J. "Applications of Geometric Phase in Optics." (2005).
[3] Yeh, P. & Gu, C. Optics of liquid crystal display (Wiley Interscience, New York, 2010).
[4] Nedelchev, Lian, …etc. "Birefringence induced in azopolymer (PAZO) films with different thickness" SPIE 9447 (2015)

Presenting author Email address: krys.sc10@nycu.edu.tw

Solvent-dependent Up-conversion Photoluminescence in Graphene Quantum Dots

Chia-Tse Chang[1], Hung-Yu Pan[1], Irwan Saleh Kurniawan[1], Ruth Jeane Soebroto[1,2], Russel Cruz Sevilla[1,2], Hsiu-Ying Huang[1,2] and Chi-Tsu Yuan[1,2*]

[1]Department of Physics, Chung Yuan Christian University, Taoyuan City, Taiwan
2Research Center for Semiconductor Materials and Advanced Optics, Chung Yuan Christian University, Taoyuan City, Taiwan

[*] Corresponding e-mail: *ctyuan@cycu.edu.tw*

Up-conversion photoluminescence (UCPL) is an optical process in which the electrons from ground state absorb lower energy photon (NIR and/or IR) to excite to the excited state and the electrons will return to the ground state while emitting higher energy photon (UV and/or visible light). In this study, the occurrence of UCPL in graphene quantum dots (GQDs), which is carbon-based nanomaterials was found. It also shows the optical properties variations of GQDs dissolved in solvent with different solvent polarity. According to the findings, it is observed that the occurrence of UCPL is independent with the interaction between GQDs and the surrounding environment. Therefore, this study will reveal the relation of GQDs dissolved in various solvent and their pivotal role in UCPL process.

Figure 1. GQDs dissolved in different solvent

Keywords: Up-conversion photoluminescence, graphene quantum dots

References:

[1] Ye, Z., Lin, X., Wang, N. *et al.* Phonon-assisted up-conversion photoluminescence of quantum dots. *Nat Commun* **12**, 4283 (2021). https://doi.org/10.1038/s41467-021-24560-4

Presenting author Email address: george14014@gmail.com

Optical Properties of Graphene Quantum Dots

Hung-Yu Pan[1], Chia-Tse Chang[1], Russel Cruz Sevilla[1,2] Ruth Jeane Soebroto[1,2], Irwan Saleh Kurniawan[1], Hsiu-Ying Huang[1,2] and Chi-Tsu Yuan[1,2]

[1] *Department of Physics, Chung Yuan Christian University, Taoyuan City, Taiwan*
[2] *Research Center for Semiconductor Materials and Advanced Optics, Chung Yuan Christian University, Taoyuan City, Taiwan*

[*] Corresponding e-mail: *ctyuan@cycu.edu.tw*

Graphene quantum dots (GQDs) are one kind of carbon-based nanomaterials which has low toxicity, high conductivity and exceptional optical properties, including tunable photoluminescence (PL) emission which could be adjusted from blue to red emission depending on the solvent. Therefore, GQDs can be used for numerous applications, such as energy conservation, luminescent solar concentrators, bio-imaging, and bio-sensing. In this study, GQDs were prepared with 1,3,6-trinitropyrene as the precursor, then dissolved in toluene (GQDs@TL). In order to understand GQDs@TL optical properties, several measurements were done. The results show that GQDs@TL has PL emission and excitation peaks at ~595 nm and ~530 nm, respectively, with PL lifetime of ~7.4 ns and PL quantum yield (QY) of ~31%. Therefore, this study will conclude the optical properties of GQDs.

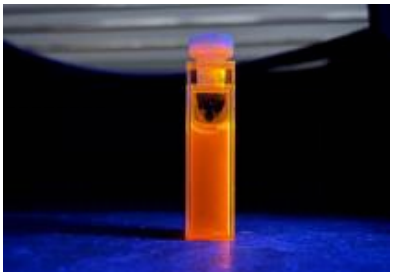


Figure 1. GQDs@TL Under UV light

Keywords: graphene quantum dots, photoluminescence, quantum yield

References:

[1] J. Phys. Chem. C 2015, 119, 9, 4983–4989 Publication Date: January 15, 2015 https://doi.org/10.1021/jp506969r

Presenting author Email address: bill860823@gmail.com

Investigation of Role of Bismuth-Dopings in the Improvement of Stability of α-phase $FAPbI_3$.

Takeshi Amma[1], Tomoyuki Yamamoto[1,*]

[1] *Faculty of Science and Engineering, Waseda University, Tokyo 169-8555, Japan*

[*] Corresponding Author e-mail: *tymmt@waseda.jp*

Perovskite solar cells (PSCs) proposed in 2009 [1] have been actively studied, in which methylammonium (MA) lead triiodide, $MAPbI_3$, has been maily used for the light absorption layer. However its lifetime is short, then various types of materials are now being considered to replace $MAPbI_3$ [2]. Among them, one of the good candidates is formamidinium (FA) lead triiodide, $FAPbI_3$, with superior conversion permanence, heat resistance than $MAPbI_3$. However, the stable phase of $FAPbI_3$ at room temperature is the α-phase, which is not good for light absortion layer and the suitable phase for light absorbing, α-phase, is not stable at room temperature. As a trigger of phase transition, perovskite reacts with water in the air, which leads to decomposition [3]. In a previous study, it has been reported that Bi doping improved the stability of α-phase of $FAPbI_3$ [4], which was explained that the Bi doping improved a crystal adhesion, preventing penetration of moisture from the air. However, the role of Bi doping in an atomic scale has not yet been understood well.

In this study, Bi-doped $FAPbI_3$ was synthesized with a spin coating method and several analytical measurements were carried out to investigate the role of Bi-doping in the improvement of α-phase stability of $FAPbI_3$. Observed X-ray diffraction (XRD) patterns of $FAPbI_3$ films are shown in Fig. 1, which suggest phase transition occurred rapidly within a few hours in non Bi-doped $FAPbI_3$, whereas slower transition can be seen in Bi-doped one. In addition to the phase identification, lattice constants of □-phase were determined by the XRD results, which showed contraction of the lattice constants by Bi-doping. Considering the ionic radii, Bi ions were likely to be substituted at Pb^{2+} site. Scanning electron microscope observation of the sample surface showed that the crystal adhesion was improved and the surface roughness was reduced by Bi-doping. X-ray photoelectron measurements were also performed to determine valence states of Bi ions, which suggested two states exists in the sample.

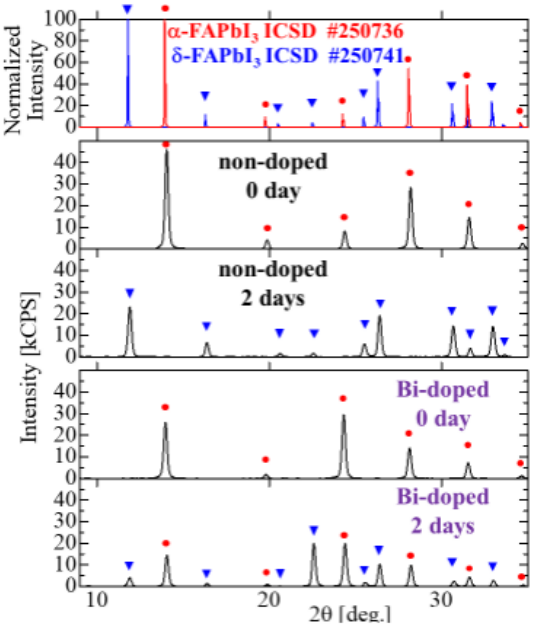


Figure 1. XRD patterns of non-doped and Bi-doped $FAPbI_3$ films over time

Keywords: Perovskite Solar Cells, $FAPbI_3$, phase transition, Bismuth, crystal adhension

References:

[1] A. Kojima et al., J. Am. Chem. Soc., 131, 6050-6051 (2009)
[2] G. E. Eperon et al., Energy Environ. Sci., 7, 982-988 (2014)
[3] B. Philippe et al., Chem. Mater., 27, 1720-1731 (2015)
[4] Y. Hu et al., J. Mater. Chem. *A*, 5, 25258-25265 (2017)

Presenting author Email address: takeshium@toki.waseda.jp

Effect of Alkaline-Metals Co-Doping on the Up-Conversion Luminescence Intensity of Er-Doped $CaMoO_4$

Tomoki Koikawa[1], Tomoyuki Yamamoto[1,*]

[1]*Faculty of Science and Engineering, Waseda University, Tokyo, 169-8555, Japan*

[*] Corresponding e-mail: *tymmt@waseda.jp*

Up-conversion (UC) phosphors, which can convert lower energy photons to higher energy ones, have been widely investigated, in which several types of oxides with rare-earth ions dopings such as Y_2O_3:Er,Yb [1] and $CaWO_4$:Er [2] were reported as efficient UC phosphors with long life time. These materials also have potential application for the enhancement of the efficienly of the solar cells [3]. It was reported that UC luminescence intensity can be enhanced by a co-doping of alkaline-metals in $CaTiO_3$:Er [4].

In this study, influence of alkaline-metals co-dopings in $CaMoO_4$:Er on its UC luminescence intensity has been investigated. Samples were prepared using a solid-state reaction method. Crystal structure analysis and phase identification were performed using X-ray diffraction (XRD) measurements, and electronic states were evaluated using UV-vis measurements. Thermo gravimetry and differential thermo analysis (TG-DTA) measurements were also carried out to see the reaction during the thermal treatments. UC luminescence measurements were performed at room temperature by 980 nm laser irradiation.

Figure 1 shows the UC luminescence spectra of non-doped and Na co-doped $CaMoO_4$:Er, which suggest significant enahancement of UC luminescence is acheived by Na co-doping in $CaMoO_4$:Er.

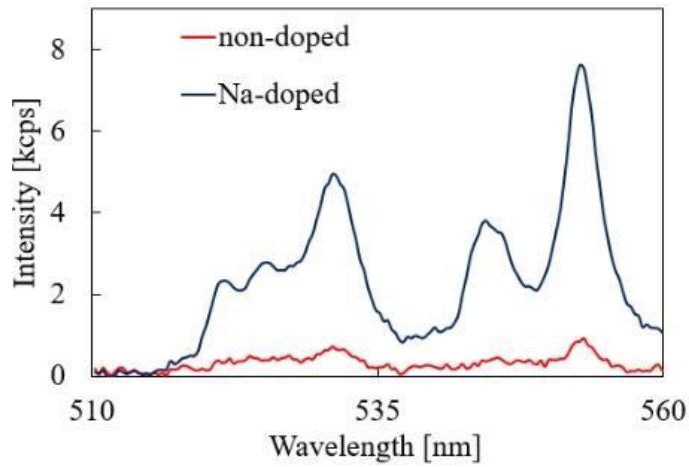


Figure 1. Up-conversion emission spectra of non-doped and Na-doped $CaMoO_4$:Er excited by 980 nm

Keywords: Up-conversion(UC) Phosphor , Solid-state reaction , Sheelite structure , Alkaline-metals

References:

[1] H. Guo et al., Opt. Mater., 31 (2009) 583-589.
[2] X. Che et al., Opt. Mater., 58 (2016) 449-453.
[3] Y. Sha et al., J. Nanomater., 5 (2015) 1782-1809.
[4] S. J. Mofo et al., Adv. Mater., 25 (2023) 89-116.

Presenting author Email address: koi-tomo0929@asagi.waseda.jp

Evaluation of α-Phase Stabilization of $FACsPbI_3$ by Ethylammonium Addition

Ayana Kishi[1], Tomoyuki Yamamoto[1,*]

[1]*Faculty of Science and Engineering, Waseda University, Shinjuku, Tokyo 169-8555, Japan*

[*] Corresponding e-mail: *tymmt@waseda.jp*

Perovskite solar cells (PSCs) renowned for their low production costs and mechanical flexibility, stand at the forefront of photovoltaic research and are going to be used in practical use, though there remains to be overcome their low durability. The integration of mixed-cation approaches has notably enhanced the operational stability and overall efficiency of these PSCs [1]. Prior research suggested that the incorporation of ethylammonium (EA) into $MAPbI_3$ matrices improves its stability [2].

In this study, $FACsPbI_3$ perovskite films were fabricated with and without EA using a spin coating method. Observed X-ray diffraction (XRD) patterns of the films are presented in Fig. 1, which reveals the retention of the desirable photo active □-phase by EA addition, implying an additive-mediated stabilization. An anomalous peak at approximately 2□□= 8 degrees indicated by star symbol in Fig. 1, which is absent in the control samples, was shown in EA added $FACsPbI_3$. The consistent presence of this peak suggests a structural expression specific to EA integration. This feature may allude to the formation of intermediate phases or a modified crystal orientation, which could be instrumental in impeding phase transitions. In addition, scanning electron microscope and other analyses were also conducted for the further understandings of the influence of EA additions in $FACsPbI_3$.

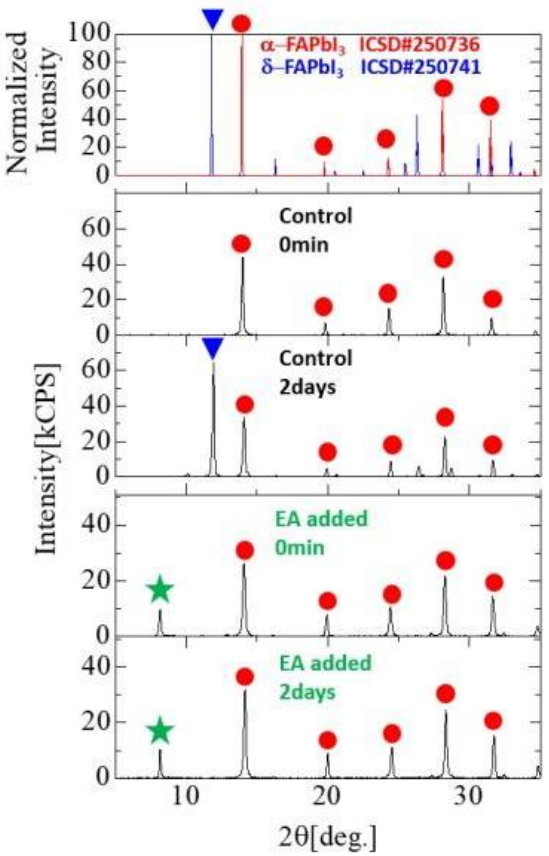


Fig. 1 XRD patterns of control and EA added $FACsPbI_3$

Keywords: Perovskite Solar Cells, Ethylammonium, $FACsPbI_3$, Phase Transition Inhibition

References:

[1] M. Saliba et al., Energy Environ. Sci., 9, 1989–1997 (2016).
[2] H.-L. Hsu et al., J. Mater. Chem. A, 3, 9271–9277 (2015).

Presenting author Email address: ayana.kishi@toki.waseda.jp

Influence of Nicotinamide Addition in FAPbI3 on Its Defect Passivation

Zhang Kaiqi[1], Tomoyuki Yamamoto[1, *]

[1] *Faculty of Science and Engineering, Waseda University, Shinjuku, Tokyo 169-8555, Japan*

[*] Corresponding e-mail : *tymmt@waseda.jp*

Perovskite solar cells (PSCs) have rapidly gained widespread attention [1] due to its relatively low fabrication cost, facile synthesis, high optical absorption coefficient, and excellent charge transfer characteristics. Among PSCs, formamidinium (FA)-based PSCs are regarded as one of the most promising materials for solar energy conversion, owing to their outstanding thermal stability and narrower bandgap than those of conventional methylammonium (MA)-based PSCs. Nevertheless, despite significant progress in this field, challenges persist in terms of stability and long-term usability. Passivation through the suppression of surface defects in thin films is considered as an effective strategy to address these issues [2].

In this study, we introduced the nicotinamide (NTM) addition to modify the precursor solution for the preparation of modified perovskite thin films [3]. Figure 1 shows the X-ray diffraction (XRD) patterns of films with and without NTM additives. It is noteworthy that the stability of the films improved with the addition of NTM. Initially, the pure $FAPbI_3$ films almost completely transferred to d-phase within a first hour, whereas the film with NTM maintained a relatively good state even after 2 hours, indicating a noticeable positive impact on the stability of the film. Additionally, we conducted in-depth studies using scanning electron microscopy and Fourier-transform infrared spectroscopy to understand the influence of NTM on the crystalline stability.

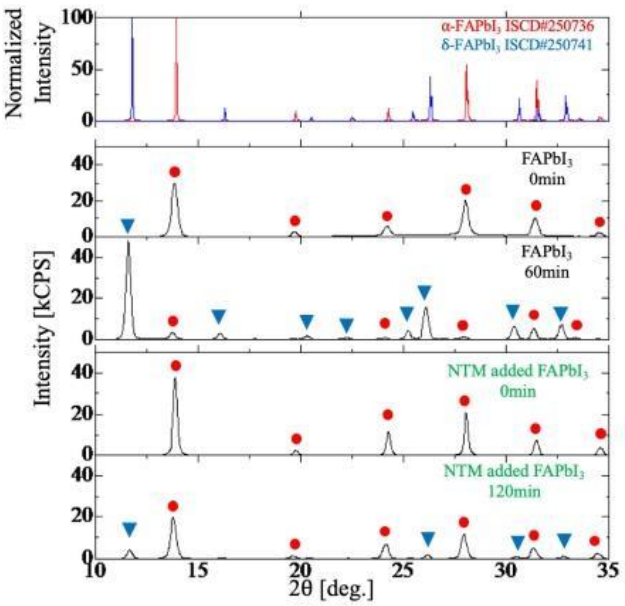


Figure 1. XRD patterns of films with and without NTM additives over time

Keywords: Perovskite Solar Cells, $FAPbI_3$, Crystalline Stability, Nicotinamide

References:

[1] Kim, M. et al., Science, 375: 302–306 (2022).
[2] Dejun, H. et al., Sci. China Mater., 66(4): 1313–1322 (2023).
[3] Zhu M. et al., ACS Appl. Mater. Interface, 52500-52508 (2020).

Presenting author Email address: zhangkaiqi@toki.waseda.jp

Interface Modification with Guanidinium Chloride in $FAPbI_3$ Based Perovskite Solar Cells

Li Shuai[1], Tomoyuki Yamamoto[1,*]

[1] *Faculty of Science and Engineering, Waseda University, Shinjuku, Tokyo 169-8555, Japan*

[*] Corresponding e-mail : *tymmt@waseda.jp*

Perovskite solar cells have emerged as a frontrunner in the renewable energy sector due to their exceptional photovoltaic performance and cost-effectiveness. However, long-term stability remains a pivotal challenge to be addressed, with the interface between the light-absorbing layer and other functional layers being a crucial determinant. The electron transport layer situated at the base is particularly critical as poor interface quality with the light-absorbing layer, which leads to carrier recombination and adversely affect the crystallinity of the overlaying absorber [1].

In this study, we have introduced guanidinium chloride (GA) modification layer [2] between the SnO_2 electron transport and the $FAPbI_3$ light-absorbing layers [3]. The experimental procedure involved sequentially depositing SnO_2, GA, and $FAPbI_3$ layers on cleaned glass substrates using the spin-coating method. Samples without the GA layer introduction were also prepared for comparison.

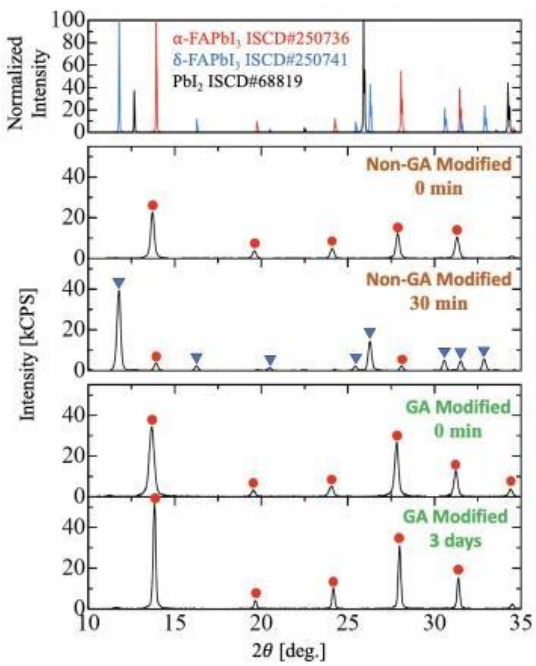


Figure 1. XRD patterns of $FAPbI_3$ with and without GA modification over time

The X-ray diffraction (XRD) patterns of the synthesized films with and without GA modifications are shown in Fig.1, where the stability of the light-absorbing $FAPbI_3$ layer with GA modification is markedly enhanced from an initial 30 minutes to an impressive duration of 3 days, accompanied by an enhancement in peak intensities. Scanning Electron Microscope analyses further confirmed a notable reduction in surface voids and cracks post-modification.

Keywords: Perovskite Solar Cells, Interface Modification, Crystalline Stability, guanidinium chloride

References:

[1] Hu, X. et al., J. Power Sources 513, 230549 (2021).
[2] Yu, M. et al., RSC Adv. 10, 19513–19520 (2020).
[3] Targhi, F. F., Jalili, Y. S. & Kanjouri, F., Res. Phys. 10, 616–627 (2018).

Presenting author Email address: lishuai@fuji.waseda.jp

Using AI drawing software scan H&E-stained rat tissue sections and harnessing AI software objectively assess student hand drawings.

Chih-Yu Hsieh[1,2], Farrah P. Salmanida[1,2] and Ko-Tung Chang[1,2,3]

[1]*Department of Biological Science and Technology, National Pingtung University of Science and Technology, Pingtung 91201, Taiwan*
[2]*Research Center for Animal Biologics, National Pingtung University of Science and Technology, Pingtung 91201, Taiwan*
[3]*Flow Cytometry Center, Precision Instruments Center, National Pingtung University of Science and Technology, Pingtung 91201, Taiwan*

* Corresponding e-mail: kotungc@mail.npust.edu.tw

The integration of artificial intelligence (AI) into pathology has significantly diminished the likelihood of human error and streamlined the time spent on predicting or diagnosing diseases through imaging analysis. The application of imaging analysis exceeds healthcare professionals, extending to students in academia who must master and visually depict various tissue structures through hand-drawn illustrations. Nevertheless, the depiction of a particular cell structure by one student may differ from another student's interpretation based on their individual perception of objects. Therefore, it becomes crucial to establish a standardized criterion to ensure fair and unbiased assessments of their drawings. Our goal is to convert Hematoxylin and Eosin stained histology sections into an AI-generated image, aiming for a visual result closely resembling a hand-drawn illustration.

