香港城市大學 City University of Hong Kong

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

ACADÉMIE DES SCIENCES INSTITUT DE FRANCE

香港城市大學 City University of Hong Kong

Hong Kong Institute for Advanced Study

INTERNATIONAL CONFERENCE ON CLEAN ENERGY FOR CARBON NEUTRALITY

https://www.cityu.edu.hk/hkice/iccecn2023/index.html

7-10 MAR 2023

HKIAS Lecture Theatre

LG/F, Academic Exchange Building

International Conference on Clean Energy for Carbon Neutrality

ICCECN-2023

Table of Contents

International Conference on Clean Energy for Carbon Neutrality, ICCECN-2023

Organized by Hong Kong Institute for Clean Energy, City University of Hong Kong, French Academy of Sciences, and Hong Kong Institute for Advanced Studies, City University of Hong Kong

Background

Energy transition to clean and renewable energy is an extremely urgent task for countries around the world to tackle both the climate and environmental crises that loom before us. The International Conference on Clean Energy for Carbon Neutrality jointly organized by the City University of Hong Kong and the French Academy of Sciences will be held on March 7-10, 2023. It offers a great opportunity to unite world-renowned scholars and researchers in promoting interdisciplinary dialogue on the challenges and future prospects of next-generation energy development and applications. The Conference will provide ample opportunities for discussing visionary knowledge with the latest scientific findings and innovative technologies on clean energy development. A broad range of topics related to scalable photovoltaics, stable and reliable battery technologies, and energy-saving and smart grid technologies for various applications will be covered. Challenges in energy generation, utilization, storage, and distribution as well as the latest development on carbon capture and zero-carbon nuclear energy will be discussed.

The Conference will consist of a series of keynote lectures and invited talks from world-leading scientists, contributed talks from junior faculty and postdocs, and discussion and sharing sessions featuring the following areas:

- Latest functional materials design and synthesis, and smart device 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: Hong Kong Institute for Clean Energy, CityU,
The French Academy of Sciences, and
Hong Kong Institute for Advanced Studies, CityU

Date: 7-10 March 2023

Venue: HKIAS Lecture Theatre, 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:
Professor Marc FONTECAVE, **Chair**, The French Academy of Sciences
Professor Alex JEN, **Chair**, City University of Hong Kong
Professor Sébastien CANDEL, The French Academy of Sciences
Professor Guohua CHEN, City University of Hong Kong
Professor Jian LU, City University of Hong Kong
Professor Didier ROUX, The French Academy of Sciences
Professor Patrice SIMON, The French Academy of Sciences
Professor Angus Hin-Lap YIP, City University of Hong Kong

Organizer

City University of Hong Kong (CityU) is a world-class institution ranked among the best universities internationally and is committed to nurturing and developing the talents of students, and creating applicable knowledge to contribute to social and economic advancement. CityU puts particular emphasis on professional education and research, covering different disciplines, namely business, creative media, data science, energy and environment, engineering, humanities and social sciences, law, science and veterinary medicine and life sciences.

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 diverse background professionals working in clean energy to train next-generation leaders and generate sustainable environmental solutions for creating societal impacts.

ACADÉMIE DES SCIENCES
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Created by Colbert in 1666, the *French Academie des Sciences* is an assembly of scientists chosen among the most distinguished French and foreign specialists. It examines the political, ethical and societal issues surrounding the current and future scientific topics. The Academy reflects, anticipates, explains and pronounces itself, mainly through opinions and recommendations and takes position when necessary. It aims to provide policy makers with a framework of expertise, counsel and alert and, more broadly, to enlighten the debates and choices of our society. In addition, the French Académie des Sciences supports research, is committed to the quality of science education and promotes scientific life at the international level.

CityU 香港城市大學 City University of Hong Kong

Hong Kong Institute for Advanced Study

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.

International Conference on Clean Energy for Carbon Neutrality

ICCECN-2023

Organized by City University of Hong Kong and French Academy of Sciences

7-10 March 2023

Event Programme

7 MAR 2023, TUE (Day 1)

HONG KONG Time (GMT+ 8 hr)	*Programme Detail*
13:00 - 13:30	**Registration**
13:30 - 14:00	**Opening Ceremony**
	Session Chair: Chun-Sing LEE, CityU
14:00 - 14:50	**P-1 Marc FONTECAVE, Collège de France** The New Carbon Economy: Direct and Indirect Electroconversion of CO_2 into Organic Chemicals
14:50 - 15:40	**P-2 Alex JEN, City University of Hong Kong** Printable Organic and Perovskite Solar Cells for Clean Energy
15:40 - 15:50	**Tea Break**
	Session Chair: Hin-Lap Angus YIP, CityU
15:50 - 16:40	**P-3 Michael GRAETZEL, Ecole Polytechnique Fédérale de Lausaane** Perovskite Photovoltaics for Electricity and Fuel Generation from Sunlight
16:40 - 17:15	**K-1 Stefaan DE WOLF, King Abdullah University of Science and Technology** Pathways to Efficient and Stable Perovskite/ Silicon Tandem Solar Cells
17:15 - 17:50	**K-2 Nouredine HADJSAÎD, Université Grenoble Alpes** Intensified Electrification for Decarbonization: Paradigm Change, Perspectives, and Challenges
17:50 - 18:10	**Panel Discussion**

8 MAR 2023, WED (Day 2)

AM Session

HONG KONG Time (GMT+ 8 hr)	*Programme Detail*
	Session Chair: Alex JEN, CityU
9:15 - 10:05	**P-4 Jacopo BUONGIORNO, Massachusetts Institute of Technology** Nuclear Batteries: a New Way in Energy
10:05 - 10:55	**P-5 Bin LIU, National University of Singapore** Sustainability Research at the National University of Singapore
10:55 - 11:05	**Tea Break**
	Session Chair: Zonglong ZHU, CityU
11:05 - 11:30	**I-1 Hin-Lap Angus YIP, City University of Hong Kong** Optical Design for High-efficiency White Perovskite LEDs
11:30 - 11:55	**I-2 Chi-Yan Edwin TSO, City University of Hong Kong** Advanced and Smart Building Skin Materials for Carbon Neutrality
11:55 - 12:15	**Panel Discussion**
12:15 - 13:45	**Lunch Break**

PM Session

HONG KONG Time (GMT+ 8 hr)	*Programme Detail*
	Session Chair: Jian LU, CityU
13:45 - 14:10	**I-3 Yun Hau NG, City University of Hong Kong** Solar Fuels (Hydrogen) via Catalytic Conversion
14:10 - 14:45	**K-3 Kazunari DOMEN, The University of Tokyo** A Large Scale Solar Hydrogen Production by Photocatalytic Water Splitting
14:45 - 15:35	**P-6 Thierry POINSOT, Institut de Mécanique des Fluides de Toulouse** Can Hydrogen Become an Important Energy Vector for Transportation? The Case of Aircraft
15:35 - 15:45	**Tea Break**
	Session Chair: Marc FONTECAVE, FAS
15:45 - 16:10	**I-4 Xue WANG, City University of Hong Kong** Efficient Upgrading of C_1 Molecules to Fuels
16:10 - 16:45	**K-4 Raffaella BUONSANTI, Ecole Politechnique Fédérale de Lausanne (EPFL)** Well-defined Catalysts for Selective CO_2 Electroreduction
16:45 - 17:20	**K-5 A. William (Bill) RUTHERFORD, Imperial College London** Reality Checks for Biofuels as Replacements for Fossil Fuels: Sustainable Avion Fuels as a Case Study
17:20 - 17:55	**K-6 Hélène OLIVIER-BOURBIGOU, IFP Énergies nouvelles** Towards Decarbonization of Industry: Focus on Carbon Capture, Storage, and Conversion into Low Carbon Fuels
17:55 - 18:15	**Panel Discussion**

9 MAR 2023, THR (Day 3)

AM Session

HONG KONG Time (GMT+ 8 hr)	*Programme Detail*
	Session Chair: Xiong Wen David LOU, CityU
10:15 - 10:50	**K-7 Wenjun ZHANG, City University of Hong Kong** Applications of Plasma Technology in Electrochemical Energy Conversion and Storage Materials
10:50 - 11:25	**K-8 Guohua CHEN, City University of Hong Kong** oCVD of Conductive Polymers on Cathode Particles for Much Improved Safety and Stability of Lithium Ion Battery
11:25 - 11:50	**I-5 Qi LIU, City University of Hong Kong** Discovery and Fundamental Studies of Cathode Materials via Advanced Synchrotron Techniques
11:50 - 12:15	**I-6 Bin LIU, City University of Hong Kong** Electrochemical CO_2 Reduction Chemistry over Model Single-Atom Catalyst
12:15 - 12:35	**Panel Discussion**
12:35 - 14:05	**Lunch Break**

PM Session

HONG KONG Time (GMT+ 8 hr)	*Programme Detail*
	Session Chair: Yun Hau NG, CityU
14:05 - 14:40	**K-9 Chi Kong Michael TSE, City University of Hong Kong**
	Complexity in Grid-Connected Power Electronics and its Impact on Power Grid Development
14:40 - 15:15	**K-10 Mao-Hsiung CHIANG, National Taiwan University**
	Development and Outlook of Taiwan Offshore Wind Power for Net Zero Carbon Emission
15:15 - 15:50	**K-11 Mauro PRAVETTONI, National University of Singapore**
	New Reliability Challenges for Solar Deployment in Urban Environment
15:50 - 16:00	**Tea Break**
	Session Chair: Chin PAN, CityU
16:00 - 16:50	**P-7 Sébastien CANDEL, Université Paris-Saclay**
	The Future of Air Transportation: Outlook for Electric and Hydrogen Aircraft
16:50 - 17:40	**P-8 Yves BRÉCHET, French Academy of Sciences**
	Sustainable Nuclear Energy and Global Warming
17:40 - 18:15	**K-12 Robert GUILLAUMONT, French Academy of Sciences**
	Greening Nuclear Energy How and When
18:15 - 18:35	**Panel Discussion**

10 MAR 2023, THR (Day 4)

AM Session

HONG KONG Time (GMT+ 8 hr)	*Programme Detail*
	Industrial Session (AM)
9:30 - 10:00	**Welcoming**
	Session Chair: Wenjun ZHANG, CityU
10:00 - 10:20	**Welcome from Alex JEN** Introduction to Hong Kong Institute for Clean Energy
10:20 - 10:40	**In-1 Xixiang XU, Vice President, LONGi Central R&D Institute** Roadmap to High-Efficiency Silicon Solar Cells and Its Mass Production
10:40 - 11:00	**Daniel FUNG, Head of Strategy & Innovation and Commercial – HK Utility, The Hong Kong and China Gas Company Ltd. (Towngas)** Clean Energy Solutions for Hong Kong
11:00 - 11:10	**Tea Break**
	Session Chair: Chunyi ZHI, CityU
11:10 - 11:30	**Wei SUN, Senior Engineer and Technical Director, Tianneng Saft Energy Joint Stock Company** The Development and Application of Lithium Energy Storage Products
11:30 - 11:50	**Yi PAN, Senior Manager, BYD Subsidiary FinDreams Battery Co., Ltd.** LIB progress and Prospects for xEV Applications
11:50 - 12:10	**Raymond LEUNG, Chief Technology Officer, Huawei International Co. Ltd.** Battery Energy Storage System of Low Voltage Smart Grid
12:10 - 12:35	**Panel Discussion**
12:35 - 12:45	**Ending session**
12:45 - 14:35	**Lunch**

PM Session

HONG KONG Time (GMT+ 8 hr)	*Programme Detail*
	Session Chair: Guohua CHEN, CityU
14:35 - 15:00	**I-7 Chunyi ZHI, City University of Hong Kong** Stable Zn Anode and High Energy Cathodes for Aqueous Zn Batteries
15:00 - 15:25	**I-8 Minhua SHAO, The Hong Kong University of Science and Technology** Development of High Performance and Durable Fuel Cell Electrocatalysts
15:25 - 16:00	**K-13 Patrice SIMON, Université Toulouse III - Paul Sabatier** Electrochemistry at the Nanoscale: Tracking Ion Fluxes in Electrodes for Energy Storage Applications
16:00 - 16:35	**K-14 Jean-François GUILLEMOLES, Institut Photovoltaïque d'Île-de-France** Hard or Soft? The Way to Resilience and Reliability for New Photovoltaic Energy Materials
16:35 - 16:55	**Panel Discussion**
16:55 - 17:05	**Ending/ Closing Remarks**

[Session P-1] Plenary Speaker: Marc FONTECAVE

The New Carbon Economy: Direct and Indirect Electroconversion of CO_2 into Organic Chemicals

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Keywords: carbon dioxide, electrolysis, ethylene, alcohols, catalysis.

Abstract

Conversion of carbon dioxide into hydrocarbons and alcohols using renewable electricity as an energy source is an attractive strategy for storing renewable energies into the form of chemical energy (a fuel) and using CO_2 as a raw material for the synthesis of chemical products. However, CO_2 activation is a complex process requiring multiple electron and proton transfers, especially for complex molecules, which can be controlled only with specific catalysts. Finding new stable, efficient and selective catalysts for CO_2 reduction is critical in order to make this strategy a practical industrial option. Here we discuss our ongoing research on CO_2 electrolysis using Cu-based catalytic materials aiming at producing ethylene and ethanol [1,2,3]. Another promising scenario, also discussed here, involves an indirect route coupling selective electroreduction of CO_2 into CO together with valorization of CO within thermal or electrochemical reactors [4,5,6]. Finally, we will also discuss our efforts to minimize overpotentials at the anode with the development of novel efficient water oxidation catalysts based on Ni and Fe oxides [7,8].

