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DMSE

2nd KAIST Emerging Materials e-Symposium

Korea Advanced Institute of Science and Technology (KAIST) / Nov. 16-18, 2021

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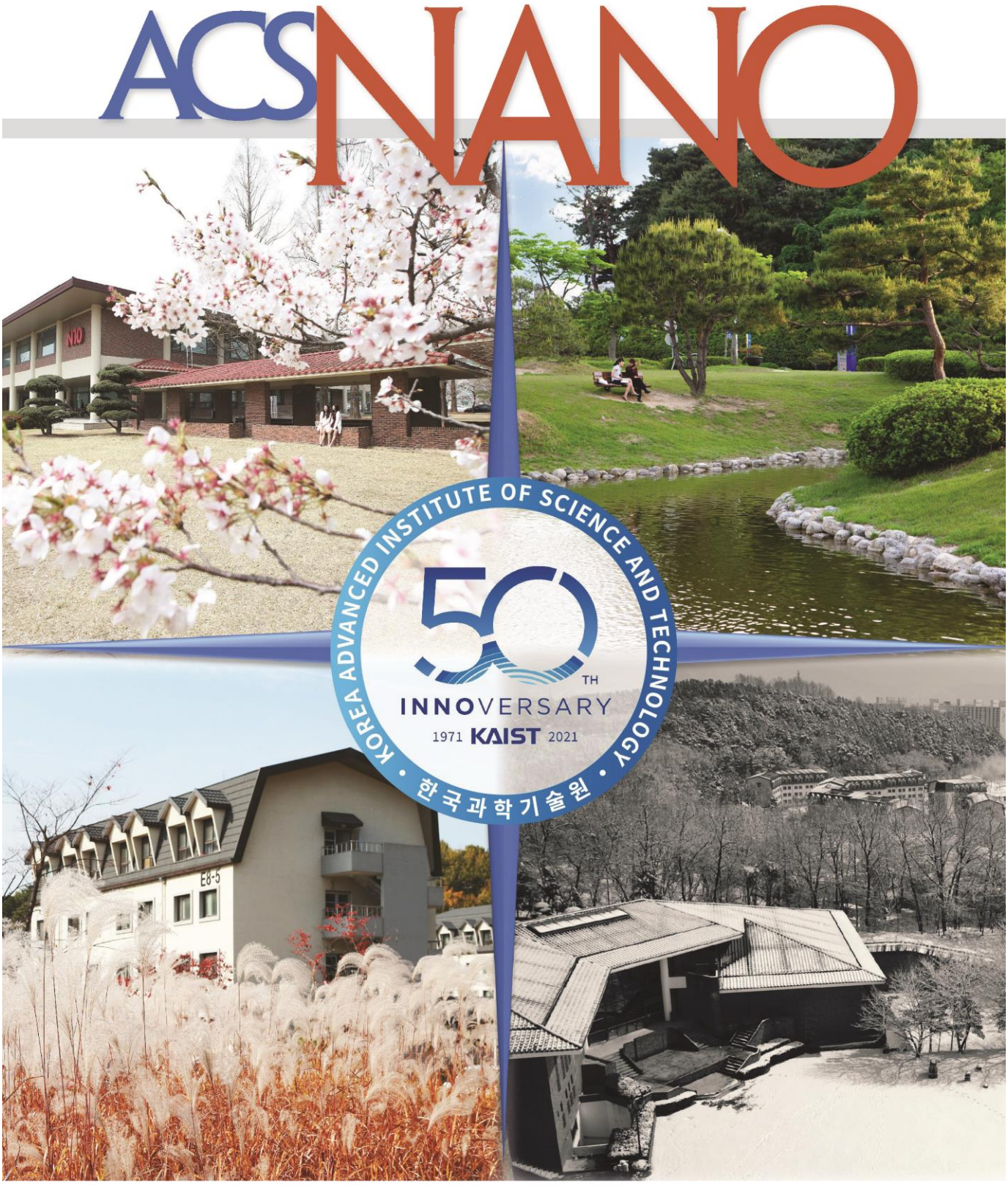


❖Highlight in MSE at KAIST

KAIST DMSE

In the recently announced " 2022 QS World University Ranking," the Department of Materials Science and Engineering (DMSE) at KAIST was ranked 16th within the subject of Materials Science. The continued rise in DMSE's standings over the past decade, from 42th at 2011, attests to the exceptional levels of improvement in the overall quality of the department. In 2020, DMSE led the publication of a commemorative editorial on ACS Nano as a celebration of the 50th anniversary of the founding of KAIST.