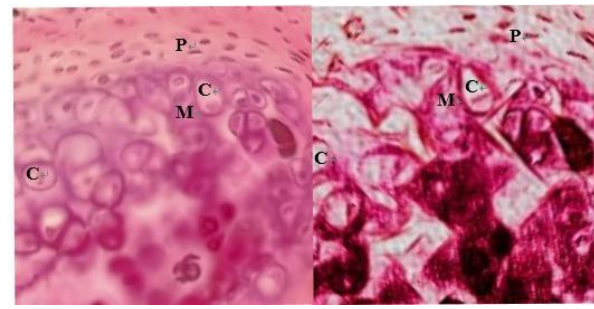


Figure 1. Compared with real H&E stain and AI Image in Hyaline cartilage.

(a) Real H&E stain (b) AI Image. Comparing a and b, you can see the same position as in a, and you can also clearly see perichondrium (P), chondrocytes (C), and matrix (M) in (b)

Following this, we intend to integrate our generated image into an Image Management System (IMS) and Laboratory Information System (LIS) to systematically store information for the pathology labeling of a tissue section derived from a hand-drawn illustration. Looking ahead, our vision involves harnessing AI software, like QuPath, to objectively assess student hand drawings, ensuring a fair and standardized assessment of their quality. Through these advancements, we aim to elevate the quality of students' learning through the practice of pen drawing.

***Keywords*:** Tissue section, Image Management System (IMS),AI Imagie, Hematoxylin and Eosin stain

References:

[1] Anthony L. Mescher.(2009).*Junqueira's Basic Histology :*TEXT & ATLAS(Sixteeth Edition). McGraw Hill / Medical.ISBN 978-1-264-26928-0

[2] Schüffler, P., Steiger, K., & Weichert, W. (2023). How to use AI in pathology. *Genes, chromosomes & cancer*, *62*(9), 564–567.

Presenting author Email address: yuyufindyou@gmail.com

Fabrication and Characterization of Implant Confined VCSEL with Dielectric DBR Mirror.

Yu-Lin Zhou[1*], Ray-Hua Horng[1]

[1]*Institute of Electronics, National Yang Ming Chiao Tung University, Hsinchu, 30010, Taiwan*

* Corresponding e-mail: *yulin.ee11@nycu.edu.tw*

To simplify the thermal oxidation process of the conditional vertical cavity surface emitting laser (VCSEL), an ion implant confined VCSEL was fabricated. The oxygen ion was used to oxidize the current confined region, which can increase the current density that flow into the multi-quantum well. This device was used the SiOx/Si as the distributed Bragg reflector (DBR), and the multi-layer was grown by the sputter which can save the cost and the processing time from the conditional DBR that grew by the metal organic chemical vapor deposition system (MOCVD).

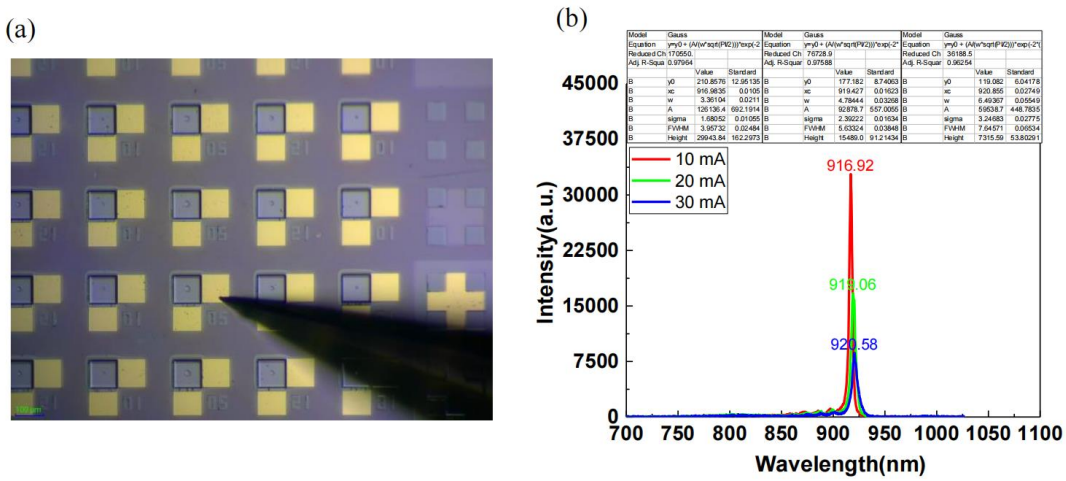


Figure 1. (a) the top view of the implant confined VCSEL (b) the emmision spectrum and the FWHM of the implant confined VCSEL.

Keywords: ion implantation, dielectric DBR

References:

[1] Takehiko Tawara, Hideki Gotoh, Tetsuya Akasaka, Naoki Kobayashi, Tadashi Saitoh, Low-threshold lasing of InGaN vertical-cavity surface-emitting lasers with dielectric distributed Bragg reflectors, Appl. Phys. Lett. 83, 830–832 (2003).

[2] Decai Sun, Wenjun Fan, Peter Kner, Julien Boucart, Member, IEEE, Takeo Kageyama, Rajiv Pathak, Dongxu Zhang, and Wupen Yuen, Sub-mA Threshold 1.5-um VCSELs With Epitaxial and Dielectric DBR Mirrors, IEEE Photonic technology letters, vol.15, no.12, 2003

Presenting author Email address: yulin.ee11@nycu.edu.tw

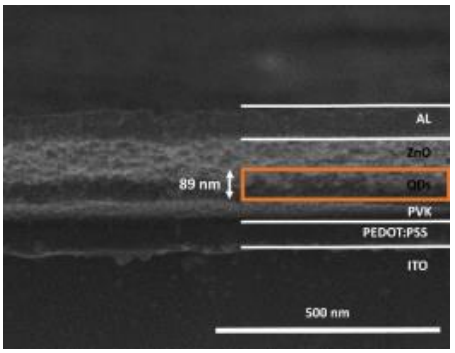
Develop Electrospray for Quantum Dot Light- Emitting Diode Fabrication

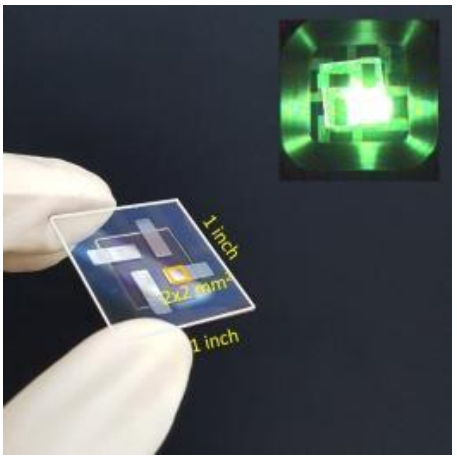
Tuan Canh Nguyen[1*], Woon-Seop Choi[2]

[1]*Faculty of Engineering Physics and Nanotechnology, VNU University of Engineering and Technology (VNU-UET)*
[2]*School of Electronics and Display Engineering, Hoseo University, Asan 31499, Chungnam, Korea*

[*] Corresponding e-mail: canhnt@vnu.edu.vn

Herein, we present a novel EHD electrospray coating system designed for the continuous fabrication of large-area quantum dot-QD thin films, contributing to high-performance LED devices. Our system allows systematic control of QD droplet size by establishing a stable EHD electrospray mode through the mixture of red QDs in n-butanol and n-hexane solvent. This mode proves to be a crucial factor for forming of large and smooth QD thin films. Additionally, the minimal consumption of QD materials during the layer-by-layer deposition process using our unique coating system is noteworthy. Furthermore, we explore and optimize the electrospray of PEDOT:PSS solution by adjusting EHD parameters and incorporating various solvents into the supply solution. This optimization process determines the final quality of the printed features. Employing the optimized ink formulations (PEDOT:PSS: Water: IPA: Triton X-100), we successfully electrospray films with precisely controllable thickness, scalability, and extremely low surface roughness (R_a of 0.55 nm). As a result, we achieve an RMS of 0.0308 µm for the electrosprayed QD thin film, with a maximum luminance of 12.082 cd m^{-2}, a maximum current efficiency of nearly 4.0 cd A^{-1}, and a maximum EQE of 1.86% for Red QD-LEDs with a regular structure. Notably, the inverted Green QDLED device (ITO/ZnO/QDs/PVK/Electrosprayed-PEDOT:PSS/Al/Encap) exhibits outstanding performance with a maximum luminance of 5692 cd m^{-2}, a current density of 3.76 cd A^{-1}, and an EQE of 2.22%.





Keywords: *quantum dots, electrospray, Red QDLED, Inverted Green QDLED,*

References:

[1] Nguyen, T. C.; Can, T. T. T.; Choi, W. S. *Scientific Reports*, **2019**, 9 (1), 1-9
[2] Park, S. H.; Kim, J.; Park, C. E.; Lee, J.; Lee, H. S.; Lime, S.; Kim, S. H.; *Org. Electron*. 38, **2016**, 48–54.
[3] Jianga, Y.; Wub, C.; Li, L.; Wang, K.; Tao, Z.; Gao, F. ; Cheng, W. ; Cheng, J. ; Zhao, X. Y. ; Priya, S.; Deng, W. Nano Energy, **2018**, 53, 440–448

Presenting author Email address: canhnt@vnu.edu.vn, nguyentuancanh1987@gmail.com

Temperature dependent ultrafast dynamics of topological material $SrCd_2Sb_2$

Hung-Viet Khuc[1*], Jiun-Haw Chu[3], Cheng-Chien Chen[7], Yu-Sheng Kuo[1], Wen-Yen Tzeng[2], Chien-Ming Tu[2], Chih-Wei Luo[2,3,4,5,6], Jiunn-Yuan Lin[1]

1Institute of Physics, National Yang Ming Chiao Tung University, Hsinchu 30010, Taiwan
2Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 30010, Taiwan
3Department of Physics, University of Washington, Seattle, Washington 98195, USA
4Taiwan Consortium of Emergent Crystalline Materials (TCECM), National Science and Technology Council, Taiwan.
5Institute of Physics and Center for Emergent Functional Matter Science, National Yang Ming Chiao Tung University, Hsinchu, 30010, Taiwan.
6National Synchrotron Radiation Research Center, Hsinchu, 30076, Taiwan.
7University of Alabama at Birmingham, Birmingham, Alabama, US
[*] Corresponding e-mail*:* *ago@nycu.edu.tw*

Topological materials (TMs) have attracted much attention for their potential to reveal fascinating physics and to pave the way for various applications like optoelectronics, spintronics and quantum computing [1-3]. Topological insulators (TIs), one kind of TMs, exhibit conducting surface states protected by time-reversal symmetry, and the gapless surface states are resulted from band inversion as well as spin-orbit coupling. With density functional theory calculations, J. M. DeStefano *et al.*[4] showed that $SrCd_2As_2$ is a narrow band gap semiconductor under ambient conditions. A negative pressure could reduce the band gap and induce the band inversion in $SrCd_2As_2$. Alloying Sb at the As site is the most promising, because of both the larger atomic size and less electronegativity of Sb than As, which will to induce band inversion [4]. The predictions of J. M. DeStefano *et al.*[4] were interesting, however the experimental results of topological $SrCd_2Sb_2$ crystal have not been reported yet. In this study, we report on the ultrafast carrier dynamics of TM $SrCd_2Sb_2$ single crystals by two-color optical pump-optical probe (OP-OP) technique with 400-nm pulses for pump beam and 800-nm pulses for probe beam. The dependence of transient reflectivity ($\Delta R/R$) of the probe pulses on time delay was recorded for various temperatures. The $\Delta R/R$ curve from 2 K to 300 K will be expected to shows the change from negative to positive signal for the decreased band gap as the same way of the chemical substitution of Sb on As lattice site of the topological critical material $SrCd_2As_2$. Analysing ultrafast carrier dynamics will provide information of electron-electron scattering and electron-phonon coupling. In addition, a magnetic field up to 6 T was applied to the c-axis of the sample to study the effect of magnetic field on the OP-OP measurements in the temperature range of 2-30 K. The detailed analysis of these results will provide a deeper understanding about band structure of $SrCd_2Sb_2$ single crystals.

Keywords: Topological materials, ultrafast carrier dynamics.

References:

[1] J. E. Moore, "The birth of topological insulators," *Nature*, vol. 464, no. 7286, pp. 194-198, 2010/03/01 2010, doi: 10.1038/nature08916.
[2] C. W. Luo et al., "Snapshots of Dirac Fermions near the Dirac Point in Topological Insulators," Nano Letters, vol. 13, no. 12, pp. 5797-5802, 2013/12/11 2013, doi: 10.1021/nl4021842.
[3] C.-M. Tu et al., "Manifestation of a Second Dirac Surface State and Bulk Bands in THz Radiation from Topological Insulators," Scientific Reports, vol. 5, no. 1, p. 14128, 2015/09/15 2015, doi: 10.1038/srep14128.
[4] J. M. DeStefano and L.-L. Wang, "Pressure effect on band inversion in $AECd_2As_2$ (*AE*=Ca, Sr, Ba)," *Physical Review B*, vol. 103, no. 11, p. 115207, 03/25/ 2021, doi: 10.1103/PhysRevB.103.115207.

Presenting author Email address: hungvietdhsptn@gmail.com

Pressure effect on unidirectional magnetoresistance in heavy metal/ferromagnetic bilayer

Riku Iimori[1*], Teppei Kimura[1], Taishiro Yamazaki[1], Kazmasa Yamada[1], Akihiro Mitsuda[1], and Takashi Kimura[1]

[1]*Department of Physics, Kyushu University, 744 Motooka, Fukuoka, 819-0395, Japan*

[*] Corresponding e-mail: *iimori.riku@phys.kyushu-u.ac.jp*

Recently, a heavy metal (HM)/ferromagnet (FM) bilayer has been paid considerable attention from the fundamental and technological view points. The HM/FM interface is known to exhibit a novel asymmetric spin-dependent scattering, namely unidirectional magnetoresistance (UMR) [1]. Since the magnetization direction can be indentified by using the UMR, the enhancement of the UMR ratio could be a key for developing next-generation spin-based electric devices. On the other hand, recently, we have shown that the pressure application to the HM/FM interface modulates the interfacial spin mixing conductance. Similarly, the UMR in the HM/FM bilayers is expected to be tuned by the application of the pressure. In the present study, we experimentally investigate the pressure effect on the UMR in the Pt/NiFe bilayer.

To investigate the pressure dependence of the UMR, we used a hybrid piston-cylinder-type high-pressure cell consisting of NiCrAl alloy (inner cylinder) and CuBe alloy (outer cylinder) as schematically shown in Fig. 1(a). As a sample for the magnetoresistance measurements, we have prepared Pt(5 nm)/NiFe(5 nm) film on a SiO_2/Si substrate by using a magnetron sputtering system as shown in the inset of Fig. 1(b). The sample has been patterned into a Wheatstone bridge shape in order to extract the asymmetric component of the magnetoresistance. The observed asymmetric resistance ΔR_{asym} spectra show perfectly asymmetric as shown in Fig. 1(b). Figure 1(c) shows the pressure dependence of the ΔR_{asym}. It should be noted that the ΔR_{asym} is enhanced with increasing the pressure. As possible origins, the enhancement can be induced by the modulation of the spin mixing conductance [2] or thermal effects including the anomalous Nernst effect. The detailed results and the microscopic origin will be presented at the conference.

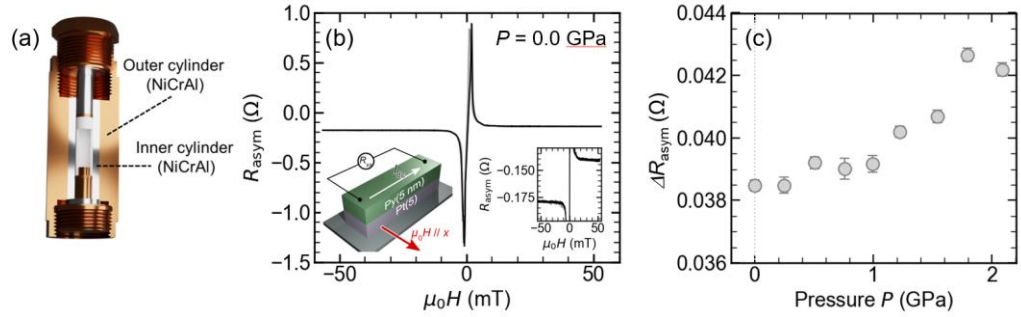


Figure 1. (a) Schematic illustration of the hybrid piston-cylinder-type high-pressure cell. (b) Asymmetric resistance R_{asym} as a function of the magnetic field H for the Pt/NiFe(Py) bilayer. (c) Pressure P dependence of ΔR_{asym}

Keywords: Pressure effect, magnetoresistance, anomalous Nernst effect, spin Hall effect

References:

[1] C. Avci *et al*., *Nature Phys* **11**, 570-575 (2015).
[2] R. Iimori *et al*., *IEEE Trans. Magn.* **59**, no. 11, pp. 1-5 (2023).

Presenting author Email address: iimori.riku@phys.kyushu-u.ac.jp

Electrical modulation of interfacial spin-charge conversion in CoFeB/Pt bilayer on PMN-PT substrate

H. Hitotsukabuto*, R. Iimori, S. Obinata, K. Yamada and T. Kimura
Department of Physics, Kyushu University, 744 Nishi-ku Fukuoka,819-0395, Japan
* Corresponding e-mail: *hitotsukabuto.hiroto@phys.kyushu-u.ac.jp*

The control of physical properties by means of the electric fields is a powerful attention in recent years. Particularly, the manipulation of the magnetization by electrical means with low power consumption is recognized as a key technique for the development of future spintronic devices. Especially, the voltage control of the magnetization has attracted considerable attention owing to its lower power consumption than the current-driven manipulation with the significant Joule heating. Multiferroic heterostructures combining ferromagnetic and ferroelectric materials with the interface magneto-electric (ME) coupling, namely interface multiferroic systems, are promising approach toward the efficient voltage control of the magnetism. The mechanism of voltage-controlled magnetization is mainly due to the strain from the ferroelectric substrate. In addition to the strain effect, other interface interactions such as the charge modulation and spin-orbit interaction are known to contribute the control of the magnetization. The proper combination of these interactions is expected to yield the efficient electrical manipulation of the magnetization [1]. In order to explore efficient electrical control of the spintronic systems, we focus on multi-layered structures consiting of ferromagnetic/ heavy metal/ ferroelectric materials (FM/HM/FE). These structures can be expected to have significant modulation effects of the magneto-tranport properties in FM/HM bilayer films through strain-mediated ME coupling. In the present study, we explore the efficient control of spin-charge interconversion by using the electric field.

We have fabricated CoFeB/Pt bilayer films on (100)-oriented $0.7Pb(Mg_{1/3}Nb_{2/3})O_3$ - $0.3PbTiO_3$ (PMN-PT) substrates using a DC magnetron sputtering system. Fig. 1(a) shows the DC voltage spectra due to the dynamical spin injection with the magnetic field at □ = 45 degree under the various electric field. The inset is a schematic diagram of side gating. It can be found that the V_{DC} peak is strongly dependent on the electric field. Furthermore, we analyze the spectra by separating as a sum of symmetric and anti-symmetric Lorentz functions. Fig. 1(b) shows the electric field dependence of the symmetric Lorentz component of V_{DC}. The V_{sym} shows both the PMN-PT strain curve and decreasing functional characteristics. This result suggests that the spin Hall angle in the Pt layer and/or the mixing conductance for CoFeB/Pt interface is modulated by the piezoelectric/electrostrictive behavior of PMN-PT and the charge transfer effect [2, 3]. Based on the systematic measurements such as angular dependence and transport properties, we will discuss the mechanism for the modulation of spin-charge conversion.

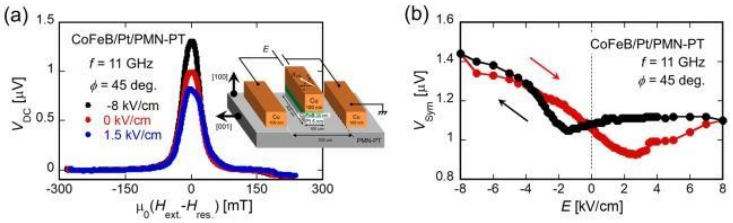


Figure 1. (a) V_{DC} spectra under the magnetic field at f = 45 degree for various electric field, and a schematic of the sample structure(inset). (b) Electric field dependence of the amplitude of the symmetric component V_{sym}.

Keywords: electric field effect, spin-orbit interaction, spin-charge conversion, dynamical spin injection

References:

[1] Song, Cheng, et al. Prog. Mater. Sci. 87 (2017): 33-82.
[2] R Iimori, et al. Appl. Phys. Express.15, 033003(2022).
[3] L. Liang, et al. Sci. Adv. 4 eaar2030, (2018).

Presenting author Email address : hitotsukabuto.hiroto@phys.kyus-u-ac.jp

Exploring Griffith's Phase and re-entrant Spin Glass state of $CuMn_{1.8}Fe_{0.2}O_4$ Spinel: Insights from Synchrotron Spectroscopy

Surajit Ghosh[1], Chia-Hao Hsu,[1] Kuan Hung Chen,[1] Wei-Xuan Lin,[1] Sambhu Charan Das,[1] Yu-Hui Liang,[1] Wei-Tin Chen,[2] Hong Ji Lin,[3] Jeng-Lung Chen,[3] Chih-Wen Pao,[3] Ting-Shan Chan,[3] Jyh-Fu Lee,[3] Chao-Hung Du[1], Way-Faung Pong [1,*]

[1]*Department of Physics, Tamkang University, Tamsui 251, Taiwan*

[2]*Center for Condensed Matter Sciences, National Taiwan University, Taipei 10617, Taiwan*

[3]*National Synchrotron Radiation Research Center, Hsinchu 300, Taiwan*

[*] Corresponding e-mail: *wfpong@mail.tku.edu.tw*

Spinel structures (AB_2O_4) exhibit diverse physical properties influenced by the specific atoms occupying the tetrahedral and octahedral sites at A- and B-sites, respectively, within the unit cell. This research delves into the magnetic characteristics of $CuMn_{1.8}Fe_{0.2}O_4$, elucidating the interplay of local electronic, atomic, and crystal structures through synchrotron radiation-based spectroscopic techniques. Single-phase of the samples was established via in-house X-ray diffraction. The investigation revealed a Griffith's phase and a low-temperature reentrant spin glass state in the structure, as evidenced by zero-field-cooled (ZFC) and field-cooled (FC) magnetization studies at low temperatures. The glassy state was further analyzed by AC susceptibility measurements at various frequencies and magnetic fields. The multivalence state of Mn ions within the structures was confirmed through $L_{3,2}$-edge X-ray absorption studies. At low temperatures, X-ray magnetic circular dichroism (XMCD) demonstrated the ordered state of Mn spins, contributing to long-range order. The glassy state's origin could be attributed to frustration among different Mn spins, while the Griffith's phase could be explained by the dilution of Mn spins with Fe spins.