Reference

[1] N.H. Tran, D. Alves Dalla Corte, S. Lamaison, L. Lutz, N. Menguy, M. Foldyna, S.-H. Turren-Cruz, A. Hagfeldt, F. Bella, M. Fontecave, V. Mougel. Proc. Natl. Acad. Sci. 2019, 116, 9735

[2] Bio-inspired hydrophobicity promotes CO_2 reduction on a Cu surface D. Wakerley, S. Lamaison, F. Ozanam, N. Menguy, D. Mercier, P. Marcus, M. Fontecave, V. Mougel Nature Materials 2019, 18, 1222-1227

[3] Electroreduction of CO_2 on Single-Site Copper-Nitrogen-Doped Carbon Material: Selective Formation of Ethanol and Reversible Restructuration of the Metal Sites D. Karapinar, Ngoc Tran Huan, N. Ranjbar Sahraie, D. W. Wakerley, N. Touati, S. Zanna, D. Taverna, L.H. Galvão Tizei, A. Zitolo, F. Jaouen, V. Mougel, M. Fontecave Angew. Chem. 2019, 58, 15098

[4] Coupling electrocatalytic CO_2 reduction with thermocatalysis enables the formation of a lactone monomer L. Ponsard, E. Nicolas, H. Ngoc Tran, S. Lamaison, D. Wakerley, T. Cantat, M. Fontecave ChemSusChem 2021, 14, 2198–2204

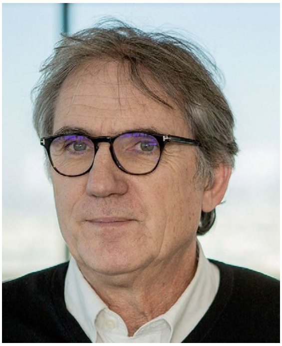
[5] Selective ethylene production from CO_2 and CO reduction via engineering membrane electrode assembly with porous dendritic copper oxide Ngoc-Huan Tran, Hong Phong Duong, G. Rousse, S. Zanna, M. W. Schreiber, M. Fontecave ACS Appl. Mat. Int. 2022, 14, 31933-31941

[6] Highly selective copper-based catalysts for electrochemical conversion of carbon monoxide to ethylene using a gas-fed flow electrolyzer Hong Phong Duong, Ngoc-Huan Tran, G. Rousse, S. Zanna, M. W. Schreiber, M. Fontecave ACS Catalysis 2022, 12, 10285-10293

[7] Benchmarking of Oxygen Evolution Catalysts on Porous Nickel Supports: Towards Optimised Anode Materials. A. Peugeot, C. E. Creissen, D. Karapinar, H. Ngoc Tran, M. Schreiber, M. Fontecave Joule 2021, 5, 1281-1300

[8] From Nickel Foam to Highly Active NiFe-based Oxygen Evolution Catalysts A. Peugeot, C. E. Creissen, M. W. Schreiber, M. Fontecave ChemElectroChem 2022, 9, e202200148

BIOGRAPHY



After a PhD at Ecole Normale Supérieure in Paris (1984), a post-doctoral internship at Karolinska Institute, Stockholm (1985-1986), 20 years as Professor of Chemistry at University Joseph Fourier, Grenoble (1988-2008), Marc Fontecave is, since 2009, Professeur at Collège de France, Paris, holder of the Chair of Chemistry of Biological Processes. He is a member of the French Academy of Sciences since 2005 and of the Royal Swedish Academy of Sciences since 2019. His research focusses on the study of catalysts (homogeneous, heterogeneous, bioinspired) and biocatalysts (metalloenzymes and artificial enzymes) as well of electrochemical devices for water splitting and the valorization of carbon dioxide as strategies for chemical storage of renewable energies (artificial photosynthesis).

[Session P-2] Plenary Speaker: Alex JEN

Printable Organic and Perovskite Solar Cells for Clean Energy

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Department of Materials Science & Engineering, City University of Hong Kong, Hong Kong

Keywords: perovskite, organic, printable solar cells, clean energy, sustainable environment

Abstract

Minimizing energy loss and increasing the field factor are key aspects to transcend the current limitations on the performance of organic photovoltaics (OPV). However, an inherent limit has set for an organic bulk-heterojunction (BHJ) blends from prominent non-geminate recombination through non-radiative charge transfer states. Our recent study on charge recombination in BHJ and Planar-Mixed Heterojunction (PMHJ) blends comprising a crystalline polymer donor with Se-containing, Y6-derived non-fullerene acceptors has shown both high photovoltaic internal quantum efficiency and high external electroluminescence quantum efficiency. Crystallographic and spectroscopic studies reveal that the pseudo-2D, fused-ring molecular acceptors are not only intrinsically highly luminescent but also meets the criteria in achieving intrinsically radiative recombination within the blend, by promoting delocalized excitons with much longer luminescent lifetime and reduced exciton binding energies. These results provide the important demonstration of radiative non-geminate charge recombination in an efficient OPV blend to achieve PCEs above 19%. Moreover, a new concept of applying “Dilution Effect” is introduced to explain the commonly observed composition-dependent Voc and reduced photovoltage loss in highly efficient ternary-based devices due to significantly reduced phonon-electron coupling. At the end, several novel interface engineering approaches will be introduced, which facilitated the demonstration of record-high PCE of ~25% in inverted

perovskite solar cells and very efficient lead-capturing from decomposed perovskite devices.

Reference
[1] "Advances and Challenges in Understanding the Microscopic Structure–Property–Performance Relationship in Perovskite Solar Cells", Y. Zhou, L. Herz, A. K-Y. Jen, and M. Saliba, Nature Energy, 7, 794 (2022).
[2] "Hydrogen Bond-Bridged Intermediate for Perovskite Solar Cells with Enhanced Efficiency and Stability", F. Li, X. Deng, Z. Shi, S. Wu, Z. Zeng, D. Wang, Y. Li, F. Qi, Z. Zhang, Z. Yang, S.-H. Jang, F. R. Lin, S.-W. Tsang, X.-K. Chen, and A. K.-Y. Jen, Nature Photonics, in press (2023).
[3] "Dilution Effect for Highly Efficient Multiple-Component Organic Solar Cells", L. Zuo, S. B. Jo, Y. K. Li, Y. Meng, R. J Stoddard, Y. Liu, F. Lin, F. Liu, D. S. Ginger, H. Chen, A. K-Y. Jen, Nature Nanotech, 17, 53 (2022).
[4] "Planar-Mixed Heterojunction Organic Photovoltaic Suppresses Recombination Loss", K. Jiang, J, Zhang, C. Zhong, F. Lin, F. Qi, Q. Li, Z. Peng, W. Kaminsky, S. H. Jang, J. Yu, X. Deng, H. Hu, D. Shen, F. Gao, H. Ade, M. Xiao, C. Zhang, and A. K-Y. Jen, Nature Energy, 7, 1076 (2022).
[5] "2D Metal–Organic Framework for Stable Perovskite Solar Cells with Minimized Lead Leakage", Shengfan Wu, Zhen Li, Mu-Qing Li, Yingxue Diao, Francis Lin, Jie Zhang, Peter Tieu, Wenpei Gao, Feng Qi, Xiaoqing Pan, Zhengtao Xu, Zonglong Zhu, Alex K.-Y. Jen, Nature Nanotech, 15, 934 (2020).

BIOGRAPHY

Professor Alex K-.Y. Jen is the Lee Shau-Kee Chair Professor and Director of the Hong Kong Institute for Clean Energy at City University of Hong Kong. As an eminent scientist and leader, he also served as the Provost of CityU during 2016-2020. He received his B.S. from the National Tsing Hua University in Taiwan and Ph.D. from the University of Pennsylvania in USA. Before arriving at CityU, he was the Boeing-Johnson Chair Professor and Chair of the Department of Materials Science & Engineering at the University of Washington, Seattle. He also served as the Chief Scientist for the Clean Energy Institute that was endowed by the Washington State Governor. He is a distinguished researcher with more than ~1000 publications, 82,000 citations, and an H-index of 148.

He has also given more than 650 plenary/invited talks and is the co-inventor of 65 patents and disclosures. His interdisciplinary research covers organic/hybrid functional materials and devices for photonics, energy, sensors, and nanomedicine.

For his pioneering contributions in organic photonics and electronics, Professor Jen was elected as a Fellow by both the European Academy of Sciences and the Washington State Academy of Sciences. He is also a Fellow of several professional societies, including AAAS, MRS, ACS, PMSE, OSA, SPIE. He was named by the Times Higher Education (THE) in 2018 as one of the “Top 10 university researchers in Perovskite Solar Cell Research”. In addition, he was recognized by Thomson Reuters as one of the "World’s Most Influential Scientific Minds of 2015 and 2016 and as a "Highly Cited Researcher" in Materials Science from 2014-2022. He was also the recipient of the 2021 Outstanding Research Award and the 2022 President Award of CityU.

Recent News:

香港城大科学家发现崭新的光物理机制 创出有机太阳能电池效率新纪录 (qq.com)

Breakthrough in making solar cells more efficient, scalable, and ‘green’

香港城大有机太阳能电池刷新光电转换效率世界纪录

HK’s CityU develops new super-efficient solar cells

[Session P-3] Plenary Speaker: Michael GRAETZEL

Perovskite Photovoltaics for Electricity and Fuel Generation from Sunlight

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Keywords: metal halide perovskite solar cells, solar generation of electricity and hydrogen, CO_2 fixation, clean energy,

Abstract

Metal halide perovskites of the general formular ABX_3 where A is a monovalent cation such as caesium, methylammonium or formamidinium, B stands for divalent lead, tin or germanium and X is a halide anion, have shown great potential as light harvesters for thin film photovoltaics [1,2]. Amongst a large number of compositions investigated, the cubic α-phase of formamidinium lead triiodide ($FAPbI_3$) has emerged as the most promising semiconductor for highly-efficient and stable perovskite solar cells (PSCs). Maximizing the performance of α-$FAPbI_3$ has therefore become of vital importance for the perovskite research. Using formate ions as pseudo-halides to mitigate lattice defects and to augment film crystallinity, we attain a power conversion efficiency (PCE) of 25.6 % (certified 25.2%) with a cell architecture of n-i-p configuration [3]. We further enhance light capture and largely suppress non-radiative recombination by SnO_2 quantum dots as electron transport layer and an amphiphilic ammonium passivating agent at the perovskite hole conductor interface enabling PSCs with a PCE of 25.7 % (certified 25.4 %) and excellent operational stability [4] as well as intense electroluminescence reaching external quantum efficiencies of 12.5 %. Our findings provide a facile access to solution processable films with unprecedented opto-electronic performance. These fundamentally new concepts have been applied to solar driven generation hydrogen from water as well as converting CO_2 to ethylene. Combining perovskite photovoltaics in a tandem with silicon has allowed reaching a solar to hydrogen conversion efficiency of close to 19 % [9]. The

current research status of this field will be presented.

Reference
[1] https://doi.org/10.1038/nmat4065
[2] https://doi.org/10.1038/nature12340
[3] http://doi.org/10.1038/s41586-021-03406-5
[4] http://doi.10.1126/science.abh1885

BIOGRAPHY

Michael Graetzel is a Professor of Physical Chemistry at the Ecole Polytechnique Fédérale de Lausanne (EPFL), where he investigates photo-induced electron transfer reactions in mesoscopic systems and their use to generate electricity and chemical fuels from sunlight.

Michael studied chemistry at the Free University of Berlin and performed his doctoral thesis work at the Technical University Berlin under the supervision of Professor Arnim Henglein. He subsequently was a postdoctoral fellow with Professor Kerry Thomas at the University of Notre Dame, Indiana (USA), investigating photo-driven electron transfer reactions and light induced charge separation in surfactant micelles and vesicles which served as a simple mimic for biological membranes. His stay in Notre Dame was supported by a grant from the Petroleum Research Foundation. After a brief return to Berlin, where he obtained his Habilitation in Physical Chemistry at the Free University under the guidance of Professor Heinz Gerischer, he moved to Lausanne Switzerland, where he joined the EPFL faculty as a professor. It was at EPFL, that he started his pioneering research on colloidal semiconductor nanocrystals and there use for solar energy conversion and storage which lead to several ground breaking discoveries. These generated new research fronts worldwide in the domain of photovoltaics, electrochemistry and photo-electrochemistry, addressing the urgent need to develop low-cost and efficient systems for the conversion of sunlight to electricity and chemical fuels. The large scientific and industrial impact of his studies is documented by over 45'000 publications in the photovoltaic domain alone and over 3000 patents both resulting from his invention.

Michael is particularly well known for his discovery of mesoscopic dyesensitized solar cells (named after him "Graetzel cells"), which in turn engendered the advent of perovskite photovoltaics, constituting the most exciting breakthrough in the recent history of photovoltaics. He also used his revolutionary concept of three-dimensional junctions of nanocrystals also to realize photo-electrochemical devices for the solar generation of hydrogen and reduction of carbon dioxide as well as for the storage of electricity in ion insertion batteries.

Michael received numerous prestigious awards for his scientific achievements. The most recent ones include: the Rank Prize in Optoelectronics. BBVA Foundation Frontiers of Knowledge Award in Basic Science, Marcel Benoist Prize, August Wilhelm von Hofmann Memorial Medal of the German Chemical Society, Global Energy Prize, Rusnano Prize, Zewail Prize and Medal in Molecular Science, Leonardo da Vinci Medal of the European Academy of Science, Paracelsus Prize of the Swiss Chemical Society, Ordre de mérite du canton de Vaud, Switzerland, King Faisal International Science Prize, Samson Prime Minister's Prize for Innovation in Alternative Fuels (Israel), First Leigh-Ann Conn Prize in Renewable Energy, University of Kentucky (USA). Paul Karrer Gold Medal, Federation of the European Material Societies (FEMS) Innovation Award. Marcel Benoit Prize, Switzerland, Albert Einstein World Award of Science, Swiss Electric Research Award, Wilhelm Exner Medal, Gutenberg Research Award, Galileo Galilei Award, Padova Italy, City of Florence Award of the Italian Chemical SocietyBalzan Prize, Balzan Foundation, Milano, Zurich. Galvani Medal of the Italian Chemical Society Millennium Technology Prize, Balzan Prize and the Harvey Prize. He received honorary doctor's degrees from 12 European and Asian Universities.