2nd KAIST Emerging Materials e-Symposium

Korea Advanced Institute of Science and Technology (KAIST) / Nov. 16-18, 2021

Welcome Letter

http://ems2021.kaist.ac.kr

Dear colleagues,

It is a great pleasure to welcome you to the **2nd KAIST Emerging Materials Symposium**, scheduled for **November 16-18, 2021 *via* Online Zoom presentation**. The 2nd KAIST Emerging Materials Symposium aims to provide a highly engaging forum for students, scientists, and engineers to share the latest breakthroughs and great achievements in the development of novel materials with unique properties and functionality supported by rigorous physical and chemical characterizations.

This symposium features highly impactful presentations by 23 distinguished keynote speakers.

The goal of 2nd KAIST Emerging Materials Symposium is to identify the key issues related to big ideas in materials science, applied physics, and chemistry including following topics: 1) Innovations for Energy Materials, 2) Advanced Nanostructures for Emerging Applications, 3) New Opportunities for Chemical and Bioengineering.

We invite you to join us at the 2nd KAIST Emerging Materials Symposium to share in this meaningful exchange of great, innovative ideas in materials research.

KAIST welcomes all the participants to join in this memorable experience. Thank you for participating!

Up to three thousand people can simultaneously access through the Zoom Webinar (when exceeded, through Youtube and KouShare), and Q&A will be conducted on the chat window. All participants will be muted during the lectures.

Prof. Il-Doo Kim
Chairman of the Organizing Committee
Il-Doo Kim
*idkim@kaist.ac.kr

Organizing Committee

- General Chair — *Il-Doo Kim** / KAIST Dept. Materials Science and Engineering
- General Co-Chair — *Seungbum Hong* / KAIST DMSE
- Program Chair — *Sung-Yoon Chung, Kibum Kang* / KAIST DMSE
- Program Committee — *Hamin Shin, Jaewan Ahn, Min Soo Kim, Chungseong Park, Lu Song* / KAIST DMSE

Co-Chair

Program Chair

Program Committee

2nd KAIST Emerging Materials e-Symposium

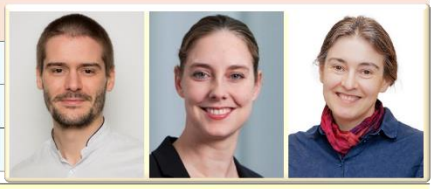
Lectures available on zoom & YouTube & 蔻享学术 KouShare

Program Overview

Korea Standard Time (KST)	**Session I** (Emerging Energy Materials)
Session Chair: Prof. WooChul Jung	Nov. 16 (Tue) 9:30 am – 12:00 pm
09:30 – 09:40	Kwang Hyung Lee (KAIST President) - Opening remarks
09:40 – 09:45	Il-Doo Kim (Chair) - Opening remarks
09:45 – 10:30	Edward H. Sargent (U. Toronto)
10:30 – 11:15	Gleb Yushin (Georgia Tech)
11:15 – 12:00	M. Stanley Whittingham (Binghamton) Nobel Prize Laureate

Session II (Emerging Energy Materials)	
Session Chair: Prof. Il-Doo Kim	Nov. 16 (Tue) 1:00 pm – 4:00 pm
13:00 – 13:45	Xin Li (Harvard)
13:45 – 14:30	Jun Lu (Argonne)
14:30 – 15:15	Chongmin Wang (PNNL)
15:15 – 16:00	Sung-Yoon Chung (KAIST)

Session III (Emerging Energy Materials)	
Session Chair: Prof. Il-Doo Kim	Nov. 16 (Tue) 6:30 pm – 8:45 pm
18:30 – 19:15	Alexis Grimaud (CNRS)
19:15 – 20:00	Jennifer L. M. Rupp (MIT & TU Munich)
20:00 – 20:45	Clare P. Grey (Cambridge)