Keywords: Spinel Structure, Griffith's phase, Spin Glass, XMCD

Presenting author Email address: surajitghosh.15@gmail.com

Helicity-dependent Terahertz Emission Spectroscopy of Topological Material $EuCd_2As_2$ Single Crystals

Xin-Yun Chang[1*], Yan-Cheng Ko[2], Ying-Kuan Ko[1], Yi-Cheng Cheng[1], Jiun-Haw Chu[3], Cheng-Chien Chen[4], Chien-Ming Tu[1], Jiunn-Yuan Lin[2], Chih-Wei Luo[1]

[1]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu, Taiwan*
[2]*Institute of Physics, National Yang Ming Chiao Tung University, Hsinchu, Taiwan*
[3]*Department of Physics, University of Washington, Seattle, WA, USA*
[4]*Department of Physics, University of Alabama at Birmingham, Birmingham, AL, USA*

* Corresponding email: *abc25956021.sc11@nycu.edu.tw*

We report on terahertz radiation of topological material EuCd2As2 single crystals under ultrafast optical excitation with different helicity. By time domain decomposition and recombination, circular photogalvanic effect signal originated from spin-polarized currents were obtained. By changing the incident angle, the circular photogalvanic effect became significant at large incident angle. This phenomenon indicates that the circular photgalvanic effect is the results from two dimensional electronic system. In low temperature experiment, we observed significant enhancement on the amplitude of THz radiation. The details of the experimental results will be shown in the poster.

Keywords: Terahertz emission, spin-polarized photocurrent, topological material

References:

[1] N. P. Armitage, et al," Weyl and Dirac semimetals in three-dimensional solids", Rev. Mod. Phys. 90. 015001 (2018)
[2] Yuto Kinoshita, et al," Terahertz radiation by subpicosecond spin-polarized photocurrent originating from Dirac electrons in a Rashba-type polar semiconductor", Phys. Rev. B 97. 161104 (2018)
[3] J.-Z. Ma, S. M. Nie, C. J. Yi, et al., "Spin fluctuation induced Weyl semimetal state in the paramagnetic phase of $EuCd_2As_2$" Science advances, vol. 5, no. 7, eaaw4718 (2019)

Presenting author Email address: abc25956021.sc11@nycu.edu.tw

Computational Study of Aptamer – Botulinum Bindings for Optimization and Design of Biosensor for Detection of Botulinum Neurotoxin

Ly Nguyen Hai[1, 2], Quynh Luu Manh[3], Viet Bac T. Phung[4], Toan T. Nguyen[2,3*]
[1]*Digital Materials Science laboratory, Center for Environmental Intelligence (VinUniversity, Hanoi 100000, Vietnam)*
[2]*Key Laboratory for Multiscale Simulation of Complex Systems – VNU Hanoi University of Science -Vietnam National University, (334 Nguyen Trai, Thanh Xuan, Hanoi 11400, Vietnam)*
[3]*Faculty of Physics – University of Science - Vietnam National University (334 Nguyen Trai, Thanh Xuan, Hanoi 11400, Vietnam)*
[4] *College of Engineering & Computer (VinUniversity, Hanoi 100000, Vietnam)*

* Corresponding email: *toannt@hus.edu.vn*

Botulism is a potentially fatal illness caused by toxin produced by a bacteria called Clostridium botulinum found in food. The treatment of this illness requires very expensive antitoxin drugs. Therefore, there is a strong need for development of sensitive biosensors for detection of the toxin in food produce. These bacteria produce a protein called Botulinum neurotoxin (BoNT). In this work, by using atomistic computer modeling and simulation, we investigate potential aptamer (single-stranded DNA orRNA) that binds BoNT protein for use in biosensor for sensitive detection at low concentrations of Botulinum neurotoxin. With our experimental colleague's focus, two types of BoNT types A and C are investigated. The 3D structure of the aptamer from the primary nucleotide sequence are constructed, and are docked to BoNT proteins. Then the complexes are simulated for 100 nanoseconds by using GROMACS 2020.4. The results show that aptamers designed for type A prefer binding to BoNT/A and vice versa. Among them, aptamer A4 was the candidate with the strongest binding energy to both types of proteins, BoNT A and BoNT C. Although, for the detection of BoNT/C only the C5 aptamer seems to be the best candidate. This computational study strongly suggests that aptamer A4 could be used in biosensors to detect both of these types of botulinum neurotoxins. This calculation method helps save expensive and time-consuming experiment laboratory

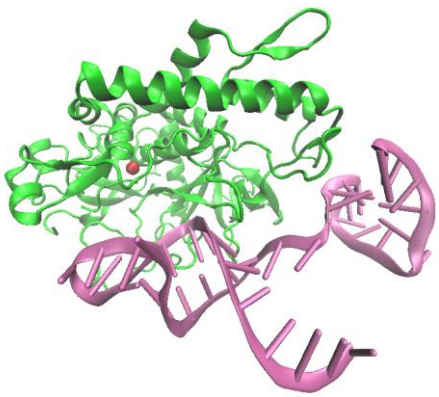


Figure 1. The three-dimensional structures of the aptamer – BoNT complex

Keywords: Botulinum neurotoxin (BoNT), aptamer, molecular dynamics simulation, protein - DNA interaction, biosensor

Presenting author email address: ly.nh2@vinuni.edu.vn

Analysis of phonon properties in Zintl layered materials *A*mgBi

T. Tran[*,1], W. Sekimoto[1], S. Fujii[1,2], M. Yoshiya[1,2], N. Matsuo[3,4] and T. Yamada[3]

[1]*Division of Materials and Manufacturing Science, Graduate School of Engineering, Osaka University, Japan,*
[2]*Nanostructures Research Laboratory, Japan Fine Ceramics Center, Japan,*
[3] *Institute of Multidisciplinary Research for Advanced Materials, Tohoku University, Japan,*
[4]*Graduate School of Engineering, Tohoku University, Japan*

* Corresponding e-mail: Thang.TRAN@mat.eng.osaka-u.ac.jp

Thermoelectric materials can realize the conversion of waste heat into electricity and operate as an energy source without side products or moving parts, effectively a maintenance-free system. They offer not only a sustainable energy generation method but also make it possible to power devices in isolated environments, ranging from outer space to body implants. Despite their potential applications, the efficiency of thermoelectric materials is tied to their transport properties, quantified by the figure-of-merit *zT*. To attain a high *zT* value, a thermoelectric material must simultaneously have a high electronic conductivity and a low thermal conductivity [1]. These two properties are positively correlated in materials in general, where phonon and electron share similar conducting paths and scattering factors. Therefore, research is currently focused on the lattice thermal conductivity of materials where electron and phonon are only weakly coupled, allowing more manipulation and control. One of these materials is NaMgBi, a Zintl compound with layered crystal structure, showing low thermal conductivity according to preceding studies by simulations and experiments [2,3]. Under the harmonic approximation, the general understanding is that a heavier element will have lower oscillations frequency, leading to slower phonon group velocity of acoustic modes and therefore lower thermal conductivity [4]. However, using first-principles calculations and lattice dynamics, we have shown that the thermal conductivity of KMgBi perfect crystal is several times higher than that of NaMgBi. Through the analysis of phonon properties, this relationship was explained, shedding light on the cause for NaMgBi's low thermal conductivity. After in-depth comparison of thermal displacement and interatomic force constants, it becomes apparent that various factors, including electronegativity and atomic radius, all play an important part in lattice thermal conductivity. This study also shows possible directions to further suppress lattice thermal conductivity while retaining desirable electronic conductivity for thermoelectricity applications.

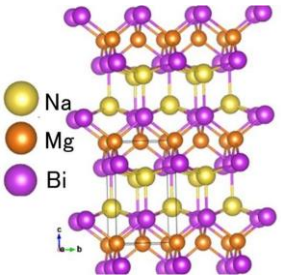


Figure 1. Crystal structure of NaMgBi

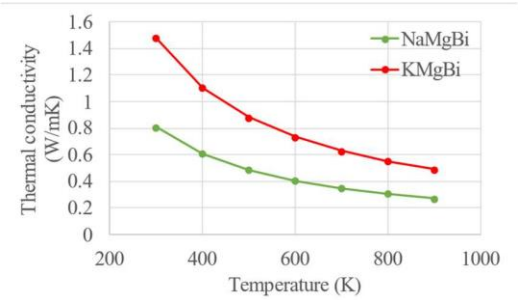


Figure 2. Calculated lattice thermal conductivity of NaMgBi and KMgBi

Keywords: first-principles calculation, lattice dynamics, lattice thermal conductivity, thermoelectric

References:

[1] G.D. Mahan, J.O. Sofo, *Proc. Natl. Acad. Sci.* **93**(15) (1996) 7436–7439.
[2] A.J. Hong, et al, *J. Mater. Chem. C*, **4** (2016) 3281.
[3] T. Yamada, et al., *Z. Naturforsch*. B, **76** (2021) 789.
[4] J. P. Perdew et al, *Phys. Rev. Lett.*, **77**, 3865-3868. (1996).

Presenting author Email address: Thang.TRAN@mat.eng.osaka-u.ac.jp

Uncertainty quantification for prediction of high-entropy alloy's yield strength

Nguyen Hai Chau[1*], Tomoyuki Yamamoto[2]

[1]*Faculty of Information Technology, VNU University of Engineering and Technology, 144 Xuan Thuy, Cau Giay, Hanoi, Vietnam*
[2]*Kagami Memorial Research Institute for Materials Science and Technology, Waseda University, Tokyo 169-0051, Japan*

[*] Corresponding e-mail: *chaunh@vnu.edu.vn*

High-entropy alloy (HEA) is an important class of materials that has been receiving significant research focus recently. The design of new HEAs is a challenging task because of a huge space of potential alloys. For instance, Miracle et al. showed that there are 592 billion potential 3-6 element HEAs [1], yet only a fraction of these have been explored. Consequently, accurate prediction of HEA's properties, such as yield strength, is crucial to refine the search space. Machine learning (ML), a novel approache for prediction of HEA's properties, is increasingly used in recent years. It has been successfully applied to predict the structure and properties of various types of materials, including yield strength of HEAs [2, 3]. Traditionally, the performance of ML prediction models is assessed on test data and expected to be good on new data. However, proficient model performance doesn't necessarily guarantee good future predictions [4]. Moreover, most ML methods offer point predictions without incorporating uncertainty information. Uncertainty quatification of ML models is vital to enhance the reliability of ML in materials science [4]. Conformal prediction [5] is one of the uncertainty quantification methods that is not computationally expensive and can be applied for any ML method. It offers a prediction region for each observation of new data.

In this research, we experimentally investigate sizes of prediction regions of HEA's yield strength on a dataset comprising 199 HEAs, sourced from the work of S. Gorsse et al. [6]. Predictors for the yield strength include valence electron concentration, electronegativity difference, atomic size difference, mixing entropy, and mixing enthalpy. Our experimental setup involves two independent variables: the size $\boldsymbol{s}$ of training datasets and the method of cross-validation, namely split (SP) or leave-one-out (LOO) [7]. The experiment's dependent variable is the size $\boldsymbol{Q}$ of prediction regions. For prediction, we employ ML methods automatically defined by the AutoGluon framework [8]. Our experimental findings are expressed through linear models as $\boldsymbol{Q} = 1215.13 - 3.18\boldsymbol{s}$ for SP and $\boldsymbol{Q} = 1165.3 - 3.18\boldsymbol{s}$ for LOO. These results imply that on average, (1) size of prediction regions of LOO is 49.83 smaller than that of SP and (2) size of prediction regions decreases by 3.18 if size of training datasets increases by 1. Additionally, the results suggest the potential benefit of adding generative data to training datasets to further reduce the size of prediction regions.

Keywords: materials informatics, high-entropy alloys, yield strength, conformal prediction

References:

[1] D.B. Miracle, *High entropy alloys as a bold step forward in alloy development,* Nature Communication 10, 1805 (2019).
[2] U. Bhandari, M. R. Rafi, C. Zhang, S. Yang, *Yield strength prediction of high-entropy alloys using machine learning,* Materials Today Communication 26 (2021).
[3] S. Giles, D. Sengupta, et al., *Machine-learning-based intelligent framework for discovering refractory high-entropy alloys with improved high-temperature yield strength,* npj Computational Materials 8 (1), 2022.
[4] F. Tavazza, B. DeCost, K. Choudhary, *Uncertainty prediction for machine-learning models of materials properties*, ACS Omega 2021, 6 (48), 32431-32440.
[5] G. Shafer and V. Vovk. *A tutorial on conformal prediction*, Journal of Machine Learning Research, 9:371–421, 2008.
[6] S. Gorsse, M.H. Nguyen, O.N. Senkov, D.B. Miracle, *Database on the mechanical properties of high entropy alloys and complex concentrated alloys*, Data Brief 21, 2664–2678 (2018).
[7] M. Juhn, K. Johnson, *Applied predictive modeling*, Springer, New York (2013).
[8] Erickson, N., et al.: *AutoGluon-tabular: Robust and accurate AutoML for structured data* (2020).

Presenting author's email address: tymmt@waseda.jp

Organic photovoltaic (OPV) modules with good stability under UV irradiation

Tran Ho Ngoc Khanh[1], Shih-Hung Lin[2], Yi-ru Lin[1], Hao-Min Zhang[2], Hsin-Fei Meng[1*],
Yu-Chiang Chao[3*], Hsiao-Wen Zan[4], Sheng-Fu Horng[2]

[1] *Institute of Physics, National Yang Ming Chiao Tung University, Hsinchu, Taiwan*
[2]*Department of Electrical Engineering, National Tsing Hua University, Hsinchu, Taiwan*
[3]*Department of Physics, National Taiwan Normal University, Taipei, 106, Taiwan*
[4]*Department of Photonic, National Yang Ming Chiao Tung University, Hsinchu, Taiwan*

** Corresponding e-mail: meng@nycu.edu.tw*

The ultraviolet (UV) radiation in the solar spectrum causes most of the decay under sunlight for solar cells based on organic photovoltaics (OPV). In addition to PCE, the most crucial consideration for practical applications is stability under sunlight irradiation. So far most papers focus on the stability of small-area OPV devices[1]. To make the OPVs practical applications, it is necessary to show that the durability of the small area can be scaled up to the large area. Even with the filter, the OPV modules decays more rapidly than the OPV small devices. To our best knowledge, there are a few papers on module sunlight stability[2] . Therefore, the high stabilized efficiency of the OPV module is the primary goal of this project. Herein, we study the photostability of OPV modules by three cells connected in series with a total effective area of 10.8 cm^2. The stability of the devices is studied under continuous irradiation by an UV LED of 365 nm with a long tracking time. The intensity of 50 W/m2 is the same as the sunlight UV. As a result, a good stability is achieved for the ternary OPV modules based on the high-performance blend PM6:Y6 with 1300 h UV half lifetime without UV filter. The series resistance is an essential factor affecting the performance and stability of OPV modules. The inverted and normal structures are also studied in this work under UV irradiation. The initial PCE of the inverted structure is higher than normal structure devices, however, the UV stability of the normal structure is found to be more stable than the inverted structure. The physical study of the related structure will be discussed in the future work section. Moreover, semitransparent OPV is promising to show a stable lifetime under UV. In the upcoming work, the UV stability of the semitransparent OPV modules will be conducted to improve the UV lifetime and transmittance.

Keywords : Module organic solar cell; photostability; ultraviolet (UV) radiation; high performance PM6:Y6; ternary organic solar cells

References:

[1] N. K. Tran Ho, C.-C. Liu, K.-Y. Chiu, H.-F. Meng, Y.-C. Chao, F. Li, P. Yu, H.-W. Zan and S.-F. Horng, *Sol. RRL*, **2022**, *6*, 2101076.
[2] Y. Jiang, X. Dong, L. Sun, T. Liu, F. Qin, C. Xie, P. Jiang, L. Hu, X. Lu and X. Zhou, *Nat. Energy*, **2022**, *7*, 352-359.

Presenting author Email address: tranhongockhanh.c@nycu.edu.tw

Measuring Electric Fields in GaN/AlGaN High Electron Mobility Transistors using Luminescence Techniques

Yu-Ting Chen, Ching-Hsueh Chiu and Ji-Lin Shen*.
Department of Physics, Chung Yuan Christian University, Taoyuan City, 32023, Taiwan
* Corresponding e-mail: *jlshen@cycu.edu.tw*

Abstract: This study explores the photoluminescence excitation (PLE) in GaN/AlGaN high electron mobility transistors (HEMTs). Based on the Franz-Keldysh effect, the electric field within the two-dimensional electron gas (2DEG) in GaN/AlGaN heterostructure was examined using PLE analysis. This research introduces a non-destructive luminescence technique for investigation the optoelectronic properties in GaN/AlGaN HEMTs at room temperature, which is advantageous for device design.

Introduction: AlGaN/GaN high electron mobility transistors (HEMTs) have attracted considerable attraction due to many applications such as biological sensors, high-frequency and high-power devices [1]. In the HEMT structure, high electric fields can be generated without doping because of the strong polarization fields and the high conduction band offset between AlGaN and GaN. The electric field strength plays an essential role in the device operation because it is the driving force to move the electrons into the channel to form two-dimensional electron gas. Here, using PLE techniques, a method for estimating internal electric fields, band offsets, and bandgaps have been proposed.

Experiments: An AlGaN/GaN HEMT structure was grown by metalorganic chemical vapor deposition on the Si (111) substrate. The layer structure consists of a GaN cap layer, an undoped AlGaN barrier layer, a AlN inter-layer, a undoped GaN channel layer, a AlGaN buffer layer, and a AlN nucleation layer. The photoluminescence (PL) and PLE were studied with FluoroMax-4PL spectrometer.

Results and Discussion: The black line in Figure 1a shows the PL spectrum of the studied HEMT under an excitation wavelength of 260 nm at room temperature. A dominant PL peak was observed, which is assigned as the donor-bound excitonic (D^0X) emission in GaN. The red line in Fig. 1a displays the PLE spectrum of HEMTs with the detection energy at 2.53 eV. The bandgap of GaN and the internal electric field in AlGaN/GaN heterostructures were obtained through a model based on the Franz-Keldysh effect. [2]

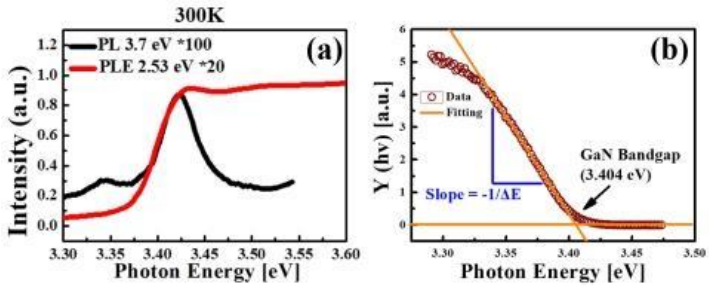


Figure 1. (c) PL and PLE of GaN/AlGaN HEMTs (b) The electric field and bandgap obtained by PLE spectrum

Conclusion: We have measured the PL and PLE of AlGaN/GaN HEMTs at room temperature. The band gap of GaN and the electric field within the two-dimensional electron gas in GaN/AlGaN heterostructure was estimated through the contactless PLE technique. Measurements of these properties is essential for the device design and applications in AlGaN/GaN HEMTs.

Keywords: photoluminescence excitation, high electron mobility transistors (HEMTs), electric field

References:

[1] Mishra, U. K., Shen, L., Kazior, T. E., & Wu, Y. F. (2008). GaN-based RF power devices and amplifiers. Proceedings of the IEEE, 96(2), 287-305.
[2] Turkulets, Y., & Shalish, I. (2018). Contactless method to measure 2DEG charge density and band structure in HEMT structures. IEEE Journal of the Electron Devices Society, 6, 703-707.

Presenting author Email address: 10412239@cycu.org.tw

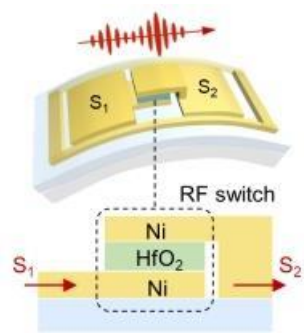
Atomically thin impedance switches for 6G communication

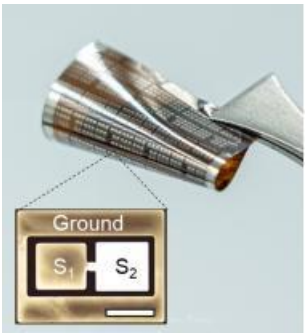
Shih-Chieh Chen[1], Yun-Chien Tseng[1], Kun-Dong Chio[1], Ting-Yue You[1], Po-Wei Huang[1], Tsung-Te Chou[2], Hsien-Yang Liu[1], Yang-Yu Jhang[2], Chen Chien Wei[2], Chun-Hsiao Kuan[3], E Ming Ho[4], Yun Jung Wu[4], Zih-I Chuang[4], Chien-Nan Kuo[1], Yu-Ting Cheng[1], Der-Hsien Lien[1]*

[1]*Institute of Electronics, National Yang Ming Chiao Tung University, Hsinchu, Taiwan*
[2]*Taiwan Instrument Research Institute, National Applied Research Laboratories, Hsinchu, Taiwan*
[3]*Department of Applied Chemistry and Institute of Molecular Science, National Yang Ming Chiao Tung University, Hsinchu, Taiwan*
[4]*Chang Chun Plastics Co., Ltd. Hsinchu Factory, Hsinchu, Taiwan.*

* Corresponding e-mail: *dhlien@nycu.edu.tw*

We present a high-performance two-terminal impedance memristor on a flexible substrate with the potential for integration with 2.5D IC technology. The switch utilizes a memristor with HfO_2 layers grown through atomic layer deposition (ALD) serving as the insulating layer. By manipulating the impedance state, it achieves modulation of radio-frequency (RF) signal transmission by switching between on and off states using a bipolar mechanism. Experimental results demonstrate that the device operates within the 6G communication frequency range, achieving a cutoff frequency of up to 160 GHz, an insertion loss S21 = -6 dB, and high isolation performance (-60 dB). The RF switch is integrated on a photosensitive polyimide (PSPI) flexible substrate, enabling potential integration as a redistribution layer (RDL) in 2.5D IC technology. Importantly, the entire manufacturing process maintains a thermal budget below 250 oC for back end of line (BEOL), making it suitable for monolithic integration with 6G functions.





