Forum on Carbon Neutrality and Sustainable Environment

Full Event Program

5-8 Oct 2022

CityU 香港城市大學 City University of Hong Kong

HK TECH FORUM

CityU 香港城市大學 City University of Hong Kong

ICE Hong Kong Institute for Clean Energy 香港清潔能源研究院

CityU 香港城市大學 City University of Hong Kong

IAS Hong Kong Institute for Advanced Study

HKTech Forum on Carbon Neutrality and Sustainable Environment

Table of Contents

HKTech Forum on Carbon Neutrality and Sustainable Environment

Background

Energy transition to clean and renewable energy is an urgent task for all of us to tackle both the climate and environmental crises that loom before us. Hong Kong Institute for Clean Energy (HKICE) offers a timely scientific Forum on Carbon Neutrality and Sustainable Environment that unites world-renowned scholars and researchers in promoting interdisciplinary dialogue on the challenges and future prospects of next-generation energy development and applications. The forum will be conducted in an atmosphere similar to the Gordon Research Conference, providing visionary knowledge with the latest scientific findings and innovative technologies on clean energy development with ample opportunities for discussions. A broad range of topics related to scalable photovoltaics, stable and reliable battery technologies, and smart energy-saving and grid technologies for various device applications will be covered. Challenges in energy generation, utilization, storage, and distribution as well as the latest development in carbon capture and zero-carbon nuclear energy will be discussed.

The forum will consist a series of keynote lectures, invited talks, discussion and sharing sessions featuring the following leading areas:

▪ Latest functional materials design and synthesis, and smart system/integration configuration for solar energy harvesting devices, (including PVs, H_2 generation, water splitting, etc.), rechargeable batteries, and energy-saving devices and applications.
▪ Fundamental principles and degradation mechanisms of energy devices that pose a limit on the large-scale, industrial applications of clean energy.
▪ Challenges of carbon capture, storage and utilization in a renewable system to support synthetic fuels, gases, and feedstocks applications.
▪ Smart grid technologies and network implementation for accelerating the clean energy transition. Innovative nuclear energy technologies for zero-carbon electricity.

Organizer: HKTech Forum, City University of Hong Kong
Hong Kong Institute for Clean Energy, CityU
Hong Kong Institute for Advanced Study, CityU

Date: 5-8 Oct 2022

Venue: LG/F, Academic Exchange Building, City University of Hong Kong, HK

Format: Hybrid Mode
- On-site at CityU
- ZOOM Webinar &Tencent Meeting

Language: English

Organizing Committee:

Alex JEN, **Chair**, CityU
Chak K CHAN, CityU
Shauhrat Singh CHOPRA, CityU
Jingdong LUO, CityU
Yun Hau NG, CityU
Chin PAN, CityU
Michael Chi Kong TSE, CityU
Angus Hin Lap YIP, CityU
Wenjun ZHANG, CityU
Chunyi ZHI, CityU

Organizers

The HK Tech Forum provides a platform for discussing new strategies and approaches to major challenges in science and technology. Topics covered in the inaugural series include Chemistry of 2D Materials, Data Science and AI, Reliability and Safety of Intelligent Systems, Advanced Matter and Materials, Carbon Neutrality and Sustainable Environment, Quantum Physics and Complex Systems, and Metabolism in Health and Disease.

Each forum will feature world-leading scientists and technologists and will promote strong collaboration between Hong Kong scholars in applying a multidisciplinary approach to tackling long-standing scientific puzzles and challenging technology issues.
The forum will be held at City University of Hong Kong (CityU) in the Gordon Research Conferences-style to facilitate idea sharing and discussion. Located in the heart of Hong Kong, CityU has a well-earned reputation as an innovative hub for research and professional education, addressing global issues, and empowering positive change.

The Hong Kong Institute for Clean Energy (HKICE) aims to be a global leader in promoting cutting-edge research, education, and technology development in clean energy to tackle the grand challenges on achieving global net-zero carbon emission. It provides a vibrant platform to integrate professionals of diverse background working in clean energy to train next-generation leaders and generate sustainable environmental solutions for creating societal impacts.

The Hong Kong Institute for Advanced Study (HKIAS) is established to gather the best minds in science to pursue curiosity-driven ideas and studies, and to conduct unfettered research based on free and deep thinking. The ultimate goals for HKIAS are to seek truth, advance knowledge and better humanity. Its current endeavours include both basic and applied research across disciplines such as mathematics, natural science (physics and chemistry), applied science, and life science.

Event Program

Day 1: 5 Oct 2022 (WED)	
13:00 - 13:30	Registration
13:30 - 14:00	Opening
14:05 - 15:05	**Geopolitics and Achieving Carbon Neutrality** Jeffery D. SACHS, Columbia University
15:05 - 15:35	**China's National Carbon Market: Development, Evaluation and Prospects** ZhongXiang ZHANG, Tianjin University
15:35 - 15:45	Tea break
15:45 - 16:35	**Recent Developments in Photovoltaics** Martin A. GREEN, University of New South Wales
16:35 - 17:25	**Metal Halide Perovskites; on the Pathway Towards a Highly Efficient and Highly Stable PV Technology** Henry J. SNAITH, University of Oxford

Day 2: 6 Oct 2022 (THU)

9:00 - 9:50	**Synthesis and Modification of MXenes for Sustainable Energy** Yury GOGOTSI, Drexel University
9:50 - 10:40	**How can research in solar energy harvesting and electrified chemical synthesis contribute to defossilization?** Edward H. SARGENT, University of Toronto
10:40 - 11:00	Tea break
11:00 - 11:50	**Nanotechnology for Global Carbon Neutral Transformation** Yi CUI, Stanford University
11:50 - 12:40	**Development of batteries for energy storage from a viewpoint of resource sustainability** Hui-Ming CHENG, Chinese Academy of Sciences
12:40 - 14:10	Lunch
14:10 - 14:40	**Perovskite solar cells towards commercialization: from high efficiency to stability** Liyuan HAN, Shanghai JiaoTong University
14:40 - 15:10	**Material design and device engineering for highly efficient organic photovoltaic cells** Jianhui HOU, Chinese Academy of Sciences
15:10 - 15:30	**Tailing the Interface for Efficient, Stable and Safe-to-Use Inverted Perovskite Solar Cells (PSCs)** Zonglong ZHU, City University of Hong Kong
15:30 - 15:50	Tea Break
15:50 - 16:20	**Maximizing Energy Efficiency by Turning Low-Temperature Waste Heat into Clean Electricity Supply** Michael Kwok Hi LEUNG, City University of Hong Kong
16:20 - 16:50	**Challenges in Power Electronics Penetrated Power Grid** Michael Chi Kong TSE, City University of Hong Kong
16:50 - 17:20	**Molecularly Engineered Interfaces in Metal Halide Perovskite Semiconductors and Optoelectronic Devices** Angus Hin-Lap YIP, City University of Hong Kong
17:20 - 17:50	**Lithium niobate photonics for power-efficient optical communication systems** Cheng WANG, City University of Hong Kong
17:50 - 18:10	**Next Generation of Green Building Technologies: Passive Radiative Cooling and Thermochromic Smart Window** Edwin Chi Yan TSO, City University of Hong Kong
18:15 - 20:00	Banquet

Day 3: 7 Oct 2022 (FRI)	
9:00 - 9:50	**Simplifying infrastructure challenges to gain high benefits from transportation electrification** Philip T. KREIN, University of Illinois Urbana-Champaign
9:50 - 10:40	**Digitization: A Path to Sustainable Decarbonization** Marija D. ILIC, Massachusetts Institute of Technology
10:40 - 10:50	Tea break
10:50 - 11:40	**Future Energy Infrastructures, Energy Platforms and Energy Storage** Jun LIU, University of Washington
11:40 - 12:30	**Photocatalytic water splitting for solar hydrogen production** Kazunari DOMEN, The University of Tokyo
12:30 - 13:50	Lunch
13:50 - 14:40	**Organic Carbonyl Electrode Materials for Li/Na Batteries** Jun CHEN, Nankai University
14:40 - 15:10	**Li-S Batteries: Challenges, Achievements and Opportunities** Guohua CHEN, City University of Hong Kong
15:10 - 15:40	**Materials Design Strategies for High-Energy and Safe Battery Systems** Yi-Chun LU, The Chinese University of Hong Kong
15:40 - 16:00	Tea Break
16:00 - 16:30	**Eco-shoreline designs for facilitating carbon neutrality and promoting marine biodiversity** Kenneth Mei Yee LEUNG, City University of Hong Kong
16:30 - 16:50	**Photoexcited Charge Transportation in Oxide Photocatalyst for Water Splitting** Yun Hau NG, City University of Hong Kong
16:50 - 17:10	**Why is environmental governance critical for achieving carbon neutrality?** Wanxin LI, City University of Hong Kong

Day 4: 8 Oct 2022 (SAT)

9:00 - 9:50	**The Role of Energy Storage in a Highly Decarbonized Electricity Sector** Robert C. Armstrong, Massachusetts Institute of Technology
9:50 - 10:40	**Nuclear Batteries: a New Way in Energy** Jacopo BUONGIORNO, Massachusetts Institute of Technology
10:40 - 11:00	Tea break
11:00 - 11:50	**Technologies for Air Pollution Control and CO2 Mitigation for Sustainable Environment** David Y. H. PUI, University of Minnesota
11:50 - 12:10	**Nuclear Energy's Role in Helping Hong Kong Decarbonise – CLP's Perspective as an Investor and Off-taker** Roger CHEN, CLP Holdings Limited
12:10 - 12:30	**Innovative Heat Transfer Concepts to Enhance Nuclear Safety** Chin PAN, City University of Hong Kong
12:30 - 14:00	Lunch
14:00 - 16:00	**- Emerging Star Series -**
	Racing towards Carbon Neutrality: The Role of International Trade Law Mandy FANG, School of Law, CityU
	Semi-Artificial Photosynthesis for Green Energy Sai Kishore RAVI, School of Energy and Environment, CityU
	Constructing effective molecular interfaces for CO2 reduction Ruquan YE, Department of Chemistry, CityU
	Modulate the in situ Reconstruction of a Layered Oxide Electrocatalyst for Superior Water Oxidation Jian WANG, School of Energy and Environment, CityU
	Battery Intercalation Strategy: Material Synthesis, Property Tuning and Applications Zhiyuan ZENG, Department of Materials Science and Engineering, CityU
	When soft matter meets interface Yu CHAI, Department of Physics, CityU
	Solution Processing of Organic Semiconductor Materials: A Theoretical Insight into Role of Additives in Film Morphology Xiankai CHEN, Department of Chemistry, CityU
	The Atomic Substitution of Transition Metal Dichalcogenides for Electrocatalytic Hydrogen Evolution Reaction Qiyuan HE, Department of Materials Science and Engineering, CityU

Geopolitics and Achieving Carbon Neutrality

Jeffrey D. SACHS
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BIOGRAPHY

Jeffrey D. Sachs is awarded the 2022 Tang Prize in Sustainable Development for leading transdisciplinary sustainability science and creating the multilateral movement for its applications from village to nation and the world. He is University Professor and Director of the Center for Sustainable Development at Columbia University, where he directed the Earth Institute from 2002 until 2016. He is President of the UN Sustainable Development Solutions Network, Chair of the Lancet COVID19 Commission, Co-Chair of the UN Council of Engineers for the Energy Transition, Commissioner of the UN Broadband Commission for Development, academician of the Pontifical Academy of Social Sciences at the Vatican, and Tan Sri Jeffrey Cheah Honorary Distinguished Professor of Sustainable Development at Sunway University. He has been Special Advisor to three United Nations Secretaries-General, and currently serves as an SDG Advocate under Secretary General António Guterres. Sachs spent over twenty years as a professor at Harvard University, where he received his B.A., M.A., and Ph.D. degrees, and has received 38 honorary doctorates. In 2021, Sachs received the TÜBA Academy Prize from the Turkish Academy of Sciences, the Legion of Honor by decree of the President of the Republic of France, the Order of the Cross from the President of Estonia, and honorary doctorates from Amrita University in Kerala, India; Macau University of Science and Technology; and the University of Siena, Italy. His most recent book is The Ages of Globalization: Geography, Technology, and Institutions (2020).

China's National Carbon Market: Development, Evaluation and Prospects

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Keywords: Carbon market, carbon price, emissions trading, border carbon adjustment mechanism, power market.

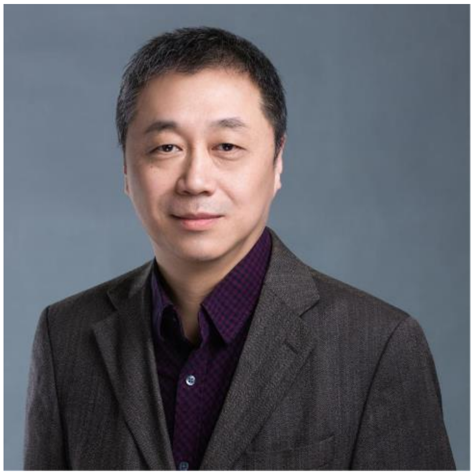
Abstract

China's commitment to carbon neutrality before 2060 came as a complete surprise to both international and Chinese communities. To achieve both carbon peak and carbon neutrality requires huge capital investment in the field of renewable energy, cross-regional power transmission, advanced energy storage, charging stations and hydrogen refueling stations in the transportation field, end-use electrification, green buildings, and energy saving and emission abating. A variety of studies project different outcomes, but all the forecasts for required investment exceed CNY 100 trillion over the next 40 years. Government finance can only cover a small portion of such a huge scale of investment, and the significant gap must be made up by social capital, which must be guided by market-oriented approaches. The carbon market can just play such a role in providing market carbon price signals, incentivizing and attracting resources to tilt towards low-carbon green projects, promote green and low-carbon development, and achieve the aforementioned dual carbon goals while helping entities cut emissions at the least cost.

Against this background, China launches the national carbon market with the power generation sector initially being covered. Since it began its first trading on 16 July 2021, the national carbon market has operated more than one year, and all entities covered had experienced one compliance cycle by the end of December 2021. It is a good time to evaluate the operation of China's national carbon market and show how the market will go in the near future.

This presentation will show how China's national carbon market operates, what characteristics we can observe from its operation, how does China's carbon market compare with the EU carbon market, what challenges it faces, what does the construction of united national market mean for carbon market, what are the focuses of the national carbon market development, what will the existing carbon pilots do to strengthen the effects of national carbon market, how does carbon market integrate with power market to achieve the desired outcomes, what are the implications of the EU border carbon adjustment mechanism? The better understanding of all these issues helps to understand the development and role of China's national carbon market in meeting the aforementioned dual carbon goals.

BIOGRAPHY



ZhongXiang Zhang is the founding dean and a distinguished university professor at the Ma Yinchu School of Economics, Tianjin University and Director of China Academy of Energy, Environmental and Industrial Economics, China. He is co-editor of Environmental Economics and Policy Studies, and serves on the editorial boards of ten other international journals including Climate Policy; Energy Policy; Environmental Science and Policy; and International Environmental Agreements: Politics, Law and Economics. He is a Fellow of Asia and the Pacific Policy Society, Australia, and is on the Scientific Council of Paris-based IDDRI, Sciences Po. He authored and edited 22 books and special issues of international journals, authored over 200 publications in English, and is among the top 20 authors from Chinese universities in all branches of social sciences based on the first-authored articles in key international journals over the 54 years. His paper is selected as the Top 20 papers ever published in the journal Climate Policy over the past 20 years. He is consecutively among the World's Top 1% Scientists based on either career-long impact or single year impact rated by Stanford University, and is consecutively ranked the 4th most cited scholar inside China in the field of economics, econometrics and finance. He served as an expert to many national and international organizations including UNCTAD, European Commission, North American Commission for Environmental Cooperation, ADB, OECD, IEA and WB, delivered eight keynotes at the International Association for Energy Economics conferences, and made the original contributions to a number of long-term goals and strategies that China has implemented, including the carbon intensity target for 2020, capping carbon emissions around 2030, and the establishment of the belt and road initiative. He began his career at the Beijing-based National Development and Reform Commission in 1980s, was a senior fellow at East-West Center, Honolulu (2001-12), and was a "Fudan Distinguished Professor" and chairman at School of Economics, Fudan University, Shanghai (2012-15). He received a Ph.D. in Economics from Wageningen University, Holland.

Recent Developments in Photovoltaics

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Keywords: Solar photovoltaics, solar energy

Abstract
Over the last decade, the cost of photovoltaic solar energy conversion has dropped very dramatically with solar photovoltaics "now the cheapest source of electricity in most countries" and "now offering some of the lowest cost electricity ever seen", according to the International Energy Agency. However, improvements are in the pipeline that are leading to an era of "insanely cheap" solar power, within the coming decade. The developments leading to these cost reductions will be described as well as the pending improvements that will allow solar to continue on its trajectory to even lower future costs over the remainder of this decade.

An example of the impact of these cost reductions is included as Figure 1. This shows both the history of the lowest bids received internationally for the supply of electricity using photovoltaics under power purchase agreements (PPAs), as compiled by the author, together with the global average solar PPA contract, as compiled by IRENA [1]. These averages include systems such as in Japan where prices are incredibly high compared to other countries. Also shown, for comparison, are the lowest bids received at a 2016 Chilean auction for the supply from more traditional sources, as a reference.