Michael is an elected member of the Swiss Academy of Technical Sciences, the German Academy of Science (Leopoldina), as well as the Royal Spanish Academy of Engineering and several other learned societies. He is an elected foreign member of the Royal Society (UK), the Chinese Academy of Science. He is also an honorary member of the European Academy of Science, the Société Vaudoise de Sciences Naturelles and the Israeli Chemical Society. A recent bibliometric ranking by Stanford University places Michael first amongst 100'000 world-wide leading scientists across all fields of science. According to the Web of Science (2022), he is currently the most cited chemist in the world.

[Session K-01] Keynote Speaker: Stefaan De WOLF

Pathways to Efficient and Stable Perovskite/ Silicon Tandem Solar Cells

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Keywords: solar cells, photovoltaics, perovskites, silicon, clean energy

Abstract

In the presentation, I will discuss the multiple ways how monolithic perovskite/silicon can be fabricated, built from textured silicon heterojunction solar cells, with an emphasis on solution processing of the perovskite top cell. Bulk and contact passivation of the perovskite are instrumental to obtain a high performance, which can be obtained through molecular additive engineering and the use of a range of contact passivation layers [1,2]. Examples of effective passivation strategies are the use of molecular films at the hole-collecting metal-oxide / perovskite interface [3] and the use of fluoride-based layers at the electron-collecting perovskite / C_{60} interface [4]. This will be followed by a discussion about the outdoor performance of such tandems [5], the need for robust and perovskite-compatible encapsulation to do so, and the first longer-term outdoor measurements [6]. I will then move on to discuss reliability aspects of such tandems under accelerated degradation tests such as damp-heat testing, including device-engineering strategies to pass such tests [7]. I will also discuss other failure mechanisms to be overcome for perovskite/silicon tandems such as mechanical failure due to top-contact delamination [8] and potential induced degradation [9]. I will conclude my talk with arguing how bifacial perovskite/silicon tandems aid in improved performance as well as stability, thanks to their reliance on narrow-bandgap perovskites for optimal performance [10,11].

Reference

[1] F.H. Isikgor, F. Furlan, J. Liu, E. Ugur, M.K. Eswaran, A.S. Subbiah, E. Yengel, M. De Bastiani, G.T. Harrison, S. Zhumagali, C.T. Howells, E. Aydin, M. Wang, N. Gasparini, T.G. Allen, A. Rehman, E. Van Kerschaver, D. Baran, I. McCulloch, T.D. Anthopoulos, U. Schwingenschlogl, F. Laquai, and S. De Wolf, Joule 5, 1566 (2021).
[2] J. Liu, E. Aydin, J. Yin, M. De Bastiani, F.H. Isikgor, A.u. Rehman, E. Yengel, E. Ugur, G.T. Harrison, Y. Gao, M. Wang, j.I. Khan, M. Babics, T.G. Allen, A.S. Subbiah, K. Zhu, X. Zheng, W. Yan, F. Xu, M.F. Salvador, O.M. Bakr, M. Lanza, T.D. Anthopoulos, O.F. Mohammed, F. Laquai, S. De Wolf, Joule 5, 3169 (2021).
[3] F.H. Isikgor, S. Zhumagali, L.V.T. Merino, M. De Bastiani, I. McCulloch, and S. De Wolf, Nature Rev. Mater. (2022). https://doi.org/10.1038/s41578-022-00503-3
[4] J. Liu, M. De Bastiani, E. Aydin, G.T. Harrison, Y. Gao, R.R. Pradhan, M.K. Eswaran, M. Mandal, W. Yan, A. Seitkhan, M. Babics, A.S. Subbiah, E. Ugur, F. Xu, L. Xu, M. Wang, A.u. Rehman, A. Razzaq, J. Kang, R. Azmi, A.A. Said, F.H. Isikgor, T.G. Allen, D. Andrienko, U. Schwingenschlogl, F. Laquai, and S. De Wolf, Science 377, 302 (2022).
[5] E. Aydin, T.G. Allen, M. De Bastiani, L. Xu, J. Avila, M. Salvador, E. Van Kerschaver, and S. De Wolf, Nature Energy 5, 851 (2020).
[6] M. De Bastiani, E. Van Kerschaver, A. Rehman, E. Aydin, F.H. Isikgor, A.J. Mirabelli, S. Zhumagali, E. Ugur, G.T. Harrison, T.G. Allen, B. Chen, Y. Hou, S. Shikin, Q. Jeangros, C. Ballif, E.H. Sargent, M.F. Salvador, and S. De Wolf, ACS Energy Lett. 6, 2944 (2021).
[7] R. Azmi, E. Ugur, A. Seithkan, F. Aljamaan, A.S. Subbiah, G.T. Harrison, J. Liu, M.I. Nugraha, M.K. Eswaran, M. Babics, Y. Chen, F. Xu, T.G. Allen, A.u. Rehman, C.-L. Wang, T.D. Anthopoulos, U. Schwingenschlogl, M. De Bastiani, E. Aydin, and S. De Wolf, Science 376, 73 (2022).
[8] M. De Bastiani, G. Armaroli, R. Jalmood, L. Ferlauto, X. Li, R. Tao, G.T. Harrison, M. Babics, E. Aydin, T.G. Allen, C. Combe, T. Kramer, G. Lubineau, D. Cavalcoli, and S De Wolf, ACS Energy Lett. 7, 827 (2022).
[9] L. Xu, J. Liu, W. Luo, N. Wehbe, A. Seitkhan, M. Babics, J. Kang, M. De Bastiani, E. Aydin, T.G. Allen, M. Alamer, W. Yan, F. Xu, A.u. Rehman, and S. De Wolf, Cell Rep. Phys. Sci. 3, 101026 (2022).
[10] M. De Bastiani, A.J. Mirabelli, Y. Hou, F. Grota, E. Aydin, T.G. Allen, J. Troughton, A.S. Subbiah, F.H. Isikgor, J. Liu, L. Xu, B. Chen, E. Van Kerschaver, D. Baran, M.F. Salvador, U.W. Paetzold, E.H. Sargent, and S. De Wolf, Nature Energy 6, 167 (2021).
[11] M. De Bastiani, A.S. Subbiah, M. Babics, E. Ugur, T.G. Allen, E. Aydin, and S. De Wolf, Joule 6, 1431 (2022).

BIOGRAPHY

Stefaan De Wolf's expertise lies in the science and technology of photovoltaics for terrestrial applications. His research focuses on the fabrication of high-efficiency silicon- and perovskite-based solar cells, with specific attention to the fundamental understanding of interface structures and electrical contact formation, relevant to solar cells and electronic devices. He is also interested in applications related to photovoltaics for hot climates and multi-junction solar cells, aimed at the improved utilization of the full solar spectrum for electricity generation. He is Clarivate Highly Cited Researcher since 2019.

[Session K-02] Keynote Speaker: Nouredine HADJ-SAID

Intensified Electrification for Decarbonization: Paradigm Change, Perspectives, and Challenges

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Keywords: intensified electrification, energy decarbonization, power grid transition, renewable energy sources, grid investment.

Abstract
Energy sector in general and power systems in particular are considered as critical infrastructures for our modern societies. However, these infrastructures are expected to play an even critical role in the perspective of decarbonation for reaching the Carbon Neutrality by 2050 or even earlier. Indeed, the energy consumption in various economy sectors such as industry, buildings and transportation, is one of the main contributors for Green House Gas Emissions (about 70%). As such, decarbonizing the energy sector is a major step for fulfilling Carbon Neutrality targets. Hence, intensifying electrification of consumptions while shifting usages from fossil-based energy to electrical-based energy is one of the most efficient levers for decarbonizing the energy sector. This can be illustrated in transportation with plug-in Electric Vehicles, in Building where the combination of electrification, energy efficiency and renewable energy supply will offset almost to zero their CO_2 emissions, and in the industry through process shifting.

In this perspective, reaching Carbon neutrality targets will require the electricity share in the final energy consumption to jump from 20-25% today to 50-60% by 2050. On the other hand, the necessity of interconnecting to the power grid massive renewable energy sources that are mostly intermittent in nature is significantly transforming the way these systems are designed, planned and operated while maintaining their resiliency. Given the short

period of transition for this complex energy sector, this move is a considerable challenge for the power system that should be adapted quickly through massive investments, more intelligence and flexibility.

The presentation will focus on the challenges of decarbonization and its impact on power system transition but also on some emerging consequences and paradigm change in this critical sector.

BIOGRAPHY

Dr. Nouredine Hadjsaïd received PhD and the "Habilitation à Diriger des Recherches" degrees from Grenoble Institute of Technology in 1992 and 1998 respectively. He is presently a full professor at the Engineering and Management Institute of the University of Grenoble Alpes (UGA) - France.

He has directed the common academia-industry research center between EDF, Schneider Electric and G2Elab (IDEA: Inventer la Distribution Electric de l'Avenir) on smartgrids from 2001 to 2013. He is presently the General Director of the Electrical Engineering lab (G2Elab – CNRS/UGA), the Director of an ENEDIS Industrial chair of excellence on "Smartgrids", the holder of an Artificial Intelligence chair with the MIAI Institute (Grenoble Institute on Artificial Intelligence), and the President of Scientific Council of Think SmartGrids France, the French industrial branch on SmartGrids.

At the international level, he served as the treasurer of IEEE Power Energy Society (elected worldwide), the vice-chair of IEEE IGETCC (Intelligent Grid and Emerging Technologies Coordination Committee), and the French representative at International Energy Agency for ISGAN-SIRFN Annex. He is presently serving as an IEEE PES VP New Initiatives and Outreach.

He was the general conference chair of IEEE PowerTech'2013 held in Grenoble-France and IEEE SG4SC (SmartGrids for SmartCities) held in Paris in 2016. Dr. Hadjsaïd has published more than 300 scientific papers in international referred journals and conferences, and has authored/co-authored and directed 7 books about power engineering and Smartgrids.

[Session P-04] Plenary Speaker: 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 over 100 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 a 2022 ANS Presidential Citation, 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).

[Session P-05] Plenary Speaker: Bin LIU

Sustainability Research at the National University of Singapore

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Abstract
Today, humanity faces the consequences of two centuries of exponential economic growth powered by fossil fuels – climate change, environmental degradation, and the combined effects of ever-increasing energy demand and diminishing fossil fuel reserves. There is a clear and urgent demand for scientific breakthroughs to mitigate these issues by replacing fossil fuels, particularly coal and oil, with sustainable green fuels. In this regard, carbon capture, utilization and storage, and hydrogen economy have emerged as critical topics to develop practical solutions. In this talk, I will provide an overview of the NUS sustainability research with special focus on the research activities of NUS Green Energy Program and the Hydrogen Centre for Innovations.

BIOGRAPHY

Liu Bin is a Distinguished Professor and Senior Vice Provost (Faculty & Institutional Development) at the National University of Singapore (NUS). Prior to taking up this appointment on 1 January 2022, she served as Vice President (Research and Technology) since September 2019.

Liu Bin is a leader in the field of organic functional materials, who has been well-recognised for her contributions in polymer chemistry and applications of organic nanomaterials for biomedical research, environmental monitoring and energy devices. She is named among the World's Most Influential Scientific Minds and the Top 1% Highly Cited Researchers by Clarivate. She is a prolific researcher with over 450 publications and holds 30 patents with 16 of them licensed to different companies in US, UK, and Asia. In 2014, she co-founded Luminicell, a NUS spin-off company that produces organic luminescent nanoparticles for use in biomedical applications.

[Session I-01] Invited Speaker: Angus Hin-Lap YIP

Optical Design for High-efficiency White Perovskite LEDs

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Abstract
Metal halide perovskite light-emitting diodes (PeLEDs) show great potential to be the next-generation lighting technology, with external quantum efficiencies (EQEs) exceeding 20% for infrared, red and green LEDs. However, the efficiencies of blue and white devices severely lag behind. To improve the performance of blue PeLEDs, we employed an integrated strategy combining dimensional engineering of perovskite film and recombination zone modulation in the LED device to obtain an EQE of up to 5 %. While further incorporating the strategy of interfacial engineering, highly efficient blue PeLEDs with EQEs over 10% have been successfully realized in our group, establishing an excellent platform for white-light emission. In our latest work, we demonstrated efficient white PeLEDs by optically coupling a blue PeLED with a red-emitting perovskite nanocrystal layer in an advanced device structure, which allows extracting the trapped optical modes (waveguide and SPP modes) of blue photons in the device to the red perovskite layer via near-field effects. As a result, white PeLEDs with EQE over 12% are achieved, representing the state-of-the-art performance for white PeLEDs.

Reference

[1] Z. Li, Z. Chen, H.-L. Yip et al. Nat. Commun. 2019, 10, 1027
[2] Z. Chen, Z. Li, H.-L. Yip et al. Joule 2021, 5, 456

BIOGRAPHY

Angus Hin-Lap Yip joined the Department of Materials Science and Engineering and the 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 at the State Key Laboratory of Luminescent Materials and Devices (SKLLMD) and the School of Materials Science and Engineering (MSE) at 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 34000 and an H-index of 97. He was also honoured as ESI “Highly Cited Researcher” in Materials Science for nine times from 2014-2022.

[Session I-02] Invited Speaker: Edwin Chi Yan TSO

Advanced and Smart Building Skin Materials for Carbon Neutrality

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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. 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. By combining both the 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 not only will 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 is also listed among the Top 2% of the world's most highly cited scientists in his own area (Mechanical Engineering) in 2020 and 2021. Dr. Tso has also filed more than 10 international patents, so he also dedicates a significant effort to promote translational research, targeted at commercialization. Towards this goal, Dr. Tso has established a start-up focusing on the passive radiative cooling technology with an angel fund of >HK$12M for the initial phase. The product of his start-up has been used by different local and international parties, indicating the success of the knowledge transfer from his research to real applications (i.e. creating an impact in society). Last, Dr. Tso is also a Member of The Hong Kong Institution of Engineers (MHKIE) and The American Society of Mechanical Engineers (MASME).