Keywords: flexible, RF switch, PSPI

Presenting author Email address: twbeatsoul.ee10@nycu.edu.tw

Electronic Synapse Memristive Switaching based on Lysine-functionalized MoS_2 Quantum Dots

Yu-Ling Liao, Yu-Ting Chen and Ji-Lin Shen*
Department of Physics, Chung Yuan Christian University, Taoyuan City, 32023, Taiwan
* Corresponding e-mail: *jlshen@cycu.edu.tw*

Abstract: Memristive synapstic devices are recognized as one of important electronic components for neuromorphic computing. In this work, a synaptic menrisistor using lysine-functionalized MoS_2 quantum dots (QDs) is reported. By adjusting the concentration of lysine concentration in the microwave-assisted synthesis, the conduction of the MoS_2 QDs change gradually after multiple conductive paths. Diverse synaptic functions such as short-term plasticity and long-term plasticity have been examined in the artificial memory devices based on MoS_2 QDs.

Introduction: As one of the fastest-growing electronic devices in the field of data storage and brain-like neuromorphic computing, memristors have attracted a lot of attention in recent years. [1][2] The memory of the memristor can be maintained for a long time, but once it is supplied with an opposite negative voltage, it may change the resistance in one second or even less than microseconds. Variation in charges will impact the resistance of the memristor in both high resistance and low resistance modes, corresponding to one and zero, and allowing data storage by recording these alterations.

MoS_2 quantum dots (QDs) are a promising candidate for a memristor due to its tunable energy gap, high reliability, stability, and low power consumption, enabling more stable non-volatile resistive switching (RS) behavior [1]. In this study, the MoS_2 QDs with functionalization of lysine provide the suitability to the memristor, which simulates a variety of synaptic functions such as such as short-term plasticity, long-term plasticity and excitatory postsynaptic current (EPSC).

Result and Discussion: Figure 1 shows a positive and negative DC voltage (0 to 2V, 2V to -2V, -2V to 0) applied to lysine-functionalized MoS_2 QDs with 100 consecutive scans. The data shows that the current decreases with the increase in the number of scans. That is, the electronic synapses will gradually change from low-resistance state (LRS) to high-resistance state (HRS). The lysine concentration was changed to control conductance, which is similar to synaptic plasticity in biological nervous systems. The localized states in lysine-functionalized MoS_2 QDs are responsible for gradual change in conductivity. When carriers are trapped in localized states, they are immobilized or have a reduced ability to move through the material, leading to a decrease in the overall current flow. This trapping effect can thus result in a gradual reduction of the maximum current during an current-voltage (I-V) scan

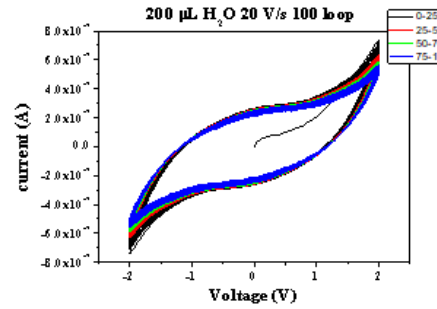


Figure 1 I-V curves under consecutive 100 times positive and negative voltage sweeps.

Conclusion: We measured the I-V curve of the lysine-functionalized MoS_2 QDs. After repeated scans with one hundred times, it was found that the current gradually decreased with the number of scans. We speculate that this is the result of carrier capture in the localized stated produced by lysine functionalization. These properties could be useful for memristor applications and design.

Keywords: Resistive Switching Behavior, Electronic Synapses, MoS_2 Quantum Dots

References:

[1] T. Zeng, Z. Yang, J. Liang et al. "Flexible and transparent memristive synapse based on polyvinylpyrrolidone/N-doped carbon quantum dot nanocomposites for neuromorphic computing" *Nanoscale Adv.* **3**, 2623-2631,2021.
[2] Z. Xu, F. Li, C. Wu et al. "Ultrathin electronic synapse having high temporal/spatial uniformity and an Al2O3/graphene quantum dots/Al2O3 sandwich structure for neuromorphic computing" *NPG Asia Mater* **11**, 11-18,2019.

Presenting author Email address : s11162001@nycu.edu.tw

Counter-Degenerate P-type Doping in Ultrathin Oxide Semiconductor

Youchen Chang[1], Chien-Wei Chen[2], Der-Hsien Lien [1*]

[1] *Institute of Electronics, National Yang Ming Chiao Tung University, Hsinchu, Taiwan)*
[2]*Taiwan Instrument Research Institute, National Applied Research Laboratories, Hsinchu, Taiwan*

* Corresponding e-mail: *dhlien@nycu.edu.tw*

Amorphous oxide semiconductor (AOS) is a promising candidate for next generation semiconductor due to their high mobility, extremely thin thickness, wafer scale growth and low temperature deposition compatiable with Back-end-of-line (BEOL) process [1]. Among these materials, indium oxide stands out as a particularly promising candidate, finding extensive application in thin-film transistors (TFTs) within the display industry [2]. However, In2O3 exhibits very high carrier concentrations [3]; the gate of the In2O3 device cannot effectively control such a large number of carriers, resulting in poor switching characteristics. Our study demonstrates a p-type doping method on ultrathin In2O3 deposited by atomic layer deposition (ALD) at a low temperature of 275°C. We performed carbon tetrafluoride plasma treatment on In2O3 devices to passivate oxygen vacancies and substitute the absorbed oxygen atoms [4], all of which contribute to a reduction in the carrier concentration in the In2O3 channel. It is worth noting that we can counter the electrical characteristics from degenerate to enhancement mode, resulting in a significantly larger positive tuning window for threshold voltage (VT). Besides, the introduced dopant can be eliminated, and the electrical characteristics can be back to original state through organic solvent cleaning. This indicates that this doping method is reversible. Finally, we successfully achieved the fabrication of a depletion-load NMOS inverter with a relatively high gain through selective doping using this method, indicating that ALD-based ultrathin In2O3 holds significant potential in the field of logic circuits.

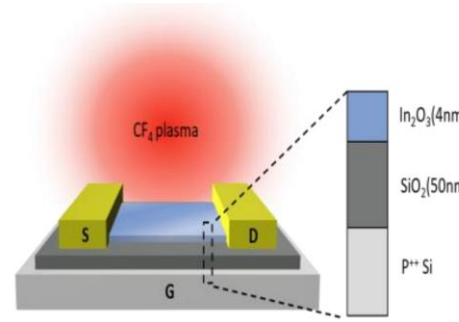


Figure 1. Schematic of counter degenerate p-tye doping

Keywords: indium oxide, Amorphous oxide semiconductor, Atomic Layer Deposition, plasma doping, Threshold Voltage

References:

[1] KAMIYA, Toshio; HOSONO, Hideo. Material characteristics and applications of transparent amorphous oxide semiconductors. NPG Asia Materials, 2010, 2.1: 15-22.
[2] ZHU, Ying, et al. Indium–gallium–zinc–oxide thin-film transistors: Materials, devices, and applications. Journal of Semiconductors, 2021, 42.3: 031101.
[3] MEDVEDEVA, Julia E., et al. Origin of high carrier concentration in amorphous wide-bandgap oxides: Role of disorder in defect formation and electron localization in In2O3− x. Journal of Applied Physics, 2020, 127.17.
[4] KAMIYA, Toshio; NOMURA, Kenji; HOSONO, Hideo. Origins of high mobility and low operation voltage of amorphous oxide TFTs: Electronic structure, electron transport, defects and doping. Journal of display Technology, 2009, 5.7: 273-288.
[5] KAWAI, H., et al. Design principle of channel material for oxide-semiconductor field-effect transistor with high thermal stability and high on-current by fluorine doping. In: 2020 IEEE International Electron Devices Meeting (IEDM). IEEE, 2020. p. 22.2. 1-22.2. 4.

Presenting author Email address: barry2325899@gmail.com

Surface defect passivation of ZnO Nanorod Arrays/p-GaN Heterostructure Devices by Nontoxic Bio-based Materials

Denice Navat Feria[1], Sung-Hao Chuang[1], Yan-Shawn Lo[1] and Tai-Yuan Lin[1*]

1Department of Optoelectronics and Materials Technology, National Taiwan Ocean University, Keelung, 202301, Taiwan

* Corresponding e-mail : tylin@mail.ntou.edu.tw

Zinc oxide (ZnO) is a II-VI compound semiconductor with excellent optical characteristics, but it is susceptible to non-radiative recombination defects, limiting its capability and performance as an optoelectronic device [1]. This study successfully demonstrated an innovative process in passivating current metal oxide semiconductor defects with non-toxic biomaterial. To illustrate, we utilized a hydrothermal synthesis technique to synthesize zinc oxide nanorods (ZnO NRs) and incorporated chicken egg white (albumen) as a defect passivator. Enhanced structural and optical characteristics were observed for the ZnO NRs with annealed albumen. X-ray diffraction (XRD) analysis reveals a significant improvement in the quality and crystallinity of the ZnO NRs following albumen incorporation. In addition to determining the chemical interaction between albumen and the pristine ZnO NRs, X-ray photoelectron spectroscopy (XPS) measurements were performed to validate the was observed that the process of annealing albumen led to the generation of sulfhydryl groups and subsequent production of disulfide bonds (which resulted in disulfide bridges) because of the chemical reaction that occurred during irreversible thermal denaturation. This interaction passivates the oxygen vacancies, preventing them from trapping charge carriers, resulting in non-radiative recombination and improving the characteristics of ZnO NRs. Near band-edge emission (NBE) and deep-level emission (DL) were observed in the steady-state photoluminescence (PL) of ZnO nanorods (NRs). The NBE significantly increases after capping and annealing the albumen compared to DL emission. The suppression of DL emission suggests that surface defects and oxygen vacancies in ZnO NRs have been reduced. Because of the advantages and improved features of annealed-albumen-capped ZnO NRs, a stable and highly efficient light-emitting device (LED) was developed which exhibited tenfold EL intensity as compared to pristine ZnO NRs devices. This work reveals the significant potential of usingbiomaterial to mitigate the existing defects of oxide semiconductor materials for developing bio-inspired and enhanced optoelectronic devices.

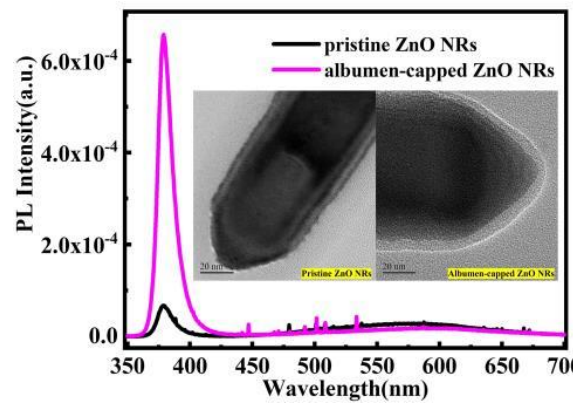


Figure 1. Photoluminescence (PL) spectra and TEM images of pristine ZnO NRs and albumen-capped ZnO NRs.

Keywords: Zinc oxide nanorods (ZnO NRs), chicken egg white (albumen), near band-edge emission (NBE), deep-level emission (DL), light-emitting device (LED)

References:

[1] Wisz G, Virt I, Sagan P, Potera P and Yavorskyi R 2017 Structural, Optical and Electrical Properties of Zinc Oxide Layers Produced by Pulsed Laser Deposition Method Nanoscale Res Lett 12 253

Presenting author Email address: dnferia@email.ntou.edu.tw

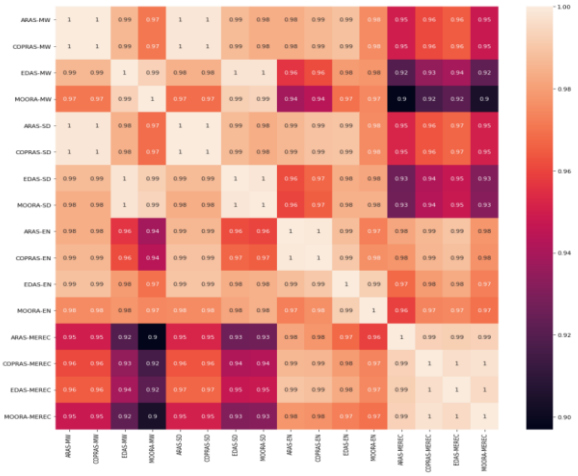
Comparative Analysis of Various MCDM Techniques for The Optimization of CVD Process Parameters to Deposit the SiCN Thin Film Coating

Sukhdev Gangwar[1], Subhash Chandra Mondal[1], Ranjan Kumar Ghadai[2*]

[1] *Mechanical Engineering Department, Indian Institute of Engineering Science and Technology, Shibpur, Howrah (West Bengal), India*
[2] *Department of Mechanical and Industrial Engineering, Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal, India*

* Corresponding e-mail: *ranjan.ghadai@yahoo.com*

Present work deals with the comparison of parametric optimization of SiCN thin film coating using chemical vapor deposition (CVD) method by four different multicriteria decision making (MCDM) methods along with different weight allocation methods. In this work the SiCN coating is deposited over p-type Si (100) substrate using CVD method considering flowrates of H2 and N2 gases and the deposition temperature as input parameters while hardness, young's modulus and ID/IG ratio were taken as response parameters. Additive ratio assessment (ARAS), Complex Proportional Assessment (COPRAS), Evaluation based on distance from average solution (EDAS) and Multi-objective optimization on the basis of ratio analysis (MOORA), MCDM methods are used for ranking of alternatives. For weight allocation of criterion four different techniques are used viz., mean weight, standard deviation, entropy and MEREC methods are used. Form the results, it is observed that the raking given by all the methods for every weight allocation is similar. From the overall discussion it observed that 120 sccm (H2 flowrate), 120 sccm (N2 flow rate) and 1250°C temperature is best suited combination to obtain optimized results for the response variables. From the correlation chart it can also be observed that the maximum variation in ranking occurs when the different MCDM methods are clubbed with MEREC weight allocation. Overall maximum variation in the correlation coefficient is 10%, which also suggests that all the methods are providing similar results.



Keywords: CVD, MCDM, ARAS, COPRAS, EDAS

References:

[1] Kumar D, Das PP, Chakraborty S, Sharma A, Swain BP. A DoE–TOPSIS meta-model for parametric optimization of silicon carbonitride (SiCN) thin film deposition process. Journal of the Brazilian Society of Mechanical Sciences and Engineering. 2019 Jul;41(7):1-2

[2] Chang K, Dong Y, Zheng G, Jiang X, Yang X, Cheng X, Liu H, Zhao G. Friction, and wear properties of TiAlN coated tools with different levels of surface integrity. Ceramics International. 2022 Feb 15; 48(4):4433- 43.

[3] Zayed ME, Elsheikh AH, Essa FA, Elbanna AM, Li W, Zhao J. High-temperature solar selective absorbing coatings for concentrated solar power systems. In Sustainable Materials and Green Processing for Energy Conversion 2022 Jan 1 (pp. 361-398). Elsevier.

Presenting author Email address: ranjan.ghadai@yahoo.com

Encoding information into Terahertz pulses via spectrally modulated ultrafast optical pulses

Ching-Wen Wang[1*], Nai-Hao Chiang[2], Yu-Chan Tai[2], Wei-Hong Huang[2], Chih-Wei Luo[2]

[1]*Institute of Physics, National Yang Ming Chiao Tung University, Hsinchu 300, Taiwan*
[2]*Department of Electrophyscis, National Yang Ming Chiao Tung University. Hsinchu 300, Taiwan*

[*] Corresponding e-mail: *c311658011.sc11@nycu.edu.tw ; cwluoep@nycu.edu.tw*

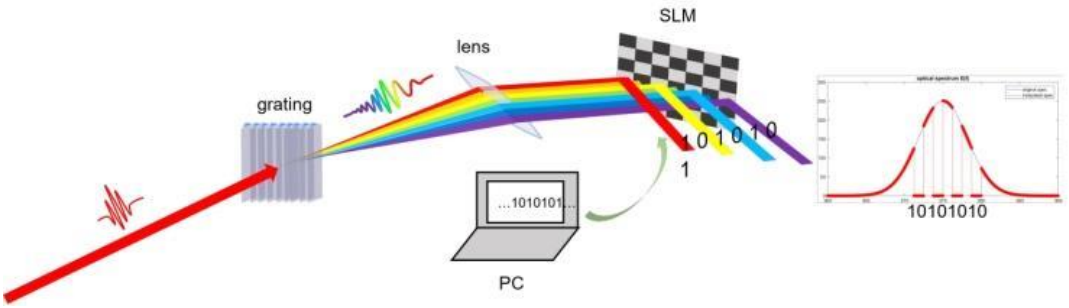


Figure 1. The schematic of spectrally modulated ultrafast optics pulsed before the photoexcitation of the PCA

We tried to achieve Terahertz communication through photoconductive antenna (PCA) working at 800-nm ultrafast optical pulses. Encoding a set of bit-wise information into the waveform of single THz-pulse, which was generated by a PCA. The bit-wise information was encoded via a spatial light modualtor (SLM) in frequency domain before the photoexcitation of the PCA. We utilized a grating to split the optical pulses to frequency domain, and employed a SLM to modulate the spectral intensity of optics pulses. The spectral frequency of pulses can be determined to pass or to be blocked by the designed pattern of the SLM. The selectively modulated pulses will stimulate the PCA and generate corresponding THz waveforms. Our simulation demonstrates that THz waveforms exhibit varying responses under different spectrally modulated injected pulses.

Keywords: THz communication, Pulse shaping, Photoconductive antenna

Presenting author Email address: c311658011.sc11@nycu.edu.tw

Generation of circularly polarized THz dual pulses

Yu-Ting Lin[1*], Hao-Keng Wei[1], Zai-Wen Chen[1], Chih-Wei Luo[1]

[1]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 30010, Taiwan*

[*] Corresponding e-mail: *yuting.sc11@nycu.edu.tw*

Since high-data-rate communication is desired, to realize terabit (Tbit) wireless telecommunication, such as 6G and beyond, new technology is being developed, and it may well rely on THz photonics. By Shannon's Capacity Theorem [1], a high frequency channel has a larger bandwidth and can carry more information than a channel at a lower frequency. Therefore, the carrier frequency of communication has been raised from megahertz (MHz) to sub-THz in present telecommunication systems [2]. However, the generation of circularly polarized (CP) THz waves remain rare, especially for high output power. In this work, we report a simple and reliable system with Michelson interferometer (MI) for the generation of circularly polarized (CP) THz dual pulses with variable helicity, frequency, and interval between pulses [3,4]. These degrees of freedom allow us to arbitrarily control the THz dual pulses of interests, which has potential applications in imaging, spectroscopy, and in next-generation communications.

Keywords: circular polarization, polarization control

References:

[1] C. E. Shannon, "A mathematical theory of communication, " The Bell Syst. Tech. J. 27, 379 (1948)
[2] M. Z. Chowdhury et al, "6G wireless communication systems: applications, requirements, technologies, challenges, and research directions" IEEE Open J. Commun. Soc. 1, 957 (2020).
[3] H. -K. Wei, et al., "Generation and manipulation of polarization-twisting dual pulses with a high degree of freedom, " Opt. Lett. 45, 6663 (2020).
[4] H.-K. Wei, et al., "Few-cycle THz wave manipulation with a high degree of freedom via f-t modulation," Opt. Lett. 48, 1016-1019 (2023)

Presenting author Email address: yuting.sc11@nycu.edu.tw

Ultrafast Dynamics of Tb_2Te_5 Single Crystal Using Optical Pump-Probe Spectroscopy

Chien-Ming Chen[1*], Wen-Yen Tzeng[3], Yu-Chan Tai[2], Hsing-Yu Yeh[1], Chih-Wei Luo[1,2]

[1]*Department of Physics, National Yang Ming Chiao Tung University, Hsinchu, Taiwan*
[2]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu, Taiwan*
[3]*Department of Electronic Engineering, National Formosa University, Yunlin, Taiwan*

* Corresponding e-mail: *chienming.sc11@nycu.edu.tw*

Rare earth (R) tellurides layered single crystal RTen (n=2, 2.5, 3) are considered to be charge density wave (CDW) materials. To gain a better understanding of the ultrafast dynamics of Tb_2Te_5 and determine whether it exhibits CDW behavior, we employed dual-color pump-probe time-resolved spectroscopy at various temperatures, as well as low-temperature X-ray diffraction. In the temperature range of 8 K to 100 K, the transient reflectivity changes ($\Delta R/R$) exhibit a 3.77 THz oscillation mode, and there are distinct trends in the variations of the b-axis length around the temperature of 120 K in the low-temperature X-ray diffraction results. By comparing these findings to CDW-liked properties observed in other CDW materials, we conclude that Tb_2Te_5 can be classified as a CDW material, with an estimated CDW phase transition temperature (TCDW) falling in the range of 110-120 K.

Keywords: pump-probe spectroscopy, rare earth tellurides

References*:*

[1] H. Hosono, et al., Mater. Today 21, 278 (2018).
[2] F. Pfuner, et al., J. Phys. Condens. Matter 24, 036001 (2011).
[3] N. Ru, et al., Phys. Rev. B 77, 035114 (2008).

Presenting author Email address: chienming.sc11@nycu.edu.tw

Generate Mid-infrared Ultrashort Pulses via Four-Wave Difference Frequency Generation for Measurements

Chun-Ying Lin[1*], Shi-Zao Chang[1], Wei-Hong Huang[1], Chih-Wei Luo[1]

[1] *Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu, 300093 Taiwan*

[*] Corresponding e-mail: *chunying.sc11@nycu.edu.tw*

We will generate mid-infrared (MIR) ultrashort pulses for measurements in this work. Through a birefringent crystal makes our fundamental pulses (800 nm, □$_1$) colinearly generate second harmonic pulses (400 nm, □$_2$). The polarization is orthogonal between the two pulses. Then tuning them for time overlapping and phase matching. And then we can rotate their polarization to control the generated pulses' polarization. We focus two-color filamentation to generate MIR pulses via four-wave difference frequency generation (FWDFG) [1]. To minimize dispersion of our pulses, we will decrease using transmissive optical components in our setup system. For the measurements part, we can use a reference beam to have it collinear focus with our MIR light source for up-converting photon energy from MIR region to visible region through a gaseous medium [2]. The spectrum can be upconverted into a visible signal (□′$_2$) through an FWDFG process. It is more convenient and quicker to measure MIR spectrum based on the detected up-conversional visible spectrum. After recomputing the signal back, we can get the MIR spectrum to obtain the information we want.