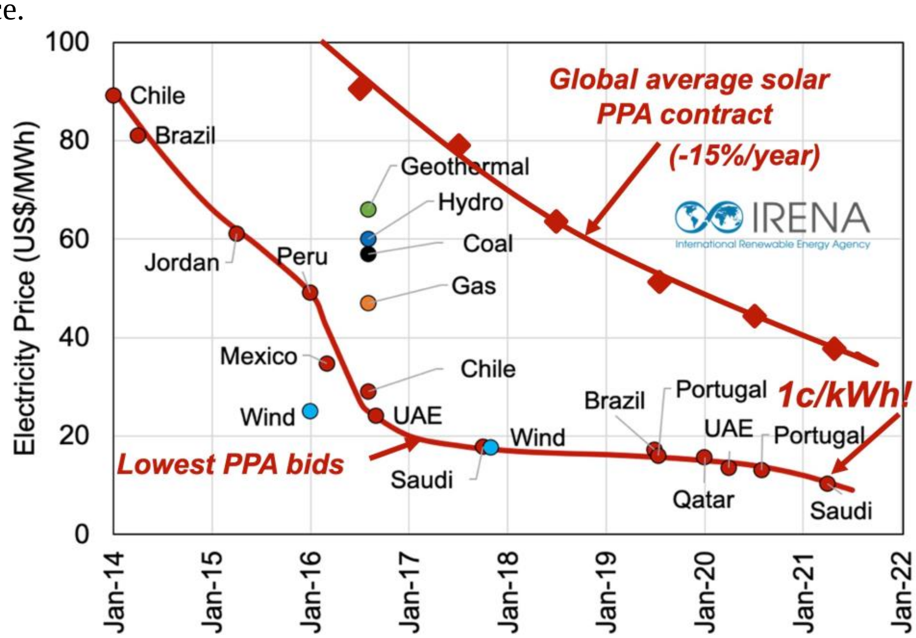

Figure 1: History of solar photovoltaic electricity prices as revealed through PPA bids and contracts.

The rapid reduction in the lowest PPA bids post-2016 stem from the introduction of new photovoltaic technology, specifically the PERC cell (passivated emitter and rear cell) invented by the author and developed by his team. PERC now accounts for over 90% of global photovoltaic production, offering not only higher sunlight conversion efficiency but also new functionalities, such as bifacial operation allowing stray light on the module rear to be converted at essentially no extra cost. The lowest PPA bid received to date was US$10.40/MWh (1c/kWh!) in Saudi Arabia in 2021.

Reference

[1] IRENA (2022), Renewable Power Generation Costs in 2021, International Renewable Energy Agency, Abu Dhabi.

BIOGRAPHY

Martin Green is Scientia Professor at the University of New South Wales, Sydney and Director of the Australian Centre for Advanced Photovoltaics, involving five other Australian Universities and research groups. His group's contributions to photovoltaics include inventing the PERC cell, now accounting for 90% of global production, and holding the silicon solar cell efficiency record for 30 of the last 39 years, regarded as a "Top Ten" milestone in solar photovoltaics history. Major international awards include the 1999 Australia Prize, the 2002 Right Livelihood Award, also known as the Alternative Nobel Prize, and most recently, the 2021 Japan Prize.

Metal Halide Perovskites; on the Pathway Towards a Highly Efficient and Highly Stable PV Technology.

Henry J. SNAITH
University of Oxford

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Abstract
Metal halide perovskites are a relative newcomer to the field of PV research, however more than ten years has passed since the first publication of metal halide perovskites use as a "sensitizer" in a solar cell, and 2022 marks ten years since 10% efficient solid-state lead halide perovskites solar cells were realised and the flourishing filed of perovskite photovoltaics began. In this talk I will highlight some of the key advances we have made in researching metal halide perovskites, with a specific focus upon materials and device stability. I will highlight why moving to higher PV cell efficiency is an important path forward for the industry and I will then focus upon the opportunities and challenges for multi-junction perovskite solar cells, which have already delivered efficiencies surpassing silicon PV, and show a pathway to achieve highly efficient wide band gap perovskites, required for multi-junction applications. I will finally discuss commercialisation efforts on the path towards industrialising the perovskite-on-silicon tandem technology.

BIOGRAPHY

Henry Snaith is the Binks Professor of Renewable Energy in the Physics Department of the University of Oxford and is also a co-founder and Chief Scientific Officer at Oxford PV Ltd. Prof Snaith's research focuses on developing and understanding new materials and device concepts for photovoltaic solar energy conversion. His election as a Fellow of the Royal Society (FRS) credits him with the discovery of the use of perovskites in efficient solar cells, which has started a new field of research gaining both academic and industrial following. In 2012, Henry was awarded the Paterson medal and prize by the Institute of Physics for his important contributions to the field of excitonic solar cells. His discovery of high-efficiency perovskite photovoltaics the following year was recognised as one of the top breakthroughs of 2013 by the journal Science. In 2013, Henry was named one of "Nature's 10" people who mattered, in recognition of his work on next-generation solar power technology. In 2018 he received the UK Blavatnik Award for Young Scientists in physical sciences. Henry won the 2020 Becquerel Prize for his ground-breaking work on perovskite solar cells and was most recently awarded the Rank Prize in Optoelectronics 2022.

[Session II-K1] Keynote Lecture: Yury GOGOTSI

Synthesis and Modification of MXenes for Sustainable Energy

Yury GOGOTSI
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Keywords: MXene, synthesis, energy storage, supercapacitor, battery

Abstract

We live in the materials word. Materials defined the progress of humanity, as people moved from Stone Age to Bronze Age and then to Iron Age. Receiving access to new materials enabled new tools and technologies. We entered the Silicon Age more that half-a-century ago and, as a result, electronic and computer technologies greatly accelerated the technical progress, changing our life. What is next? Probably the Nanomaterials Age. The era of assembly of new materials, structures and devices from nanoscale building blocks providing any imaginable, but impossible in conventional materials, combinations of properties and functions. Assembly from nanoparticles will allow integration of electronics, energy harvesting and storage, creating self-powered internet of things and wearable internet. It may also minimize the waste during product manufacturing. 2D materials, like graphene, dozens of which are available nowadays and thousands more expected soon, provide very attractive building blocks, because they can easily assemble and self-assemble into dense structures, just like bricks in the wall.

There are currently many insulating and semiconducting 2D materials available, which can be used as single sheets in devices, or as building blocks. 2D transition metal carbides and nitrides (MXenes) have been expanding rapidly since their discovery at Drexel University in 2011 [1]. They added metallically conductive 2D building blocks to the available materials list. About 50 different MXenes have been synthesized, and the structure and properties of numerous other MXenes have been predicted using DFT calculations. Moreover, the availability of solid solutions on M (transition metal) and X (carbon or nitrogen) sites, control of surface terminations, and the discovery of ordered double-M MXenes offer the potential for synthesis of dozens of new materials. This presentation will describe the synthesis of MXenes, their and assembly into films and 3D structures. Their properties and applications in energy storage and electrocatalysis will be discussed [2].

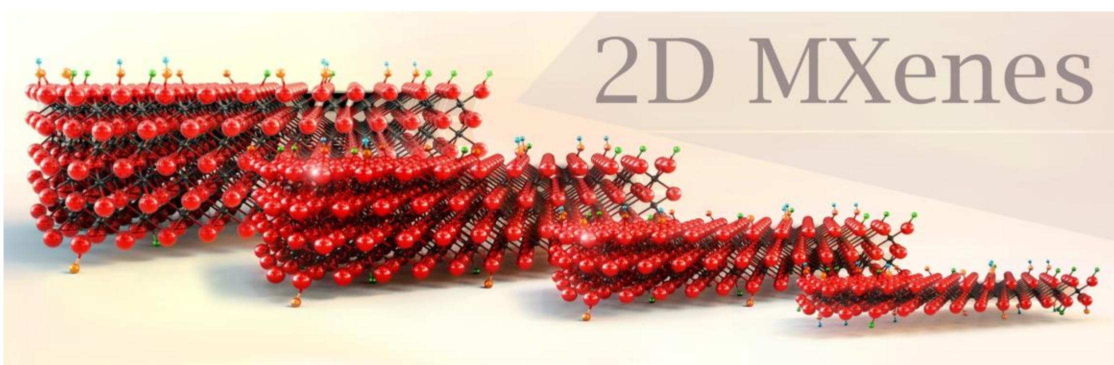

Figure 1: Schematic of 4 typical MXene structures (courtesy of A. VahidMohammadi).

Reference

[1] A. VahidMohammadi, J. Rosen, Y. Gogotsi, The World of Two-Dimensional Carbides and Nitrides (MXenes), Science, 372, eabf1581 (2021).
[2] X. Li, Z. Huang, C. E. Shuck, G. Liang, Y. Gogotsi, C. Zhi, MXene chemistry, electrochemistry, and energy storage applications, Nature Reviews Chemistry, 6 (6), 389–404 (2022).

BIOGRAPHY

Yury Gogotsi is Distinguished University Professor and Charles T. and Ruth M. Bach Professor of Materials Science and Engineering at Drexel University. He also serves as Director of the A.J. Drexel Nanomaterials Institute. His research group works on 2D carbides and nitrides (MXenes), nanostructured carbons, and other nanomaterials for energy, environmental and biomedical applications. His key contributions to materials science include discovery of MXenes and development of a family of carbide-derived carbons with tunable structure and porosity. He also made principal contributions to development of materials for electrochemical capacitors. His published about 800 papers, which have been cited more than 180 000 times. He is recognized as Highly Cited Researcher in Materials Science and Chemistry, and Citations Laureate by Clarivate Analytics (Web of Science). He has received numerous awards for his research including the Ceramic Prize from the World Academy of Ceramics, Materials Research Society (MRS) Medal, American Chemical Society (ACS) Award in the Chemistry of Materials, Gamow Prize, European Carbon Association Award, and S. Somiya Award from IUMRS. He has been elected a Fellow of the World Academy of Ceramics, the European Academy of Sciences, American Association for Advancement of Science, Materials Research Society, American Ceramic Society, the Electrochemical Society, Royal Society of Chemistry, and the International Society of Electrochemistry. He holds honorary doctorates from several European Universities.

How can research in solar energy harvesting and electrified chemical synthesis contribute to defossilization?

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Keywords: Photovoltaics, perovskites, quantum dots, CO_2 capture, CO_2 utilization/upgrade

Abstract
While much progress has been made to scaling solar technologies in the field, there remains a massive further (costly, and energy-intensive) build to be completed to meet the global community's ambitious net zero 2050 goals. Electrifying fuels and chemical synthesis is less far along, with the technologies for CO_2 capture and utilization/upgrade still seeing ongoing development and the subject of fundamental scientific research. I will overview progress in each and then propose some targets and exciting directions for these intertwined topics.

BIOGRAPHY

Ted Sargent holds the rank of University Professor at the University of Toronto. He holds the Canada Research Chair in Nanotechnology and recently completed a term as Vice President – Research for the University of Toronto. His publications have been cited 80,000 times. 140 of his works have been cited 140 times or more. In 2021, it was announced that he will join Northwestern University as the Lynn Hopton Davis and Greg Davis Professor, with appointments in the Department of Chemistry and the Department of Electrical and Computer Engineering.

For more information:
https://light.northwestern.edu

Nanotechnology for Global Carbon Neutral Transformation

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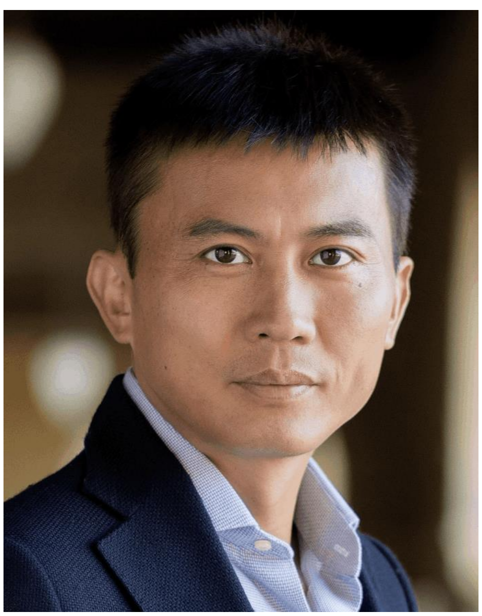
Keywords: Net-zero, battery, air filtration, water filtration, textile

Abstract
This lecture will introduce what's the meaning of net-zero carbon transformation for the global economy and how Stanford University organizes its energy ecosystem to help this transformation. Professor Cui will introduce his materials technology innovations for net-zero transformation and sustainability, including: 1) high energy battery technology for electrical transportation; 2) large scale energy storage technology for integrating solar and wind electricity into the grids; 3) air filtration technology for removal of PM2.5 and COVID viruses; 4) Warming and cooling textile technology for energy efficienncy; 5) Energy wall paper for building energy saving; 6) Water filtration technology to kill bacteria and viruses and to remove heavy metal; 7) Soil cleaning technology. He will also present his efforts on technology translation into the real world.

BIOGRAPHY



At Stanford University, Yi Cui is the Director of the Precourt Institute for Energy, co-director of the StorageX Initiative, and professor of materials science and engineering, as well as professor of photon science at Stanford's SLAC National Accelerator Laboratory. He earned his bachelor's degree in chemistry in 1998 from the University of Science & Technology of China and his PhD in chemistry from Harvard University in 2002. Cui was a Miller Postdoctoral Fellow at the University of California, Berkeley from 2002 to 2005 before joining the Stanford faculty. He has founded four companies to commercialize technologies from his lab: Amprius Inc., 4C Air Inc., EEnotech Inc. and EnerVenue Inc.
A preeminent researcher of nanotechnologies for better batteries and other sustainability technologies, Cui has published more than 500 studies and is one of the world's most cited scientists. He is an fellow of the American Association for the Advancement of Science, the Materials Research Society, and the Royal Society of Chemistry. He is an executive editor of Nano Letters and co-director of the Battery500 Consortium.

Cui's honors include the Global Energy Prize (2021), Ernest Orlando Lawrence Award (2021), Materials Research Society Medal (2020) and Blavatnik National Laureate (2017).

[Session II-K4] Keynote Lecture: Hui-Ming CHENG

Development of batteries for energy storage from a viewpoint of resource sustainability

Hui-Ming CHENG
[1] Institute of Technology for Carbon Neutrality, Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences
[2] Shenyang National Laboratory for Materials Science, Institute of Metal Research, Chinese Academy of Sciences

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Keywords: Energy storage, lithium ion battery, dual-ion battery, resource, recycling

Abstract
Electrical energy storage is becoming more and more important due to the widespread use of electrical vehicles and large-scale storage of electricity from wind farms and solar power plants for grid. Lithium ion batteries are taking a dominant role in these fields, and their consumption is exponentially increasing in recent years. However, the major elements of lithium, cobalt, nickel, etc used in lithium ion batteries are either rare or geographically unbalanced, mostly relying on import. Therefore, it is essential to find some alternative ways to replace lithium ion batteries or to recycle these substances greenly and efficiently. We have attempted in both ways in recent years. On the one hand, we have tried to explore resource-abundant dual-ion batteries and multiple ion batteries, and on the other hand, we have making efforts to directly recycle electrode materials from the spent lithium batteries in a green, cost-effective, and short-processing ways. In particular, we have obtained high-voltage cathode materials, regenerated graphite anode materials, and multi-functional high-performance electrocatalysts from the spent lithium ion batteries with good feasibility based on technical economic analysis.

BIOGRAPHY

Hui-Ming Cheng graduated from Hunan University, China in 1984 and received his Ph. D in 1992 from Institute of Metal Research, Chinese Academy of Sciences (IMR CAS). He is the director of both the Advanced Carbon Research Division of Shenyang National Laboratory for Materials Science, IMR CAS since 2001, and the Institute of Technology for Carbon Neutrality, Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences since 2021. He is a member of Chinese Academy of Sciences and a fellow of TWAS. He used to work at Kyushu Research Center of AIST and Nagasaki University, Japan from 1990 to 1993 and MIT, USA from 1997 to 1998.

His research activities focus on carbon nanotubes, graphene, other 2D materials, energy storage materials and photocatalytic materials. He has published over 850 papers and is a Highly Cited Researcher in both chemistry and materials science fields. He has given over 200 plenary/keynote/invited lectures at various conferences, and won three State Natural Science Award of China (2006, 2017 and 2020), Charles E. Pettinos Award from American Carbon Society, Felcht Award from SGL, Germany, and ACS Nano Lecture Award. He has also spun off several high-tech companies. He used to be an Editor of Carbon from 2000 to 2015 and Editor-in-Chief of New Carbon Materials from 1998 to 2015, and now is the founding Editor-in-Chief of Energy Storage Materials and Associate Editor of Science China Materials.

[Session II-I1] Invited: Liyuan HAN

Perovskite solar cells towards commercialization: from high efficiency to stability

Liyuan HAN
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Abstract

Highly efficient and low-cost perovskite solar cells (PSCs), one of the most promising next-generation photovoltaic technology, triggered intensive research around the world. Up till now, PSCs have achieved the record power conversion efficiency of 25.7% and the device stability has been improved substantially. To push forward the development of PSCs, researchers from home and abroad have been overcoming the obstacles of commercialization. According to our estimation of the levelized cost of electricity, the key to future applications is to reduce the cost of PSCs which strongly depend on high efficiency and long stability. In this presentation, I will introduce our recent works on promoting the efficiency and stability of PSCs from aspects of crystallization, passivation, and ion-migration blocking.

We introduced a perovskite crystal array (PCA) with regular distribution to assist the growth of the perovskite absorption layer. The PCA provided nuclei where the crystallization can commence without overcoming the critical Gibbs free energy for nucleation and induces a controllable bottom-up crystallization process under solvent annealing. As a result, the device achieved power conversion efficiency of over 25.1%. Furthermore, we constructed a composite electrode of copper-nickel (Cu-Ni) alloy stabilized by in situ grown bifacial graphene. The device with the copper-nickel electrode showed an efficiency of 24.34% (1cm2) and stability: 95% of their initial efficiency is retained after 5,000 hours at maximum power point tracking under continuous 1 sun illumination.