[Session I-03] Invited Speaker: Yun Hau NG

Solar Fuels (Hydrogen) via Catalytic Conversion

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Keywords: hydrogen, photocatalysis, photoelectrochemical system, solar fuels.

Abstract

Hydrogen is one of the potential sources of energy which has potential to substitute fossil fuel. Hydrogen can play a role in contributing to a resilient, sustainable energy future in two major directions: (1) current/ traditional practice of hydrogen usage, dominantly present in industrial activities (e.g. refinery, steel production, fertilizer manufacturing etc.), can use hydrogen produced from greener alternative methods; (2) hydrogen receives interest in new and emerging applications mainly in electricity generation, heating source and transportation (fuel cell vehicle FCV). Hydrogen can be directly used in its pure form stored in different physical states (including uncompressed gas, compressed gas, liquefied hydrogen and solid-state hydrogen as metal hydride). Alternatively, it can be converted to hydrogen-based fuels such as ammonia, methane or liquid alcohol fuels. With this multiple facets of hydrogen, there is potential to connect different parts of the energy system with hydrogen-derived fuels.

Solar hydrogen production from photocatalytic and photoelectrochemical reactions employing photoactive semiconductors under visible light has been considered a potential alternative to make solar energy storable and transportable [1-3]. Hydrogen generation from photocatalytic splitting of water as well as photocatalytic conversion of CO_2 into chemical fuels (e.g. methane and methanol) are two good examples of solar fuels production assisted by solar energy. These reactions have demonstrated potential to simultaneously address the energy shortage and environmental issues by

minimizing the usage of fossil fuel. A great number of photoactive semiconductors (be it oxide, nitride, sulphide or others) has attracted extensive attention due to its affordability, mostly non-toxic, and with considerable theoretical photocurrent density for fuels generation. The challenges in extending their capability in this application lie on several aspects, such as the extension of the solar spectrum absorption, the charges transportation, and the photo-stability of the materials. For example, TiO_2 absorbs only UV wavelength, Cu_2O suffers from photocorrosion and many others experience significant charges recombination processes. Introduction of nanosctructures or secondary components into the parental semiconductor is a potential way in tackling the above mentioned issues.

The main driving force for our research in School of Energy and Environment at CityU is to improve (if not overcome) the above shortfalls by using several different electrochemical and chemical approaches. In this talk, strategies in developing efficient oxide-based photocatalysts for the above-mentioned reactions will be shared.

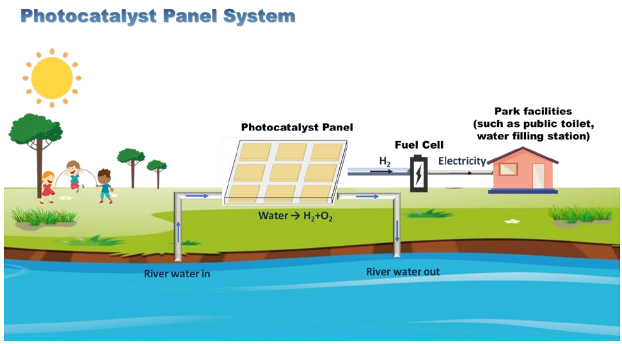

Figure 1: Schematic illustration of potential use of photocatalyst panel for hydrogen production

Reference
[1] H. Wu, L. Zhang, A. Du, R. Irani, R. van de Krol, F. F. Abdi, Y. H. Ng, Nature Commun. 2022, 13, 6231.
[2] H. Wu, R. Irani, K. Zhang, L. Jing, H. Dai, H. Y. Chung, F. F. Abdi, Y. H. Ng, ACS Energy Lett. 2021, 6 (10), 3400-3407.
[3] H. Wu, H. T. Tan, C. Y. Toe, J. Scott, L. Wang, R. Amal, Y. H. Ng, Adv. Mater. 2020, 32 (18), 1904717.

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 K-03] Keynote Speaker: Kazunari DOMEN

A Large Scale Solar Hydrogen Production by Photocatalytic Water Splitting

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Keywords: particulate photocatalyst, panel reactor, visible light

Abstract

Sunlight-driven water splitting using particulate photocatalysts has been attracting growing interest because such systems can be spread over large areas by potentially inexpensive processes [1]. In fact, 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 [2]. Nevertheless, 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 materials as photocatalysts for water splitting. Recently, the apparent quantum yield (AQY) of $SrTiO_3$ has been improved to more than 90% at 365 nm, equivalent to an internal quantum efficiency of almost unity, by refining the preparation of the photocatalyst and cocatalysts [3]. This observation means that particulate photocatalysts can drive the endergonic overall water-splitting reaction with almost no recombination loss. For practical solar hydrogen production, it is essential to develop photocatalysts that are active under visible light. Recently, Ta_3N_5 [4], $Y_2Ti_2O_5S_2$ [5], TaON [6], and $BaTaO_2N$ [7] were found to be active in photocatalytic overall water splitting via one-step excitation under visible light. In these achievements, the synthesis of well-crystallized semiconductor particles and the loading of composite cocatalysts were important for improving photocatalytic activity. It is also possible to combine hydrogen evolution photocatalysts (HEPs) and oxygen evolution photocatalysts (OEPs) and decompose water into hydrogen and oxygen via two-step excitation. Such a process is also known as Z-scheme. Particulate photocatalyst sheets consisting of La- and Rh-codoped $SrTiO_3$ as the HEP and Mo-doped BiVO4 as the OEP immobilized onto Au and C layers split water into hydrogen and oxygen with STH values exceeding 1.0% [8, 9]. Some other (oxy)chalcogenides and (oxy)nitrides with long absorption edge wavelengths are also applicable to Z-schematic photocatalyst sheets [10] and hold the promise of realizing greater STH values.

Reference

[1] Hisatomi et al., Nat. Catal. 2, 387 (2019).
[2] Nishiyama et al., Nature 598, 304 (2021).
[3] Takata et al., Nature 581, 411 (2020).
[4] Wang et al., Nat. Catal. 1, 756 (2018).
[5] Wang et al., Nat. Mater. 18, 827 (2019).
[6] Xiao et al., Angew. Chem. Int. Ed. 134, e202116573 (2022).
[7] Li et al., ACS Catal. 12, 10179 (2022).
[8] Wang et al., Nat. Mater. 15, 611 (2016).
[9] Wang et al., J. Am. Chem. Soc. 139, 1675 (2017).
[10] Hisatomi et al., Catal. Sci. Technol. 8, 3918 (2018).

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-SrTiO3 photocatalyst for overall water splitting reaction, which was one of the earliest examples achieving stoichiometric H2 and O2 evolution on a particulate system. In 2005, he has succeeded in overall water splitting under visible light (400 nm<λ<500nm) on GaN:ZnO solid solution photocatalyst.

[Session P-06] Plenary Speaker: Thierry POINSOT

Can Hydrogen Become an Important Energy Vector for Transportation? The Case of Aircraft

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Keywords: hydrogen, aircraft, engines, safety, simulation

Abstract
While combustion of fossil fuels is obviously a main cause for global warming, combustion may actually also be a significant part of the solution to this problem: going to renewable energies will be impossible if new, massive capacities for energy storage are not developed. This is exactly what hydrogen solutions can bring through the development of Power to X solutions where H_2 is produced from renewable energies, stored in large quantities for long periods of time before being burnt when needed. Combustion becomes a method to store and recover the energy of renewable sources. This hydrogen can then be used for many applications requiring energy, for example in the field of transportation. We will discuss the specific case of the hydrogen aircraft which is probably the most extreme application of hydrogen energy.

Such an application requires significant advances in combustion science, in terms of kinetics and flame structures, explosion safety, flame control, burner design. This talk will summarize the main challenges for H_2 aircraft development and provide first simple examples of hydrogen studies for aircraft in terms of engine design and safety scenarios. It will also highlight the role of High Performance Computing to design new engines and analyze safety scenarios.

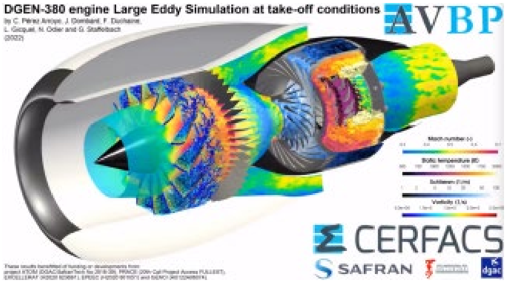

Figure 1: Numerical simulation of a full aircraft gas turbine (Credits: C. Perez Arroyo, J. Dombard)

BIOGRAPHY

Dr Thierry Poinsot is a research director at CNRS (Institut de Mécanique des Fluides de Toulouse), senior researcher at CERFACS, senior research fellow at Stanford University, consultant for various companies and member of the French Academy of Sciences. His work focuses on combustion, energy, propulsion, numerical methods, High Performance Computing. He has authored more than 230 papers in refereed journals and 200 communications. He is the author of the textbook "Theoretical and numerical combustion" with Dr D. Veynante and one of the editors in chief of «Combustion and Flame». He is the leader of two ERC (European Research Council) grants on combustion and hydrogen: INTECOCIS (intecocis.inp-toulouse.fr) and SCIROCCO (cerfacs.fr/scirocco).

[Session I-04] Invited Speaker: Xue WANG

Efficient Upgrading of C_1 Molecules to Fuels

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Keywords: electrocatalysis, carbon-zero, renewable fuels

Abstract
The CO_2 electroreduction reaction (CO_2RR) to feedstocks and valuable fuels, powered using renewable electricity, offers a sustainable approach to store intermittent renewable energy, and also to reduce CO_2 emission associated with chemicals (Figure 1). A wide range of different products from C_1 to C_3 is typically generated in CO_2RR; thus, to realize industrial application, improved selectivity, as well as high activity, stability, and energy efficiency, must be further pursued. In this talk, I will present our recent progress towards the more practical electrosynthesis of fuels from C_1 molecules, looking both at the catalyst and at the system. The mechanism of fuel electrosynthesis on the catalysts will also be discussed [1-3].

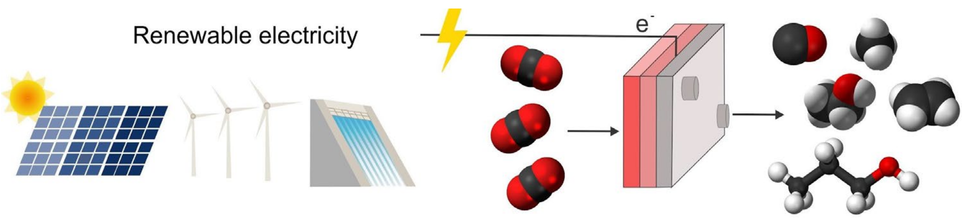
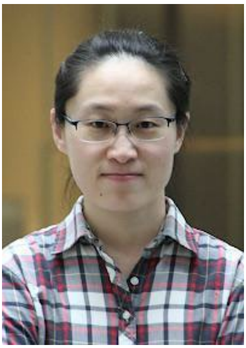


Figure 1: CO_2RR to fuels and chemicals using renewable electricity.

Reference

[1] X. Wang, Z. Wang, F.P.G. de Arquer, C.-T. Dinh, A. Ozden, Y.C. Li, D.-H. Nam, J. Li, Y.-S. Liu, J. Wicks, Z. Chen, M. Chi, B. Chen, Y. Wang, J. Tam, J.Y. Howe, A. Proppe, P. Todorović, F. Li, T.-T. Zhuang, C.M. Gabardo, A.R. Kirmani, C. McCallum, S.-F. Hung, Y. Lum, M. Luo, Y. Min, A. Xu, C.P. O'Brien, B. Stephen, B. Sun, A.H. Ip, L.J. Richter, S.O. Kelley, D. Sinton and E.H. Sargent. Nature Energy 5, 478 (2020).
[2] X. Wang, A. Xu, F. Li, S.-F. Hung, D.-H. Nam, C.M. Gabardo, Z. Wang, Y. Xu, A. Ozden, A.S. Rasouli, A.H. Ip, D. Sinton and E.H. Sargent. J. Am. Chem. Soc. 142, 3525 (2020).
[3] X. Wang, P. Ou, A. Ozden, S.-F. Hung, J. Tam, C.M. Gabardo, J.Y. Howe, J. Sisler, K. Bertens, F.P.G. de Arquer, R.K. Miao, C.P. O'Brien, Z. Wang, J. Abed, A.S. Rasouli, M. Sun, A.H. Ip, D. Sinton and E.H. Sargent. Nature Energy 7, 170 (2022).

BIOGRAPHY



Dr. Xue Wang received her Ph.D. degree in Chemistry from Xiamen University in 2015. During her graduate studies, she worked at the Georgia Institute of Technology as a visiting graduate student (2013-2015). After her Ph.D. graduation, she was appointed as associate professor at Lanzhou Institute of Chemical Physics, Chinese Academy of Sciences (2016-2017). Then she worked as a postdoctoral fellow at University of Toronto, prior to joining the City University of Hong Kong as an assistant professor in the School of Energy and Environment in January 2023. Dr. Wang's research expertise covers nanomaterial design, electrocatalysis, and reaction engineering, with a particular emphasis on energy-related applications. To date, she has published over 50 peer-reviewed articles (including Nature Energy, Nature Commun., Nature Catalysis, JACS, Nano Letters, ACS Nano, Advanced Materials, Green Chem., etc. as the first/co-first/co-corresponding author) with > 5,000 citations.