Keywords: mid-infrared (MIR), four-wave difference frequency generation (FWDFG), up-conversion

References:

[1] Fuji, Takao, and Toshinori Suzuki. "Generation of sub-two-cycle mid-infrared pulses by four-wave mixing through filamentation in air." Optics letters 32.**22**, 3330-3332. (2007)

[2] Y. Nomura, Y.-T. Wang, T. Kozai, H. Shirai, A. Yabushita, C.-W. Luo, S. Nakanishi, and T. Fuji, "Single-shot detection of mid-infrared spectra by chirped-pulse upconversion with four-wave difference frequency generation in gases," Opt. Express **21**, 18249-18254 (2013)

Presenting author Email address: chunying.sc11@nycu.edu.tw

Ultrafast Electron Dynamics in 1T-$TiSe_2$ by Tr-ARPES

Shih-Chi Hung[1,3], Zhi-Ling Chen[2,3], Sheng-Chiao Wang[2,3], Hao-Hsiang Jia[3,4], Woei-Wu Pai[5], Chih-Wei Luo[2]*, Ping-Hui Lin[3]*

[1]*Department of Physics, National Yang Ming Chiao Tung University, Hsinchu, Taiwan*
[2]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu, Taiwan*
[3]*National Synchrotron Radiation Research Center, Hsinchu, Taiwan*
[4] *Institute of Photonics Technologies, National Tsing Hua University, Hsinchu, Taiwan*
[5]*Center for Condensed Matter Sciences, National Taiwan University, Taipei, Taiwan*

* Corresponding e-mail: *cwluoep@nycu.edu.tw*, *lin.pinghui@nsrrc.org.tw*

We study the ultrafast electron dynamics in 1*T*-TiSe2 within femtosecond scale via time- and angle-resolved photoelectron spectroscopy (Tr-ARPES). By extracting the transient evolution of the electron population, we provide a dynamic picture to describe the electron-hole pair generation and the electron-phonon interaction within TiSe2. The charge density wave (CDW) phase transition in 1*T*-TiSe2 whose origins are still not completely understood.

Keywords: time-angle-resolved photoemission spectroscopy, charge density wave, ultrafast electron transport dynamics

References:

[1] H.Hedayat *et al*, "Excitonic and lattice contributions to the charge density wave in 1*T*-TiSe2 revealed by a phonon bottleneck, " *Phys. Rev. R* **1**,023029 (2019)
[2] Monney C *et al*, "Revealing the role of electrons and phonons in the ultrafast recovery of charge density wave correlations in 1*T*-TiSe2," *Phys. Rev. B* **94**,165165 (2016)
[3] T. Jaouen *et al*, "Phase separation in the vicinity of Fermi surface hot spots" *Phys. Rev. B* **100**, 075152 (2019)
[4] Maria Hellgren *et al*, "Critical Role of the Exchange Interaction for the Electronic Structure and Charge-Density-Wave Formation in TiSe2," *Phys. Rev. Lett* **119**,176401 (2017)

Presenting author Email address: shih.sc11@nycu.edu.tw

Pump fluence-dependent effective mass in 1T-$TiSe_2$

Zhi-Ling Chen[1,2], Shih-Chi Hung[1,2], Sheng-Chiao Wang[1,2], Hao-Hsiang Jia[2,3], Woei-Wu Pai[4], Chih-Wei Luo[1,*], Ping-Hui Lin[2,*]

[1]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu, Taiwan*
[2]*National Synchrotron Radiation Research Center, Hsinchu, Taiwan*
[3]*Institute of Photonics Technologies, National Tsing Hua University, Hsinchu, Taiwan*
[4]*Center for Condensed Matter Sciences, National Taiwan University, Taipei, Taiwan*

* Corresponding e-mail: *cwluoep@nycu.edu.tw*, *lin.pinghui@nsrrc.org.tw*

We investigated the ultrafast electron dynamics of the charge density wave (CDW) material 1*T*-TiSe2 using the time- and angle-resolved photoemission spectroscopy (Tr-ARPES) system. The experimental results provide a direct visualization of the Ti-3*d* conduction band and the indirect correlation between effective mass and the CDW phase. The data show that the effective mass of the Ti-3*d* electron pocket displays two opposite behaviors at different pump fluences and temperature regimes, which indicates varying degrees of suppression of the CDW phase. Notably, transient completed suppression of the CDW phase with a fluence above $F = 0.5\ mJ\ cm^{-2}$. We also present the time evolution of the Ti-3*d* band, and the change of effective mass suggest the recovery of the CDW phase.

Keywords: charge density wave, time- and angle-resolved photoemission spectroscopy, effective mass

References:

[1] C. Monney *et al*, "Dramatic effective mass reduction driven by strong electronic correlations". Europhysics Letters **92**, 47003 (2010).
[2] H. Hedayat *et al*. "Excitonic and lattice contributions to the charge density wave in 1*T*-TiSe2 revealed by a phonon bottleneck". Physical Review Research **1**, 023029 (2019).
[3] Dolgirev, P. E. *et al*. " Amplitude dynamics of the charge density wave in LaTe3 : Theoretical description of pump-probe experiments". Physical Review B **101**, 054203 (2020).

Presenting author Email address: lynn.sc11@nycu.edu.tw

Generation of circularly polarized ultra-broadband MIR pulses through the laser-induced filament of atmosphere

Wei-Hong Huang[1]*, Yi-Ruei Sie[1], Chih-Wei Luo[1]

[1]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 30010, Taiwan*

* Corresponding e-mail: nc7410@nycu.edu.tw

Circularly polarized MIR pulses were generated by polarization-twisting optical dual pulses via a modified Michelson interferometer with the turnability of frequency, helicity, and time interval between two pulses. Different configurations of DWPs can control the applied two-color fields, and the resultant polarizations of MIR pulses were shown in Fig 1. When azimuthal angle φ of DWP was matched with the polarization of fundamental pulses, the polarization of $\omega 1$ and $\omega 1$ were perpendicular to each other due to the phase match of SHG. As a result, the output MIR powers were pretty weak as shown in Fig. 1(a,c). On the other hand, when φ was at 0 or 135 degree, the polarized combinations of two-color pulses were shown in Fig. 1(e). Based on the results in Fig. 1(b, d), we can clearly find the circularly polarized MIR pulses is only determined by the polarized type of 800-nm fundamental pulses, $\omega 1$. Besides, both circularly polarized $\omega 1$ and $\omega 2$ can enhance the efficiency of FWM MIR generation.

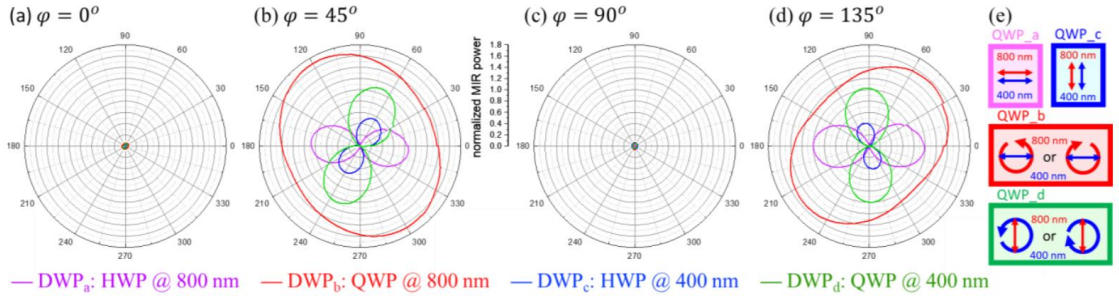


Figure 1. The power of FWM MIR pulses after passing through a MIR polarizer.

Keywords: MIR pulses, two-color filamentation, circularly pilarized MIR

References:

[1] W.-H. Huang, Y. Zhao, S. Kusama, C.-W. Luo, and T. Fuji, *Generation of sub-half-cycle 10 μm pulses through filamentation at kilohertz repetition rates*, Opt. Express **28**, 36527 (2020).

[2] Z. Zhang, Y. Chen, S. Cui, F. He, M. Chen, Z. Zhang, J. Yu, L. Chen, Z. Sheng, and J. Zhang, *Manipulation of polarizations for broadband Terahertz waves emitted from laser plasma filaments*, Nat. Photonics **12**, 554 (2018).

[3] Y.-Y.Tu, C.Meng, X.Sun, H.-Z.Wu, P.Song, C.-S.Meng, X.-W.Wang, Z.-Y.Zhou, Z.-H.Lyu, D.-W.Zhang, Z.-X.Zhao, and J.-M.Yuan, *Enhancement of Terahertz radiation from a filament by using circularly polarized two-color laser fields*, J. Opt. Soc. Am. B **39**, A83 (2022).

[4] Q. Song, X. Yuan, S. Hu, J. Huang, H. Zhong, Q. Lin, H. Wang, X. Lu, M. Zheng, Y. Cai, X. Zeng, and S. Xu, *Enhance Terahertz radiation and its polarization-control with two paralleled filaments pumped by two-color femtosecond laser fields*, Opt. Express **29**, 22659 (2021).

Presenting author Email address: nc7410@nycu.edu.tw

High Efficiency Terahertz Emission from Weyl Semimetal $EuCd_2Sb_2$ Single Crystals

Yan-Cheng Ko[1], Xin-Yun Chang[1], Ying-Kuan Ko[1], Yi-Cheng Cheng[1], Jiun-Haw Chu[2], Cheng-Chien Chen[3], Chien-Ming Tu[1], Jiunn-Yuan Lin[4], and Chih-Wei Luo[1]

[1]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu, 300093 Taiwan*
[2]*Department of Physics, University of Washington, Seattle, WA, 98195 USA*
[3]*Department of Physics, University of Alabama at Birmingham, Birmingham, AL, 35294 USA*
[4]*Institute of Physics, National Yang Ming Chiao Tung University, Hsinchu, 300093 Taiwan*

*Corresponding e-mail: *cwluoep@nycu.edu.tw*

We report on high efficiency terahertz radiation of Weyl semimetal $EuCd_2Sb_2$ single crystals under ultrafast optical excitation. Huge amplitude of THz radiation were observed from $EuCd_2Sb_2$ single crystals, and its' amplitude is at least one-order in magnitude larger than the THz radiation from standard sample InAs under the same condition. We also performed sample orientation measurement to confirm the THz generation mechanism. The details of the experimental results will be shown in the poster.

Keywords: Terahertz emission, Weyl semimetal, Nonlinear optics.

Reference:

[1] Hao Su, Benchao Gong, Wujun Shi, et al. ," Magnetic exchange induced Weyl state in a semimetal $EuCd_2Sb_2$", APL Mater. 8, 011109 (2020)
[2] Pettine, J., Padmanabhan, P., Sirica, N. et al.," Ultrafast terahertz emission from emerging symmetry-broken materials.", Light Sci Appl 12, 133 (2023).

Presenting author email address: keyancheng.sc12@nycu.edu.tw

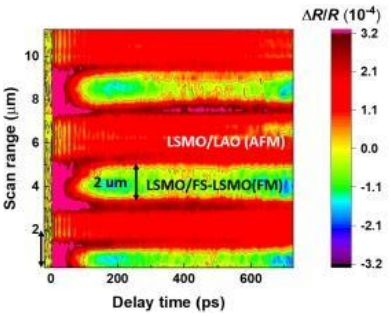
Ultrafast Carrier Dynamics of the Grain Boundaries in LSMO Homostructure by Spatial Resolved Ultrafast Pump-Probe Spectroscopy

Jia-Yuan Sun[1]*, Wen-Yen Tzeng[1], Jan-Chi Yang[2], Chih-Wei Luo[1]

[1]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu, Taiwan*
[22]*Department of Physics, National Cheng Kung University, Tainan, Taiwan*

* Corresponding e-mail: *jysun.sc10@nycu.edu.tw*

Perovskite manganites are known as functional materials showing colossal magnetoresistance (CMR) and one of perovskite-$LaSr_{1-x}Mn_xO_3$ (LSMO) is kind of classic half-metallic oxide that exhibits large spin polarization and CMR effect. Recent research shows that an unconventional butterfly-shaped hysteresis magnetoresistance is observed in grain boundaries of LSMO homostructure, to further exploit its potential, we study the quasiparticle dynamics of the LSMO homostructure with the spatial resolved ultrafast pump-probe microscopy.



Keywords: Homostructure, Half metal, Carrier dynamics.

References:

[1] Phys. Rev. B Vol. 66, Iss. 9 — 1 September 2002
[2] NATURE COMMUNICATIONS | (2022) 13:2565
[3] Physical Review Applied, 15(6).
[4] Journal of Applied Physics, 99(4), 043908.
[5] Applied Physics Letters, 104(14), 141602.

Presenting author Email address: jysun.sc10@nycu.edu.tw

Photocatalytic degradation of metronidazole by TiO_2 and Bi-Se-Te /TiO_2 nanomaterials

Ngo Ngoc Uyen[1,2], Le Thi Cam Tuyen[3], Nguyen Thi Thu Tram[4], Le Minh Nhan[4], Tho Chau Minh Vinh Do[5], Ly Anh Tu[1], Phuoc Huu Le [6,2*], Chih-Wei Luo[7]

[1]*Faculty of Applied Science, Ho Chi Minh City University of Technology - VNUHCM, 268 Ly Thuong Kiet Street, District 10, Ho Chi Minh City, Vietnam*

[2]*Department of Physics and Biophysics, Faculty of Basic Sciences, Can Tho University of Medicine and Pharmacy, 179 Nguyen Van Cu Street, Can Tho City, Vietnam*

3Faculty of Chemical Engineering, Can Tho University, 3-2 Road, Can Tho City, Vietnam

[4]*Department of Chemistry, Faculty of Basic Sciences, Can Tho University of Medicine and Pharmacy, 179 Nguyen Van Cu, Can Tho 94000, Vietnam*

[5]*Faculty of Pharmacy, Can Tho University of Medicine and Pharmacy, 179 Nguyen Van Cu Street, Can Tho City, Vietnam*

[6]*Center for Plasma and Thin Film Technologies, Ming Chi University of Technology, New Taipei City 24301, Taiwan*

[7]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 30010 Taiwan*

*Corresponding e-mail: lhuuphuoc@ctump.edu.vn

Antibiotic residues in aquaculture wastewater are considered as an emerging environmental problem, as they are not efficiently removed in wastewater treatment plants. To degrade antibiotic residues in aqueous environment, we fabricated TiO_2 nanowires on nanotube arrays (TNWs/TNAs), Bi-Se-Te nanoparticle (NP)-decorated-TNWs/TNAs, which were applied for assessing the photocatalytic degradation of metronidazole with initial concentration of 300 ng/mL. The TNWs/TNAs was synthesized by anodization using an aqueous NH_4F/ethylene glycol solution, meanwhile Bi-Se-Te NPs were synthesized by plasma- assisted exfoliation method from Bi_2Se_2Te single crystal, and used to decorate on TNWs/TNAs. The photocatalytic performance of TNWs/TNAs and Bi-Se-Te NPs-TNWs/TNAs was studied by monitoring the degradation of metronidazole under ultraviolet (Uv)-visible (Vis) illumination by a high-performance liquid chromatography (HPLC). All the TiO_2 nanostructures exhibited anatase phase and well-defined morphology of nanowires on nanotubes. The TNWs/TNAs and Bi-Se-Te NPs-TNWs/TNAs nanomaterials degraded metronidazole effectively and rapidly, in which the metronidazole removal percentages of TNWs/TNAs and Bi-Se-Te NPs-TNWs/TNAs were 71.8% and 83.0% after 20 min treatment under UV-VIS irradiation (100 $mW \cdot cm^{-2}$), respectively. In addition, the reaction rate constant of Bi-Se-Te NPs-TNWs/TNAs was higher than that of TNWs/TNAs (85.4×10^{-3} min^{-1} vs. 60.7×10^{-3} min^{-1}), which could be attributed to the localized surface plasmon resonance effect of Bi-Se-Te NPs and the enhanced charge separation effect in hydrid Bi-Se-Te NPs-TNWs/TNAs system. TNWs/TNAs and Bi-Se-Te NPs-TNWs/TNAs were synthesized successfully and possessed high-performance in photocatalytic degradation of a representative antibiotic of metronidazole.

Keywords: TiO_2 nanowires on nanotube arrays, Bi-Se-Te, metronidazole, HPLC.

Presenting author Email address: nnuyen@ctump.edu.vn

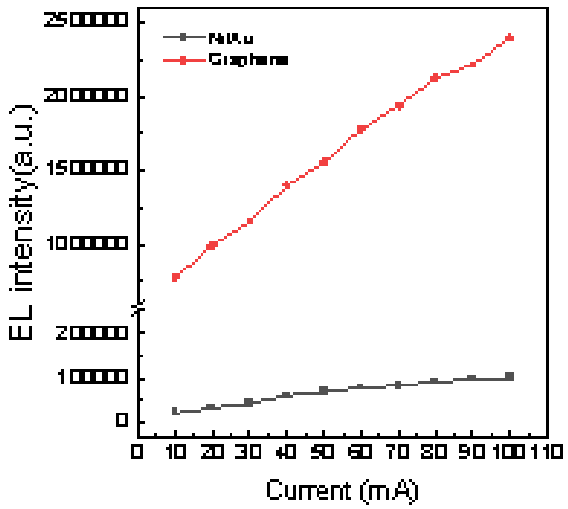
Enhancing Deep Ultraviolet Light-Emitting Diodes by Graphene Transparent Conductive Layer

Yu-Hsiang Liao[1], Yi-Hsiang Liao[2], and Wen-Cheng Ke[3*]

[1]*Department of material science and engineering, National Taiwan University of Science and Technology, Taipei, Taiwan*

[*] Corresponding e-mail: *wcke@mail.ntust.edu.tw*

Graphene is a tow-dimensional carbon material with a hexagonal lattice structure. It has excellent properties such as low sheet resistance (~250 Ω-cm), high thermal conductivity (2000~4000 W/mK) and excellent carrier mobility. Compared with traditional indium tin oxide (ITO), graphene has a transmittance of more than 90% at wavelength below 280 nm, making it an excellent choice for the transparent conductive layer od deep ultraviolet light-emitting diodes (DUV-LEDs). The experiment used a low-pressure chemical vapor deposition process to synthesize graphene on copper foil and then transferred it to a DUV-LED substrate. And the electroluminescence spectra in DUV-LEDs containing graphene can be studied through metal electrodes formed by thermal evaporation in high vacuum. The results show that compared with DUV-LEDs using traditional nickel-gold electrodes as shown in Figure 1, the luminous intensity is significantly increased by 20 times. This improvement shows the key role of graphene as a current diffusion layer, enhancing the luminous intensity of DUV-LEDs. Utilizing graphene as a transparent conductive layer to enhance DUV-LED performance opens up a promising avenue for the development of more efficient and high-performance DUV-LEDs.



Keywords: DUV-LEDs, cuttent diffusion layer, graphene

Presenting author Email address: M11204202@mail.ntust.edu.tw

Preparation of Graphene Mask using Solid State Carbon Source

Ashutosh Shirsat[1], Frazna Parastuti[2], Nafila Amalia Syahida[3], Wen-Cheng Ke*

[1]*Materials Science and Engineering, National Taiwan University of Science and Technology, Taipei, Taiwan.*

*Corresponding Email: wcke@mail.ntust.edu.tw

Gallium Nitride (GaN) and similar materials with wide band gaps and high critical fields are commonly used in optoelectronics components and are emerging as viable semiconductors for energy-efficient power electronic systems. In fact, integrating GaN-based materials in power electronics can improve device efficiency and lower electric power consumption. However, the lack of high-quality gallium nitride impedes the advancement of nitride technology. Currently, all the GaN-based devices are heteroepitaxially grown on foreign substrates such as sapphire (Al_2O_3), because of the lack of native substrates. This introduces significant lattice mismatch and difference in thermal expansion coefficient between the layer and substrates, leading to the formation of multiple strained layers with a high threading dislocation density and cracking behaviour. To address these challenges, the sapphire substrate is considered a promising platform, which shares a hexagonal symmetry with GaN. However, its lattice constants are very different from those of GaN. In this study, we aim to improve the uniformity of a patterned graphene mask using nitrogen-doped ultrananocrystalline diamond (N-UNCD) employed as a carbon source for graphene synthesis offering high thermal stability, excellent adherence on a sapphire substrate which can be further used for epitaxial lateral overgrowth technology. This mask helped to enhance the heat dissipation using graphene and reduce the threading dislocation and strain relaxation moreover, it also helped in achieving lateral epitaxial overgrowth, leading to better crystal quality of GaN and improving the device performance. The fabrication involved the growth of N-UNCD on a sapphire substrate via microwave plasma chemical vapour deposition (MP CVD), a 100 nm Ni layer was subsequently deposited on N-UNCD to convert it into graphene using a rapid thermal process (RTP) using a low-pressure CVD system. Wet etching effectively removed the residue resulting in a uniform graphene layer. To create a dot mask, 30nm of Ni was deposited onto the uniform graphene layer using a metal mask via thermal evaporation, followed by an O2 plasma etching process. The characterisation of the graphene mask could be done through qualitative and quantitative analysis using Raman scattering and scanning electron microscopy (SEM) as shown in **Figure 1.** In our Raman scattering we obtained an Id/Ig ratio of 0.3 additionally, scanning electron microscopy (SEM) confirmed that a uniform graphene layer could be achieved successfully.

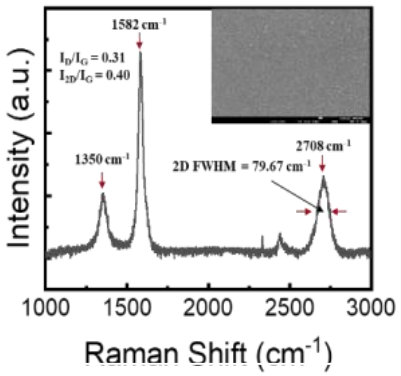


Figure 1. Raman scattering of graphene mask and inset SEM of graphene mask

Keywords: Sapphire substrate, N-UNCD, Graphene mask, threading dislocation, lattice mismatch.

References:

[1] Y. Haoa, "Optical properties evolution of GaN film grown via lateral epitaxial overgrowth," *Applied Surface Science*, 2020.

[2] Wen-Cheng Ke, "Nitrogen-doped ultrananocrystalline diamond conductive layer grown on InGaN-based light-emitting diodes using nanopattern enhanced nucleation," Applied Surface Science, 2021.