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BIOGRAPHY

Professor Liyuan Han has great attainments in novel low-cost solar cells including dye-sensitized solar cells and perovskite solar cells.

He proposed the equivalent circuit model for dye-sensitized solar cells for the first time, which contributed to improving the conversion efficiency and long-term stability. Through in-depth and systematic research on the electron transport mechanism, he achieved the world records of highly efficient dye-sensitized solar cells and modules for several times.

In recent years, Professor Liyuan Han turned on his interest to investigation of the perovskite solar cells and made major breakthroughs. In 2015, Science published his work on the heavy-doped inorganic materials to improve the charge transfer capability and enhance the stability of the device. For the first time, a world record of the device certification efficiency of 15% for 1 cm2 was obtained. In 2017, Nature published his work on the large-area and uniform perovskite films by a pressure-assisted method under atmosphere and low temperature without vacuum or solvent. In this work, he obtained the first world record of certificated large-area perovskite module, which provides a novel route for large-scale production of low-cost photovoltaic modules. Professor Liyuan Han is an inventor of more than 150 patents and an author in ca 300 scientific papers on top-level journals such as Science, Nature, Nature Energy, Energy & Environmental Science, and Advanced Materials in the field of next generation solar cells. He is selected as a highly cited researcher during 2019-2021.

His current research interests involve fundamental research in next generation solar cells such as perovskite solar cells and dye-sensitized solar cells, to fabricate large-area, highly efficient and stable solar cells for commercialization.

[Session II-I2] Invited: Jianhui HOU

Material design and device engineering for highly efficient organic photovoltaic cells

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Keywords: Organic solar cell, material design, tandem device, power conversion efficiency.

Abstract

Organic solar cell (OSC) is a very promising photovoltaic technology. Over the past decades, the power conversion efficiencies (PCEs) of OSCs have been promoted from about 1% to currently over 19% for single-junction devices and over 20% for double-junction tandem devices. The development of new organic photovoltaic materials, including donor, acceptor and interlayer material, contributed greatly to the rapid increase of PCEs. A variety of effective molecular design and aggregation structure control methods have been developed to optimize the molecular energy levels, absorption spectra, mobility and phase separation morphology of the photovoltaic active layers. In this presentation, some general and efficient molecular design strategies related to these two polymer donors will be summarized and introduced. What is more, some of our recent progress including the single-junction OSCs with over 19% PCE [1] and the double-junction tandem OSCs with over 20% PCE[2] will be briefly introduced.

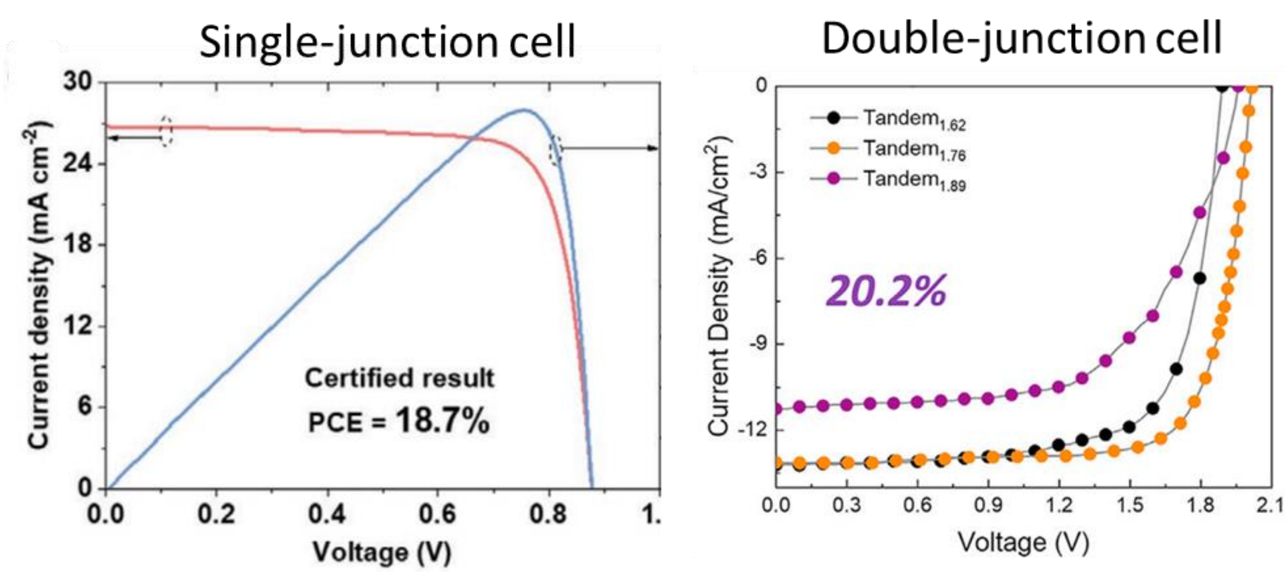

Figure 1: Photovoltaic characteristics of the highly efficient single- and double-junction organic solar cells.

Reference

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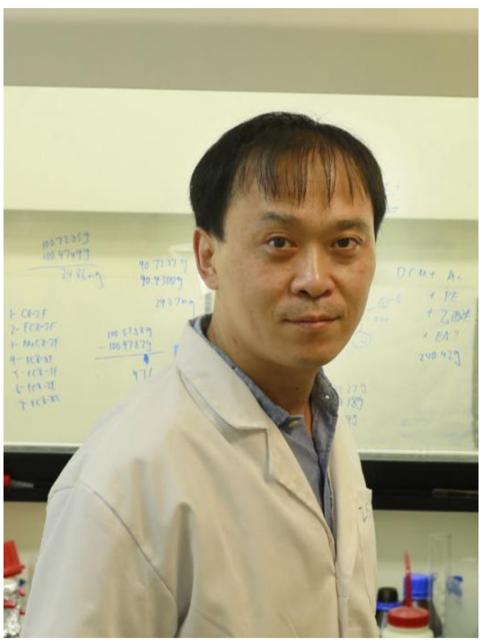

Jianhui Hou, PhD, Professor, Institute of Chemistry, Chinese Academy of Sciences (ICCAS). In 2006, Dr. Hou got his PhD degree at ICCAS; during 2006-2008, he worked at UCLA as the postdoctoral researcher; during 2008-2010, he worked in Solarmer Energy Inc. as the Director of the research division. At the end of 2010, he joined ICCAS and build a research team. Dr. Hou's research focuses on organic photovoltaic materials. Two of his major interests: (a) Design and synthesis of new conjugated polymers towards the applications in highly efficient polymer solar cells; (b) Improving photovoltaic performance of polymer solar cells by morphology control. In the past few years, he has co-authored >300 papers in peer-reviewed journals and published 25 patents.

Tailing the Interface for Efficient, Stable and Safe-to-Use Inverted Perovskite Solar Cells (PSCs)

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Abstract
Hybrid organic-inorganic halide perovskites are remarkable materials with combined features of hard and soft matters, which show great potential for photovoltaic and optoelectronic applications. In this talk, I will present our recent works on manufacturing high-efficiency, stable and environmentally friendly PSCs using an integrated approach to design and develop novel compositionally engineered stable perovskite absorbers with tailored cations/anions and tailor-made charge transport/extraction layers. To enhance the perovskite absorber stability, functionalized organometallic interfacial materials were developed to create suitable interfaces. Further improvements of PCE and stability can be obtained by using molecular-engineered charge-transporting materials (CTMs) for efficient collection of electrons and holes. Finally, to realize the environmentally friendly PSCs, surface coating and novel encapsulation that can physically or chemically capture the leaked Pb ions from degraded devices will also be integrated into the PSCs.

BIOGRAPHY

Dr. Zonglong Zhu obtained his B.S. degree (Chemistry) in 2010 from Nanjing University (China). In 2015, he earned his Ph.D. degree from Hong Kong University of Science and Technology (HKUST). Then he moved to the department of materials science and engineering in University of Washington, Seattle and worked as a postdoctoral fellow. Dr. Zhu joined the City University of Hong Kong as an Assistant Professor in June 2018.

Dr. Zhu has published over 110 SCI papers, including 83 papers with impact factor (IF) > 10, of 20 paper as the first author 39 papers as corresponding author (39). He received over 9000 times citations (google scholar) with H-factor 50 and have 17 papers selected in ESI High Cited papers. Since joining City University of Hong Kong in 2018, he has published 38 SCI papers as the corresponding author, including Science, Nat. Nanotech. , Nat. Commun., Acc. Chem. Res., J. Am. Chem. Soc. Adv. Mater., Angew. Chem. Int . Ed., Joule Adv. Energy Mater., Adv. Funct. Mater.), etc.. He has been selected as the top 2% scientists with the most citations in the world in 2021, and the Nanoscale Emerging Investigator 2022, Mater. Chem. A Journal Emerging Investigator 2021.

[Session II-I3] Invited: Michael K.H. Leung

Maximizing Energy Efficiency by Turning Low-Temperature Waste Heat into Clean Electricity Supply

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Keywords: Waste heat recovery, modified organic Rankine cycle, nanostructured biphilic surfaces, desuperheating, subcooling

Abstract

Carbon neutrality is recognized as an urgent global issue. The International Energy Agency (IEA) has reported that increasing the end-use energy efficiency is the best strategy to reduce carbon emission. Many countries and cities have set challenging targets for energy saving as it represents one of the most significant contributions to achieve net zero.

Among various energy consumers, the thermal energy consumers, such as air-conditioning, space heating, hot water, dehumidification, etc. play the dominating role. All of the above commonly reject large amount of low-temperature waste heat (< 80 deg C) during normal operation. The waste heat can be directly used for preheating water. However, our hot water demand is relatively a lot lower than the waste heat available. Therefore, we have developed modified organic Rankine cycle (ORC) to convert the low-temperature waste heat into electricity supply. The innovative system design involves the integration among vapor compression refrigeration cycle, heat pump and Rankine power cycle into a single multi-functional thermodynamic cycle. Nanostructured biphilic surfaces designed for coalescence-induced jumping droplets are employed to enhance the heat exchangers. The system is controlled to operate at the optimal condition for maximum energy efficiency.

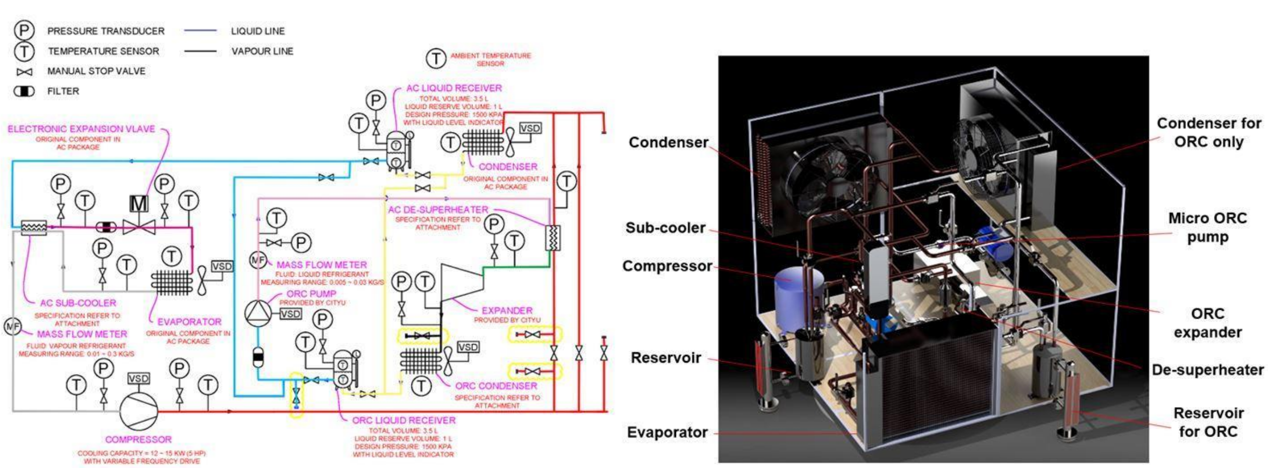

Figure 1: Modified organic Rankine cycle (ORC) for low-temperature waste heat recovery

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BIOGRAPHY

Prof. Michael Leung started his academic career as a Lecturer in the Department of Manufacturing Engineering and Engineering Management at the City University of Hong Kong (CityU) in 2000. In 2002, he joined the Department of Mechanical Engineering at The University of Hong Kong as a Research Assistant Professor and later became an Assistant Professor. In 2010, he joined the School of Energy and Environment (SEE) at CityU as an Associate Professor. In 2015, he became a Professor. He served as an Associate Dean in SEE in 2012-2018.

Prof. Leung is elected to be the Representative (China) in the International Solar Energy Society (ISES)/Board of Directors 2022-23. Prof. Leung is also a Registered Professional Engineer, Chartered Engineer, Fellow Member of HKIE, Past Chairman of HKIE Education and Examinations Committee, Past Chairman of the Energy Institute (Hong Kong Branch) and Editor of Applied Energy and HKIE Transactions.

Prof. Leung's main research interests include solar photocatalysis, fuel cell, hydrogen power, advanced refrigeration/air-conditioning and carbon management. His research is well recognized as he is listed among the top 2% of the world's most highly cited scientists published by Stanford University. He is also listed in Highly Cited Researchers 2018 by Clarivate Analytics (https://hcr.clarivate.com/) that recognizes world-class researchers selected for their exceptional research performance. He is also listed in The Most Cited Researchers in Energy Science and Engineering, Developed for Shanghai Ranking's Global Ranking of Academic Subjects by Elsevier (http://www.shanghairanking.com). Prof. Leung has totally received HK$40M+ research funding as a PI from ITF, RGC, NSFC, ECF, SDF, industrial sponsorships, university internal grants, donations, etc. He has published 200+ journal papers, 80+ conference papers, 18 books/book chapters, and 10 patents.

Challenges in Power Electronics Penetrated Power Grid

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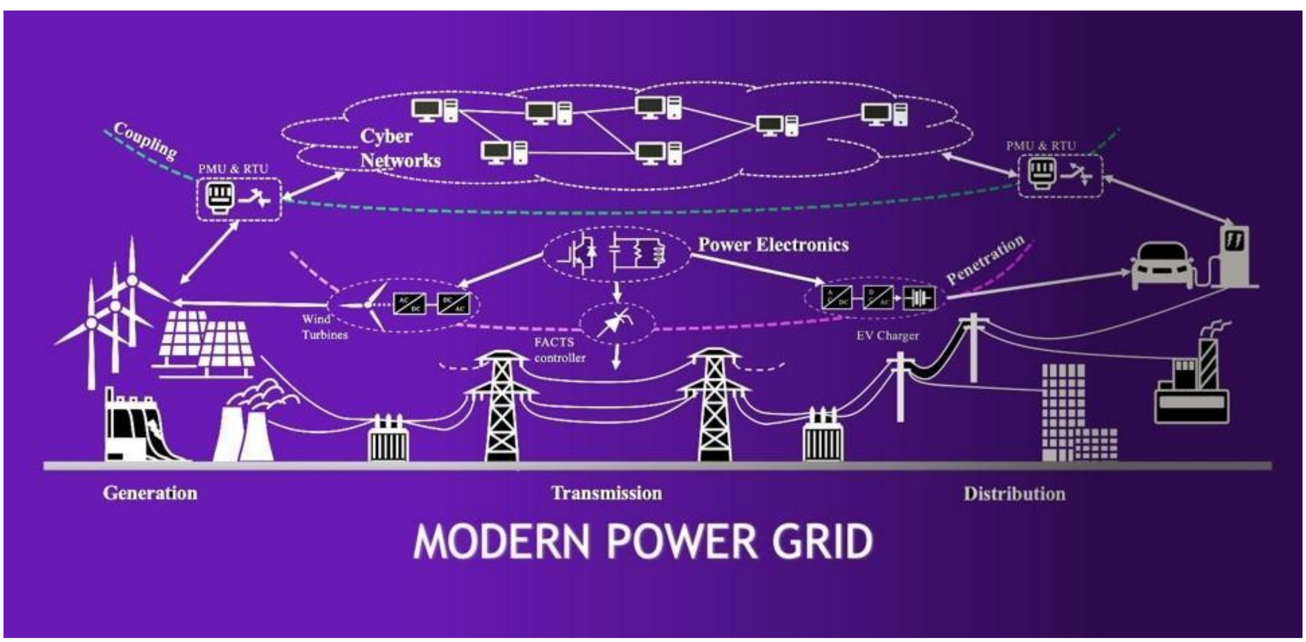
Keywords: Power electronics, power grid, stability, robustness

Abstract
The penetration of power electronics into power generation and distribution systems has deepened in recent years, as prompted by the increasing use of renewable sources, the quest for higher performance in the control of power conversion, as well as the increasing influence of economic plans that necessitate power trading among different regions or clusters of power distribution. As a result of the increased use of power electronics for controlling power flows in power systems, interactions of power electronics systems and conventional synchronous machines' dynamics would inevitably cause stability and robustness concerns, which can be readily understood by the coupling effects among interacting dynamical systems of varying stability margins (or transient performances) [1]. In this talk, we discuss the various problems of power electronics penetration into power grids and the implications on the stability and robustness of power networks, and examine the current progress and future direction of research in power systems amidst the extensive deployment of power electronics.