[Session K-04] Keynote Speaker: Raffaella BUONSANTI

Well-defined Catalysts for Selective CO_2 Electroreduction

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Keywords: carbon-zero, clean energy, CO_2 reduction, electrochemistry, catalysis

Abstract
The electrochemical CO_2 reduction reaction (CO_2RR) offers the opportunity to convert CO_2 into fuels and chemical feedstocks, while mitigating anthropogenic CO_2 emissions and storing renewable energy. Multi-carbon (C_{2+}) compounds (e.g., ethylene, ethanol, propanol) are among the most attractive CO_2RR products owing to their commercial value and high energy densities. However, optimizing the selectivity of CO_2RR electrocatalysts towards one particular product remains a crucial challenge that is not trivial to address because multiple intermediates are involved in the CO_2 to C_{2+} conversion pathway.

In these context, unambiguous relationships between the activity, selectivity and stability of the catalyst with its structure and composition becomes crucial to make concrete progress in this field.

In this talk, I will showcase a few examples which highlight how shape-controlled nanocrystals can contribute to address the selectivity challenge in CO_2RR. First of all, I will discuss how size control of Cu nanocubes and Cu octahedra has revealed the importance of facet-ratio to maximize the selectivity towards ethylene and methane, respectively. Second, I will present our recent computational-experimental efforts towards using well-defined NCs, in the framework of a tandem scheme based on the coupling of Cu nanocrystals with CO-generating Ag, to elucidate selectivity rules at the

hydrocarbons/alcohols branching nodes in the CO_2RR pathway and increase ethanol production. Finally, I will discuss a few examples of Cu-based bimetallic catalyst which evidence the opportunities and challenges in this area.

BIOGRAPHY

Professor Raffaella Buonsanti is an Associate Professor in the Department of Chemistry and Chemical Engineering at EPFL. She leads a multidisciplinary research program which spans from nanoscience to materials chemistry and electrocatalysis. She has received an ERC Starting Grant in 2016 and an ERC Consolidator Grant in 2022 in addition to numerous awards, including the Swiss Chemical Society Werner Price in 2021 and the European Chemical Society Lecture Award and the Royal Chemical Society ChemComm Emerging Investigator Lectureship in 2019. She is also the chair of the Nanoscience Subdivision of the ACS Division of Inorganic Chemistry and is an Associate Editor of ACS Catalysis.

[Session K-05] Keynote Speaker: A. William (Bill) RUTHERFORD

Reality Checks for Biofuels as Replacements for Fossil Fuels: Sustainable Avion Fuels as a Case Study

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Keywords: sustainable aviation fuels, life-cycle analysis, energy accounting, resource scaling

Abstract

Aviation is a difficult sector to decarbonize due the energy density needed in jet-fuel. To be a legitimate replacement for fossil fuels, an alternative fuel must result in significantly smaller net emissions of green-house gases (GHG) and should be energy efficient, as estimated by GHG and energy Life Cycle Analyses (LCAs). The production of the fuel must also be scalable to the level of the fuel demand and feasible in terms of the resources required. Here we analyzed the options for decarbonizing aviation focusing on a range of alternative fuels.

We performed GHG and energy LCAs for bio-jet fuel production from rapeseed grown in the UK. We analyzed the extensive literature covering this and other bio-feedstocks (energy crops, agricultural and forest waste) and fuel production processes. We also estimated the resources needed to make bio-jet fuels at scale. For energy crops, we used the land area needed for their production as a scaling measure. For waste, we compared the fuel requirement with the amount of existing and/or available waste.

We also did scaling calculations for hydrogen, ammonia, and artificial hydrocarbon fuels (e-fuels), all of which are considered future alternative jet fuels. In addition, we considered the option of continued fossil jet fuels-use but with a compensatory level of carbon capture. For these cases, we took "sustainable" electricity use (solar and wind power), as the main energy resource and as a feasibility measure at scale.

LCAs data for energy crop-based bio-jet fuel are scattered, but if extreme outliers (both good and bad) are ignored, and we take only the relevant, real-world scenarios, some small savings in GHG may be made. But these do not hit targets for sustainability (e.g., EU renewable energy directive RED). When bio-jet fuels are blended with fossil fuel, as currently required, the GHG savings become barely significant. The scaling results are clear: bio-jet fuel production at scale from energy crops requires unfeasibly large areas (~68% of UK agricultural land), and when scaled down to be feasible, they have a negligible effect on GHG emissions, while being a disproportionate drain on resources, not least by competing with food, and also damaging the environment.

For biowaste feedstocks, the LCAs are dubious as most “waste” is not waste: it has other uses. Thus, replacements of current uses must be accounted for in the LCAs. Scaling to the required amounts of jet fuel shows that in most cases, there is far too little waste to be significant.

For H_2, NH_3 and e-fuels production, huge amounts of sustainable energy are needed. This is also the case for carbon capture to compensate for current fossil fuel use.

The present assessment needs correcting to account for CO_2 emissions making-up ~1/3 of the GHG emissions from aviation while NO_x and contrails make 2/3. This multiplies the problem by 3. There is no technological silver bullet, thus higher costs and demand reduction seem inevitable.

BIOGRAPHY

Bill Rutherford of Imperial College London is a biochemist/biophysicist who studies the bioenergetics of photosynthesis: solar-driven, biological energy-conversion. He did his BSc in Biochemistry at the University of Liverpool, his PhD at University College London. He did post-doctoral work at i) the University of Illinois, ii) Riken, Saitama, Japan and iii) CEA Saclay, near Paris, France. He joined the CNRS as a researcher at Saclay, becoming head of the CNRS unit and then of the Service of Bioenergetics CEA, before moving to Imperial College in 2011 as the Chair in Biochemistry of Solar Energy. His interests and contributions include structure/function aspects of the water splitting enzyme and photosynthetic reaction centres, proton-coupled electron transfer, evolution of photosynthesis, photochemistry, mechanisms of photoinhibition, redox tuning, bioinorganic chemistry, molecular enzymology of water splitting, long wavelength oxygenic photosynthesis, artificial photosynthesis, and energy accounting. He is a member of EMBO, was awarded the Medaille d'Argent du CNRS in 2001, was the Craig Professor of Chemistry at ANU Canberra in 2005, a Visiting Professor at Queen Marys College London 2007-2011. He was the president of the International Society of Photosynthesis Research 2011-2013 and was awarded an honorary Doctorate in Chemistry from Uppsala University in 2013. He was elected a fellow of the Royal Society in 2014. He is also active in accessing the feasibility of policies aimed at mitigating the climate crisis. Publications: ~273, (refereed journals: 219, others >50). Metrics: Google Scholar h-index 86 (>19,000 citations). Web of Science h-index is 73 (>14,600 citations, ~53 average citations per item)

Google scholar:
https://scholar.google.co.uk/citations?user=aogee_YAAAAJ&hl=en
ResearcherID: http://www.researcherid.com/rid/A-7831-2019
ORCID: https://orcid.org/0000-0002-3124-154X

[Session K-06] Keynote Speaker: Hélène OLIVIER-BOURBIGOU

Towards Decarbonization of Industry: Focus on Carbon Capture, Storage, and Conversion into Low Carbon Fuels

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Keywords: CO_2, carbon capture, CCUS, Synthetic fuels, e-Biofuels.

Abstract
Achieving carbon neutrality by 2050 requires a rapid shift towards cleaner energy systems. Among the transformations proposed for the energy sector, heavy industries and transport, carbon capture, storage and utilization (CCUS) is ranked among the top solutions. It is an unavoidable technology to reduce emissions of hard-to-abate industries which include steel, cement, and chemical manufacturing. This is also today one of the most effective options for low-carbon hydrogen production. Large scale deployment of CCUS is expected at the latest in 2030, with some challenge and barriers to overcome. This will require the development of clusters to allow the capture of small CO_2 volume, to create possible commercial synergies, to share transport and storage infrastructures, and to reduce costs. To facilitate the deployment of CCUS, IFPEN has been present on the whole chain for more than 20 years as described in the Figure below. The presentation will point out the further potential research and development directions. A focus will be made on the emerging DMX™ technology which represents a real breakthrough for post-combustion CO_2 capture. Based on chemical absorption by a demixing solvent, it shows promising results in terms of energy penalty reduction and process stability [1,2]. Diversification of energy supply is also part of the solutions to the road to cleaner energy systems. The production of low carbon synthetic fuels from captured CO_2 combined with hydrogen produced by water electrolysis and low-carbon electricity is the first alternative. Moreover, an optimized integration with advanced biofuels productions pathways,

thermochemical (gasification and Fischer-Tropsch) or biochemical (enzymatic hydrolysis and fermentation), respectively named BioTfueL® and Futurol™ technologies [3], allow to improve performances, to optimize biomass use and to valorize biogenic CO_2. These different solutions will be further discussed.

Reference
[1] L. Raynal et al., Chemical Engineering Journal, 171, 3, 742 (2011).
[2] P. Broutinet al., Energy Procedia, 114, 2561 (2017).
[3] Y. Bernardet al., Decarbonization Technology, May 2022, 61 (2022).

BIOGRAPHY

Hélène Olivier-Bourbigou obtained her PhD in Chemistry from the University of Paris VI under the guidance of Prof. Henri Kagan and Yves Chauvin in 1988. She joined IFP Energies nouvelles (IFPEN) in 1989 where she has been the leader of different projects combining fundamental studies and the development of new industrial processes in the field of catalysis for energy and chemistry. In 2020 she joined the IFPEN Scientific management as program manager to coordinate the overall fundamental research. Her scientific and technical achievements focus on highly competitive areas with special emphasis on the design of new homogeneous catalytic systems and the development of eco-efficient and more sustainable processes. She was one of the pioneers in the design and applications of ionic liquids. As a result of 30 years of intense research on Catalysis, Hélène Olivier-Bourbigou has published about 100 research articles including 8 reviews and 16 book chapters. She holds more than 95 patents. She has been recognized for these contributions by the Irène Joliot Curie Award «Scientific Woman of the Year» in 2014, EFCATS "Applied Catalysis" Award, "Grand Prix Pierre Süe" from Société Chimique de France and the "Grand prix Codron" - Fondation Codron Fautz / Fondation de l'Institut de France in 2021. She is member of the French "Académie des technologies".

[Session K-07] Keynote Speaker: Wenjun ZHANG

Applications of Plasma Technology in Electrochemical Energy Conversion and Storage Materials

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Keywords: Plasma, electrode engineering, batteries, electrocatalysis

Abstract

A plasma is a partially ionized gas, which is one of the four fundamental states of matter. The rich energetic species in plasmas enable them to be employed as a powerful tool for material synthesis, ranging from thin films to nanomaterials. The materials prepared with the plasma-enhanced techniques show some distinctive features, e.g., novel structure, improved efficiency, and defect control. Plasma technology may also facilitate reactions which are difficult for normal thermal approaches and reduce the growth temperatures. In this talk, the applications of microwave plasmas in the synthesis and modification of several nanomaterials such as diamond nanostructures, 3D vertical graphene arrays, and heterocrystalline and bicrystal ZnS nanowires, and their related properties, will first be introduced. Then some recent advances in the use of plasma technology in preparing nanomaterials for electrochemical energy conversion and storage applications will be discussed.

BIOGRAPHY

Wenjun Zhang obtained his Doctor of Philosophy degree in 1994 from Lanzhou University. He was a postdoc at the Fraunhofer Institute for Surface Engineering and Thin Films (1995 to 1997) and at the City University of Hong Kong (1997 to 1998). From 1998 to 2000, he worked as a Science and Technology Agency Fellow at National Institute for Research in Inorganic Materials. He joined CityU in 2000 again as a Senior Research Fellow. He is now a Chair Professor in the Department of Materials Science and Engineering and the Department of Chemistry, the director of the Center Of Super Diamond and Advanced Films (COSDAF), and the associate director of Hong Kong Institute for Clean Energy. His research focuses on thin film technology, surface and interface engineering, and nanomaterials and devices. He received the Japan Society of Applied Physics (JSAP) Best Paper Award in 2002, the Friedrich Wilhem Bessel Research Award of Alexander von Humboldt Foundation, Germany, in 2003, the Outstanding Research Award of CityU in 2015, and President’s Award in 2019. Prof. Zhang is also the Visiting Professor in Siegen University, Germany, Cuiying Guest Professor (萃英讲席教授) in Lanzhou University, Guest Professors in National Yang Ming Chiao Tung University, Soochow University, Hefei University of Technology, Technical Institute of Physics and Chemistry (CAS), and Shenzhen Institute of Advanced Technology (CAS).

[Session K-08] Keynote Speaker: Guohua CHEN

oCVD of Conductive Polymers on Cathode Particles for Much Improved Safety and Stability of Lithium Ion Battery

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[2] Chemical Sciences and Engineering Division, Argonne National Laboratory, USA
[3] Department of Chemical Engineering, Rowan University, USA
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[5] Materials Science and Engineering, Stanford University, USA
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Keywords: CVD, SEI, Ni-rich cathode, PEDOT, NCM cathode

Abstract

This talk will present the results of oxidative chemical vapor deposition of conductive polymer (oCVD), PEDOT, on the surface of the cathode materials. It will start with the overview of the CVD process, the control of thickness and characterization of the polymeric coating. Then, the PEDOT coating effects on the performance of the cathode materials of lithium ion batteries will be presented in terms of safety and stability. The mechanism of the improved performance will be discussed based on the physical, chemical and electrochemical characterization.

oCVD was found to be able to coat PEDOT on the primary particles as well as secondary particles. The PEDOT coating thickness can be trolled by regulating the chemical reaction time. The coated thin layer (~10nm) was found to be able to prevent the HF in the electrolyte from contacting the surface of NCM

cathode materials. It can also supress the phase change of the cathode materials during repeated charging/discharging. The safety especially at high charging voltage can be obtained with the stability of the cathode prolonged significantly [1]. Crack-free was observed from the PEDOT coated single-crystal NMC under harsh condition [2]. PEDOT coating can also inhibit the metal dissolution (cross-talk) and surface reconstruction giving a highly resilient NCM cathode for lithium ion batteries [3].

oCVD of conductive polymers presents a new strategy for emerging Ni-rich NCM cathode materials.