Presenting author Email address: Ashutoshshirsat444@gmail.com

Wide-range and area-selective threshold voltage tunability in quasi-2D oxide semiconductor

Po-Han Tseng[1], Sung-Tsun Wang[1], Tanveer Ahmed[1], Yi-Yu Pan[1], Shih-Chieh Chen[1], Che-Chi Shih[2], Wu-Wei Tsai[2], Hai-Ching Chen[2], Chi-Chung Kei[3], Tsung-Te Chou[3], Wen-Ching Hung[4,5], Jyh-Chen Chen[4], Yi-Hou Kuo[6], Chun-Liang Lin[6], Wei-Yen Woon[2]*, Szuya Sandy Liao[2], Der-Hsien Lien[1]*

National Yang Ming Chiao Tung University, Hsinchu, Taiwan
[2]Research & Development, Taiwan Semiconductor Manufacturing Company, Hsinchu, Taiwan
[3]Taiwan Instrument Research Institute, National Applied Research Laboratories, Hsinchu, Taiwan
[4]Department of Mechanical Engineering, National Central University, Jhongli City, Taiwan
[5]K-Jet Laser Tek Inc., Hsinchu, Taiwan
[6]Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu, Taiwan

* Corresponding e-mail: *wywoona@tsmc.com, dhlien@nycu.edu.tw*

The scaling of transistors with thinner channel thicknesses has led to a surge in research on two-dimensional (2D) and quasi-2D semiconductors. However, modulating the threshold voltage (V_T) in ultrathin transistors is challenging, as traditional doping methods are not readily applicable. In this work, we introduce a novel optical-thermal method, combining ultraviolet (UV) illumination and oxygen annealing, to achieve broad-range V_T tunability in ultrathin In_2O_3. This method can achieve both positive and negative V_T tuning and is reversible. The modulation of sheet carrier density, which corresponds to V_T shift, is comparable to that obtained using other doping and capacitive charging techniques in other ultrathin transistors, including 2D semiconductors. With the controllability of V_T, we successfully demonstrate the depletion-load inverter and multi-state logic devices, and wafer-scale V_T modulation, showcasing its potential for low-power circuit design and non-von Neumann computing applications.

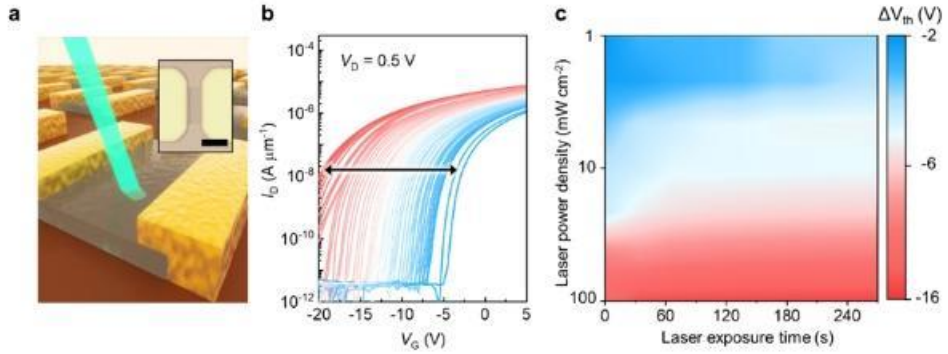


Figure 1. (a) A schematic of V_T tuning in ultrathin In_2O_3 transistors through UV exposure combined with thermal annealing. (b) Transfer curves of 2 nm In_2O_3 transistors with channel width/length of 10/2 μm and after exposure to UV light. (c) A contour plot of V_T shifts as a function of UV exposure time and power density.

Keywords: quasi-2D, oxide semiconductor, V_T modulation, UV exposure, wide-range

Presenting author Email address: robert10096901.ee09@nycu.edu.tw

Abnormal short channel effect in ultrathin oxide semiconductors

Yi-Yu Pan[1], Der-Hsien Lien[1*]

[1] *Institute of Electronics, National Yang Ming Chiao Tung University, Hsinchu 30010, Taiwan, ROC*

[*] Corresponding e-mail: *dhlien@nycu.edu.tw*

Ultrathin In_2O_3 at sub-2 nm thickness has recently emerged as a promising channel material for achieving high-performance ultrathin transistors with excellent transport characteristics. However, short-channel effects (SCEs) have been observed in In_2O_3 transistors at channel lengths (L_{ch}) far longer than the short-channel limit. Our experimental and simulation studies indicate that the observed SCEs are caused by the annealing effect during the high-energy metal deposition, which shifts the threshold voltage (V_{th}) of the oxide semiconductors. The inhomogeneous heating effect results in a V_{th} gradient formed along the channel of the transistor, where the measured V_{th} is determined by the lowest V_{th} within the gradient. As L_{ch} shortens, this heating effect becomes more pronounced due to limited heat dissipation capability, leading to greater V_{th} shifts and the observed SCEs. Based on these findings, we formulate deposition conditions to engineer the V_{th} gradient and mitigate the observed SCEs in ultrathin In_2O_3 transistors. Our results shed light on the impact of local heating in ultrathin transistors and provide guidelines for the design of high-performance and reliable devices based on ultrathin oxide semiconductors.

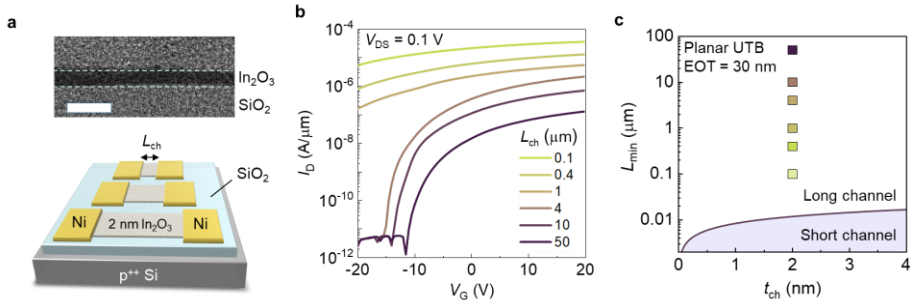


Figure 1. (a) Schematic diagram of the back-gated In_2O_3 transistor. (b) Transfer characteristics of ultrathin In_2O_3 transistors with different L_{ch}. (c) Natural scaling length calculated for planar UTB with an equivalent oxide layer thickness (EOT) of 30 nm. Scatter square points indicate the L_{ch} of the transistors demonstrated in this study.

Keywords: Ultrathin oxide semiconductor, Thin-film Transistor (TFT), short-channel effects, V_{th} shift

References:

[1] M. Si, and P. D. Ye, "Why In2O3 Can Make 0.7 nm Atomic Layer Thin Transistors," Nano Lett. 21, 500 (2021)
[2] M. Si, and P. D. Ye, "Enhancement-Mode Atomic-Layer-Deposited In2O3 Transistors With Maximum Drain Current of 2.2 A/mm at Drain Voltage of 0.7 V by Low-Temperature Annealing and Stability in Hydrogen Environment," IEEE Transactions on Electron Devices 68, 1075 (2021)
[3] G. Alexander, "Interplay between O2 and SnO2: oxygen ionosorption and spectroscopic evidence for adsorbed oxygen." Chemphyschem. 7, 2041 (2006).

Presenting author Email address: yypan.ee10@nycu.edu.tw

Insights into the Formation of Cu_2O Nanostructures and Ion Exchange Reactions by In-Situ X-Ray Absorption Spectroscopy

Heng-An Chen[1], Yu-Chung Chang[1], Jeng-Lung Chen[2], and Chun-Hong Kuo[1]*

[1]*Department of Applied Chemistry, National Yang Ming Chiao Tung University, Hsinchu, 300093, Taiwan*
[2]*National Synchrotron Radiation Research Center, Hsinchu, 300092, Taiwan*

* Corresponding e-mail: *chenann.sc09@nycu.edu.tw*

Cu_2O is a kind of *p*-type semiconductor. The nanoparticles of Cu_2O have been widely used as the catalysts in the realms of photocatalysis, electrocatalysis and CO reduction reaction. Furthermore, Cu_2O nanoparticles can serve as morphological templates to form Cu_2S and ZnS. In this study, we applied in-situ X-ray absorption spectroscopy to investigate the changes in the electronic Figure 1. Scheme of structure of Cu_2O and the process of anion and cation exchange. Possible ion exchange process intermediates formed during the reaction will also be examined. Hopefully, the approaches may be beneficial for understanding the formation of Cu_2O nanoparticles and the mechanism of ion exchange reactions, broadening the applications in future.

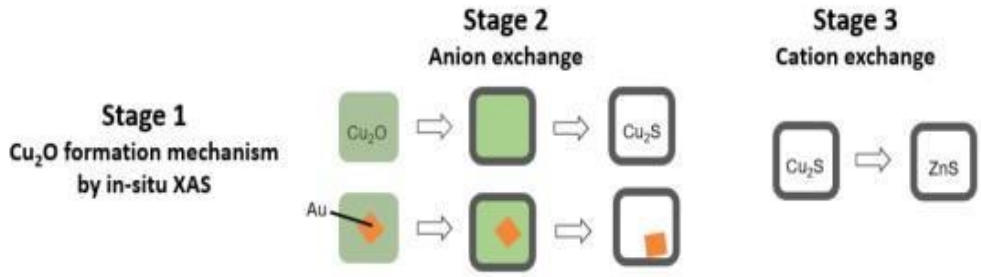


Figure 1. Scheme of ion exchange process

Keywords: Cu_2O, ZnS, XAS, ion-exchange

References:

[1] Huang, W.-C.; Lyu L.-M.; Yang Y.-C.; Huang, M. H. Synthesis of Cu_2O Nanocrystals from Cubic to Rhombic Dodecahedral Structures and Their Comparative Photocatalytic Activity. *J. Am. Chem. Soc.* **2012**, *134*, 1261–1267.
[2] Kuo, C.-H.; Hua, T.-E.; Huang, M. H. Au Nanocrystal-Directed Growth of Au-Cu_2O Core-Shell Heterostructures with Precise Morphological Control. *J. Am. Chem. Soc.* **2009**, *131*, 17871–17878.
[3] Wu, H.-L.; Sato, R.; Yamaguchi, A.; Kimura, M.; Haruta, M.; Kurata, H.; Teranishi, T. Formation of Pseudomorphic Nanocages from Cu_2O Nanocrystals through Anion Exchange Reactions. *Science* **2016**, *351*, 1306−1310

Presenting author Email address: chenann.sc09@nycu.edu.tw

Formation of Nickel After WS_2 Hydrogen-Cracking Modifications

Wei-Tung Liu[1], Hui-Ting Liu[1, 2], Wan-Hsin Chen[1], Shu-Jui Chang[2], Kuan-Yu Chen[1], Chun-Liang Lin[1], Chenming Hu[2]

[1]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 300, Taiwan.*
[2]*Center for Semiconductor Technology Research, National Yang Ming Chiao Tung University, Hsinchu 300, Taiwan.*

[*] Corresponding e-mail: *clin@nycu.edu.tw*

Tungsten disulfide (WS_2), with a lighter carrier mass among all transition-metal dichalcogenides (TMDs), is attractive with potentially high carrier mobility for next-generation electronic devices [1]. In advance of future application, we should overcome an obstacle, a relatively high contact resistance between metals and TMD materials, which results inthe poor performance of electronic devices and impedes the further application of two-dimensional materials. Nickel is often used as the contact metal in modern electronic devices. We have tried growing Ni islands on pristine WS_2 under an ultra-high vacuum condition, but a scanning tunneling microscopy (STM) study revealed that Ni atoms form large and irregular size and shapes clusters, which is unideal as metal-TMD contact.

Here, we tried to develop a better formation for Ni grown on the WS_2 surface by exposing it to cracked H to introduce S defects on the surface. STM images clearly show that the Ni islands grow layer-by-layer mode on the defective surface instead of island growth on the pristine surface. This change in the growth behavior is expected to improve the contact resistance in the electronic device in future studies.

Keywords: transition-metal dichalcogenides (TMDs), STM , hydrogen, contact resistance

References:

[1] Pin-Chun Shen; Cong Su; Yuxuan Lin; Ang-Sheng Chou. Ultralow contact resistance between semimetal and monolayer semiconductors. Nature 2021, *593(7858):211-217*.

Presenting author Email address: tony25875522.sc12@nycu.edu.tw

Tomography Scan of Charge Density Wave in $NbSe_2$

Jyun-Yu Wu[1*], Yung-Ting Lee[2], Guan-Hao Chen[1, 4], Zheng-Hong Li[1], Chang-Tsan Lee[1], Jie-Yu Hsu[1], Chia-Nung Kuo[3], Juhn-Jong Lin[1], Wen-Hao Chang[1, 4], Chin-Shan Lue[3, 5], Noriaki Takagi[7], Po-Tuan Chen[2], Cheng-Tien Chiang[6, 9], Chien-Cheng Kuo[8], Chien-Te Wu[1], Chi-Cheng Lee[9*], Ming-Chiang Chung[10*], Hung-Chung Hsueh[9*], Chun-Liang Lin[1*]

[1]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 300, Taiwan*
[2]*Department of Vehicle Engineering, National Taipei University of Technology, Taipei 106, Taiwan*
[3]*Department of Physics, National Cheng Kung University, Tainan 701, Taiwan*
[4]*Research Center for Applied Sciences, Academia Sinica, Taipei 115, Taiwan*
[5]*Consortium of Emergent Crystalline Materials, National Science and Technology Council, Taipei 106, Taiwan*
[6]*Institute of Atomic and Molecular Sciences, Academia Sinica, Taipei 106, Taiwan*
[7]*Graduate School of Human and Environmental Studies, Kyoto University, Kyoto 606-8501, Japan*
[8]*Department of Physics, National Sun Yet-Sen University, Kaohsiung 804, Taiwan, Taiwan*
[9]*Department of Physics, Tamkang University, New Taipei City 251, Taiwan*
[10]*Department of Physics, National Chung Hsing University, Taichung 402, Taiwan*

[*] Corresponding e-mail: *clin@nycu.edu.tw*

Charge density wave (CDW) resulting from a periodic distortion in the lattice creates new orders beyond the original lattice. In *2H*-$NbSe_2$, one of the layered transition metal dichalcogenides (TMD), the 3×3 charge order appears in two-dimensional (2D) layers. Although CDW can be observed by different techniques, the spatial distribution within a 2D layer has never been systematically visualized. Here, by using scanning tunneling microscopy (STM) and density functional theory (DFT), we monitored the evolution of CDW along the *c*-axis and realized a tomography scan of CDW of the topmost layer. The results show that the appearance of the CDW varies while tuning the tunneling current and undergoes a transition from the outermost Se level to Nb level. The calculation of orbital charge distributions shows that both CDW intensity modulation and the transition are strongly correlated with the distribution of Se 4*p* orbitals and Nb 4*d* orbitals.

Keywords: Charge density wave (CDW), Scanning tunneling microscopy (STM), Transition metal dichalcogenides (TMD), Density functional theory (DFT)

References:

[1] Jyun-Yu Wu, Chun-Liang Lin[*] *et al*. arXiv:2303.12053vl.

Presenting author Email address: joe880207@gmail.com

Radiation and Annealing Effects on N-Channel MOSFETs

Po Hung Lin, Chih En Hsu, Sheng Qian Li, Wen Bin Jian

Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu, Taiwan

*Corresponding e-mail : *wbjian@nycu.edu.tw*

Metal-oxide-semiconductor field-effect transistors (MOSFETs) are common and essential electronic components that are widely used in digital and analog circuits. In this paper, we will discuss the radiation effects encountered by MOSFETs when they are applied to low-earth orbit satellites. That may result in electrical degradations or component damages.

In this study, *n*-type MOSFETs were selected as the devices under test (DUT) for the investigation of radiation damages and annealing effects under proton irradiation at mean energy of 200 MeV and fluence up to $\sim 10^{11}\ \mathrm{particles/cm^2}$.

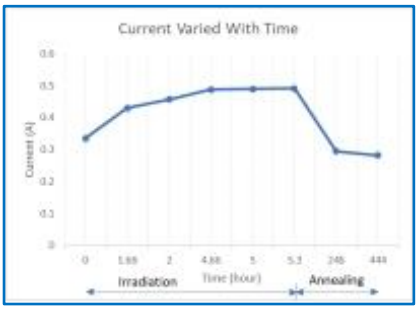


Figure 1. Curent varied with time

The electrical characteristics were measured before and after the proton irradiation. The experimental findings indicate changes in the current-voltge (I-V) curves after irradiation. It correlats with increasing conductivity that could be attributed to a creation of oxide charges in the channel of *n*-type MOSFETs.

After reviewing the impacts of the radiation effect on the MOSFETs, there are some approach strategies that can be concluded to ensure the reliability of MOSFETs under the irradiation environments of low-Earth orbit (LEO).

Keywords: Metal-oxide-semiconductor field-effect transistor (MOSFET), Total ionizing dose (TID), Low-earth orbit (LEO).

References:

[1] TASTI2023 - Low Dose Rate Radiation Damage Effects on Power MOSFETs.
[2] TASTI2023 - Failure Analysis of Proton-Irradiated Solid-State Drive.

Presenting author Email address: r411651011.sc11@nycu.edu.tw

Exploring Anisotropy of Electrical and Thermoelectric Properties in FewLayer $ReSe_2$ Field-Effect Transistors

Shin-Lin Tsai[1*], Pang-Chia Chang[1], Chun-Yang Ho[1], Zheng-Ji Ou[1], Ching-Hwa Ho[2], Wen-Bin Jian[1]

[1]*Department of Electrophysics, National Chiao Tung University, Hsinchu, Taiwan*
[2]*Graduate Institute of Applied Science and Technology, National Taiwan University of Science and Technology, Taipei, Taiwan*

[*] Corresponding e-mail: sltsai.sc12@nycu.edu.tw

Recently, transition-metal dichalcogenide (TMD) materials have been extensively studied in electronic and thermoelectric devices due to their unique physical properties. Among them, rhenium diselenide ($ReSe_2$) manifests itself due to its strong anisotropy of its atomic structure from array clusters Re atoms. It exhibits a low symmetry 1T structure. The shape of isolated $ReSe_2$ flakes usually exhibit long straight edge in optical microscope images thus it is easy to determine its axis along the long straight edge as the b-axis which is in line with the direction of chains of clustered Re atoms. In this report, we will discuss the anisotropy effect of electrical and thermoelectric characterizations in the $ReSe_2$ basal plane.

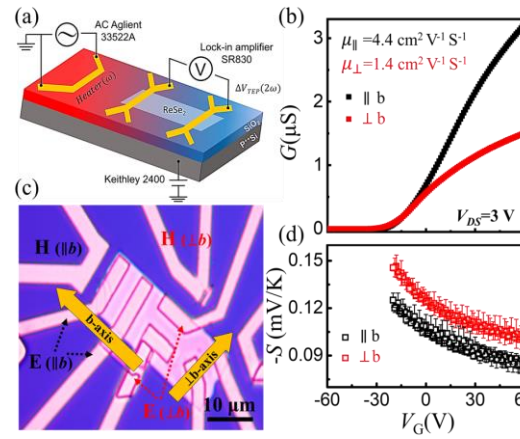


Figure 1. (a) Schematic diagram of $ReSe_2$ thermoelectric device (b) Correlation between conductivity G and back gate voltage V_G for each of the two measurement angles. (c) $ReSe_2$ device used in this experiment to measure the anisotropic properties. (d) Seebeck coefficient S versus back gate voltage V_G.

In electrical characterizations, we fabricated $ReSe_2$ field-effect transistors with 12 electrodes evenly spaced at 30° to measure the angle dependences of electron mobilities and conductivities. It was found that the maximum and minimum of mobilities are 29 and 17 $cm^2/V{\cdot}s$, respectively, with a 90° change, which corresponding to the parallel to b-axis and perpendicular to b-axis.

In addition, we further explored the anisotropy effect of thermoelectric properties. We made heating electrodes parallel and perpendicular to the b-axis for the test of anisotropy. This arrangement allowed us to measure thermopowers due to temperature gradient on $ReSe_2$ during the heating process thus we estimated the Seebeck coefficients of the few-layer $ReSe_2$.

Our data supports that the mobility and conductivity is higher in the direction parallel to the b-axis of $ReSe_2$ whereas the Seebeck coefficient and the thermoelectric power factor are lower which is opposition to anisotropic electrical manners.

Keywords: Rhenium diselenide, Transition-metal dichalcogenide, anisotropy, Seebeck effect

References:

[1] E. Liu, Y. Fu, Y. Wang, Y. Feng, H. Liu, X. Wan, W. Zhou, B. Wang, L. Shao, C.-H. Ho, Y.-S. Huang, Z. Cao, L. Wang, A. Li, J. Zeng, F. Song, X. Wang, Y. Shi, H. Yuan, H. Y. Hwang, Y. Cui, F. Miao, and D. Xing, Nat. Commun. 6, 6991 (2015).

[2] J. Wu, H. Schmidt, K. K. Amara, X. Xu, G. Eda, and B. Özyilmaz, Nano Lett. 14, 2730 (2014).

[3] K. Hippalgaonkar, Y. Wang, Y. Ye, D. Y. Qiu, H. Zhu, Y. Wang, J. Moore, S. G. Louie, and X. Zhang, Phys. Rev. B 95, 115407 (2017

Presenting author Email address: sltsai.sc12@nycu.edu.tw

Photo-Excitation of Gray Excitons in a WSe_2 Monolayer with Vector Vortex Beams

Oscar Javier Gomez Sanchez[1], Guan-Hao Peng[1], Wei-Hua Li[1], Ching-Hung Shih[2], Chao-Hsin Chien[2], and Shun-Jen Cheng[1*]

[1] *Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 300, Taiwan*
[2] *Institute of Electronics, National Yang Ming Chiao Tung University, Hsinchu 300, Taiwan*

[*] Corresponding e-mail: *sjcheng@nycu.edu.tw*

A light beam can be structured in its complex amplitude to possess orbital angular momentum (OAM), adding to the inherent spin angular momentum (SAM) linked to circular polarization. Combining two differently twisted lights with distinct SAM and OAM creates a vector vortex beam (VVB) in non-separable states [1]. In these states, not only the complex amplitude but also polarization are spatially structured and entangled. Additionally, the SAM and OAM in a VVB are interconnected through optical spin-orbit interaction, constitute the profound spin-orbit physics in photonics.

Our investigation focuses on the interaction between VVBs and WSe2 monolayers (WSe_2-MLs), particularly with gray excitons (GXs), a type of spin-forbidden dark exciton [2]. Utilizing the longitudinal field of twisted light, we observe a significant enhancement in photo-excitation of GXsOur research showcases that spin-orbit-coupled VVBs remarkably imprint orbital angular momentum information onto the optical matrix elements of gray excitons. This imprinting remains resilient against inherent decoherence mechanisms within materials, highlighting the robustness of this approach [3]. This finding proposes an effective approach to decode transferred angular momentum from structured lights to excitons.

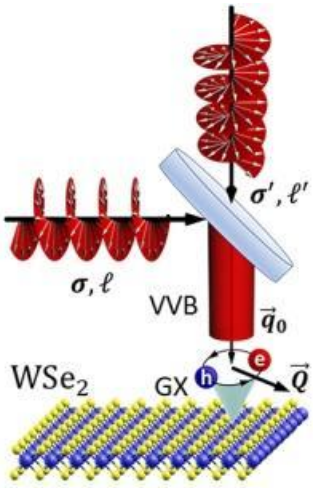


Figure 1. Vector vortex beam (VVB) as a light source for the phto-generation of excitons in a $WWSe_2$-ML.