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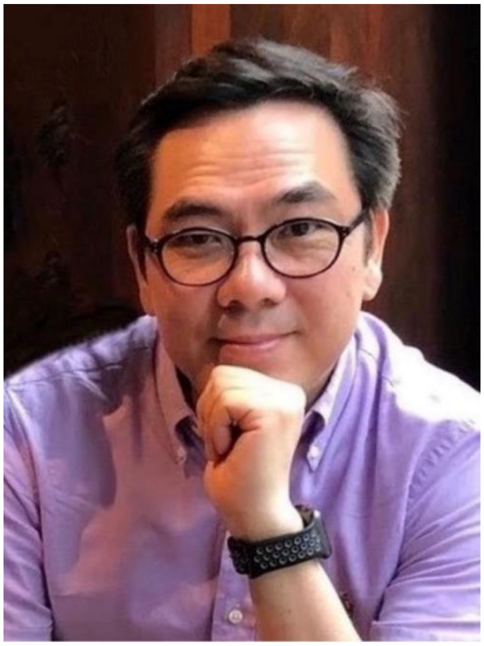

Chi K. Michael Tse received the BEng degree with first class honors and the PhD degree from the University of Melbourne, Australia. He is presently Associate Vice-President (Strategic Research) and Chair Professor of Electrical Engineering at City University of Hong Kong. He has been appointed to honorary professorship and distinguished fellowship by a few Australian, Canadian and Chinese universities, including the Chang Jiang Scholar Chair Professor with Huazhong University of Science and Technology, Honorary Professor of Melbourne University, Distinguished International Research Fellow with the University of Calgary, and Distinguished Professor-at-Large with the University of Western Australia. His research interests include complex network applications, power electronics and nonlinear systems. The IEEE Circuits and Systems Society awarded him the Charles A. Desoer Technical Achievement Award in 2022 in recognition of his outstanding contributions and continued leadership in the development of research in complex behavior of power electronics and energy systems. He is an IEEE Fellow (elected 2005) and an IEAust Fellow (2009)

[Session II-I5] Invited: Angus Hin-Lap YIP

Molecularly Engineered Interfaces in Metal Halide Perovskite Semiconductors and Optoelectronic Devices

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Keywords: Perovskite solar cells, perovskite LEDs, heterojunction, interface engineering, power generation and power saving

Abstract

Over the past few years, organic-inorganic hybrid perovskites have emerged as a new class of solution processable semiconductor for many optoelectronic applications, such as solar cells and LEDs. Their electronic, electrical and optical properties can be controlled by tuning their compositions and crystal structures. In this talk, I will discuss how to control the dimension and nanostructure of perovskites by introducing small molecules and polymers with tailored functional groups that can strongly interact with the perovskite crystals (Fig.1). Using such strategy, we have developed very stable quasi-2D perovskite solar cells[1] with much improved stability and efficiency as well as highly efficient blue[2] and white[3] emitting perovskite LEDs. I will also discuss how to lean on the experience in interface engineering for organic solar cells and design new electron and hole transport conjugated polymer materials with proper interfacial properties to provide surface defeat passivation functionality and improve the charge collection efficiency of perovskite solar cells,[4-6] as well as organic/perovskite tandem solar cells.[7]

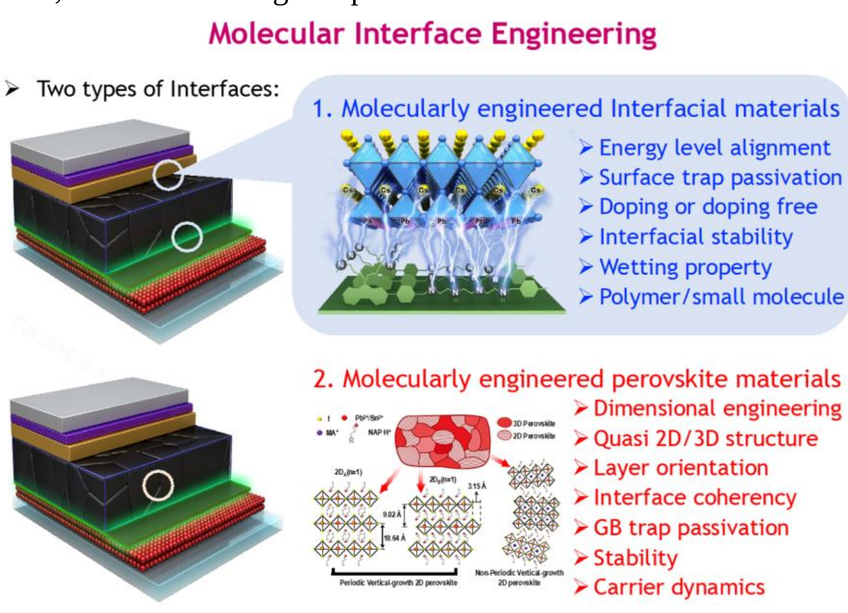

Figure 1: Schematic illustration of the two types of interfaces that can be molecularly engineered in perovskite optoelectronic devices.

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BIOGRAPHY

Angus Hin-Lap Yip joined the Department of Materials Science and Engineering and School of Energy and Environment at City University of Hong Kong as Professor in 2021. He also serves as the associate director for Hong Kong Institute for Clean Energy since 2022. He is an elected member of the Hong Kong Young Academy of Sciences. From 2013-2020, he was a Professor in the State Key Laboratory of Luminescent Materials and Devices (SKLLMD) and the School of Materials Science and Engineering (MSE) in South China University of Technology (SCUT). He got his BSc (2001) and MPhil (2003) degrees in Materials Science from the Chinese University of Hong Kong (CUHK), and completed his PhD degree in MSE in 2008 at the University of Washington (UW), Seattle. His research focuses on the use of an integrated approach combining materials, interface, and device engineering to improve both polymer and perovskite optoelectronic devices. He has published more than 270 scientific papers with citations over 33000 and a H-index of 94. He was also honored as ESI "Highly Cited Researcher" in Materials Science for eight times from 2014-2021.

[Session II-I6] Invited: Cheng WANG

Lithium niobate photonics for power-efficient optical communication systems

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Keywords: Power-efficient, optical communications, photonic integrated circuits, lithium niobate.

Abstract
As global IT traffic continues to grow at double-digit annual rates, the underlining hardware in contemporary optical and wireless networks is facing increasing challenges in the footprint, power consumption and cost. Photonic integrated circuits could address these challenges by simultaneously integrating many optical components on a single photonic chip. Among various photonic material platforms, lithium niobate (LN) is a particularly attractive candidate due to its strong electro-optic effect, wide transparency window and low optical loss. While LN has been widely deployed in the telecommunications industry for decades, the material has long been perceived as one that cannot be integrated due to difficulties associated with its nanofabrication. In this talk, I will first discuss our efforts in LN device fabrication techniques that have enabled thin-film LN devices and circuits that simultaneously feature sub-wavelength light confinement, low propagation loss and wafer-scale fabrication capability. Based on this platform, we have demonstrated a series of power-efficient integrated photonic components, including electro-optic modulators with CMOS-compatible drive voltages and electro-optic bandwidths covering the entire millimeter-wave band, ring-assisted Mach-Zehnder modulators with ultrahigh linearity, low-power-consumption frequency-comb generation, as well as efficient wavelength converters. The excellent device performances, together with the low optical loss and wafer-scale processes, could enable a variety of energy-efficient applications in future intra- and inter-datacenter optical links, microwave and millimeter-wave photonics, as well as analog and neuromorphic optical computation.

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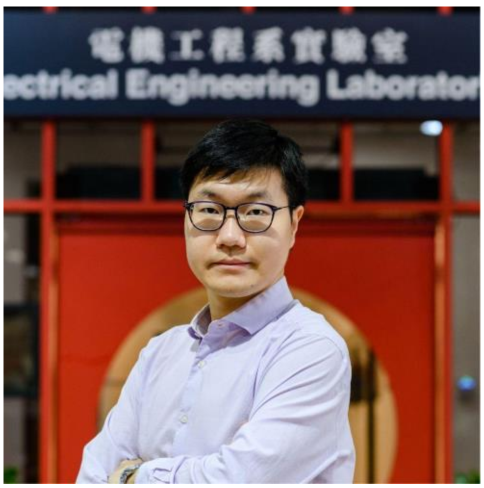

Cheng Wang received his B.S. degree in Microelectronics from Tsinghua University in 2012. Afterwards, he joined Harvard University as a Ph.D. student in the School of Engineering and Applied Sciences, advised by Prof. Marko Loncar. He received his S.M. and Ph.D. degrees, both in Electrical Engineering from Harvard University, in May 2015 and May 2017, respectively. From 2017 – 2018, Cheng conducted research as a postdoctoral fellow at Harvard, before joining City University of Hong Kong as an Assistant Professor in June 2018. Dr. Wang's research focuses on the design and nanofabrication technology of integrated photonic devices and circuits. His current research effort focuses on realizing integrated lithium niobate photonic circuits for applications in optical communications, millimeter-wave/terahertz technologies, nonlinear optics, and quantum photonics. Since joining CityU, Dr. Wang has received a number of awards, including the NSFC Excellent Young Scientist Fund (HK & Macau) (2019), the Croucher Innovation Award (2020), The President's Award, CityU (2020), and 35 Innovators Under 35 (China), MIT Technology Review (2021).

[Session II-S2] Short Talk: Edwin Chi Yan TSO

Next Generation of Green Building Technologies: Passive Radiative Cooling and Thermochromic Smart Windows

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Keywords: Passive radiative cooling, thermochromic smart windows, thermal management, energy and built environment.

Abstract

With the development of economy, the energy consumption of air conditioning systems has become a major concern. This problem is more serious in Hong Kong, which is located in the subtropical region and has a hot and humid climate. Therefore, the research and development of green building technologies for air conditioning energy-saving plays a vital role in addressing the issues of climate change and energy crisis for both Hong Kong and the world. In this talk, we present a new technology that combines passive radiative cooling and thermochromic smart windows to provide new insights for building energy saving. Specifically, the patented passive radiative cooler is applied to the roof and exterior walls, which can reflect almost all sunlight while emitting mid-infrared thermal radiation to the cold universe, thereby achieving an "electrical-free cooling" effect. We have fabricated a passive radiative cooling ceramic tile, showing a strong solar reflectivity (99%) with high mid-infrared emissivity (95%). A local field test has also been conducted in which the surface temperature of the cooling ceramic tile is ~10 °C lower than a commercial white ceramic tile with a cooling power of 130 W/m2. In addition, the thermochromic smart windows can automatically change their color subject to the ambient temperature, intelligently tuning the heat gain and loss through the windows, so that the indoor environment can be warm in winter and cool in summer. Specifically, we have developed a near-infrared-activated thermochromic perovskite smart window in which the window can selectively absorb near-infrared to generate heat and activate the thermochromism of perovskite, smartly modulating the solar heat gain from the window. This high-level smart window demonstrates reversible color change with a transmittance of τlum = 65.7% and 25.6% at the cold and hot states, smart solar modulation ability of Δτsol = 17.5%, strong near-infrared absorption of ANIR = 78.2%, and low emissivity of ε < 0.3. Importantly, for the first time, under natural sunlight without any atmosphere control strategies, a self-activated reversible thermochromic cycle is successfully observed in the field test, which is highly desired in practical applications. Moreover, a large 8 oC indoor air temperature reduction is achieved by using the window. Overall, combining with passive radiative cooling and thermochromic smart window technologies, the cooling load of air conditioning can be effectively reduced, achieving significant building energy saving and carbon reduction. The technologies will not only reduce energy consumption and help address the problem of climate change but also bring innovative ideas to the green building industry, promoting economic development and carbon neutrality globally.

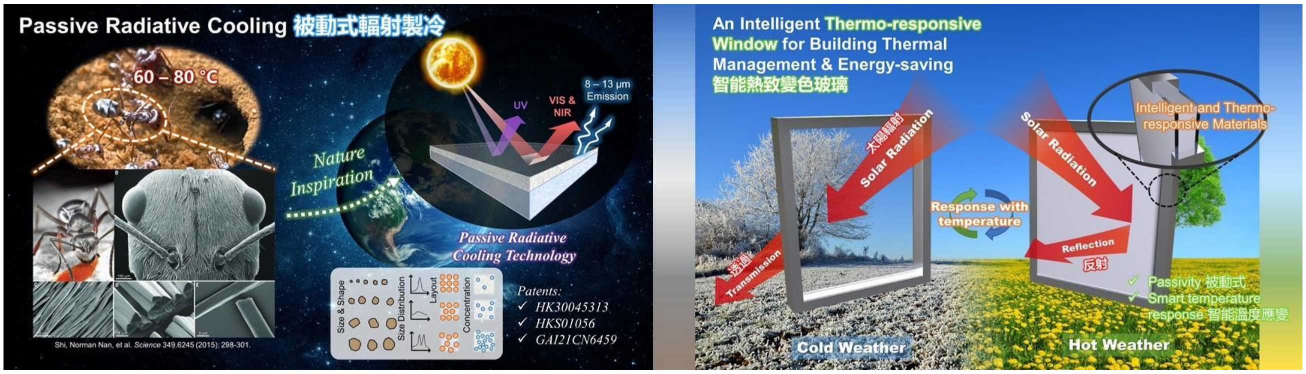

Figure 1: Smart and green building "skin" technology: passive radiative cooling and thermochromic smart windows

BIOGRAPHY

Dr. Tso is currently an Assistant Professor of School of Energy and Environment at the City University of Hong Kong (CityU). He received his Bachelor's degree in Mechanical Engineering (1st class), MPhil degree in Environmental Engineering and PhD degree in Mechanical Engineering from The Hong Kong University of Science and Technology (HKUST) in 2010, 2012 and 2015, respectively. He was awarded the Fulbright – Research Grant Council (RGC) Hong Kong Research Fellowship in 2014, and studied at the University of California, Berkeley (UC Berkeley) in 2015. Upon returning to Hong Kong from UC Berkeley, Dr. Tso worked as a Research Associate at the Department of Mechanical and Aerospace Engineering (MAE), HKUST from 2015 - 2016, before he was promoted to the rank of Research Assistant Professor (2016 - 2018). While at HKUST, Dr. Tso was also a Junior Fellow at the HKUST Jockey Club Institute for Advanced Study (2016 - 2018). In September of 2018, Dr. Tso joined CityU as an Assistant Professor.

Dr. Tso's research focuses on understanding the fundamentals of heat transfer, energy conversion, and engineered materials. He strives to integrate theory and experiments to create innovative solutions for enhancing thermal management, built environments, space cooling and refrigeration, micro-droplet manipulation, and energy-efficient building technologies, making a great and global impact by addressing the biggest needs and issues in our world. Dr. Tso has published over 65 journal papers and more than 30 conference papers. He is recently listed among the top 2% of the world's most highly cited scientists in 2022. Dr. Tso is also a Member of The Hong Kong Institution of Engineers (MHKIE) and The American Society of Mechanical Engineers (MASME). Dr. Tso is also active in entrepreneurship and technology transfer, and has obtained more than 10 international patents and has been involved in setting up a start-up in late 2012.

Simplifying infrastructure challenges to gain high benefits from transportation electrification

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Keywords: Transportation electrification, infrastructure, reduced carbon transportation, battery charging

Abstract
The shift to more-electric cars and transportation brings opportunities for control, extreme performance, energy reduction and flexibility, cheaper operation, and lower emissions. Customers see limited range, battery performance limits, slow refueling, and lack of charging facilities as big drawbacks. This presentation shows how to simplify infrastructure requirements. The energy needs of electric and plug-in hybrid passenger cars can be met with conventional single-phase electrical outlets [1]-[4]. Safety protection, metering, billing, and other functions can be supported by a car to turn a "dumb" electrical outlet into a smart vehicle charge point. Flexibility supported within a vehicle can minimize carbon impact and enhance environmental benefits. Actual driver needs are discussed, showing how more advanced chargers fit in and why "slow charging" is a fallacy most of the time. The results provide perspective to the context of present intensive effort on fast charging [5], [6]. Survey results on the University of Illinois campus help to support the ideas. The talk explores how to think differently about electric cars, energy, and how infrastructure interaction can work. Flexibility can make electric vehicles important partners for low-carbon power grids.

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BIOGRAPHY

Philip T. Krein received the B.S. degree in electrical engineering and the A.B. degree in economics and business from Lafayette College, Easton, PA, and the M.S. and Ph.D. degrees in electrical engineering from the University of Illinois at Urbana–Champaign. He was an engineer with Tektronix, Beaverton, OR, and then returned to the University of Illinois at Urbana–Champaign. He was a Senior Fulbright Scholar at the University of Surrey, Guildford, U.K., from 1997 to 1998. From 2003 to 2014, he was a founder and director of SolarBridge Technologies, Inc., Austin, TX as they developed ac photovoltaic panels. From 2016 through 2020, he was Executive Dean of the Zhejiang University/University of Illinois at Urbana–Champaign Institute, Haining, China. At present, he is the Illinois director of the joint University of Illinois/Zhejiang University Dynamic Research Enterprise for Multidisciplinary Engineering Sciences (DREMES). He holds the Grainger Endowed Chair Emeritus in Electric Machinery and Electromechanics at the University of Illinois at Urbana–Champaign and is an Adjunct Distinguished Professor at Zhejiang University. His current research interests include all aspects of power electronics, machines, drives, and electric transportation, with emphasis on nonlinear control approaches. Dr. Krein received the IEEE William E. Newell Power Electronics Award in 2003 and the IEEE Transportation Technologies Award in 2021. He holds 42 U.S. patents. He is a past president of the IEEE Power Electronics Society, a past member of the IEEE Board of Directors, a past chair of the IEEE Transportation Electrification Community, and an Associate Editor of the IEEE Open Journal of Power Electronics. He is a Registered Professional Engineer in Illinois and Oregon. He is a Fellow of the U.S. National Academy of Inventors and a member of the U.S. National Academy of Engineering.

Digitization: A Path to Sustainable Decarbonization

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Keywords: Dynamic Monitoring and Decision Systems (DyMonDS); social-ecological energy systems (SEES); cyber physical systems (CPS); digitization; decarbonization.