Reference

[1] Gui-Liang Xu, Qiang Liu, Kenneth KS Lau, Yuzi Liu, Xiang Liu, Han Gao, Xinwei Zhou, Minghao Zhuang, Yang Ren, Jiadong Li, Minhua Shao, Minggao Ouyang, Feng Pan, Zonghai Chen, Khalil Amine, Guohua Chen, Building ultraconformal protective layers on both secondary and primary particles of layered lithium transition metal oxide cathodes, Nature Energy 4 (6), 484-494 (2019)

[2] Qiang Liu, Yu-Tong Liu, Chen Zhao, Qing-Song Weng, Junjing Deng, Inhui Hwang, Yi Jiang, Chengjun Sun, Tianyi Li, Wenqian Xu, Ke Du, Amine Daali, Gui-Liang Xu, Khalil Amine, Guohua Chen, Conformal PEDOT Coating Enables Ultra-High-Voltage and High-Temperature Operation for Single-Crystal Ni-Rich Cathodes, ACS nano, 16 (9) (2022) 14527-14538

[3] Xiang Liu, Xinwei Zhou, Qiang Liu, Jiecheng Diao, Chen Zhao, Luxi Li, Yuzi Liu, Wenqian Xu, Amine Daali, Ross Harder, Ian K Robinson, Mouad Dahbi, Jones Alami, Guohua Chen, Gui-Liang Xu, Khalil Amine, Multiscale Understanding of Surface Structural Effects on High-Temperature Operational Resiliency of Layered Oxide Cathodes, Advanced Materials, 34(4)(2022)2107326.

BIOGRAPHY

Professor Chen is the Dean, School of Energy and Environment, Chair Professor of Smart Energy Conversion and Stirage, City University of Hong Kong.

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.He was an Associate Vice President (Research Support), Chair Professor of Energy Conversion and Storage, at The Hong Kong Polytechnic University (2017-2021).

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 the Chairman, World Chemical Engineering Council, Deputy Director, Chemical Industry and Engineering Society China, Editor-in-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, Environmental Scicen & Technology.

Professor Chen's recent research interests include electrochemical technologies for energy and environmental applications. He has published over 300 journal papers with more than 34,000 Google citations and an H-index of 96. 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 I-05] Invited Speaker: Qi LIU

Discovery and Fundamental Studies of Cathode Materials via Advanced Synchrotron Techniques

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Keywords: Lithium ion batteries, synchrotron, cathode, energy storage.

Abstract
Because of their high energy density, lithium ion batteries (LIBs) have become a rapidly growing energy storage technology, particularly in mobile applications, such portable electronics, electric vehicles, etc. Typically, in the LIBs, the cathode materials are considered to be the performance-limiting factor in research designed to increase cell energy and power density. During the cathode materials exploration, the advanced synchrotron-based characterization techniques, such as high-resolution synchrotron X-ray diffraction (HRXRD), in situ high-energy synchrotron X-ray diffraction (HEXRD), and in situ X-ray absorption spectroscopy (XAS), provide novel and powerful tools for investigating the structural evolution of battery materials [1]. Here, in my presentation, I will briefly introduce how synchrotron-based techniques could be utilized for phase identification, fundamental study of structure dynamics, reaction mechanism and doping mechanism. Then, the presentation will be centered on fundamental studies of $LiNi_xMn_yCO_zO_2$ (x+y+z=1) as the cathode materials for Li-ion batteries. Typically, the in-depth investigation of phase transformation behavior in $LiCoO_2$ and single crystal Ni-rich NMC materials will be systematically studied [2-3].

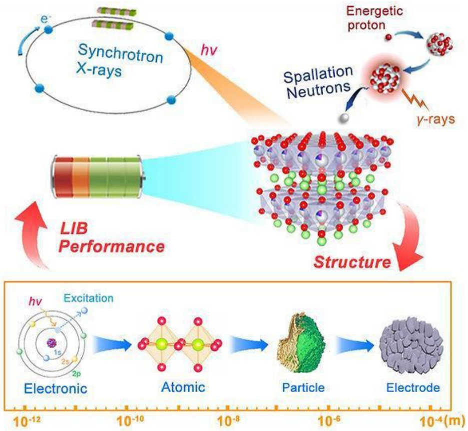

Figure 1: Discovery and Fundamental Studies of Cathode Materials via Advanced Synchrotron Techniques

References

[1] H. Zhu, Y. Huang and Q. Liu et al., **8**, 2003534(2021)

[2] Q. Liu et al., Nature Energy **3**, 936 (2018).

[3] H. Zhu and Q. Liu et al., Nano Letters 21, 9997(2021).

BIOGRAPHY

Dr. Liu Qi is currently an assistant professor in the Department of Physics, City University of Hong Kong. He obtained his Ph.D from Purdue University in 2014. Before joining CityU, he worked as a postdoctoral fellow at Argonne National Laboratory. His current research interests focus on the structure-property-studies of functional materials via multiple neutron- and synchrotron-based techniques. His broad research activities include the design and synthesis of novel energy storage materials, phase transition mechanism and neutron-/synchrotron physics.

[Session I-06] Invited Speaker: Bin LIU

Electrochemical CO_2 Reduction Chemistry over Model Single-Atom Catalyst

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Department of Materials Science and Engineering, City University of Hong Kong

Keywords: Single-atom, CO_2 reduction, in-situ/operando, reaction mechanism.

Abstract

Noble-metal and transition-metal based materials have been demonstrated as promising catalysts for selective electrochemical CO_2 reduction reaction (CO_2RR), however, neither the detailed structures of catalytic intermediates nor the key surface species have been unambiguously identified. In this talk, I am going to present a series of single transition-metal atom catalysts with well-defined structures as model systems to explore the electrochemical CO_2RR chemistry (Figure 1). Employing a combination of operando X-ray absorption spectroscopy, attenuated total reflectance surface enhanced infrared absorption spectroscopy, Raman spectroscopy and Mössbauer spectroscopy, we successfully captured the dynamic evolution of the catalytic centers during the CO_2RR process.

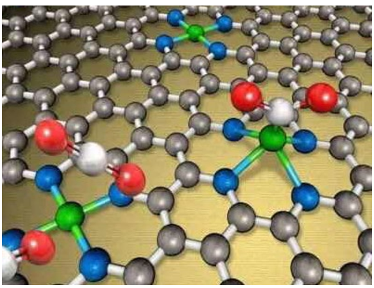

Figure 1. Electrochemical CO_2 reduction over a model single-atom catalyst.

BIOGRAPHY

Bin Liu received his B.Eng. (1st Class Honors) and M.Eng. degrees in Chemical Engineering from the National University of Singapore and obtained his Ph.D. degree in Chemical Engineering from University of Minnesota in 2011. Thereafter, he moved to University of California, Berkeley and worked as a postdoctoral researcher in Department of Chemistry during 2011–2012 before joining School of Chemical and Biomedical Engineering at Nanyang Technological University as an assistant professor in 2012. He was promoted to associate professor in 2017. In February 2023, he moved to Hong Kong, and now he is a professor at the Department of Materials Science and Engineering in City University of Hong Kong. His main research interests include electrocatalysis, photoelectrochemistry, and in situ/operando characterization.

[Session K-09] Keynote Speaker: Michael Chi Kong TSE

Complexity in Grid-Connected Power Electronics and its Impact on Power Grid Development

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Department of Electrical Engineering, City University of Hong Kong

Abstract
A variety of active loads and power conversion systems are connected to the power grid to support various emerging and essential applications. The types of loads and power conversion interfaces are becoming diverse, including EV chargers, power supplies for datacenters, interface systems for renewable sources and storages, grid-forming systems, etc. These systems interact with the grid and with each other, posing stability challenges to the power delivery system due to the complex dynamics of grid-connected power electronics systems as well as the weakening of the inertia necessary for maintaining frequency and voltage control. In this talk, we will present the key set of phenomena arising from the complex dynamics of power converters. We will focus on the two main categories of converters, namely, grid-following and grid-forming converters, and discuss the implications of their inevitable inclusion in the power grid as we strive to escalate the development of cleaner power supply systems.

BIOGRAPHY

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 awarded a number of research and invention prizes, including several Best Paper Prizes from IEEE and other journals, Grand Prize and Gold Medal with Jury's Commendation in Silicon Valley International Invention Festival 2019, Gold Medals with Jury's Commendation in International Exhibition of Inventions of Geneva in 2009 and 2013, Silver Medal in iCAN 2016. He was selected and appointed as IEEE Distinguished Lecturer in 2005, 2010 and 2018. In 2022, the IEEE Circuits and Systems Society awarded him the IEEE CASS Charles A. Desoer Technical Achievement Award in recognition of his outstanding contributions and continued leadership in the development of research in complex behavior of power electronics and energy systems. He has also 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. He is an IEEE Fellow (elected 2005) and an IEAust Fellow (2009).

[Session K-10] Keynote Speaker: Mao-Hsiung CHIANG

Development and Outlook of Offshore Wind Power for Net Zero Carbon Emission in Taiwan

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Keywords: offshore wind, floating wind turbine, Taiwan offshore wind farm, localization, talent cultivation.

Abstract
Taiwan is aiming for 5.7 GW of installed offshore wind capacity by 2025, and overall capacity to 20.7 GW by 2035 for carbon reduction and energy indigenous. Taiwan's first operational offshore wind farm is Formosa 1 Phase 1, whose two 4 MW wind turbines were officially commissioned in April 2017. By combining with the offshore wind farm development and in consideration of domestic industry technical maturity and foreign company planning, commitment of local supply chain and localization of offshore wind turbine, foundation, maritime engineering, etc. are ongoing. For that, the related research and the talent cultivation for wind farm development and supply chain localization become urgent in Taiwan. In December 2022, the first 3 GW auction of Phase 3 Zonal Development for 2026 and 2027 has been open and selected. The trend to develop deeper water zone with water depth over 60 m is clear. The floating offshore wind turbine has become a significant and urgent issue in Taiwan. This presentation introduces the current status and the outlook of policy, industry development, research, and talent cultivation of offshore wind power in Taiwan.

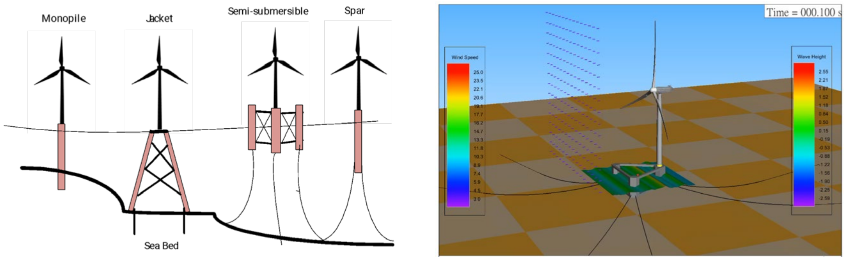

Figure 1: Different types of foundation, and TaidaFloat developed by NTU.

BIOGRAPHY

Prof. Dr. Ing. Mao-Hsiung Chiang obtained the Bachelor degree at the Department of Naval Architecture and Ocean Engineering, National Taiwan University in 1990, and his Master degree at the same department in 1992. Subsequently, he began his study in Institute of Fluid Power Transmission and Control (IFAS), RWTH Aachen University, Germany, in 1994 and achieved the Dr.-Ing. degree in Fluid Power Control in 1998. After that, he was Assistant Professor and then Associate Professor until 2006 at the Institute of Automation and Control, National Taiwan University of Science and Technology. In 2006 he was Associate Professor at the Department of Engineering Science and Ocean Engineering, National Taiwan University (NTU), Taipei, Taiwan. Since 2012, he has been Full Professor at the same department, and from 2015 to 2021 he was the Department Chairman at the same department. Since 2021, he becomes Associate Dean and Distinguished Professor of College of Engineering, NTU. Besides, from 2016 to 2019 he was Principal Investigator, Offshore Wind Power and Marine Energy Focus Center, National Energy Program NEP II, Taiwan. Since 2018, he is Director of Energy Research Center, NTU. He has awarded by many different conference and organization, including Outstanding Research Award, National Science and Technology Council in 2019. His recent research interests include renewable energy system dynamic simulation and control, opto-mechatronic system design and control, and fluid power control.

[Session K-11] Keynote Speaker: Mauro PRAVETTONI

New Reliability Challenges for Solar Deployment in Urban Environment

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Keywords: solar energy, sustainable environment, floating PV, module reliability, BIPV

Abstract

The recent evidence of the need for a further boost in solar photovoltaic (PV) deployment has triggered actions from policymakers, for example in South-East Asia [1]. These are leading to a change of paradigm in the PV community, from established PV applications (mainly: rooftop, and utility-scale for commercial PV modules; but also, space for high-efficiency cells; and to a certain extent indoor and gadgets) towards the exploitation of new "integrated" applications [2]. In 2022 our Institute has co-launched the 1st International Integrated-PV Workshop, bringing together worldwide experts in the following areas: building-integrated PV (BIPV), vehicle-integrated PV (VIPV), agro-PV, floating-PV, and PV integrated into urban infrastructures (e.g. noise-barrier PV, PV fence, road-integrated PV, PV shields, PV-carports, etc.). Modules designed for these novel PV applications require to rethink the test procedures for their qualification and new advanced stress tests will be needed to ensure that modules can withstand these specific operational environments. In this talk, the author will address the stresses to be assessed soon, to ensure PV module reliability in the new paradigm of PV deployment. These can be drafted from the IEC 60068 standard series, taking into account those parameters that are related to floating PV but currently not yet fully integrated into the PV module qualification standards, some of which are summarized in Table 1.