Keywords: gray-exciton; vector vortex beam; transition-metal dichalcogenide;

References:

[1] Forbes, Andrew, Michael de Oliveira, and Mark R. Dennis, Nat. Photonics 15, 253-262 (2021).
[2] S.-Y. Chen, T. Goldstein, T. Taniguchi, K. Watanabe, and J. Yan, Nat. Commun. 9, 3717 (2018).
[3] Sanchez, O. J. G., Peng, G. H., Li, W. H., Shih, C. H., Chien, C. H., & Cheng, S. J, arXiv preprint 2307.10916 (2023).

Presenting author Email address: gomezsanchez.oscarjavier@gmail.com

Surface Morphology and Crystal Structure of Gallium Monochalcogenides Grown by Molecular Beam Epitaxy

Nhu Quynh Diep[1], and Wu-Ching Chou[1*]

[1]*Department of Electrophysics, National Yang-Ming Chiao-Tung University, Hsinchu 300093, Taiwan.*

[*] Corresponding e-mail: *wcchou957@nycu.edu.tw*

During the past decade, many researchers have demonstrated that leveraging hybrid dimensionality figures of merits, such as integration of 2D-layered materials with 3D substrates/templates via heteroepitaxy could be a crucial benefit to enhance the performance of 2D-based optoelectronic devices. This work aims to demonstrate that molecular beam epitaxy (MBE) is reliable for achieving the GaXs (X = Se, Te) materials on 3D substrates with highly controlled crystal structures, morphologies, and physical properties, by using in-situ reflection high-energy electron diffraction (RHEED) and surface morphology characterization techniques. A coexistence of hexagonal-GaTe (h-GaTe) and monoclinic-GaTe (m-GaTe) phases in the film was explored, leading to the formation of lateral h/m-GaTe heterophase-homojunction in the MBE-grown GaTe on GaAs (001). Moreover, the growth fashions of GaSe on 3D substrates, screw-dislocation-driven (SDD) mode, or layer-by-layer (LBL) mode, are demonstrated to be controllable via tuning the growth temperature, resulting in various film morphologies with distinct physical properties. Typically, high-density and uniform spiral structures were observed in the SDD-GaSe at low temperatures, whilst μm-scale triangular LBL-GaSe morphology was dominant at a high-temperature regime. As a result, a significant blueshift of ~ 0.21 eV in PL spectra of the LBL-GaSe layer concerning the SDD-GaSe layer indicated, opening up the probability for band structure engineering of the 2D-GaSe epitaxial layers by switching the growth mode.

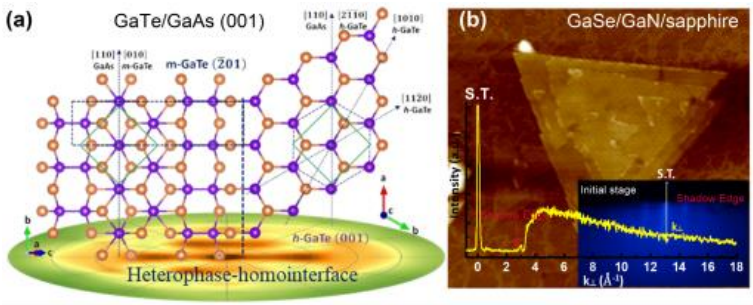


Figure 1. (a) Azimuthal RHEED 2D reciprocal map of GaTe/GaAs (001), and (b) LBL-GaSe grown on GaN/sapphire.

Keywords: GaSe, GaTe, Molecular Beam Epitaxy.

References:

[1] **Nhu Quynh Diep**, Cheng-Wei Liu, Ssu-Kuan Wu, Wu-Ching Chou*, Sa Hoang Huynh and Edward Yi Chang, "Screw-Dislocation-Driven Growth Mode in two Dimensional GaSe on GaAs(001) Substrates Grown by Molecular Beam Epitaxy", Scientific Reports, 9:17781, 2019.

[2] Sa Hoang Huynh, **Nhu Quynh Diep**, Tan Vinh Le, Ssu Kuan Wu, Cheng Wei Liu, Duc Loc Nguyen, Hua Chiang Wen, Wu Ching Chou,* Van Qui Le, Thanh Tra Vu, "Molecular Beam Epitaxy of Two-dimensional GaTe Nanostructures on GaAs (001) substrates: Implication for Near Infrared Photodetection", ACS Applied Nano Materials, 4, 8913−8921, 2021.

[3] **Nhu Quynh Diep**, Quynh Trang Tran, Thi Bich Tuyen Huynh, Hua Chiang Wen, Wu Ching Chou, Sa Hoang Huynh, Van Qui Le, Ying Hao Chu, and Thanh Tra Vu, "Growth temperature-driven growth mode transition in two-dimensional GaSe on three-dimensional GaN/sapphire platform for photodetecting applications", being under review by ACS Applied Nano Materials

Presenting author Email address: diepnhuquynh83.sc08@nycu.edu.tw

Epitaxial Growth of 2D β-In_2Se_3/3D β-Ga_2O_3 Heterostructure on c-Sapphire by PA-MBE

Umeshwar Reddy Nallasani[1], Ssu-Kuan Wu[1], Nhu Quynh Diep[1], Yen-Yu Lin[1], Hua-Chiang Wen[1], Wu-Ching Chou[1,*] and Chin-Hau Chia[2]

[1]*Department of Electrophysics, College of Science, National Yang Ming Chiao Tung University, 1001 University Road, Hsinchu 300093, Taiwan, R.O.C.*
[2]*Department of Applied Physics, National University of Kaohsiung, 700 University Road, Kaohsiung 81148, Taiwan, R.O.C*

[*] Corresponding e-mail: *wcchou957@nycu.edu.tw*

The integration of two-dimensional (2D) layered van der Waals (vdWs) materials with wide bandgap semiconductors (WBS) has unveiled impressive opportunities for exploring novel physics and device concepts. Most of the studies realized these heterostructures using the exfoliation techniques or transfer methods, and this can limit their usage in large area applications due to the reduced scalability and may be prone to the origination of defects or contamination issues. A more reliable method to fabricate this heterostructure *in situ* can overcome these challenges and further enhance its practical usage. In the present study, we realized 2D βIn_2Se_3 on 3D β-Ga_2O_3/c-sapphire heterostructure by plasma-assisted molecular beam epitaxy. In the initial stage, we employed a two-stepped β-Ga_2O_3 film on c-sapphire under low temperature (LT-450^{o}C) and high temperature (HT-700^{o}C) conditions, with the LT film used as a nucleation step to optimize the crystalline quality of the HT film. This heterostructure follows the in-plane epitaxial relationship of [010] β-Ga_2O_3 ‖ [1010] c-sapphire and [102] β-Ga_2O_3 ‖ [11-20] c-sapphire and further yielded the in-plane 'b' lattice constant of β-Ga_2O_3 (~3.038 Å) as evaluated by *in-situ* reflection high-energy electron diffraction (RHEED) patterns. The growth of single-phase β-Ga_2O_3 films on c-sapphire was confirmed by X-ray diffraction and Raman measurements. In the next stage, for the first time, 2D In_2Se_3 layers were epitaxially realized on 3D β-Ga_2O_3 film by employing a substrate temperature of 280^{o}C and Se/In flux ratio ~28. Despite the 3D surface morphology of the Ga_2O_3 film, the single phase β-In_2Se_3 layers were successfully realized which is a consequence of vdWs epitaxy and followed the in-plane epitaxial relationship of [11-20] β-In_2Se_3 ‖ [010] βGa_2O_3 and [10-10] β-In_2Se_3 ‖ [102] β-Ga_2O_3. Also, the in-plane 'a' lattice constant of β-In_2Se_3 was evaluated to be ~4.027Å. The surface of the grown In_2Se_3 layers exhibited a triangular domain morphology with an average size of ~ 450nm. The fabrication of this mixed dimensional 2D β-In_2Se_3/3D β-Ga_2O_3 heterostructure realized in this study with their bandgaps ranging from near-infrared (~ 1.43eV) [1] to deep ultraviolet (~5.04 eV) can reveal potential applications in the field of optoelectronics.

Keywords: 2D layered materials, In_2Se_3, Ga_2O_3, mixed-dimensional heterostructure, Molecular Beam Epitaxy

References:

[1] Balakrishnan, N. *et al.* Epitaxial growth of γ-InSe and α, β, and γ-In_2Se_3 on ε-GaSe. *2D Materials* **5**, 035026 (2018).

Presenting author Email address: umeshnalasani@gmail.com

Molecular Beam Epitaxy growth and characterization of 2D GaSe-based heterostructures

Quynh Trang Tran[1], Nhu Quynh Diep[1], Bich Tuyen Huynh Thi[1], Wu Ching Chou[1*]

[1] *Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 300093, Taiwan*

[*] Corresponding e-mail: *wcchou957@nycu.edu.tw*

Since the discovery of graphene, the rapid development of two-dimensional (2D) materials has become a leading topic in materials science and condensed matter physics. The 2D GaSe belonging to the group III-metal monochalcogenide (GIIIMC) with outstanding properties offers great potential in 2D material-based heterostructure for next-generation electronic and optoelectronic applications. In this work, by manipulating the growth temperature and fixing the VI/III ratio, the growth mechanism of 2D-GaSe could be driven from the Layer-by-layer (LBL) to the Screw-Dislocation-Driven (SDD) growth mode, resulting in various surface morphologies. In addition, the influence of 2D-GaSe/sapphire surface characteristics with distinct growth modes on the growth of InGaSe ternary alloy by molecular beam epitaxy was also discussed. It is found that even at a low In/Ga flux ratio, Indium incorporation efficiency could strongly affect the crystal structure and growth mechanism of InGaSe ternary alloy. This study provides an understanding of the GaSe-MBE growth mechanism and opens up the opportunity to investigate GaSe-based heterostructure for realizing future nanodevices.

Keywords : 2D heterostructures, Molecular Beam Epitaxy, group III-metal monochalcogenide, GaSe

Presenting author Email address: tranquynhtrang.sc11@nycu.edu.tw

Growth and Characterizations of InGaSe Ternary Alloys on c-sapphire by Molecular Beam Epitaxy

Bich Tuyen Huynh Thi[1*], Nhu Quynh Diep[1], Quynh Trang Tran[1], Wu Ching Chou[1]

[1]*Department of Electrophysics, College of Science, National Yang Ming Chiao Tung University, Hsinchu, Taiwan*

[*] Corresponding e-mail: *wcchou957@nycu.edu.tw*

Going beyond graphene and Transition Metal Dichalcogenides (TMDs) materials, Group III-metal chalcogenide (GIIIMC) appears as a bright star with unique properties that could widen the potential of applications in the semiconductor industry. In this work, for the first time, full-range InGaSe ternary alloys were grown on the c-sapphire substrate using Molecular Beam Epitaxial (MBE). This report aims to discuss the crystal structure evolution of InGaSe ternary alloys versus the Indium (In) flux ratio. Based on the in-situ observation via Reflection High-Energy Electron Diffraction (RHEED) and ex-situ characterizations of the alloys, it is found that the growth mechanism of the InGaSe ternary alloy undergoes two-dimensional (2D) to three-dimensional (3D) growth mechanism relying on the In/Ga flux ratio. With the current growth condition, at low In concentration, the MBE growth of InGaSe transferred from 2D-$In_xGa_{1-x}Se$ to 3D zinc blende $(In_xGa_{1-x})_2Se_3$. On contrary, the growth mechanism may be driven by the transformation from 2D β- $In_xGa_{1-x}Se$ to 3D wurtzite $(In_xGa_{1-x})_2Se_3$ at very high flux ratio. The results obtained from this study provide a preliminary idea for the influence of Indium components on the physical properties of the GaSe host material, which could propose the premise for the growth of 2D InGaSe ternary alloys in the near future.

Keywords: InGaSe ternary alloys, 2D to 3D transition, MBE

Presenting author Email address: tuyenhuynh.sc11@nycu.edu.tw

Tuning of unoccupied band by surface decoration

Pratyay Amrit[1], Naoya Kawakami[1], Noriaki Takagi[2], Chun-Liang Lin[1*], Hiroshi Ishida[3], Ryuichi Arafune[4*]

[1]*Department of Electrophysics, National Yang Ming Chiao Tung University, 1001 University Rd., Hsinchu 300, Taiwan*
[2]*Graduate School of Human and Environmental Studies, Kyoto University, Kyoto 606-8501, Japan*
[3]*College of Humanities and Sciences, Nihon University, Tokyo 156-8550, Japan*
[4]*Research Center for Materials Nanoarchitectonics (MANA), National Institute for Materials Science (NIMS), 1-1 Namiki, Ibaraki 304-0044, Japan*

[*] Corresponding e-mail: *clin@nycu.edu.tw, ARAFUNE.Ryuichi@nims.go.jp*

It is interesting to see how surface modification or reconstruction can be used to manipulate the physical properties and electronic properties of unoccupied states on solid surfaces. An important representative of unoccupied surface states is the image potential state [1,2]. This state exhibits unique characteristics, such as long lifetime and strong confinement near the surface, making it valuable for understanding the forces experienced by the electron in the vicinity of the metal.

The periodicity of atoms results in the opening of bandgaps, a common occurrence. However, the image potential state has not shown bandgap opening due to the long-range periodic potential within the material. Nevertheless, surface reconstruction, such as the formation of a (5×1) superstructure with Iridium (Ir), can potentially affect the image potential state by introducing additional confinement and modifying electron wavefunctions.

In this study, we have employed two-photon photoemission (2PPE) spectroscopy to investigate the states above the Fermi level. Our observations revealed that the Ir(001)-(5×1) reconstructed surface exhibits a band gap, which arises from the surface reconstruction, whereas such a band gap is not seen on Ir(001)-(1×1) surface. This difference can be attributed to the distinct surface reconstructions of the two structures. This study of the Ir system with surface reconstructions, such as the (5×1) superstructure, offers a platform to investigate electronic properties and phenomena associated with confined electron dynamics.

Keywords: Two-Photon Photoemission, Image Potential State, Surface Modification, Iridium

References:

[1] P. Echenique et al., J. Phys. C: Solid State Phys. 11 2065 (1978).
[2] P. Echenique et al., Prog. Surf. Sci. 32 111 (1989).

Presenting author Email address: pratyay.sc08@nycu.edu.tw

Growth and Characteristics of $InSe_{1-x}Te_x$ Ternary Compound Thin Films with an Indium Precursor Layer by Molecular Beam Epitaxy

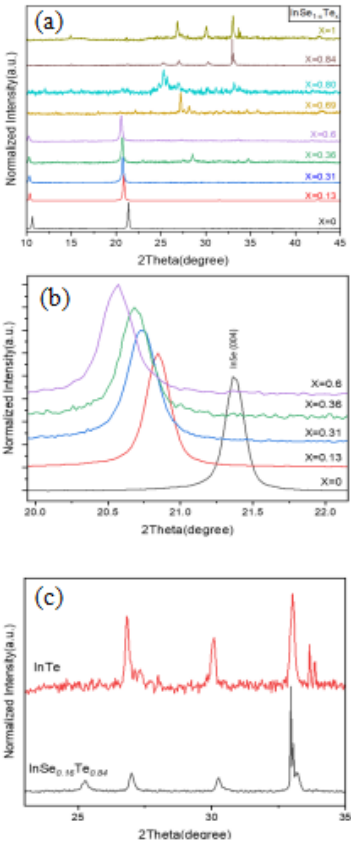
Jia-Cheng Yang [1], Chu-Shou Yang[1*], Hao-Ning Yang[1], Chao An Jong[2], Sheng-Wei Hsiao[3] Ssu kuan wu[4]

[1] *Institute and Department of Electrical Engineering, Tatung University, Taipei, Taiwan*
[2] *National Applied Research Laboratories Taiwan Semiconductor Research Institute*
[3] *National Synchrotron Radiation Research Center*
[4] *Department of Electrophysics, National Yang-Ming Chiao-Tung University, Hsinchu 30010, Taiwan*

[*] Corresponding e-mail: csyang@gm.ttu.edu.tw

In this work, a series ternary compounds of indium selenide-telluride ($InSe_{1-x}Te_x$, $0 \leq x \leq 1$) van der Waals (vdW) thin films were grown via the indium precursor assisted molecular beam epitaxy (MBE). The advantage of indium precursor method provides an easy way to produce a vdW thin films with low relationship of substrate [1]. Base on this idea, the atomic flat silicon dioxide (SiO_2/Si) substrates were employed in this experiment. Initially, the InSeTe thin films were deposied at various temperature with a fixed elemental flux ratio to opimize the crystal quality and figure out the growth parameters. The growth temperature were used from 450 to 600 °C. In the Raman scattering spectra of these samples, the narrowest full width at half maximum and the largest singnal to noise ratio of A_1' phonon mode are employed to select the growth temperature. Finally, the growth temperature was optimized at around 550 °C.

Figure 1 dispalies the X-ray diffriction spectra of $InSe_{1-x}Te_x$ ($0 \leq x \leq 1$) thin films. The crystalline of these samples divids into three phases. When x less than 0.6, InSe related crystalline dominates the spectrum. The lattice constant enlarges with increasing the tellurium content. The relationship between lattice constant and composition does not satisfy Vegard's Law, especially when the tellurium concentration is low, as shown in Fig. 1(b). When x higher than 0.6, the crystalline is complex. It is consistent with InSe-related and InTe-related. When the composition of tellrium closes to 1, InTe-related crystallography dominates, as shown in Fig. 1(c). The changes in surface morphology detected by scanning electron microscope are similar to the crystal structure analyzed by XRD. In Raman scattering analysis, it was found that the longitudinal phonon mode is significantly affected by tellurium concentration, and the difference in phonon energy states can be up to four times greater than that of the transverse phonon mode



Figs. 1(a) X-ray diffriction spectra of $InSe_{1-x}Te_x$ (0*x*1) thin films. (b) XRD signal of InSe (004) of *x* between 0 and 0.6 and (c) Focus on InTe and $InSe_{0.16}Te_{0.84}$.

Keywords: indium telluride, indium selenide, van der Waals film, indium precursor

References:

[1] Sheng-Wei Hsiao, Chu-Shou Yang, Hao-Ning Yang, "Novel Method for the Growth of Two-Dimensional Layered InSe Thin Films on Amorphous Substrate by Molecular Beam Epitaxy" doi:10.3389/fmats.2022.871003

Presenting author Email address: henry60706@gmail.com

Ultrafast dynamics in quasi-2D CDW systems $LaTe_3$ and $LaSeTe_2$

Nguyen Nhat Quyen[1]*, Wen-Yen Tzeng[2], Jia-Yuan Sun[1], Chien-Ming Tu[1], Chia-Nung Kuo[3], Chien-Te Wu[1,7], Chin-San Lue[3*], Chih-Wei Luo[1,4,5,6*]

[1]*Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 30010, Taiwan*
[2]*Department of Electronic Engineering, National Formosa University, Yunlin 632, Taiwan*
[3]*Department of Physics, National Cheng Kung University, Tainan 70101, Taiwan*
[4]*National Synchrotron Radiation Research Center, Hsinchu 30076, Taiwan*
[5]*Taiwan Consortium of Emergent Crystalline Materials (TCECM), National Science and Technology Council, Taiwan*
[6]*Institute of Physics and Center for Emergent Functional Matter Science, National Yang Ming Chiao Tung University, Hsinchu 30010, Taiwan*
[7]*Physics Division, National Center for Theoretical Sciences, Taipei, Taiwan*

* Corresponding e-mail: *cwluoep@nycu.edu.tw*

Charge density waves (CDW) involved with electronic and phononic subsystems simultaneously are a common quantum state in solid-state physics, especially in low-dimensional materials. This study presents a detailed analysis of time-resolved spectra on $LaTe_3$ and $LaSeTe_2$, quasi-two-dimensional paradigmatic CDW systems. Numerous coherent (Raman active) modes appear upon the phase transition into the CDW state. Using the time-dependent Ginzburg-Landau model, we examine the temperature dependence of mode frequencies, their damping times, and their oscillator strengths. These low-temperature modes originate from the linear coupling between the normal-state phonons at the CDW wave vector and the modulation of the conduction electron density induced by Fermi surface nesting. Furthermore, we can identify the nature of excitation of these coupled modes. The softening mode was discovered to be an overdamped mode, which is primarily electronic in nature. The experimental observation and theoretical. Understanding of ultrafast dynamics may offer insight into other general principles behind nonequilibrium phase transitions in many-body systems

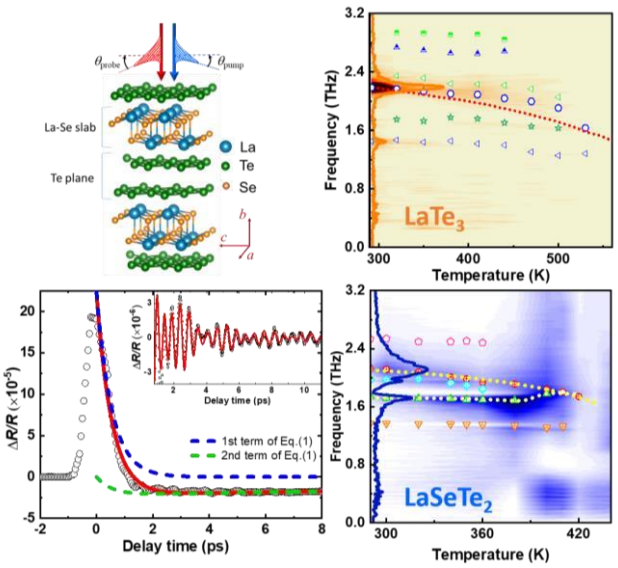


Figure 1. Ultrafast dynamics at various temperatures n the *ac*-plane of $LaTe_3$ and $LaSeTe_2$ single crystals.

Keywords: time-resolved ultrafast spectroscopy, charge density wave

References:

[1] Pavel E. Dolgirev *et al.*, Phys. Rev. B **101**, 054203 (2020).
[2] H. Schaefer *et al.*, Phys. Rev. B **89**, 045106 (2014).