Abstract

In this talk we explore how today's operations of electric power grids can be enhanced by evolving a hierarchically-designed and operated physical system into an interactive Cyber-Physical System (CPS). Today, the operation is fundamentally coordinated by the Energy Management Systems (EMS) sending commands to controllable power plants in their area to produce energy in a feed-forward manner. This is done at the Balancing Authority (BA) level where EMS uses its SCADA-enabled state estimator to predict power imbalances. The hard -to-predict imbalances are managed by the BAs, most often implemented using dedicated communication and control schemes.

Important for understanding new opportunities for digitization is to understand the assumptions implied in today's operation and to design hardware and software needed to relax them. The emerging poly-centric approach to electricity services is described as a possible way forward [1]. The next generation SCADA becomes a Dynamic Monitoring and Decision System (DyMonDS) which relaxes major assumptions through interactive information exchange [2, 3]. This brings about inter-temporal and inter-spatial flexibility as a means of implementing cooperative gains and the ability to increase efficiency without sacrificing QoS. This CPS design is non-unique for any given social-ecological energy system (SEES) since it depends on the performance objectives and its resources, end users, governance system and their interactions. System governance and policy making determine the overall organization of the physical system into sub-systems with their own sub-objectives, and rules for information sharing in operations and planning. As such, they must be accounted for when building physical man-made portions of the system and the supporting CPS architecture. Design of a man-made physical grid and its cyber are done to enhance the performance of an existing man-made system. At the same time, digitization is needed to improve dynamic interactions of the SEES components and to align their sub-objectives to the best degree possible. Several real-world power grid examples are shown to illustrate its key role and potential benefits.

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BIOGRAPHY

Marija Ilić, is a Professor Emerita at Carnegie Mellon University (CMU). She currently has a joint appointment of an Adjunct Professor in EECS Department and Senior Research Scientist at the MIT Laboratory for Information and Decision Systems (LIDS) at the Massachusetts Institute of Technology (MIT). She is an IEEE Life Fellow and an elected member of the US National Academy of Engineering, and the Academia Europaea. She was the first recipient of the NSF Presidential Young Investigator Award for Power Systems in the US. She has co-authored several books on the subject of large-scale electric power systems, and has co-organized an annual multidisciplinary Electricity Industry conference series at Carnegie Mellon (http://www.ece.cmu.edu/~electriconf) with participants from academia, government, and industry. She was the founder and co-director of the Electric Energy Systems Group (EESG) at Carnegie Mellon University (http://www.eesg.ece.cmu.edu). Currently she is building EESG@MIT, in the same spirit as EESG@CMU. Most recently she has offered an open EdX course at MIT entitled ``Principles of Modeling, Simulations and Control in Electric Energy Systems”. She is founder and chief scientist at New Electricity Transmission Solutions (NETSS), Inc.

Future Energy Infrastructures, Energy Platforms and Energy Storage

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Keywords: Renewable energy, clean energy, energy infrastructure, energy platform, energy storage

Abstract
Today fossil energy dominates energy consumption across the world. There has been an increasing momentum to reduce fossil energy consumption and increase renewable energy utilization. Such high penetrations of distributed renewable resources bring large uncertainty and complexity that cannot be easily handled by the current infrastructure. Here we discuss a platform-based approach, called the energy platform as a viable solution for addressing the renewable energy challenges. The energy platform consists of an array of computational algorithms, sensing and control technologies for key industry, energy generators and users to jointly manage and control the complex energy infrastructure. The energy platform also requires breakthroughs in many areas, including large scale energy storage, efficient power electronics, sensors and controls, new mathematical and computational tools, and deep integration of energy technologies and information sciences to control and stabilize such complex systems.

BIOGRAPHY

Dr. Jun Liu is the Washington Research Foundation Innovation Chair in Clean Energy, Campbell Chair Professor of Materials Science & Engineering, Professor of Chemical Engineering, and a Battelle Fellow at the Pacific Northwest National Laboratory (PNNL). He also serves as the Director for Innovation Center for the Battery500 Consortium, a multi-institute program supported by the U.S. Department of Energy (DOE) with the goal of developing next generation batteries. In the past, he has served as senior researchers at the Pacific Northwest National Laboratories, Bell Laboratories and Sandia National Laboratories. He also served as the Department Manager for Chemical Synthesis and Nanomaterials at Sandia, the Thrust Leader for the Complex Materials for the Integrated Center for Nanotechnologies (CINT), Lead Scientist for Cross-Cutting Sciences for the Joint Center for Energy Storage Research (JCESR), Laboratory Fellow and Division Director for Energy Processes and Materials Division at PNNL.

[Session III-K4] Keynote Lecture: Kazunari DOMEN

Photocatalytic water splitting for solar hydrogen production

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Keywords: Particulate photocatalyst, panel reactor, gas separation, scalability

Abstract
Sunlight-driven water splitting is studied actively for production of renewable solar hydrogen on a large scale. Overall water splitting using particulate photocatalysts has been attracting growing interest, because such systems can be spread over wide areas by inexpensive processes potentially [1]. However, it is essential to radically improve the solar-to-hydrogen energy conversion efficiency (STH) of particulate photocatalysts and develop suitable reaction systems. In my talk, recent progress in photocatalytic materials and reaction systems will be presented.

The author's group has studied various semiconductor oxides, (oxy)nitrides, and (oxy)chalcogenides as photocatalysts for water splitting [2]. $SrTiO_3$ is an oxide photocatalyst that has been known to be active in overall water splitting under ultraviolet irradiation since 1980. Recently, the apparent quantum yield (AQY) of this photocatalyst in overall water splitting has been improved to more than 90% at 365 nm, equivalent to an internal quantum efficiency of almost unity, by refining the preparation conditions of the photocatalyst and the loading conditions of cocatalysts [3]. This quantum efficiency is the highest yet reported and indicates that a particulate photocatalyst can drive the endergonic overall water splitting reaction at a quantum efficiency comparable to values obtained in photon-to-chemical and photon-to-current conversion processes by photosynthesis and photovoltaic systems, respectively. The author's group has also been developing panel reactors for large-scale applications. A solar hydrogen production system based on 100-m^2 arrayed photocatalytic water splitting panels and an oxyhydrogen gas-separation module was built, and its performance and system characteristics including safety issues were reported recently [4].

For practical solar energy harvesting, it is essential to develop photocatalysts that are active under visible light irradiation. Ta_3N_5 and $Y2Ti_2O_5S_2$ photocatalysts are active in overall water splitting via one-step excitation under visible light irradiation [5,6]. Particulate photocatalyst sheets efficiently split water into hydrogen and oxygen via two-step excitation, referred to as Z-scheme, regardless of the size. In particular, a photocatalyst sheet consisting of La- and Rh-codoped $SrTiO_3$ and Mo-doped $BiVO_4$ splits water into hydrogen and oxygen via the Z-scheme, showing a STH exceeding 1.0% [7]. Some other (oxy)chalcogenides and (oxy)nitrides with long absorption edge wavelengths are also applicable to Z-scheme photocatalyst sheets and hold the promise of realizing greater STH values.

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BIOGRAPHY

Kazunari Domen received B.S. (1976), M.S. (1979), and Ph.D. (1982) honors in chemistry from the University of Tokyo. Dr. Domen joined Chemical Resources Laboratory, Tokyo Institute of Technology in 1982 as Assistant Professor and was subsequently promoted to Associate Professor in 1990 and Professor in 1996. Moving to the University of Tokyo as Professor in 2004, and Cross appointment with Shinshu University as Special Contract Professor in 2017. University Professor of the University of Tokyo in 2019.

Domen has been working on overall water splitting reaction on heterogeneous photocatalysts to generate clean and recyclable hydrogen. In 1980, he reported NiO-$SrTiO_3$ photocatalyst for overall water splitting reaction, which was one of the earliest examples achieving stoichiometric H_2 and O_2 evolution on a particulate system. In 2005, he has succeeded in overall water splitting under visible light (400 nm$<\lambda<$500nm) on GaN:ZnO solid solution photocatalyst.

[Session III-K5] Keynote Lecture: Jun CHEN

Organic Carbonyl Electrode Materials for Li/Na Batteries

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Abstract

Lithium-ion batteries (LIBs) have dominated the market of portable electronics and electric vehicles due to their high energy density and long-term cyclability, and are moving forward to scale energy storage applications such as regulating the output of electricity generated by sustainable energy. Nevertheless, the current electrochemistry of LIBs based on Li-ion interaction/de-interaction between graphite anode and oxide cathode is suffering from intrinsic limitations of energy density, scarce natural resource (Li, Co, Ni *etc.*), and high energy consumption/CO_2 emission involved in the production of electrodes. Organic redox compounds, especially conjugated carbonyl compounds that have been studied since 1969, are reviving in the recent years due to the advantages of high capacity, abundant resources, and structural designability. Moreover, the electrochemical redox mechanism of organic carbonyl electrode materials mainly based on charge compensation enables the battery applications with versatile charge carriers (Li^+, Na^+, H^+ *etc.*). The key challenges of organic carbonyl electrode materials are their high solubility in electrolyte during cycles and poor electronic conductivity, leading to fast capacity decay and inferior rate performance, respectively. This report focuses on the redox chemistry, structure-performance relationship, and applications of organic carbonyl electrode materials for Li and Na batteries. We developed several strategies from the aspects of molecular design (electrode level) and electrolyte optimization (electrolyte level) to solve the issues of organic carbonyl electrodes and construct high-performance Li/Na batteries. With elaborate design, organic carbonyl electrode materials have demonstrated promising interest for large-scale electrochemical energy storage in the foreseeable future.

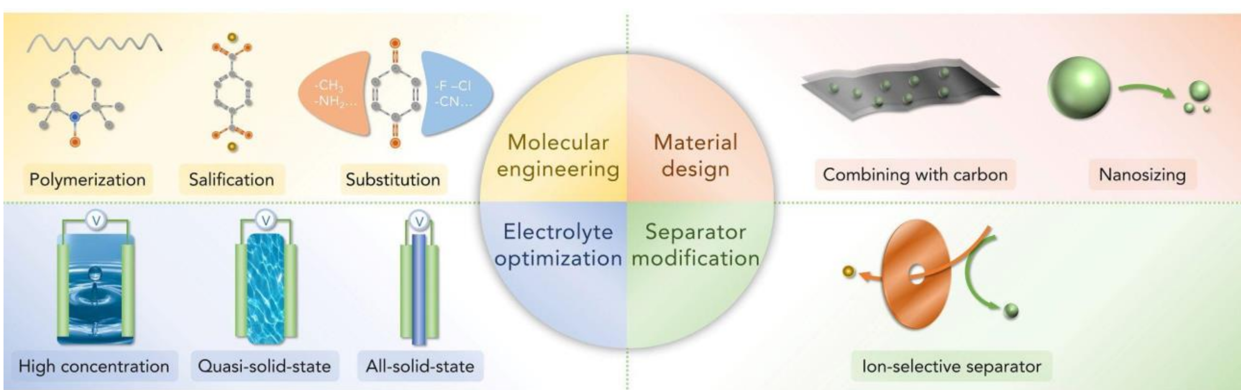

Figure 1. Proposed strategies toward improving the electrochemical performance of organic carbonyl electrodes for Li/Na batteries.

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BIOGRAPHY

Prof Jun CHEN was elected the academician of the Chinese Academy of Sciences in 2017. He join the Communist Party of China in December 1988. Chen studied in the chemistry department of Nankai University during 1985 to 1992 and was awarded the bachelor's degree and master's degree successively. He stayed for work in Nankai University in 1992. From 1996 to 1999, he studied in the materials department of Wollongong University (Australia) with a doctorate degree. From 1999 to 2002, he was a research fellow in Japanese New Energy and Industrial Technology Development Organization (NEDO) at the Osaka Institute of Industrial Technology, Japanese Industrial Technology Institute. Jun Chen served as a professor of Nankai University and doctoral supervisor from 2002. He is currently the vice President of Nankai University, the director of Key Laboratory of Advanced Energy Materials Chemistry (Ministry of Education) and the Chairman of the Chinese Society of Electrochemistry.

He is mainly engaged in the research of inorganic solid chemistry. He has made an important and innovative contribution to the synthesis of inorganic solid functional materials, the preparation of solid electrode and the development of new battery electrode materials. So far, he has published 400 papers, been authorized 30 invention patents and written 16 books (chapters). He was awarded The National Science Fund for Distinguished Young Scholars in 2003, distinguished professor of Chang Jiang Scholars Program (Ministry of Education) in 2005, Chief expert of 973 Program in 2010, the second prize of national award for natural sciences in 2011, Chinese Electrochemical Contribution Award in 2013 and Leader in Science and Technology Innovation Talents in 2014, fellow of the Royal Society of Chemistry in 2014, the First Outstanding Talents of Tianjin in 2016. He is the deputy editor of the Inorganic Chemistry Frontiers and Applied Chemistry. He is the international editorial advisory board member of Solid State Sciences, ACS Sustainable Chem. Eng., ACS Energy Lett., J. Energy Chem., Nano Research Science China: Materials, Acta Chimica Sinica, Acta Physico-Chimica Sinica, Electrochemistry, Power Supply Technology and other journals.

[Session III-I1] Invited: Guohua CHEN

Li-S Batteries: Challenges, Achievements and Opportunities

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Keywords: Electrolyte, Metal-organic frameworks, Polysulfide, Sulfur-carbon composite, Shuttle effect

Abstract

To realize a low-carbon economy and sustainable energy supply, the development of energy storage devices has aroused intensive attention. Lithium-sulfur (Li-S) batteries are regarded as one of the most promising next generation battery devices because of their remarkable theoretical energy density, cost-effectiveness, and environmental benignity. However, the practical application of Li-S batteries is hindered by such challenges as low sulfur utilization (<80%), fast capacity fade, short service life (<200 redox cycles), and severe self-discharge. The reasons behind the challenges are: i) low conductivity of the active materials, ii) large volume changes during redox cycling, iii) serious polysulfide shuttling and, iv) lithium-metal anode contamination/corrosion and dendrites formation. Significant achievements have been made to address these problems in the past decade. In this review, the recent advances in material synthesis and technology development are analyzed in terms of the electrochemical performances of different Li-S battery components. The critical analysis was conducted based on the merits and shortcomings of the reported work on the issues facing the individual component. A versatile 3D printing technique is also examined on its practicability for Li-S battery production. The insights on the rational structural design and reasonable parameters for the Li-S batteries are highlighted along with the “five 5s” concept from a practical point of view. The remaining challenges are outlined for researchers to devote more efforts on the understanding and commercialization of the device in terms of materials preparation, cell manufacturing, and characterization [1].

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BIOGRAPHY

Professor Chen received his Bachelor of Engineering degree in Chemical Engineering from Dalian University of Technology (DUT) in China. He then obtained a Master of Engineering degree and Ph.D. degree from McGill University in Canada.

Professor Chen joined the Department of Chemical and Biomolecular Engineering of The Hong Kong University of Science and Technology (HKUST) as a Visiting Scholar in 1994, then as Assistant Professor in 1997, and rising through the academic ranks to Professor in 2008. Professor Chen also assumed the headship of the Department of Chemical and Biomolecular Engineering during 2012-2016.

Professor Chen has served in many professional societies and editorial boards of key international journals. Apart from serving as the Chairman, Chemical Discipline for the Hong Kong Institution of Engineers during 2009 and 2012, he was the President of the Asian Pacific Confederation of Chemical Engineering (2015-2017), is Editor-Chief (Environmental), Process Safety and Environmental Protection, Editor of Separation and Purification Technology, Associate Editor of the Chinese Journal of Chemical Engineering, Associate Editor of the Canadian Journal of Chemical engineering, and the editorial board member of Journal of Electrochemistry, Drying Technology-An International Journal, Environmental Technology Reviews, etc. He is an Adjunct Professor of DUT and Changjiang Scholar (Chair), Ministry of Education in China.

Professor Chen's recent research interests include electrochemical technologies for energy and environmental applications. He has published over 300 journal papers with more than 32,500 Google citations and an H-index of 93. Professor Chen edited 3 books, and was granted three US patents and over ten China patents. In relation to his research achievements, Professor Chen received the Certificate of Excellence from the World Forum of Crystallization, Filtration and Drying in 2007, the inaugural Research Excellence Award from the School of Engineering of HKUST in 2011, the Merit Award for individual research from Faculty of Engineering, HKPolyU in 2019. He is a Fellow of Hong Kong Institute of Engineers, American Institute of Chemical Engineers, and Canadian Academy of Engineering.

[Session III-I2] Invited: Yi-Chun LU

Materials Design Strategies for High-Energy and Safe Battery Systems

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Keywords: Energy storage, aqueous batteries, redox flow batteries

Abstract
Energy storage system is a critical enabling factor for deploying unstable and intermittent renewable power sources, such as solar and wind power sources. Non-aqueous lithium ion batteries dominate the battery markets owing to its high energy density. However, they are flammable, which could bring catastrophic damages in large-scale applications. Redox flow batteries are promising technologies for large-scale electricity storage, owing to its design flexibility in decoupling power and energy capacity. However, redox flow batteries have been suffering from low energy density, which significantly decreases its competitiveness for both stationary and transportation applications. In this presentation, we will discuss strategies to improve the safety, energy density, and cycle life of Li-ion batteries and redox flow batteries. Ultimately, we aim to enable stable and efficient high-energy-density energy storage systems to address the intermittency of the renewable power sources. This will bridge the gap between intermittent renewable power supplies and power demands in grid-storage and electric-vehicles.