	Mechanical	Thermal /humidity	Irradiance	Chemical
BIPV	Structural performance Noise reduction Vibration	Heat transmittance PID & colour	IAM UV discoloration Hot spot (multi-colour) Reflectance/glare	Salt mist corrosion Ammonia corrosion
VIPV	Vibration Stone impact Sand abrasion Noise reduction Aerodynamic test	Heat transmittance PID + salt mist	IAM (curvature) Hot spot (curvature)	Salt mist corrosion
Agro-PV	Vibration Stone impact Sand abrasion Sand fall	Heat transmittance PID + salt mist / sand fall	IAM (for vertical installations) Photo-transmittance	Salt mist corrosion Ammonia corrosion Soiling cementation
Floating	Dynamic torsion Water shock/drop	PID + salt mist Thermal shock		Salt mist corrosion Ammonia corrosion
Urban-PV	Vibration Stone impact Shock/drop Noise reduction		IAM (vertical PV) UV discoloration Hot spot (multi-colour) Reflectance/glare	Soiling cementation

Table 1: List of stress mechanisms that shall be addressed for novel integrated PV applications.

This research is supported by the National Research Foundation, Singapore. SERIS is a research institute at the National University of Singapore (NUS). SERIS is supported by NUS, the National Research Foundation Singapore (NRF), the Energy Market Authority of Singapore (EMA) and the Singapore Economic Development Board (EDB).

Reference

[1] https://www.greenplan.gov.sg/
[2] IRENA (2019), “Future of Solar Photovoltaic”, Abu Dhabi.

BIOGRAPHY

Dr Mauro Pravettoni is Director of PV Modules for Urban Solar at the Solar Energy Research Institute of Singapore (SERIS), National University of Singapore (NUS). He got his PhD at the Imperial College London. He is co-convenor of Singapore's International Electrotechnical Commission (IEC) Mirror Committee for Solar Energy. He is member of IEC TC82, of the British Society for the Philosophy of Science and Technical Assessor for NATA, the Australian National Agency of Testing Authorities. From 2007 to 2010 he worked at ESTI, the European centre of reference for solar testing. From 2010 to 2016 he did his research on solar metrology in Switzerland. Since 2017 he works at NUS, where he leads SERIS' ISO 17025 accredited Laboratory for Characterization & Reliability of solar modules. Since 2018 he is member of the International Scientific Committee at SNEC, Shanghai. He wrote 30+ peer-reviewed papers, books, and a number of conference proceedings. In 2008 he co-developed the world record efficiency luminescent solar concentrator.

[Session P-07] Plenary Speaker: Sébastien CANDEL

The Future of Air Transportation: Outlook for Electric and Hydrogen Aircraft

Sébastien CANDEL*, **Véranika Latour, Nicolas Vaysse, Antoine Renaud, and Daniel Durox**

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Abstract

Reduction of CO_2 emissions motivated by climate change constitutes a major challenge for society as a whole as it implies a transition from large scale utilization of fossil fuel sources to low carbon energies. The difficulties that will rise from this transition are often underestimated by the public and by decision makers. The challenge for the aviation industry is considerable because this sector has limited alternatives for carbon-neutral power and energy of the kind that exist for ground-based systems which may rely on more wind, solar, hydroelectric, geothermal and nuclear sources of energy. Although aviation is only a minor contributor to the total green house gas output it is committed to reduce its emissions and bring the level to net zero by 2050. This may be conceptually feasible by combining actions in complementary directions. One option consists in pursuing technological improvements in propulsion, aircraft aerodynamics and structural design, a track which has already allowed considerable reductions in fuel burn. The corresponding evolutionary improvements in efficiency are certainly valuable but their potential is limited. A second track that is envisioned is to replace current kerosene fuel by sustainable aviation fuels (SAFs) derived from renewable carbon sources like biomass and hydrogen obtained from low carbon electric energy. More disruptive paths to decarbonization rely on electrically powered aircraft or on hydrogen propulsion. These revolutionary concepts are the subject of scientific and technological evaluation as well as considerable research and development. The objective of this presentation is to provide a comprehensive assessment of these two options starting from basic principles. The focus will be on identifying limitations of current electrical storage and drive units for reducing commercial aviation emissions. A second objective will be to assess

the potential of hydrogen aircraft and analyze some of the key challenges in the utilization of hydrogen as a fuel.

BIOGRAPHY

Sebastien Candel is a University professor emeritus at CentraleSupélec, University Paris-Saclay. He obtained an engineering degree from Ecole Centrale Paris, a PhD from the California Institute of Technology and a Science Doctorate from UPMC (University of Paris 6). His research in the field of combustion focused on flame structures, dynamics and control of combustion, modeling and simulation of turbulent flames, transcritical combustion of cryogenic propellants and his fundamental contributions to the field of aeroacoustics have applications in the energy sector and in the aeronautical and space propulsion domain. Among many distinctions, Sébastien Candel has received the CNRS silver medal, the Marcel Dassault Grand Prize of the French Academy of sciences, the Pendray aerospace literature award of the AIAA, the silver and gold (Zeldovich) medals both from the Combustion Institute. Sebastien Candel is currently chairing the scientific council of EDF. Member and former president of the French Academy of sciences, he is a founding member of the French Academy of Technologies and a foreign member of the National Academy of Engineering of the United States and of the Chinese Academy of Engineering.

[Session P-08] Plenary Speaker: Yves BRÉCHET

Sustainable Nuclear Energy and Global Warming

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French Academy of Sciences
Former High Commissaire for atomic energy, Research Professor in Monash University

Abstract

Nuclear energy is known to be a very low carbonated energy source, and it provides a mature technology providing electricity which can be easily integrated in electrical networks. As such, it can be a powerful tool for decarbonation of our economies, via electrification, and should be considered as such in any long term planning to fight global warming.

As far as matter or space needs are concerned, nuclear energy is a very efficient way f producing electricity. However, various issues need special attention for this solution to be a sustainable one. These issues are on one side with waste management, on the other side on the efficient use of resources in fissile materials. These questions will be addressed from a scientific viewpoint, insisting on the “closure of the fuel cycle”, and on the efficiency of fast neutron devices to do so.

BIOGRAPHY

Yves Bréchet graduated from École Polytechnique (1981), École des hautes études en sciences sociales (1992) and obtained his doctoral degree and habilitation from Joseph Fourier University in 1987 and 1992, respectively.

He has been a full professor at Grenoble INP/Phelma between 1987 and 2012, an adjunct professor of materials science and engineering at McMaster University (Canada), a senior Research Professor at the Institut Universitaire de France, and a member of the SIMaP (Materials and Processes Science and Engineering) Laboratory with the University of Grenoble.

On 30 November 2010 he was elected to the French Academy of Sciences.

He has been a member of the international scientific council of ArcelorMittal and the Commissariat à l'énergie atomique, and a scientific advisor to Rio Tinto Alcan, EDF and ONERA, as well as several editing boards of scientific journals.

On 19 September 2012 he was named to the position of High Commissioner for Atomic Energy and Alternative Energies by the President of the French Republic, succeeding Catherine Cesarsky.

He resigned from this position in 2018, and is now Scientific director of Saint Gobain, while keeping a position as Distinguished Research professor at Monash university, adjunct professor at McMaster university and advisory professor at Jiaotong university. Since 2018 he has been giving a course on "Scientific analysis for political decisions" at the Ecole Nationale d'Administration. He is also president of the Scientific council of Framatome, and president of the scientific council of the non-profit "Maisons pour les Sciences" foundation for scientific education founded by Georges Charpak.

His activities have spanned the fields of physical metallurgy, thermodynamics, microstructures, phase transformations, plasticity, fracture micromechanics, material selection, structural materials design, biointerfaces, structural biomimetics. He has written more than 600 papers, co-authored 6 books and supervised more than 80 doctoral students.

[Session K-12] Keynote Speaker: Robert GUILLAUMONT

Greening Nuclear Energy How and When

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Keywords: nuclear energy, UOX fuel, MOX fuel, long lived radwaste

Abstract
An energy is green if its implementation has low environmental impacts and if it is endless or almost endless. The energy drawn from the flows (light, wind, water, …) is a priori greener than that drawn from stocks (hydrocarbon resources, uranium, ...), but only life cycle analyses make it possible to objectively compare environmental impacts. In normal operation, nuclear energy from thermal neutron power reactors is almost as green as wind or photovoltaic energy, except for the sustainability of the uranium resource and the management of spent fuel. There is debate. Moreover, in the event of an accident leading to the meltdown of the reactor core and loss of containments, the environmental impacts are drastic. That also opens-up controversy about the green aspect of nuclear energy. To increase to green color of nuclear energy, it would be necessary to make better use of uranium, speed up the storage of radioactive waste and increase the containment of radioactivity by reactors in the event of an accident. At the heart of these problems is nuclear fuel.

The most widely used nuclear fuel in thermal neutron reactors (PWR and BWR) is uranium oxide enriched to less than 5% in U235 (UOX) packaged in pellets stacked in zircaloy tubes (clad) themselves joined into sub-assemblies. The enrichment of around 7 tons of natural uranium produces 1 ton of such UOX and 6 tons of depleted uranium. At the best 50 GWd/t per ton of UOX is extracted, i.e. around 1% of the potential energy of fission of natural uranium. Spent nuclear fuel is radioactive and contains unconsumed uranium (U235 and 238) and in-situ produced plutonium. By extracting 50 GWj/t per ton of MOX fuel (8% plutonium oxide mixed with depleted uranium oxide), 10% of natural

uranium is saved, 20% if uranium is also recycled. Multi-recycling could improve the use of uranium.

academic research was on radiochemistry and actinide chemistry along forty years. His expertise focuses on the chemistry matching the nuclear fuel cycle (from uranium mining to waste management to spent fuel reprocessing) and nuclear energy issues. He got his doctorate from the Radium Institute in Paris, Curie laboratory. He headed the Radiochemical Laboratory of the Institute of Nuclear Physic in Orsay and the high-level French teaching of radiochemistry for twelve years. He has been president or member of many French and international committees dealing with nuclear energy and the use of radionuclides for physicians.

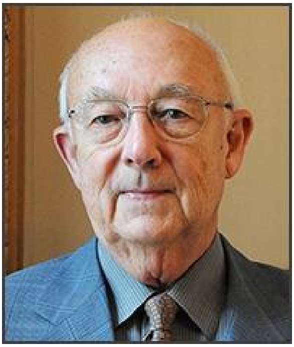
The most widely used nuclear fuel in thermal neutron reactors (PWR and BWR) is uranium oxide enriched to less than 5% in U235 (UOX) packaged in pellets stacked in zircaloy tubes (clad) themselves joined into sub-assemblies. The enrichment of around 7 tons of natural uranium produces 1 ton of such UOX and 6 tons of depleted uranium. At the best 50 GWd/t per ton of UOX is extracted, i.e. around 1% of the potential energy of fission of natural uranium. Spent nuclear fuel is radioactive and contains unconsumed uranium (U235 and 238) and in-situ produced plutonium. By extracting 50 GWj/t per ton of MOX fuel (8% plutonium oxide mixed with depleted uranium oxide), 10% of natural uranium is saved, 20% if uranium is also recycled. Multi-recycling could improve the use of uranium.

The disposal in underground deep geological formation (500 m) of spent fuel or long-lived radioactive waste from its reprocessing to extract uranium and plutonium is the world's reference. Two spent fuel granite storage facilities are under construction (Finland and Sweden). In France the file of a disposal in clay is in progress.

The rise in core temperature of an uncooled reactor above 1000°C leads to the deterioration of the clad, the first containment barrier. Many chemical reactions come into play. The clad can be made stronger by various treatments. Ceramic clads are even being considered.

The theoretical prospects offered by multi-recycling Generation IV fast neutron reactors multi-recycling their own spent fuel, or even transmuting long-lived radionuclides as well as small modular reactors in all their forms, fueled by solid or liquid fuels, and above all intrinsically safe, are attractive for greening nuclear energy. But this is a paradigm shift in nuclear energy that still requires long research and technological maturation. Then the nuclear energy of the future, if implemented, could be greener than today.

BIOGRAPHY



Robert Guillaumont is emeritus Professor of Chemistry/Radiochemistry at Paris XI-Orsay (now Paris-Saclay) University. He is a member of the French Academy of Sciences (chemistry section) and of the Academy of Technology (founding member). His field of academic research was on radiochemistry and actinide chemistry along forty years. His expertise focuses on the chemistry matching the nuclear fuel cycle (from uranium mining to waste management to spent fuel reprocessing) and nuclear energy issues. He got his doctorate from the Radium Institute in Paris, Curie laboratory. He headed the Radiochemical Laboratory of the Institute of Nuclear Physic in Orsay and the high-level French teaching of radiochemistry for twelve years. He has been president or member of many French and international committees dealing with nuclear energy and the use of radionuclides for physicians.

[Session In-1] Invited Speaker: Xixiang XU

Roadmap to High Efficiency Silicon Solar Cells and Its Mass Production

Xixiang XU

Vice President
LONGi Central R&D Institute

BIOGRAPHY

Dr. Xixiang Xu is the vice president of LONGi Central R&D Institute. He has over 30-year experience in photovoltaic & semiconductor device technology development, technology transfer and materials characterizations. His research work focuses on photovoltaic technology, including silicon heterojunction solar cell, perovskite tandem solar cell, back-contacted solar cell and other innovative PV technologies. He leads the research team at LONGi and broke the efficiency record of SHJ cell 12 times, pushing the efficiency to 26.81% which is the highest efficiency of all silicon based solar cells. He is a recipient of grant for “outstanding young scientists” of National Foundation of Science and Technology, Japan NEC C&C Foundation fellowship and “Hundred Talent Plan” in Sichuan, China.

[Session In-2] Invited Speaker: Daniel FUNG

Clean Energy Solutions for Hong Kong

Daniel FUNG

Head of Strategy & Innovation and Commercial – HK Utility
The Hong Kong and China Gas Company Ltd. (Towngas)

BIOGRAPHY

Mr. Daniel Fung joined Towngas as Graduate Trainee in 1987. He has worked in customer services, sales and marketing, corporate investment, e-commerce, strategy and innovation areas during the last 35 years. He is currently the Head of Strategy & Innovation and Commercial - HK Utility, responsible for formulating strategy and fostering innovation culture for the Group as well as looking after the gas business in Hong Kong.