Presenting author's Email address: *nhatquyen126@gmail.com*

Growth Dynamic of Pure Indium Selenide via the Indium Precursor Method by using Molecular Beam Epitaxy

Hao-Ning Yang[1], Chu-Shou Yang[1*], Jia-Cheng Yang[1], Sheng-Wei Hsiao[2], Ssu-Kuan Wu[3], Chao-An Jong[4]

[1]*Institute and Department of Electrical Engineering, Tatung University, Taipei, Taiwan*
[2]*National Synchrotron Radiation Research Center*
[3]*Department of Electrophysics, National Yang-Ming Chiao-Tung University, Hsinchu 30010, Taiwan*
[4] *National Applied Research Laboratories Taiwan Semiconductor Research Institute*

* Corresponding e-mail*:* csyang@gm.ttu.edu.tw

In the pursuit of high-performance nanosemiconductors, the twodimensional material Indium Selenide (InSe) stands out as an exceptional subject for study. Two-dimensional materials, distinguished by their atomicscale thickness, offer higher mobility compared to the widely used material Silicon. Importantly, InSe shares a similar bandgap with Silicon while maintaining its classification as a two-dimensional material.

Our research has been diligently focused on the growth of InSe using molecular beam epitaxy (MBE), incorporating with general MBE, solid phase epitaxy [1], and the indium precursor method [2]. In our previous result, the indium precursor layer provides larger growth window, *i.e.* the larger, parameter setting range. In this study, we aim to delve further into the mechanism of the indium precursor layer. An observed phenomenon is that the additional indium atoms, which come from indium precursor layer, diffuse into the subsequent growing of indium selenide. In this moment, the growth condition was set under indium-poor, which is suitable to form In_2Se_3. In the result, the indium precursor layer assisting to fabricate a pure InSe thin film. Our methodology involves precise control of the indium-to-selenium flux ratio and manipulation of the growth time to observe resulting differences.

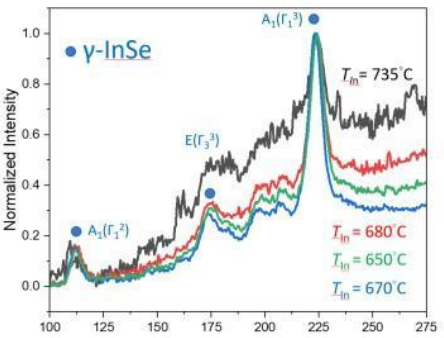


Figure 1. Raman spectra of InSe thin films with T_{In}=650, 670, 680, and 735 °C, respectively.

In Figure 1, the differences in intensity and signal-to-noise ratio are depicted at various indium cell temperatures (650°C, 670°C, 680°C, and 735°C) during the synthesis of InSe. To discern key points in the mechanism, we employ surface morphology analysis to observe smoothness, Raman spectroscopy to verify the presence of pure InSe, and X-ray diffraction (XRD) to observe crystalline quantity. Additionally, Transmission Electron Microscopy (TEM) is deployed to observe the quantity of residue containing indium. Base on these experimental resoults, although the indium cell temperature changes 30 degree, these samples still exhibt single InSe phase.

Keywords: Two-dimensional material, Indium precursor layer, Indium Selenide

References:

[1] Chia-Hsing Wu, Yu-Che Huang, Yen-Teng Ho.; *et al.* Solid Phase Epitaxy of Single Phase TwoDimensional Layered InSe Grown by MBE. Nanomaterials 2022, 12, 2435.
[2] Sheng-Wei Hsiao, Chu-Shou Yang, Hao-Ning Yang,; *et al.* Novel Method for the Growth of TwoDimensional Layered InSe Thin Films on Amorphous Substrate by Molecular Beam Epitaxy. Front. Mater 2022.871003.

Presenting author Email address: stevensteven167@gmail.com

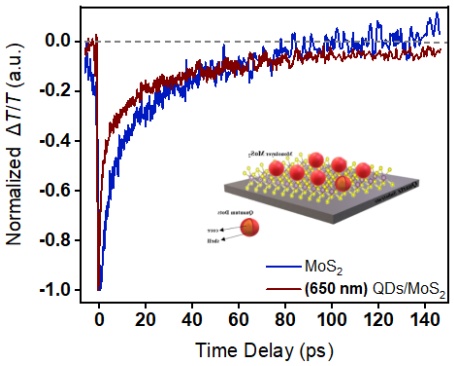
Energy Transfer Between Quantum Dots and Monolayer MoS_2 Studied by Ultrafast optical Pump-Probe Spectroscopy

Bo-Jun Lai[1+], Yi-Hung Lin[1], Yu-Chan Tai[1], Jhen-Dong Lin[1], Ruei-Jhe Tu[1], Shao-Yu Chen[2,3], Chun-Liang Lin[1], Shun-Jen Cheng[1], Chih-Wei Luo[1]

[1]*Department of Electrophysics, National Yang Ming Chaio Tung University, Hsinchu, 30010, Taiwan*
[2]*Center of Atomic Initiative for New Materials, National Taiwan University, Taipei, 10617, Taiwan*
[3]*Center for Condensed Mater Science, National Taiwan University, Taipei, 10617, Taiwan*

[*] Corresding e-mail: *cwluoep@nycu.edu.tw*

We observed the nonradiative energy transfer (NRET) in the hybrid structure of semiconducting quantum dots (QDs) spin-coated on a monolayer (ML) molybdenum disulfide (MoS_2). This study investigated the ultrafast dynamics of excitons in the ML MoS_2 with and without the QDs using optical pump-probe spectroscopy. From photoexciting the heterostructure of QDs/MoS_2, we obtained a faster relaxation and a longer lifetime in the transient transmission spectra. By inspecting the energy l evels of QDs and ML MoS_2, we address the dipole-dipole coupling between QDs and ML MoS_2 as the observation of NRET that appeared in the photoexcited heterostructure of QDs/MoS_2.And we construct the physical model to obtain the efficiency of energy transfer process by using QDs with different emission wavelengths, so that we can uncover the mechanism of NRET in QDs/MoS_2.



Keywords: energy transfer, quantumn dot, 2D material, exciton

References:

[1] Y. Li. *et al*. Phys. Rev. Lett. B. 90, 205422 (2014)
[2] H. Wang. *et al*. Nano. Lett. 15, 339 (2015)
[3] F. Prins. *et al*. Nano. Lett. 14,6087 (2014)
[4] A. Camellini. *et al*. ACS. Photonics. 5, 3363 (2018)
[5] A. Chernikov. *et al*. Phys. Rev. Lett. 113, 076802 (2014)
[6] I. Ahmed. *et al*. Light.Sci. Appl. 10, 174 (2021)
[7] Meng. Xing. Na, Ziliang. Ye. Science. 370, 1166 (2020)
[8] M. K. Man. *et al*. Sci. Adv. 7:eabg0192 (2021)

Presenting author Email address: zach.sc11@nycu.edu.tw

Study of the ablation thresholds of monolayer MoS_2 from femtosecond to picosecond regime

Li-Yang Jiang[1], Yin-Huan Gao[1], Yu-Chan Tai[1], Chih-Wei Luo[1,2,3,4,5]

[1] *Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 300, Taiwan.*
[2] *Institute of Physics and Center for Emergent Functional Matter Science, National Yang Ming Chiao Tung University, Hsinchu 300, Taiwan.*
[3] *National Synchrotron Radiation Research Center, Hsinchu 300, Taiwan.*
[4] *Taiwan Consortium of Emergent Crystalline Materials (TCECM), National Science and Technology Council, Taiwan.*
[5] *Department of Physics, University of Washington, Seattle, Washington 98195, USA.*

[*] Corresding e-mail: *liyangjiamg.sc11@nycu.edu.tw; cwluoep@nycu.edu.tw*

We utilized a single-shot pulsed laser to ablate monolayer MoS_2, employing both Ti:sapphire and Yb-KWG lasers. Ablation areas were measured under varying dispersion conditions. The Ti:sapphire laser covered a pulsewidth range from 60 fs to 4 ps, while the Yb-KWG laser, with multiplate compression (MPC), covered a range from 4.9 fs to 97 fs. Through the relationship between ablation area and pulse energy, we calculated spot sizes and ablation thresholds under different dispersion conditions. Our observations show a decrease in the ablation threshold as pulsewidth decreases. This ablation thresholds-pulse dispersion relation was categorized into three intervals; ionization mechanisms, coulomb interaction in the many-body effect, and bandgap renormalization effects can explain each trend.

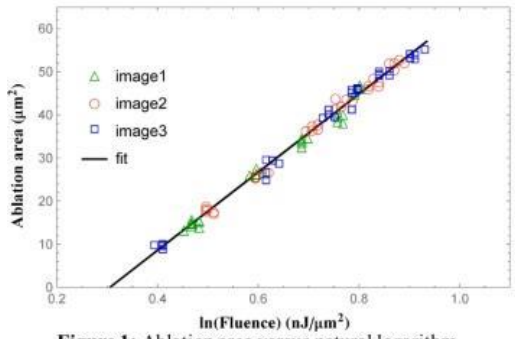


Figure 1: Ablation area versus natural logarithm energy density relationship diagram

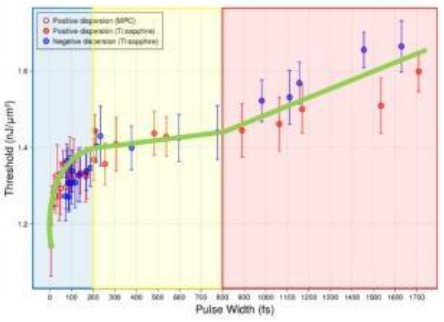


Figure 2: Variation of ablation threshold under different pulsewidths

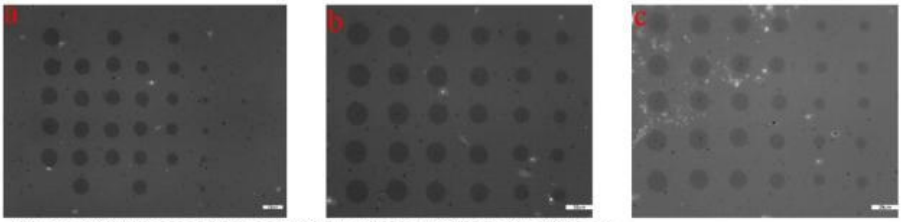


Figure 3: OM images of pulse ablation (a) image1 (b) image2 (c) image3

Keywords: 2D material, laser ablation, strong-field effect

References:

[1] S. K. Sundaram, E. Mazur, "Inducing and probing non-thermal transitions in semiconductors using femtosecond laser pulses," Nature Materials **1**, 217-224 (2002).

Presenting author Email address: liyangjiamg.sc11@nycu.edu.tw

USEFUL INFORMATION

1. Airport

- Taoyuan International airport
- Taipei Songshan airport

2. Currency

The New Taiwan dollar (code: TWD; symbol: NT$, also abbreviated as NT) is the official currency of Taiwan

Bank and exchange in Hsinchu city

- **Bank of Taiwan**

Address: No. 29號, Linsen Rd, East District, Hsinchu City, 300

Working hours: 9:00 – 15:30 on weekdays

- **Mega International Bank**

Address: 300, Hsinchu City, East District, Section 2, Guangfu Rd, 132號155 巷

Working hours: 9:00 – 15:30 on weekdays

- **Cathay United Bank**

Address: No. 369號, Section 1, Guangfu Rd, East District, Hsinchu City, 300

Working hours: 9:00 – 15:30 on weekdays

3. Languages

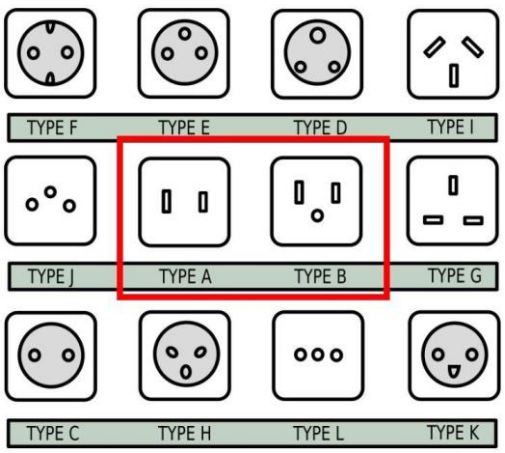
- Taiwanese
- English

4. Time zone, dial code

- GMT (+8)
- Please press 002 or 009 to call from Tawan to other countries and the dial country code of Taiwan is (+886)

5. Electricity

Taiwan has the same electrical outlets as the United States and uses **110 V** electricity. Traveling to Taiwan may need an adapter and a converter.



(Source: https://www.justaiwantour.com/blog/2020/05/21/%E3%80%90taiwan-travel-guide%E3%80%91a-quick-overview-of-taiwans-plug-type-and-weather/)

Taiwan uses Plug type A, which has two flat parallel pins, and Plug type B, which has two flat parallel pins like type A but with an extra prong for grounding.

6. Hotels Information

Hotel	Address	Link
和選旅 **The HO Hotel (4 starts)**	新竹市大學路16號 No. 16, Daxue Road, 300 Hsinchu City, Taiwan	**https://www.thehohotel.com.tw/** **10 minutes by walk from meeting site of NYCU campus** *Pick-up service* *From Taoyuan Airport:* *Up to 2 people: 2000 NTD* *Up to 5 people: 2400 NTD* *From Taipei Songshan Airport:* *Up to 2 people: 3000 NTD* *Up to 5 people: 3400 NTD*
NYCU Guest House	**The second Guest house: 2nd floor of female dormitory 2** 300, Hsinchu City, East District, Daxue Rd, 1001, National Yangming Chiao Tung University. **Tel.:** (03)5712121, ext: 51912	**https://ga.nycu.edu.tw/english/regulations** 5 minutes by walk from meeting site of NYCU campus
	The third Guess house: **Next to the North gate of NYCU)** 3rd Guest House, East District, Hsinchu City, 300 **Tel:** (03)5712121, ext: 89100	5 minutes by walk from meeting site of NYCU campus
NSRRC Guest house	國家同步輻射研究中心版權所有 新竹市 30076科學園區新安路101號 National Synchrotron Radiation Research Center. 101 Hsin-Ann Road, Hsinchu Science Park, Hsinchu 30076, Taiwan R.O.C. **Tel.:**+886-3-578-0281#4130	**https://gh.nsrrc.org.tw/news/newsInfo** 10 minutes by walk from the meeting site of the NYCU campus
新竹老爺酒店 **Hotel Royal (5 starts)**	300新竹市東區光復路一段227號 No. 227, Section 1, Guangfu Road , East Distric, Hsinchu City, Taiwan	**https://www.hotelroyal.com.tw/zh-tw/HSINCHU/** 10 minutes by taxi from meeting site of NYCU campus ***Note:*** *Pick-up service only available after finishing your booking.*
達龍商旅 **Darlon Hotel (4 starts)**	新竹市光復路二段808號 No. 808, Section 2, Guangfu Road, Hsinchu City, Taiwan	**https://hotel.darlon.biz/** 15 minutes by taxi from meeting site of NYCU campus *Pick-up service* *Only from Taoyuan Airport:* • *1-4 people: 1400 NTD* • *5-8 people: 1800 NTD*
晶悅精品旅館 **Grand Crystal Hotel (3 starts)**	新竹市關新二街49號 No. 49, Guanxin Second Street, 300 Hsinchu City, Taiwan	**http://grandcrystalhotel.com/photos.htm** 10 minutes by taxi from meeting site of NYCU campus *No pick-up service*

EPISODE 新竹伊普索酒店 (5 starts)	新竹市東區公道五路二段111號 No. 111, Section 2, Gongdaowu Road East District, 300 Hsinchu City, Taiwan	**https://www.hotelepisode.com/zh/hsinchu** 10 minutes by taxi from meeting site of NYCU campus *Pick-up Service* ● *1-4 people: 1600 NTD-1800 NTD* ● *5-8 people:* *From Taipei Songshan Airport: 2800 NTD-3000 NTD;* *From Taoyuan Airport: 2000 NTD -2200 NTD*
煙波大飯店 新竹都會館 **Lakeshore Hotel Hsinchu Metropolis (3 starts)**	新竹市民生路177號 No. 177號, Minsheng Rd, East District, Hsinchu City, 300	**https://metropolis.lakeshore.com.tw/en/** **20 minutes by taxi from meeting site of NYCU campus, in downtown area.** **It's convenient if you want enjoy nightlife of downtown** *Pick-up service* ● *1-4 people:* *From Taipei Songshan Airport: 2400 NTD;* *From Taoyuan Airport: 1650 NTD* ● *5-8 people:* *From Taipei Songshan Airport: 2900 NTD;* *From Taoyuan Airport: 2050 NTD*
芙洛麗大飯店 **Fleur Lis (4 starts)**	新竹市民族路69號 No. 69號, Minzu Rd, East District, Hsinchu City, 300	**http://www.fleurlis.com.tw/en/** 20 minutes by taxi from meeting site of NYCU campus, in downtown area. It's convenient if you want enjoy nightlife of downtown *No pick-up service*

7. Transportation information

The 7th International Symposium on Frontiers in Materials Science (**FMS 2024**) will be held at National Yang Ming Chiao Tung University (**Guangfu campus**).

Address: Science Building III, No 1001, Daxue Road, East District, Hsinchu City 300, Taiwan.

Guideline to reach National Yang Ming Chiao Tung University (**Guangfu campus**):

7.1. Driving Directions

Google map: https://goo.gl/maps/Dc135RntKArmmBMa8

- From ***Taoyuan International Airport (TPE)***: take National Highway No.1 southbound through Daxue Road to reach North Gate, NYCU.
- From ***Kaohsiung International Airport (KHH)***: take National Highway No.1 northbound through Hsinchu Interchange (Science Park) and drive on Hsin Ann Road to reach South Gate, NYCU.

7.2. By Taiwan High-Speed Rail (THSR)

a. From TPE to THSR Hsinchu station

Step 1: Take the Taoyuan Airport MRT

- Route: From A12 (Taoyuan Airport T1) to A18 (Taoyuan HSR station).
- Note: Please use **Easy card** (you can buy it at the convenience stores like 7-11, Family Mart…) or Single journey ticket at the station.

Step 2: Take THSR

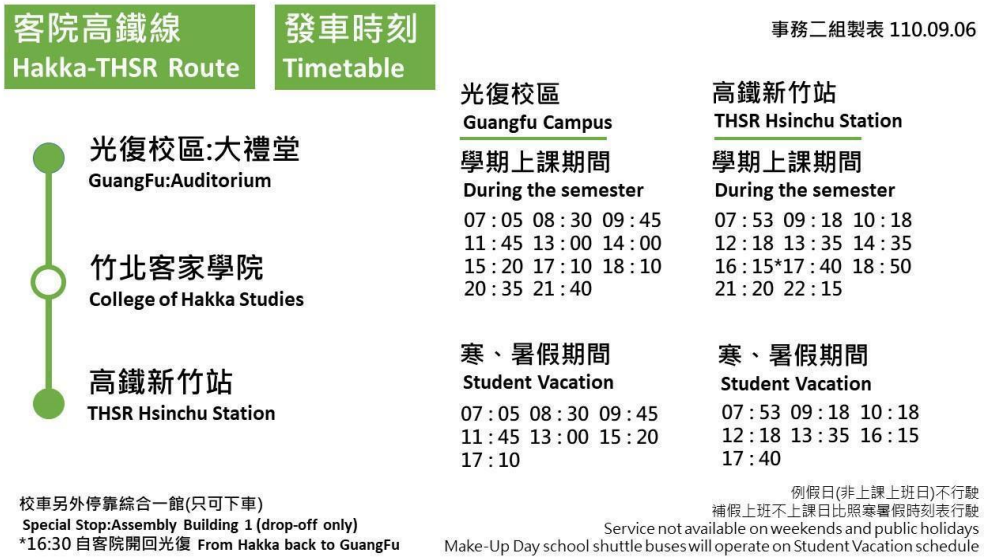
- Route: Southbound (Taoyuan – Hsinchu).

b. From THSR Hsinchu station to NYCU

Everyone can go from THSR Hsinchu station to NYCU by:

- ❖ ***Taxi:*** taxi station in front of the THSR Hsinchu.
- ❖ ***Shuttle bus:***

- Arrive at THSR Hsinchu station and exit at the main entrance.
- Take the bus shuttling between THSR and Guangfu Campus NYCU, following the timetable:



Further information: *https://ga.nycu.edu.tw/english/campuslife/traffic/bus*

7.3. By bus

Step 1: Take the bus No.1250 (from TPE to National Tsing Hua University (NTHU), Hsinchu)

Step 2: Take the bus No.2 (NTHU – NYCU) to arrive at NYCU (15 NTD)

Note: Passengers can use **easy card** or **cash** to pay for the bus fee

Further information:

- Bus No.1250: https://yunbus.tw/lite/en/route.php?id=THB12500
- Bus No.2: https://yunbus.tw/lite/en/route.php?id=HSZ0020

7.4. By Taxi

Some of Taiwan's most notable taxi companies:

- ✔ ***Taiwan Taxi 55688***: just dial 55688 on your phone and press 2 for English service.
- ✔ ***Taiwan Metro Taxi 55178***: just dial 55178 on your phone and confirm your reservation.
- ✔ ***Taiwan Uber:*** turn on your GPS and select your location on Uber application. The approximate cost will be displayed.

Further information:

- Tip: If you need assistance finding a taxi, you may go to a nearby convenience store and ask the store employee for help or do it yourself using the ***Ibon machine*** (**7-11 store**).
- How to call taxi in **7-11**: https://www.youtube.com/watch?v=KTPxo8ZVcLc
- NYCU (Guangfu campus) address in Chinese: 30010新竹市東區大學路1001號

To receive additional information/support, please contact the Symposium Secretariat via email: 2024fms@gmail.com

AUTHOR INDEX

FMS 2024

The 7th International Symposium on Frontiers in Materials Science

National Yang Ming Chiao Tung University, Hsinchu City, Taiwan

January 21-24, 2024

Supervisors: Prof. Wu-Ching Chou
Prof. Michael Lang
Prof. Tomoyuki Yamamoto
Prof. Yoon-Hwae Hwang
Prof. Nam Nhat Hoang

Editors: Nhu Quynh Diep
Bich Tuyen Huynh Thi
Quynh Trang Tran
Ssu-Kuan Wu
Hong-Jyun Wang

Co-organizers

國立陽明交通大學
NATIONAL YANG MING CHIAO TUNG UNIVERSITY

TAIWAN

國家同步輻射研究中心
National Synchrotron Radiation Research Center

CORE

Sponsors

NSTC 國家科學及技術委員會
National Science and Technology Council

國立陽明交通大學
NATIONAL YANG MING CHIAO TUNG UNIVERSITY

國家同步輻射研究中心
National Synchrotron Radiation Research Center

Quantum Design
TAIWAN

SGService

attolight™

FMS 2024

The 7th International Symposium on Frontiers in Materials Science

National Yang Ming Chiao Tung University, No. 1001號, Daxue Rd,
East District, Hsinchu City, Taiwan 300093

2024fms@gmail.com | https://fms2024.conf.nycu.edu.tw