BIOGRAPHY

Prof. Yi-Chun Lu received her Ph.D. degree from MIT in 2012. She is a Professor in the Department of Mechanical and Automation Engineering at The Chinese University of Hong Kong (CUHK). She serves as the Associate Editor of Journal of Materials Chemistry A and Materials Advances from Royal Society of Chemistry. She is Fellow of Royal Society of Chemistry, Founding Member of Young Academy of Science of Hong Kong and was the recipient of RGC Research Fellow 2022, Xplorer Prize 2021, IBA Early Career Award 2021, Excellent Young Scientists, National Natural Science Foundation of China (2019), and Hong Kong SAR Research Grants Council Early Career Award (2014). Prof. Lu's research interest centers on developing fundamental understandings and material design principles for clean energy storage and conversion. Specifically, her research group is studying: Electrode and electrolyte design for high-energy aqueous batteries, metal-air and metal sulfur batteries; Redox-active components and solution chemistry for redox-flow batteries; Electrode and electrolyte design for high-voltage aqueous batteries; Mechanistic understanding of interfacial phenomena governing electrochemical energy conversion and storage processes.

Eco-engineered shoreline designs for facilitating carbon neutrality and promoting marine biodiversity

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Abstract
Reclamation and marine infrastructure projects often adopted simple artificial vertical or slope seawalls as coastal defences against wave action, flooding and land erosion. However, these structures do not possess any microhabitats that can be readily occupied and used by marine organisms as refuges and feeding grounds. Through incorporating the knowledge of marine ecology and collaboration with ecologists and architects, engineers now are able to design eco-friendly artificial structures to serve dual roles as coastal defences and functional ecosystems for enhancing marine biodiversity and ecosystem services such as carbon squassation and biofiltration. In this lecture, I will introduce the basic ecological principles for eco-engineered shorelines and draw examples from different parts of the world. I will also highlight the results of several recent trials of eco-engineered shorelines in Hong Kong.

BIOGRAPHY

Kenneth Mei-Yee Leung is Chair Professor of Environmental Toxicology and Chemistry, and Acting Head at Department of Chemistry in City University of Hong Kong, where he also serves as the Director of the State Key Laboratory of Marine Pollution. His research interests encompass marine pollution, ecotoxicology, marine ecology, biodiversity conservation and ecological restoration using eco-engineering. So far, he has published over 250 peer-reviewed articles in these areas. Owing to his professional achievements and dedicated community services, he was selected as one of the "Ten Outstanding Young Persons" for Hong Kong in 2010 and appointed as a Justice of the Peace by the Hong Kong SAR Government in 2018. In 2017, he was awarded the 19th Biwako Prize for Ecology by the Ecological Society of Japan in recognition of his contributions to aquatic ecology in Asia-Pacific, and conferred as a Fellow of the Society of Environmental Toxicology and Chemistry (SETAC). He was selected as one of the top 100 Asian Scientists by Asian Scientist Magazine in 2018, and recognized as one of the top 2% scientists in Marine Biology & Hydrobiology in the world by the Stanford-Elsevier Indicators in 2021. He was elected as a Fellow of the Royal Society of Chemistry and a Fellow of the Royal Society of Biology in May and July 2022, respectively. Currently, Professor Leung is leading the Global Estuaries Monitoring (GEM) Programme which has been endorsed by the United Nations as an Action Programme under the UN Decade of Ocean Science for Sustainable Development (2021-2030). Through concerted global efforts in monitoring pollution at major urbanised estuaries and developing practical strategies for pollution minimisation, the GEM Programme aims to create cleaner and safer estuaries for all.

[Session III-S1] Short Talk: Yun Hau NG

Photoexcited Charge Transportation in Oxide Photocatalyst for Water Splitting

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Keywords: Water splitting, hydrogen generation, solar fuels, photocatalyst

Abstract
Hydrogen production from photocatalytic water splitting under visible light has been considered a potential alternative to make solar energy storable and transportable. Oxide photocatalysts are perhaps the most popular and promising class of materials for water splitting, either via photocatalytic or photoelectrochemical pathways. Typically, oxide photocatalysts possess deep and energetic valance band, endowing them with impressive oxidative performance (such as water oxidation to O2, oxidative organic degradation). The conduction band of oxides is relatively mild in reducing capability and often in needs of other modification (such as doping and introduction of co-catalyst). By manipulating the band structures of photocatalysts, the redox performance can be improved and the product selectivity can be modulated. Our group is interested in the phenomena of charge transportation in semiconductors upon photoexcitation. Fascinated by its complexity, the tuning of band structure to strengthening or weakening certain half reaction of redox, together with the design of defects or surface states on photocatalyst, photoexcited electron-hole pairs can experience distinctive transportation behaviour. Those impacts can be used constructively in the targeted redox reaction (in this case, water splitting). Collectively studied over previous years, the group has accumulated some experience in understanding and controlling the charge behaviour of oxide photocatalyst.

In this talk, a general strategy in improving the shuttling of charges in bismuth vanadate (BiVO4) will firstly be shared. Facet engineering and nanoscaling are generally adopted by the community. Subsequently, the originally weak conduction band of BiVO4 can be uplifted through the introduction of quantum confinement effect. Conduction band is lifted sufficiently to enable proton reduction for H2 generation. The original incapability in hydrogen production of BiVO4 has now been extended into efficient hydrogen evolution. By careful surface functionalisation with suitable co-catalyst, overall water splitting using only BiVO4 is achievable. Insights on such materials engineering will be discussed more thoroughly in the presentation.

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BIOGRAPHY

Yun Hau Ng is a Professor at the School of Energy and Environment, City University of Hong Kong. He received his Ph.D (Chemistry) from Osaka University in 2009. After a brief research visit to Radiation Laboratory at University of Notre Dame, he joined the Australian Research Council (ARC) Centre of Excellence for Functional Nanomaterials at UNSW with APD fellowship in 2011. He became a lecturer (2014) and Senior Lecturer (2016) in the School of Chemical Engineering at the University of New South Wales (UNSW) before joining City University of Hong Kong in 2018.

His research is focused on the development of novel photoactive semiconductors (particles and thin films) for sunlight energy conversion, including hydrogen generation from water and conversion of carbon dioxide to solar fuels. He was awarded the Honda-Fujishima Prize in 2013 by the Electrochemical Society of Japan in recognition of his work in the area of photo-driven water splitting. He was also selected as Emerging Investigator in Energy Materials by the RSC Journal of Material Chemistry A in 2016. In 2018, he received the Distinguished Lectureship Award from the Chemical Society of Japan. In 2019, He was awarded APEC Science Prize for Innovation, Research and Education (ASPIRE) in Chile for his work in artificial photosynthesis. He is also the recipient of the Japanese Photochemistry Association Kataoka Lectureship Award for Asian and Oceanian Photochemist 2021. He has published over 200 peer-reviewed research articles (including Nature Catalysis, JACS, Angewandte Chemie, Advanced Materials, Energy & Environmental Science, Chemical Society Reviews, Chemical Reviews and etc) with >18,000 citations.

[Session III-S2] Short Talk: Wanxin LI

Why is environmental governance critical for achieving carbon neutrality?

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Keywords: Carbon neutrality, institution building

Abstract
Climate finance in various forms such as ESG investing and carbon emissions trading, has become mainstreamed globally. The market mechanisms do not reduce carbon emissions themselves but can potentially incentivize the invention and deployment of technologies and practices, and achieve economic efficiency in climate mitigation and adaptation. Unfortunately, the effectiveness of those market mechanisms has been largely compromised by a lack of integrity in the monitoring/measurement, verification and reporting of ESG performance and carbon emissions embedded in business operations. The third parties are contracted to provide carbon emissions data for regulators, green investors, and the public, who are the principals financing climate actions and bearing the consequences of climate change. Thus, the integrity of the information and data supporting system is a function of the institutional design of environmental monitoring and reporting, especially how the principal-agent problem has been dealt with, which is context specific. Because carbon and air pollution reduction complement each other and face common challenges, it is beneficial to unpack the contractual relationships in both to inform institution building for achieving carbon neutrality and local health co-benefits in China.

According to transaction cost economics, the principal bears the following three contractual hazards, asset specificity, observability and enforceability, which are contingent upon the ex ante screening, contract design and execution, and ex post evaluation. The centralization and marketization reform in air quality monitoring in 2015 was found to be partially effective in addressing asset specificity and enforceability. However, resorting to the market is not a panacea because the emitters and local government are still motivated to form a shadow clientele relationship with those qualified data providers, given climate finance and government responsibility system offer economic gain and career prospects, respectively. The public interest litigation initiated by the China Federation for Environmental Protection in July 2022 against the two consulting firms for falsifying carbon emissions data offers ad hoc evidence on the perennial challenge of holding the agents accountable for environmental data provision that sets necessary foundation for climate finance to work. A country-wide systematic review is in order to stocktake and diagnose contract terms and practices of the environmental monitoring services industry, given the regional variations in local contexts and the power and reach of the local government. Without the ground work, it is impossible to build necessary institutions and a professional work force for creating a level playing field and achieving carbon neutrality in the future.

BIOGRAPHY

Wanxin Li is highly experienced with evidence-based and transdisciplinary policy research for achieving sustainability transitions. She is particularly interested in intellectual explorations on the following four topics : (1) socio-technological innovation, (2) policy design and governance, (3) institutional capacity, and (4) economic and social well-being.

Having had the privilege working with the World Bank, OECD, and Tsinghua University, she contributed significantly to discovering why and how socio-technological innovations emerge and make impacts, in the context of the multi-level governance structure in China. Her research output appears in tier one academic journals such as Nature and Land Use Policy. Besides the academia, her work has been well received by policymakers, practitioners, and international organizations. For example, she was invited to speak at the OECD International Conference on Environmental Compliance Assurance in Paris, and the Trade and Environment Session of the WTO Public Forum in Geneva.

She is also highly effective in guiding students to learn the craft of designing and executing problem driven independent projects. For example, she guided three undergraduate students who majored in Environmental Policy and 35 CityU student volunteers to work together on the 2016 Hong Kong Rugby Sevens Green Ambassador Scheme. Students were encouraged to apply research skills learned in the class to invent and evaluate the impacts of their own designed transparent recycling bins in promoting green mega-events in Hong Kong. This was selected as one of the flagship projects presented at the Climate Change Stakeholder Engagement Forum held by the Hong Kong SAR Government on 12 July 2016.

The Role of Energy Storage in a Highly Decarbonized Electricity Sector

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Keywords: energy storage, net-zero, electricity sector, batteries, thermal storage

Abstract
A central strategy for achieving global, net zero economy wide emissions is decarbonizing the electricity sector while using this decarbonized electricity to electrify as much of the rest of the economy as possible. Electricity sector decarbonization has focused on replacing fossil fueled generation with variable renewable energy (VRE) generation, primarily solar and wind. At small penetration of VRE's, incorporation of these resources into the electricity system is fairly straightforward. However, as electricity systems around the world deploy significant amounts of VRE's, it is impossible to match electricity supply and demand without incorporating energy storage into the system. This presentation examines the role that grid-scale storage used as electricity-to-storage-to-electricity can play in deeply decarbonized electricity systems We look at technology options, system design incorporating storage, and policy/regulatory changes that may be needed to facilitate these future systems. The results presented here are based on the recent *Future of Energy Storage* study [1].

Four categories of grid-scale energy storage are considered: electrochemical, mechanical, thermal, and chemical. Among electrochemical technologies, we focus on three: lithium-ion batteries (the incumbent technology), redox flow batteries, and metal-air chemistries. Mechanical storage examines pumped hydro-storage and compressed air energy storage. Thermal storage includes sensible heat storage in very low-cost materials, e.g., molten salts and rocks, as well as heat pumps. Finally chemical storage is illustrated with hydrogen, which if not ultimately used would certainly be a precursor to candidate storage chemicals. Operating characteristics and cost estimates projected out to 2050 are developed for each one of these technologies. All technologies studied are TRL level 6 or higher.

A capacity expansion model (GenX) is used to build out least cost electricity systems in different regions around the US as well as in India and Nigeria. In this way we are able to see how regional resources, weather patterns, and types of loads affect choice of overbuilding renewables, adding transmission, adding storage (of different types), and shifting demands.

Finally, policy and regulatory issues for these highly decarbonized electricity systems are discussed for several regions in the US. Specific policy and regulatory changes will certainly be affected by market structures and public attitudes among other factors in different parts of the world.

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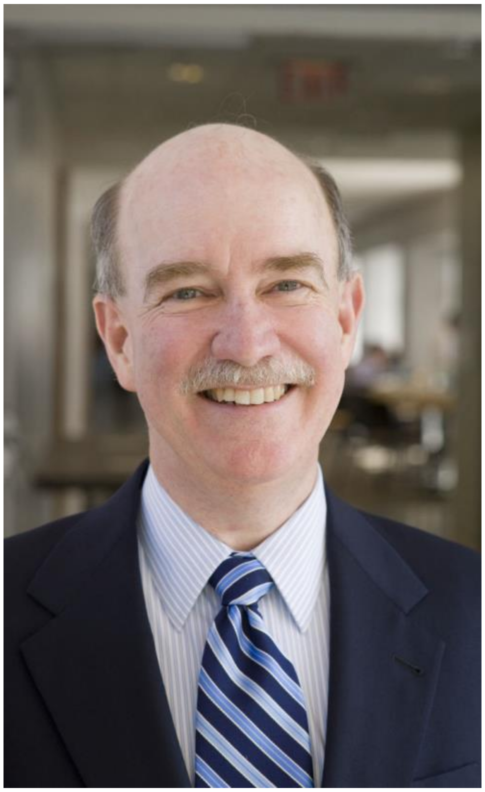

Professor Robert C. Armstrong directs the MIT Energy Initiative, an Institute-wide effort at MIT linking science, technology, and policy to transform the world's energy systems. A member of the MIT faculty since 1973, Armstrong served as head of the Department of Chemical Engineering from 1996 to 2007. His research is focused on pathways to a low-carbon energy future.

Armstrong has been elected into the American Academy of Arts and Sciences (2020) and the National Academy of Engineering (2008). He received the Founders Award for Outstanding Contributions to the Field of Chemical Engineering (2020), Warren K. Lewis Award (2006), and the Professional Progress Award (1992), all from the American Institute of Chemical Engineers. He also received the 2006 Bingham Medal from the Society of Rheology, which is devoted to the study of the science of deformation and flow of matter.

Armstrong was a member of MIT's Future of Natural Gas and Future of Solar Energy study groups. He advised the teams that developed MITEI's recent reports, The Future of Nuclear Energy in a Carbon-Constrained World (2018) and Insights into Future Mobility(2019), and is chaired the new MITEI study, The Future of Energy Storage. He co-edited Game Changers: Energy on the Move with former U.S. Secretary of State George P. Shultz.

[Session IV-K2] Keynote Lecture: Jacopo BUONGIORNO

Nuclear Batteries: a New Way in Energy

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Abstract
In the 21st century humanity faces three formidable and intertwined challenges: (i) climate change, (ii) geopolitical instability, and (iii) economic and social inequality. There is one tool that is key to the resolution of all three challenges: energy! The availability of plentiful, clean, reliable and affordable energy will power climate change mitigation and adaptation efforts, will reduce competition for natural resources among the nations, and will drive new and beneficial economic activities on a global scale.

In the US there is growing bipartisan support among policymakers and energy regulators for nuclear energy to play a substantial role in addressing these challenges, in particular decarbonizing and strengthening the global energy system. There is also recognition that the traditional nuclear deployment model based on field construction of large GW-scale reactors, taking over a decade to license and build, requiring multi-billion dollar investments, and ultimately selling commodity electrons on the grid, is no longer economically sustainable. As such, considerable interest is now being placed on smaller reactors that can be deployed at a fraction of the cost and time, and can serve a variety of users beyond the electric grid. The window of opportunity for new nuclear is real but narrow, i.e., if economically viable nuclear technologies are not commercialized before the end of the decade, it is unlikely that they will be relevant to addressing the aforementioned challenges.

In this presentation I will introduce the concept of the Nuclear Battery, i.e., a standardized, factory-fabricated, road transportable, plug-and-play micro-reactor. Nuclear Batteries have the potential to provide on-demand, carbon-free, economic, resilient and safe energy for distributed heat and electricity applications in every sector of the economy. Particular attention will be given to the Nuclear Battery economic potential, which stems from bypassing the need for costly and fragile energy transmission and storage infrastructure typical of clean-energy alternatives.

BIOGRAPHY

Jacopo Buongiorno is the TEPCO Professor of Nuclear Science and Engineering at the Massachusetts Institute of Technology (MIT), and the Director of Science and Technology of the MIT Nuclear Reactor Laboratory. He teaches a variety of undergraduate and graduate courses in thermo-fluids engineering and nuclear reactor engineering. Jacopo has published 90 journal articles in the areas of reactor safety and design, two-phase flow and heat transfer, and nanofluid technology. For his research work and his teaching at MIT he won several awards, among which the ANS Outstanding Teacher Award (2019), the MIT MacVicar Faculty Fellowship (2014), the ANS Landis Young Member Engineering Achievement Award (2011), the ASME Heat Transfer Best Paper Award (2008), and the ANS Mark Mills Award (2001). Jacopo is the Director of the Center for Advanced Nuclear Energy Systems (CANES). In 2016-2018 he led the MIT study on the Future of Nuclear Energy in a Carbon-Constrained World. Jacopo is a consultant for the nuclear industry in the area of reactor thermal-hydraulics, and a member of the Accrediting Board of the National Academy of Nuclear Training. He is also a member of the Secretary of Energy Advisory Board (SEAB) Space Working Group, a Fellow of the American Nuclear Society (including service on its Special Committee on Fukushima in 2011-2012), a member of the American Society of Mechanical Engineers, past member of the Naval Studies Board (2017-2019), and a participant in the Defense Science Study Group (2014-2015).