Daniel holds a Master degree in Information System and a Bachelor degree in Industrial Engineering. He is a chartered member of the Institution of Gas Engineer and Manager. He is currently Council Member and Chairman of Group 6 of The Federation of Hong Kong Industries, Member of Hong Kong Q-Mark Council, and Member of Advisory Committee of School of Energy and Environment (SEE) of City University of Hong Kong.

[Session In-3] Invited Speaker: Wei SUN

The Development and Application of Lithium Energy Storage Products

Wei SUN
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Senior Engineer and Technical Director
Tianneng Saft Energy Joint Stock Company

BIOGRAPHY

Wei Sun is a senior engineer and technical director at Tianneng Saft Energy Joint Stock Company. He got his Ph. D degree at Dalian Institute of Chemical Physics, CAS and was research associate at IUPUI (Indiana University-Purdue University Indianapolis) for 3 years; His research fields include Lithium ion batteries, Fuel cells, and related key parts etc. Having experience of materials research, cell development, system integration. Since joining Tianneng group, he developed lithium ion battery and pack with high energy density and long cycle life for EV and ESS applications. He is a key member in the team of " Leading innovative technology in Zhejiang Province". In 2016, he was selected as a key member in 151 talents project in Zhejiang Province.

[Session In-4] Invited Speaker: Yi PAN

LIB progress and Prospects for xEV Applications

Yi PAN

Senior Manager
BYD Subsidiary - FinDreams Battery Co., Ltd.

BIOGRAPHY

Worked for the lithium-ion battery business of BYD Co. for 16 years, engaged in the development of new energy vehicle battery technology. Has been responsible for various technology research and product development projects, proficient in mechanism research and innovation. Currently serves as the head of the basic research team, committed to promoting cutting-edge innovation in lithium-ion batteries.

[Session In-5] Invited Speaker: Raymond LEUNG

Battery Energy Storage System of Low Voltage Smart Grid

Raymond LEUNG

Chief Technology Officer
Huawei International Co. Ltd.

BIOGRAPHY

Raymond Leung is currently the Chief Technology Officer of Huawei International Co. Limited. He is a strategy leader with board experience in defining and implementing strategic plans to capture the growth opportunities of digital transformation. Prior to working with Huawei, Raymond has been associated with reputed organizations such as Schneider Electric to deliver advance digital solution and energy management platform in the market. He has also played a key role in establishing overall setups in Mainland China and secured multiple contracts at Siemens. Throughout his working experience in different countries, Raymond has demonstrated a proven track record and dedicated to work in the past 30 years. Raymond is a control and instrumentation engineer and a Bachelor in Engineering from the University of Hong Kong.

[Session I-07] Invited Speaker: Chunyi ZHI

Stable Zn Anode and High Energy Cathodes for Aqueous Zn Batteries

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Keywords: carbon-zero, clean energy, sustainable environment

Abstract

Development of energy storage system in the past year focus on improvement of energy density. While the progress is remarkable, safety problems of lithium-ion batteries (LIB) have been intensively exposed. On one hand, LIB is not intrinsically safe with very active anode, flammable electrolyte and oxygen-releasing cathode; on the other hand, many application scenarios actually don't require very high energy density.

Numerous reports of extremely stable Zn anode judged from the symmetrical cells have been published, which remarkably deviated from data of the asymmetrical or full cells in terms of accumulated cycling lifetime. After a thorough analysis, we conclude that soft short circuit, which cannot be distinguished by the widely used galvanostatic cycling tests, prevails in a plethora of reported Zn anodes and leads to a super-stable illusion. Then we propose several pertinent test protocols that can be combined with galvanostatic cycling test to evaluate a symmetric cell and characterize the stability of a Zn anode. In particular, the R_{ct}^{0} measured at a low current density and the Ea of the stripping/plating reactions can be two complementary indicators for the occurrence of SS, thereby avoiding mis-judgment of the Zn anode stability. The comprehensive understanding of SS in this work can be a good start to inspire more rational and reliable endeavours toward the Zn anode research. Since other metal anodes (Li, Na, K, Mg et.al) share similarities in electrochemical behaviours, the proposed protocols in this commentary can also be extended for reporting reliable results in those research fields.

Reference
[1] Zhao, Y.; Lu, Y.; Li, H.; Zhu, Y.; Meng, Y.; Li, N.; Wang, D.; Jiang, F.; Mo, F.; Long, C.; Guo, Y.; Li, X.; Huang, Z.; Li, Q.; Ho, J.; Fan, J.; Sui, M.; Zhu, W.; Liu, W.; Zhi, C., Few-layer bismuth selenide cathode for low-temperature quasi-solid-state aqueous zinc metal batteries, Nature Communications 13, (2022): 752.
[2] Li, Q.; Chen, A.; Wang, D.; Zhao, Y.; Wang, X.; Jin, X.; Xiong, B.; Zhi, C., Tailoring the metal electrode morphology via electrochemical protocol optimization for long-lasting aqueous zinc batteries, Nature Communications 13 (2022): 3699.
[3] Chen, Z.; Cui, H.; Hou, Y.; Wang, X.; Jin, X.; Chen, A.; Yang, Q.; Wang, D.; Huang, Z.; Zhi, C.; Anion chemistry enabled positive valence conversion to achieve a record high-voltage organic cathode for zinc batteries, Chem 8 (2022):2204.
[4] Li, X.; Huang, Z.; Shuck, C.; Liang, G.; Gogotsi, Y.; Zhi, C., MXene chemistry, electrochemistry and energy storage applications, Nature Review Chemistry 6 (2022): 389.

BIOGRAPHY

Prof. Chunyi ZHI obtained B.S. degree in Physics from Shandong University and Ph.D. degree in condensed matter physics from Institute of Physics, Chinese Academy of Sciences. After two years' postdoc in National Institute for Materials Science (NIMS) in Japan, he was promoted to be ICYS researcher, researcher (faculty) and senior researcher (permanent position) in NIMS. Dr. Zhi is now a professor in MSE, CityU. Dr. Zhi has extensive experiences in flexible energy storage, aqueous electrolyte batteries, zinc ion batteries and highly thermally conducting insulating polymer composites. He has published more than 400 papers with an h-index of 105 and other-citation of ~39000 (ISI). He has been granted more than 100 patents. Dr. Zhi is a recipient of the outstand research award and the President's Award City University of Hong Kong, NML researcher award, and Beijing Science and Technology Award (first class). He is Clarivate Analytics Global highly cited researcher (2019-2022, Materials Science), RSC fellow and member of The Hong Kong Young Academy of Sciences.

[Session I-08] Invited Speaker: Minhua SHAO

Development of High Performance and Durable Fuel Cell Electrocatalysts

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Abstract
Low temperature fuel cells are electrochemical devices that convert chemical energy directly to electricity. They have great potential for both stationary and transportation applications and are expected to help address the energy and environmental problems that have become prevalent in our society. Despite their great promise, commercialization has been hindered by lower than predicted efficiencies and high loading of Pt-based electrocatalysts in the electrodes. For more than five decades, extensive work has being focused on the development of novel electrocatalysts for fuel cell reactions. In this talk, I will present recent progress in developing advanced electrocatalysts and their fuel cell performance in my group, with an emphasis on core-shell and non-previous metal materials.

BIOGRAPHY

Minhua Shao is Cheong Ying Chan Professor of Energy Engineering and Environment, Chair Professor in the Department of Chemical and Biological Engineering at the Hong Kong University of Science and Technology (HKUST). He is also the Director of the HKUST Energy Institute. He earned BS and MS degrees in Chemistry from Xiamen University, and a PhD degree in Materials Science and Engineering from the State University of New York at Stony Brook. Dr. Shao joined UTC Power in 2007 leading the development of advanced electrocatalyts for fuel cells, and was promoted to UTC Technical Fellow in 2012. In 2013, he joined Ford Motor Company to conduct research on lithium-ion batteries. He then joined HKUST in 2014. He is an Associate Editor of Journal of the Electrochemical Society. He has published over 230 peer-reviewed articles, 1 edited book and filed over 30 patent applications (19 issued). He has also received a number of awards, including the International Outstanding Young Chemical Engineer Award (2022), Supramaniam Srinivasan Young Investigator Award from the ECS Energy Technology Division (2014). He is one of the founding members of Young Academy of Science of Hong Kong.

[Session K-13] Keynote Speaker: Patrice SIMON

Electrochemistry at the Nanoscale: Tracking Ion Fluxes in Electrodes for Energy Storage Applications

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Abstract
This presentation will give an overview of the research work achieved on capacitive (porous carbon) and high-rate redox (pseudocapacitive) materials, and will show the challenges/limitations associated with the development of these materials. Starting with porous carbons [1,2], we will present the state-of-the art of the fundamentals of ion adsorption mechanism in confined pores of porous carbon electrodes and its practical applications. Moving from double layer to high-rate redox materials, we will show how the control of the material and electrode structures can help in preparing high power battery electrodes using 2-Dimensional MXene materials [3-5]. This set of results suggests that understanding of electrosorption under confinement in porous and layered materials, that results in improved electrochemical performance, could be explained by the electrolyte ion partial desolvation observed when confined in nanopores (porous carbons) or in interlayer spacing (2D materials) [6]. Understanding confined electrochemical systems and coupling between chemical, electrochemical, and transport processes in confinement may open tremendous opportunities for energy applications in the future.

In a last part, we will introduce a new in-plane electrochemical impedance spectroscopy technique that allows to deconvolute the ionic and electronic contributions of the total impedance in the plane of the electrode, at different potentials. This novel set-up comes as a new tool to further evaluate and improve the performance of electrode materials for energy storage devices by bringing new insights regarding the electronic and ionic transport mechanisms in energy storage electrodes during operation.

Reference
[1] H. Shao. et al., Chemical Society Reviews, 2020, 49, 3005-3039
[2] P. Simon and Y. Gogotsi, Nature Materials 19 (11), (2020) 1151-11633
[3] I. Wu et al., Angew. Chem. (2021),133,2–8.
[3] B. Anasori et al., Nature Reviews Materials, vol. 2, no. 2, 2017, pp. 17.
[4] X. Wang, et al., Nature Energy 4, 241–248 (2019)
[5] Y. Li et al., Nature Materials (2020), 19, (2020) 894–899
[6] S. Fleischmann et al., Nature Energy 2022.

BIOGRAPHY

Patrice Simon is Distinguished Professor of Material Science at the Université Toulouse III - Paul Sabatier and member of the French Academy of Sciences (2019) and French Academy of Technology (2018).

He is former director of the Alistore European Research Institute (www.alistore.eu) dedicated to Li-ion battery research and Deputy Director of the French network on Electrochemical Energy Storage (RS2E, www.energie-rs2e.com).

His research activities focus on the fundamental understanding of electrochemical processes occurring at the material / electrolyte interfaces in electrodes for electrochemical energy storage devices (batteries and electrochemical capacitors). He published about 250 papers (h-index 86, 70,000 citations).

He received several awards for his scientific contribution including Grants from the European Research Council (2012, 2020), Conway Prize in Electrochemistry from ISE (2018), the Silver Medal from the CNRS (2015), International RussNanoprize (2015). He is Fellow of the International Society of Electrochemistry (2017), RSC Horizon Prize (2021).

Patrice Simon is member of the European Academy of Sciences (2019), and Institut Universitaire de France (2017).

[Session K-14] Keynote Speaker: Jean-François GUILLEMOLES

Hard or Soft? The Way to Resilience and Reliability for New Photovoltaic Energy Materials

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Keywords: solar energy, sustainable materials, resilient materials

Abstract

Materials for photovoltaic energy conversion have made huge progress in the past decades, both in labs, and for applications. They had first to demonstrate high efficiency: solar cells at 40% efficiency in standard operating conditions have been demonstrated [1]. Low cost and economic sustainability had also to be achieved. Today, solar energy is the best option in many places around the world. Last but not least, reliability is also one of the roadblocks to large scale applications and current technologies can operate for 30 years or more.

Yet, evidence for reliability is slow by nature: it has to be shown in the field, over time, under all the extreme conditions that can be encountered. Under environmental stresses, heat, cold, water, hails and storms, space radiations, bond breaks, atoms move and react, leading to defects that catalyse conversion losses. No wonder that most used photovoltaic materials are sturdy materials, with strong bonds, such as single crystalline Silicon. Is there another way? This presentation will discuss defect mitigation and self-healing in photovoltaic materials. Evidence for self-healing has already been demonstrated in the past [2-5]. New evidence will be presented, together with correlations between such self repair of materials and some fundamental, a priori unrelated, thermomechanical properties.

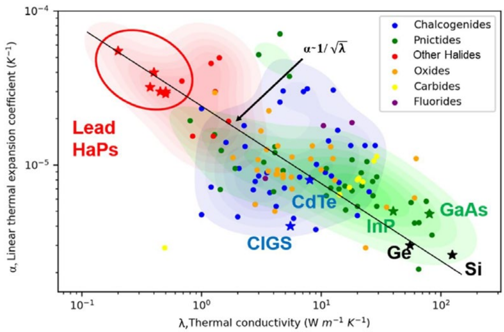

Figure 1: Ashby-like plot of thermo-mechanical properties or important photovoltaic materials compared to other semiconductors.

Reference
[1] Martin A. Green, et al, Progress in Photovoltaics, https://doi.org/10.1002/pip.3646.
[2] J.-F. Guillemoles, U. Rau, L. Kronik, H.-W. Schock, and D. Cahen, Adv. Mater. 11, 957 (1999)
[3] S. Kumar, G. Hodes, and D. Cahen, MRS Bull. 45, 478 (2020)
[4] D.R. Ceratti, Y. Rakita, L. Cremonesi, et al., Adv. Mater. 30, 1706273 (2018).
[5] D. Cahen, L. Kronik, and G. Hodes, ACS Energy Lett. 6, 4108 (2021).

BIOGRAPHY

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