Technologies for Air Pollution Control and CO_2 Mitigation for Sustainable Environment

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Keywords: Air pollution control, CO_2 mitigation, filtration, sustainable environment

Abstract

We are developing green technologies to benefit sustainable environment, which will enable people and the environment to prosper together. The Center for Filtration Research (CFR) at the University of Minnesota, collaborating with 20 leading international filtration manufacturers and end users, was established to find filtration solutions to mitigate $PM_{2.5}$ and other environmental pollutants. CFR investigators perform fundamental and applied research on air, gas and liquid filtration. There are more than 15 on-going research projects performed at CFR. I will select 6 projects to demonstrate the scope of the research topics: 1. Reduction of aerosol concentration in classrooms under various HVAC conditions to prevent virus transmissions; 2. Filtration performance improvement using beaded nanofiber; 3. Ozone removal using Zeolite catalysts; 4. Saliva evaporation experiment at low pressure environment; 5. Development of a microsensor for real-time detection of bioaerosols and particles in bulk liquids and aerosols; 6. Temperature resistant nano-scale membrane for enhanced ceramic wall-flow filter performance.

Large scale air cleaning towers are established in Xi'an and Yancheng in China, and two additional towers in Delhi, India. They are developed to mitigate $PM_{2.5}$ pollutants in urban air. The second-generation tower in Yancheng is developed to reduce not only the $PM_{2.5}$ but also CO_2 in the atmosphere. All these research and development activities are helping to improve sustainable environment.

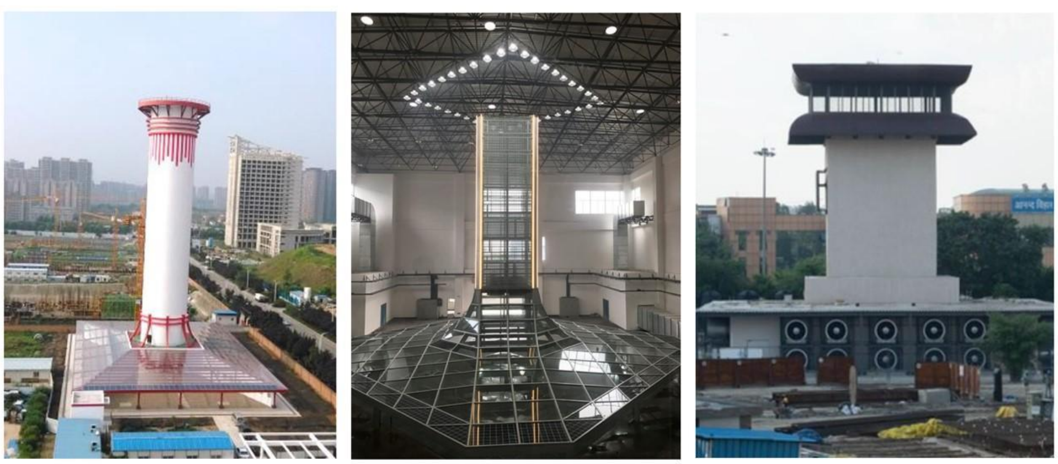

Figure 1: Three generations of air cleaning towers for urban pollution control and CO_2 mitigation.

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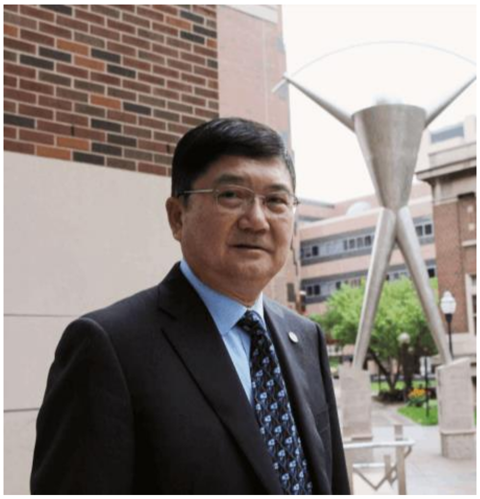

David Y. H. Pui is a Regents Professor and LM Fingerson/TSI Inc. Chair in Mechanical Engineering at the University of Minnesota. He is a Member of the U.S. National Academy of Engineering (NAE) and the Director of the world-renowned Particle Technology Laboratory at the University of Minnesota. He is also the Director of the Center for Filtration Research (CFR) consisting of 20 leading international filtration manufacturers and end users. Dr. Pui has a broad range of research experience in aerosol and nanoparticle engineering and filtration technology and has over 350 journal papers and 40 patents. He has developed several widely used commercial aerosol instruments for PM2.5 measurements. His recent interest involves developing green technologies for mitigating vehicle emissions, and for urban air cleaning using the Solar Assisted Large Scale Cleaning System (SALSCS). Dr. Pui has received many awards, including the Max Planck Research Award (1993), the Humboldt Research Award for Senior U.S. Scientists (2000), the Fuchs Memorial Award (2010) -- the highest disciplinary award conferred jointly by the American, German and Japanese Aerosol Associations. He served as President of the American Association for Aerosol Research (2000-2001), and President of the International Aerosol Research Assembly (2006-2010) consisting of 16 member associations from around the world.

[Session IV-S1] Short Talk: Roger CHEN

Nuclear Energy's Role in Helping Hong Kong Decarbonise – CLP's Perspective as an Investor and Off-taker

Roger CHEN
CLP Holdings Limited

Abstract
The CLP Group is an investor and operator in the Asia-Pacific energy sector with investments in Hong Kong, Mainland China, Australia, India, Southeast Asia and Taiwan that span across the energy supply chain. The company first brought nuclear energy to Hong Kong in 1994 through the investment in the Daya Bay Nuclear Power Station, the first large-scale commercial nuclear power station in China. Since then, nuclear energy has been safely and reliably meeting a significant part of Hong Kong's energy needs. Nowadays, a quarter of Hong Kong's electricity demand is powered by nuclear energy imported from Daya Bay Nuclear Power Station.

In joining global efforts on combating climate change, the short talk will introduce how CLP, as one of the major energy providers in Hong Kong and the Asia-Pacific region, sets its vision and goal to decarbonise its business in a longer term, and how nuclear energy has been playing a key part in the journey. The presentation will talk about nuclear power's benefits to Hong Kong and to CLP as an investor and off-taker. Amid the latest nuclear energy development worldwide, in particular the rapid development in China in recent decades, the talk will also share views on future opportunities offered by nuclear energy to Hong Kong in the energy transition journey.

BIOGRAPHY

Mr Roger Chen joined CLP, through CLP Executive Program, in 2002. He is currently the Senior Director at CLP Holdings responsible for CLP's nuclear business. He was seconded to Guangdong Nuclear Power Joint Venture Company, a joint venture between CLP and China General Nuclear Group (CGN), as the Deputy General Manager in 2017 before taking up his current role.

Prior to joining CLP's nuclear business, Mr Chen held various managerial positions across CLP Power Hong Kong and CLP Holdings, where his responsibilities covered corporate strategy and development, business planning, asset management, and fuel procurement.

Mr Roger Chen holds a Bachelor of Science in Engineering from the Shanghai Jiao Tong University and a Master of Business Administration (MBA) from Richard Ivey School of Business at the University of Western Ontario, Canada.

[Session IV-S2] Short Talk: Chin PAN

Innovative Heat Transfer Concepts to Enhance Nuclear Safety

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Keywords: Nuclear safety, seawater, two-phase natural circulation, counter flow diverging microchannel

Abstract
Nuclear power, with its low carbon nature, could be a very effective option for carbon neutrality in 2050-2060. Nuclear safety, which is strongly related to heat transfer, is the key to broaden the acceptance of nuclear power. Indeed, a severe accident like Fukushima Daiichi one results from poor heat transfer due to loss of coolant or flow while the nuclear fuel elements are still releasing significant amount of decay heat. This talk presents some of our innovative heat transfer studies to enhance nuclear safety.

We explored natural seawater as an alternative emergency coolant for nuclear power plants located at seashore. The quenching of hot metal spheres, up to 1000 °C, in natural seawater at room temperature was investigated. Unlike that in de-ionized water, the study reveals that film boiling is completely suppressed in natural seawater leading to much more rapid quenching in natural seawater than that in de-ionized water. This demonstrates the beneficial side of using natural seawater, which is abundant for nuclear power units located at sea coast, as an alternative emergency coolant to enhance nuclear safety. Currently, we are exploring the two-phase natural circulation of artificial seawater, which could provide passive cooling for reactor core. Bubble foam is found to be typical for boiling in seawater due to lack of bubble coalescence resulting in significantly different two-phase natural circulation phenomena.

In addition, a new concept of heat transfer design promoting nuclear safety is proposed. Recently, we have developed a Counter Flow Diverging Microchannel (CFDM) heat sink with ultra-high performance through an innovative combination of diverging microchannels and counter-flow manifold. Such a counter flow with diverging channel design enables extensive channel-to-channel heat transfer and may result in a void fraction distribution nearly uniform along the channel at high heat fluxes. Consequently, the critical heat flux may be significantly increased, while the two-phase flow pressure drop may not increase significantly with increase in heat flux. Such a high performance and robust heat transfer concept may be considered for an innovative design of a steam generator or reactor core. The thermal margin to the critical heat flux may be significantly enhanced and, therefore, nuclear safety as well.

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BIOGRAPHY

Professor Pan Chin is Head and CLP Power Chair Professor of Nuclear Engineering of the Department of Mechanical Engineering of City University of Hong Kong (CityU). He joined CityU in February 2018 and became acting head of the Department in July and head in October of the same year. Before joining CityU, Professor Pan was a faculty member of National Tsing Hua University (NTHU) in Taiwan for 32 years, from associate professor in 1986, professor in 1990, to Tsing Hua Distinguished Professor in 2011. Professor Pan received his bachelor's degree from NTHU in 1979 and his PhD degree in nuclear engineering from the University of Illinois at Urbana-Champaign in the United States of America in 1986.

Professor Pan has vast experience and an excellent performance background in academic administration. He served as Chairperson of the Department of Engineering and System Science, formerly the Department of Nuclear Engineering, of NTHU from 2001 to 2004, Founding Director of the Center for Energy and Environmental Research from 2003 to 2008 and the Low Carbon Energy Research Center in 2011, and Dean of the College of Nuclear Science from 2005 to 2011. Professor Pan served as Chairperson of the Advisory Committee on Nuclear Safety of Taiwan's Atomic Energy Council from 2008 to 2017, Convenor of the Energy Programme of the Ministry of Science and Technology of Taiwan from 2014 to 2016, and President of the Chung-Hwa Nuclear Society from 2012 to 2018.

Professor Pan is an internationally well-recognised scholar in the fields of boiling heat transfer and two-phase flow. He received an outstanding research award in 1998 from National Science Council of Taiwan and the First Grade Service Medal from the Executive Yuan of Taiwan in 2018.

Racing towards Carbon Neutrality: The Role of International Trade Law

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Abstract
As the biggest sustainable development challenge the international community has had to address to date, climate change poses a grave danger to society, the environment, and the economy. In many countries, achieving carbon neutrality as a means to tackle climate change has received a wide array of supportive measures and policies, some of which intersect with international trade in different ways and thus, fall under the scrutiny of the World Trade Organization (WTO) law. The talk provides a comprehensive assessment of WTO rules and procedures that are relevant to the examination of carbon neutrality measures and discusses the role of WTO in assisting members to become carbon neutral. Amid a time when the backlash against multilateralism is on the rise, it is critically important to ensure the compatibility of the design and implementation of carbon neutrality measures with members' obligations under WTO rules.

BIOGRAPHY

Dr FANG Meng Mandy joined CityU School of Law as Assistant Professor in July 2020. Dr. FANG held post-doctoral fellowships at the Chinese University of Hong Kong (CUHK) and the National University of Singapore. She obtained her Ph.D. from CUHK, her LLM from University College London, and Bachelor of Management and Bachelor of Laws degrees from Chongqing University. Her research interests focus on the interface between international trade, environmental protection, and energy transition. Her publications appear in leading journals such as the Virginia Journal of International Law, Leiden Journal of International Law, and other SSCI-listed journals including, Journal of World Trade; Journal of World Energy Law & Business; Utilities Policy, and edited books published by Cambridge University Press, among others.

Semi-Artificial Photosynthesis for Green Energy

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Keywords: Biohybrids, Semi-Artificial Photosynthesis, Bio-electrochemical cells, Photosynthetic Proteins

Abstract

Can the abundantly available solar energy be tapped sustainably to meet our energy demands with zero burden on the environment? Exploring nature's tiny solar factories – photosynthetic biomolecules could hold the key.

Photosynthetic pigment-protein complexes found in plants and certain types of bacteria transduce sunlight into biologically useful forms of energy through a photochemical charge separation that has ~100% quantum efficiency. Mimicking the photovoltaic and catalytic processes found in natural photosynthetic organisms has interesting implications for solar fuel generation and bioelectricity. Artificial photosynthesis has therefore been hailed as the 'Holy Grail of science'. However, the practical realization of "fully artificial" photosynthesis remains a grand challenge simply because of the stunning complexity of even the simplest forms of natural photosystems we find on earth, making the biomimicry of such systems a tantalizing goal.

The idea of semi-artificial photosynthesis is now emerging as a promising route, as the core functional component of such a system no longer needs to be synthesized but is something that is abundantly available in nature or can be effortlessly grown as we need! The question now is – how can we "wire" the natural living/biogenic systems to materials in ways that can effectively tap the photochemical power while retaining the structural and functional integrity of their biological components? Finding effective solutions to this challenge is central to developing green biohybrid technologies.

In this talk, I will give an overview of the structural and functional characteristics of biological photosystems that make them so attractive for green solar technologies and touch on the design considerations that are critical when combining biological and synthetic materials in functional devices. I will explain how aligning biotic and abiotic photophysical processes can help us design better biohybrid devices for energy harvesting.

BIOGRAPHY

Dr. Ravi earned his PhD from the Department of Materials Science & Engineering at the National University of Singapore (NUS), working on biohybrid energy conversion/storage devices. His doctoral research involved studying natural biological complexes in plants and bacteria from a materials science perspective and exploiting the light-harvesting and charge transport mechanisms in the natural systems for energy and optoelectronic applications. After graduation, he continued at NUS as a post-doctoral researcher, working on semi-artificial photosynthesis. As part of his PhD and post-doctoral research at NUS, Dr. Ravi designed semi-artificial device architectures for photovoltaics, photocapacitors, and tactile sensors. His works have been published in prestigious journals like Advanced Materials, Advanced Energy Materials, Advanced Functional Materials, Energy & Environmental Science, Nature Communications, and Science Advances, and also won NUS's Annual Best Publication Awards in Material Science for the years 2016, 2017 and 2018. Dr. Ravi joined the City University of Hong Kong as an Assistant Professor in Aug 2022. Besides Semi-Artificial Photosynthesis, Dr. Ravi's research experience extends to developing functional materials for air filtration, solar desalination, and atmospheric water harvesting. His work on the Nanofibrous Air Filter won the 'Prestigious Engineering Achievement Award 2018' awarded by the Institution of Engineers, Singapore (IES). The air filter has been patented (US 10,682,602 B2) and licensed. Dr. Ravi has also served as an Associate Editor for renowned journals like Advanced Materials, Advanced Energy Materials, Advanced Energy & Sustainability Research, Advanced Materials Technologies, and Energy Technology.

Constructing effective molecular interfaces for CO_2 reduction

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Keywords: CO_2 reduction, interface, ionic catalysts, molecular catalysts

Abstract
Electrochemical carbon dioxide reduction reaction (CO_2RR) using renewable electricity is an effective process for the production of useful fuel and chemical commodities. Among numerous, molecular complexes for the production of CO have attracted significant research attention as CO is an important precursor for diverse commodity chemicals synthesized by the Fischer–Tropsch process. However, aggregation and leaching are two major obstacles to the synthesis of efficient and durable heterogeneous molecular catalysts. These problems are even more severe for charged molecules, which not only result in unsatisfactory performance, but also lead to a misleading evaluation of charged functionalities. In this presentation, we will start with the significance of interface design in improving CO_2RR performance.[1][2] The effect of molecular stacking and peripheral functionalities will be discussed. Then we will introduce the problems associated with the ionic molecular catalysts. Two approaches, as recently developed in our group to stabilize the ionic molecules, will be shown. These include the covalent grafting of molecules into conductive substrates[3,4], and the implantation of ionic moieties in a layered matrix[5]. These strategies significantly improve the CO_2RR performance by orders of magnitude, and also uncover the overlooked roles of ionic functional groups in CO_2RR. Lastly, we will briefly introduce the development of other catalysts for reducing CO_2 to other value-added products.

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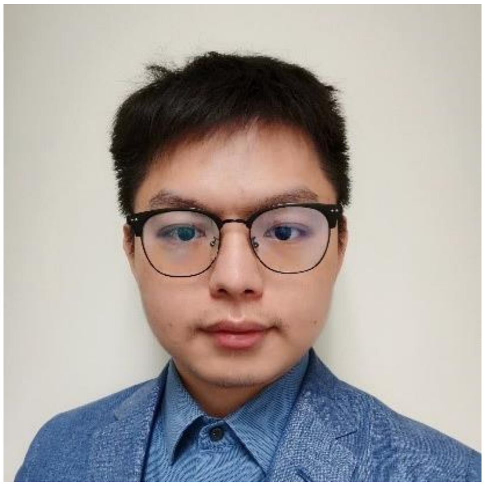

Ruquan Ye is an assistant professor in Chemistry, City University of Hong Kong. He received his B.S. (Chemistry) in 2012 from Hong Kong University of Science and Technology under Prof. Ben Zhong Tang's supervision, and his Ph.D. (chemistry) in 2017 from Rice University mentored by Prof. James M. Tour. He worked with Prof. Karthish Manthiram as a postdoctoral associate in Chemical Engineering at the Massachusetts Institute of Technology (2017–2018). He was named World's Top 2% scientists by Standford University in 2020 and 2021. He was awarded Rising Stars by Small, Wiley in 2021, and Emerging Investigators by Journal of Materials Chemistry A, Royal Society of Chemistry in 2022.

Dr. Ye's current research interests include developing cost-effect methods for materials manufacturing and investigating their applications in energy and environmental science. He is one of the pioneers in developing the laser-induced graphene technique, which uses a readily available CO_2 laser to synthesize porous graphene. The laser-induced graphene method has been widely adopted across the globe to fabricate graphene-based films and devices. He also investigated the electrochemical CO_2 reduction reactions, aiming to mitigate the carbon emissions while providing valuable chemicals. His research focuses on catalyst synthesis and interface design.

[Session V-E4] Emerging Star: Jian WANG

Modulate the in situ Reconstruction of a Layered Oxide Electrocatalyst for Superior Water Oxidation

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Keywords: Green hydrogen, water oxidation, in situ reconstruction, modulate, redox tuning.

Abstract
Water electrolysis conditions accelerate the dissolution and corrosion of electrocatalysts, changing their surface and/or bulk composition/structure from the original states. This dynamic reconstruction process redefines the catalytically active species and determines the overall performance. However, rational control of the in situ reconstruction for electrocatalysts is tremendously challenging. Here, we proposed a redox-tuning method to precisely modulate the reconstruction and to favor the water oxidation activity. For a category of layered transition metal oxide (AMO_2: A = alkaline metal, M = transition metal), redox of transition metal during the alkaline OER was in situ tuned to engineer the catalyst leaching potential, manipulate the cation leaching amount, and redirect the dynamic catalyst reconstruction. For example, Cl doping lowered the cobalt valence state of $LiCoO_2$ and the further OER potential for its in situ cobalt oxidation triggering Li leaching. Operando XAFS and DFT calculations confirmed that such modulation bypassed the less favorable reconstruction by forming Li1-xCo_2O_4-type spinel structure, transforming the surface of $LiCoO_{1.8}Cl_{0.2}$ into a more catalytically-active (oxy)hydroxide phase. By further regulating the redox current, the reconstruction level was facilely modulated. The proposed method could be potentially generalized to manipulate the surface reconstruction of other pre-catalysts.

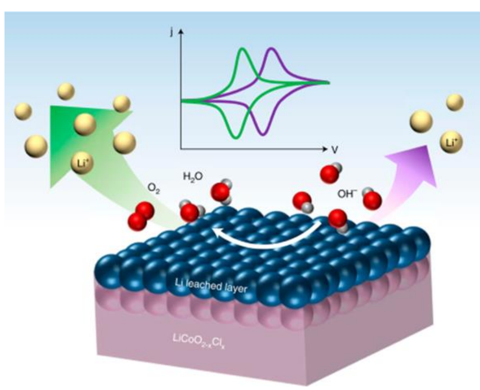

Figure 1: Redox-tuning method redirects the in situ surface reconstruction of layered $LiCoO_2$

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Dr. Jian WANG obtained his BEng degree in Energy, Power System, and Automation Engineering from Xi'an Jiaotong University (XJTU, China) in 2013. After the undergraduate education, he took one year's postgraduate course at XJTU majoring in solid mechanics, and then he moved to HKUST for Ph.D study. In 2017, he visited Northwestern University (USA) working with Prof. Sossina Haile on developing solid oxide fuel cells, and in 2018 he received Ph.D degree from HKUST. Before taking the current position at CityU, he worked as the SNU Science Fellow researcher at Seoul National University (Korea). Dr. Wang currently leads the DEEP (Dynamic Electrochemical Energy Process) research group and focuses on the characterization & modulation of electrochemical cells for energy conversion and storage applications. DEEP develops several in situ experimental setups to operando probe electrochemical cells across multiple scales, establishes dynamic composition-structure-performance relationships for several types of energy materials in fuel cells/water electrolyzers, and designs several high-performance energy materials with application prospects. Dr. WANG publishes 59 peer-reviewed journal papers with an H-index of 27. Among them, 27 are (co)first/corresponding author papers including Nat. Catal (2)./Nat. Energy/Nat. Commun., and 4 are WOS hot/highly-cited papers.

Battery Intercalation Strategy: Material Synthesis, Property Tuning and Applications

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Keywords: Battery intercalation strategy, In-situ liquid phase TEM, Cathode-Electrolyte Interphase, Transition-metal dichalcogenide, Water desalination.

Abstract
We developed a lithium ion battery intercalation & exfoliation method with detailed experimental procedures for the mass production of 11 two dimensional TMDs and inorganic nanosheets, such as MoS_2, WS_2, TiS_2, TaS_2, ZrS_2, graphene, h-BN, $NbSe_2$, WSe_2, Sb_2Se_3 and Bi_2Te_3, among them 3 TMDs achieved mono- or double layer yield > 90%. This method involves the electrochemical intercalation of lithium ions into layered inorganic materials and a mild sonication process. The whole experimental procedure takes 26-38 h for the successful production of ultrathin inorganic nanosheets. The Li insertion can be monitored and finely controlled in the battery testing system, so that the galvanostatic discharge process is stopped at a proper Li content to avoid decomposition of the intercalated compounds. The intercalation strategy can also be used to tune 2D TMDs' physical and chemical properties for various applications. For example, we developed an one-step covalent functionalization method on MoS_2 nanosheets for membrane fabrication, which exhibited excellent water desalination performance. For battery intercalation mechanism, the state-of-the-art In-Situ Liquid Phase TEM is an ideal technique for identifying the phase changes during intercalation process. With self-designed electrochemical liquid cell utilized, we can directly vapture the dynamic electrochemical lithiation and delithiation of electrode in a commercial $LiPF_6$/EC/DEC electrolyte, such as LiF nanocrystal formation, lithium metal dendritic growth, electrolyte decomposition, and solid-electrolyte interface (SEI) formation. Combining with other in-situ techniques, such as in-situ XAS, XRD and Raman, etc., the underlying lithium intercalation mechanism in TMDs were further investigated, which render us a comprehensive understanding of the intrinsic correlation between the intercalation process and TMDs layered structures.

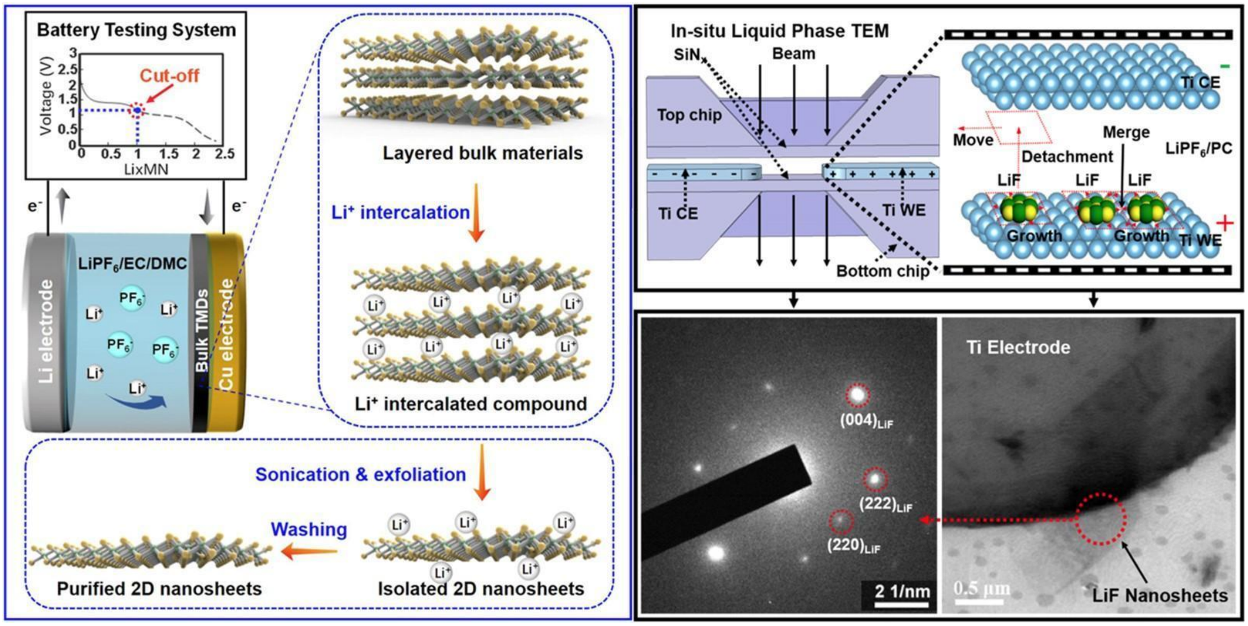

Figure 1 (A) Lithium Ion Intercalation Strategy to prepare 2D transition metal dichalcogenide (TMD) nanosheets; (B) In-Situ Liquid Phase TEM to probe cathode-electrolyte interphase.

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Dr Zhiyuan Zeng received his BSc, MPhil and PhD degrees all in Material Science & Engineering from Central South University, Zhejiang University and Nanyang Technological University in 2006, 2008 and 2013, respectively. He continued his postdoc training at Lawrence Berkeley National Laboratory (2013-2017). Then he jumped into industry in Silicon Valley working for Applied Materials Inc. As Process Engineer/Senior Process Engineer (2017-2019). Dr. Zeng joined CityU-MSE in 2019. His research interests are using battery intercalation strategy, in-situ liquid phase TEM technique to investigate TMDs and TMOs, which can be used for energy and environmental applications. He has published 100 SCI papers (63 IF>10) with total citation 17000 + times and H-index 50 (google scholar), 19 Papers were listed as ESI Highly Cited Papers, which include Nat. Mater., Nat. Protoc., Nat. Commun., Matter, Adv. Mater., Angew. Chem. Int. Ed., Nano Lett., ACS Nano, etc. He has been listed as the Highly Cited Researcher (Top 1%, Clarivate Analytics) in 2020 and 2018. He has also been listed as the World's Top 2% Scientists in Nanosci. & Nanotechnol. for single year in 2021 and 2020 (by Stanford University). His other awards include the Rising Star by Advanced Materials (2022); the Emerging Investigator by Chemical Communications (2021); the Emerging Investigator by Journal of Materials Chemistry A (2020); the Early Career Scheme award by Research Grants Council of Hong Kong (2019).

When soft matter meets interface

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Abstract
Soft matter, including polymers, DNA, and colloidal particles, is a class of materials where thermal fluctuations strongly influence their structures and behaviors. The variety of weak interactions in soft matter make its properties challenging to study yet they crucially determine the suitability for technological applications in various fields including biomedicine, flexible electronics, energy harvesting, etc. In this talk, I will show our efforts on using state-of-the-art instruments to gain nanoscopic insights into soft materials when they are put near an interface and how these exotic properties can be used to develop novel applications. First, I will talk about how we use in situ atomic force microscopy (AFM) to reveal the existence of a nano-meter thick liquid-like layer on the top of a glass. Combining in situ AFM measurements and theoretical modeling, we found the surface of a solid can even flow while the interior remains immobile [1, 2]. Second, I will show our recent progress in using AFM to directly measure the self-assembly of nanoparticles at a fluid interface [3, 4]. The local packing and dynamic information of these small particles revealed by in situ AFM allow us to develop different soft devices, including all liquid robots capable of transporting mass and responding to external stimuli [5].

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BIOGRAPHY

Dr. Yu Chai is an assistant professor in the physics department at the City University of Hong Kong. He joined CityU in April 2020. Before that, he worked as a postdoctoral researcher at the University of California, Berkeley, and Lawrence Berkeley National Laboratory. He got his Ph.D. in physics at the University of Waterloo, Canada, in 2016. Dr. Chai has a long-term research interest in soft matter with a particular focus on surfaces and interfaces. With the help of state-of-the-art in situ instruments, including atomic force microscopes, he and his group have discovered many interesting behaviors of various soft materials at the surfaces and interfaces. Over the past decade, Dr. Chai has published more than 30 peer-reviewed papers, most of which are in prestigious journals, including Science, Science Advances, Nature Communications, PNAS, Advanced Materials, Nano Letters, ACS Nano, etc.

Solution Processing of Organic Semiconductor Materials: A Theoretical Insight into Role of Additives in Film Morphology

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Keywords: Organic Semiconductors, Solution Processing, Additives, Film Morphology, Theoretical Insight.

Abstract

Film morphology of organic semiconductors such as organic solar cells (OSCs) is crucial to their optoelectronic properties and device stability.[1] The incorporation of additive has been considered as an effective strategy for adjustment of film morphology. However, role of additive in adjustment of film morphology is not understood well at the molecular level. In the present work, through all-atom molecular-dynamics (AA-MD) simulations, we took the Y6 molecule (that has been extensively exploited as an electron-acceptor material and shown record-high power conversion efficiencies in OSCs) as an example, and studied how five additives with different chemical structures (e.g., pi-conjugation extent) impact nano-scale molecular packings in the Y6 film. Our AA-MD results have demonstrated that all five studied additives have stronger interaction with the end groups of Y6 than its core moiety. Thermodynamically, pi-conjugation of additive molecules leads to stronger van-der-Waals interactions between additive and Y6 molecules and thus smaller values of Flory-Huggins interaction parameter, χ. Dynamically, the pi-conjugated additive molecules gradually insert into the two Y6 molecules via the interaction between them and the Y6 end groups, thus opening more space for the relaxation of Y6 molecules to promote more ordered packing. Our computational results are consistent with the experimental observations via grazing-incidence wide-angle x-ray scattering (GIWAXS). The present theoretical work reveals the fundamental molecular-level mechanism behind adjustment of film morphology via solution engineering, thus providing a theoretical insight into molecular designs of additives to optimize morphologies of organic semiconductor films.

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His research interests include multi-scale simulations of organic materials via combinations of quantum-chemistry approaches, condensed-matter physical models, and molecular dynamics simulations.

His goal is to determine the nature of the physico-chemical mechanisms in organic material systems leading, for instance, to: (a) strong luminescence or photovoltaic response; (b) efficient charge or spin transport behavior; (c) novel quantum properties for quantum information science.

The Atomic Substitution of Transition Metal Dichalcogenides for Electrocatalytic Hydrogen Evolution Reaction

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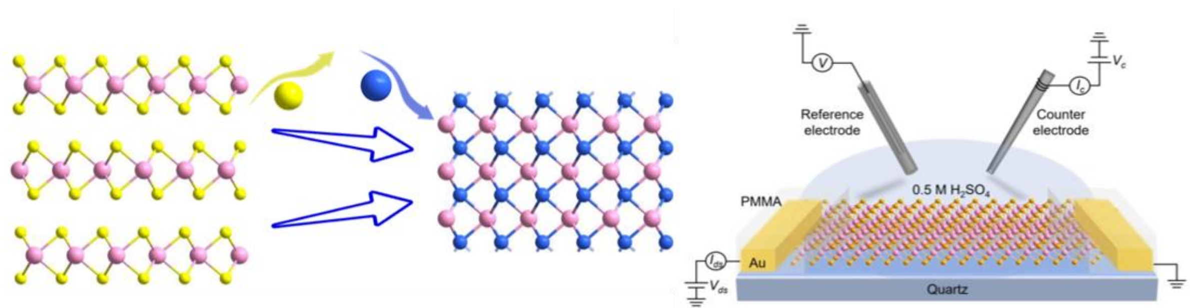
Keywords: two-dimensional materials, hydrogen evolution reaction, transition metal dichalcogenides, on-chip electrochemistry

Abstract
Transition metal dichalcogenides (TMDs) are one family of two-dimensional layer materials (2DLMs), which have found intense applications in energy devices such as batteries and electrocatalytic water splitting. In particular, MoS_2 is considered one of the most prominent non-noble metal electrocatalyst for HER. However, pristine MoS_2 are considered electrochemically inert. Diverse strategies have been attempted to activate the inert basal plane of MoS_2 including defect engineering, phase engineering, chemical doping, and electronic engineering. Among them, chemical doping, a common strategy to engineer functional materials, has been widely explored. In this talk, we will introduce on several of our finds along the way to chemically dope MoS_2 as efficient HER catalysts. We will first introduce the edge effect in chemical doping of 2DLMS and how it affects the electrocatalytic performance. We will show how we utilize the emerging on-chip electrochemical methods to resolve the intrinsic electrochemical behavior of 2DLMs at individual nanosheet level. Then, a unique atomic substitution reaction of TMDs at 2D limit will be presented. In this work, we will elaborate on a surface confined chemical transition of layered 2D TMDs to non-layered transition metal phosphide, both in single crystalline and amorphous form. This new gas-phase atomic substitution reaction may lead to new synthetic strategies towards non-traditional 2D materials and 2D catalytic systems.



BIOGRAPHY

Dr. He is currently an Assistant Professor in the Department of Materials Science & Engineering at the City University of Hong Kong. He obtained his PhD Degree from Nanyang Technological University in Singapore in 2013. He then joined the University of California, Los Angeles as a Postdoctoral Fellow before returning to Nanyang Technological University as a Research Fellow in 2016. Dr He's research scope is highly interdisciplinary, focusing on the fundamentals of semiconductor interfaces and their applications in nanoelectronics, iontronics, chemical/biological sensors, catalysis, and on-chip electrochemistry. He has published over 90 research papers in highly-esteemed journals such as Nature, Nature Chemistry, Nature Materials, Nature electronics, Advanced Materials, Nano Letters, and ACS Nano. He has over 17,000 citations with an H-index of 45 (SCOPUS). He has also been listed as a Highly Cited Researcher (cross-field) by Clarivate in 2018 and 2021.

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