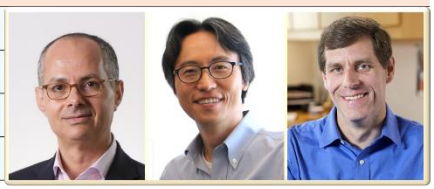


Session IV (Emerging Bio- & Nano-Materials)	
Session Chair: Prof. Kibum Kang	Nov. 17 (Wed) 9:00 am – 12:15 pm
09:00 – 10:00	ACS Nano Editors Session (Panel Discussion)
10:00 – 10:45	Reginald M. Penner (UC Irvine)
10:45 – 11:30	Raymond E. Schaak (Penn State)
11:30 – 12:15	Cherie R. Kagan (U. Penn)

Session V (Emerging Advanced Materials)	
Session Chair: Prof. Byungha Shin	Nov. 17 (Wed) 1:00 pm – 4:00 pm
13:00 – 13:45	Deji Akinwande (UT Austin)
13:45 – 14:30	Jillian M. Buriak (U. Alberta)
14:30 – 15:15	Ali Javey (UC Berkeley)
15:15 – 16:00	Paul S. Weiss (UCLA)

Session VI (Emerging Functional Materials)	
Session Chair: Prof. Il-Doo Kim	Nov. 17 (Wed) 6:30 pm – 8:45 pm
18:30 – 19:15	Wolfgang J. Parak (U. Hamburg)
19:15 – 20:00	Yury Gogotsi (Drexel)
20:00 – 20:45	Patrice Simon (UT3 Paul Sabatier)

Session VII (Advanced Nanomaterials)	
Session Chair: Prof. Steve Park	Nov. 18 (Thu) 9:30 am – 12:00 pm
09:30 – 10:15	Omar M. Yaghi (UC Berkeley)
10:15 – 11:00	Jiwoong Park (U. Chicago)
11:00 – 11:45	Mark C. Hersam (Northwestern)
11:45 – 12:00	Closing remarks



KAIST
Korea Advanced Institute of Science and Technology

2nd KAIST Emerging Materials e-Symposium

ACS Nano Panel Discussion

***Zoom online webinar* / 09:00 - 10:00, Nov. 17, 2021 (KST)**

ACS Panel Discussion: Future Opportunities in Materials Science Research

It is with great pleasure that I write to invite you to the ACS Nano Panel Discussion session at the 2nd KAIST Emerging Materials e-Symposium, on November 17 2021. The discussion will offer the panelists' thoughts on the future opportunities in materials science research.
Attending panelists are Prof. Paul S. Weiss (EIC), Prof. Ali Javey, Prof. Cherie Kagan, Prof. Deji Akinwande, Prof. Jillian Buriak, Prof. Mark Hersam, Prof. Raymond Schaak, Prof. Reginald Penner, Prof. Wolfgang Parak, and Prof. Yury Gogotsi (Assoc. editor). We believe this discussion will be particularly beneficial to the graduate students, and we would like to encourage all graduate students to attend the session. The session will commence from 09:00 AM to 10:00 AM *via* Zoom online webinar (KST). Additional information about the event can be found in the attached leaflet.
I look forward to seeing you at the ACS Nano Panel Discussion on November 17.

Yours sincerely,
Prof. Il-Doo Kim Il-Doo Kim

ACS Chemistry for Life®

ACSNANO

About ACS Nano

ACS Nano is an international forum for the communication of comprehensive articles on nanoscience and nanotechnology research at the interfaces of chemistry, biology, materials science, physics, and engineering. Moreover, the journal helps facilitate communication among scientists from these research communities in developing new research opportunities, advancing the field through new discoveries, and reaching out to scientists at all levels.

Paul S. Weiss
UCLA

Ali Javey
UC Berkeley

Cherie R. Kagan
U. Penn

Deji Akinwande
UT Austin

Jillian M. Buriak
U. Alberta

Mark C. Hersam
Northwestern

Raymond E. Schaak
Penn State

Reginald M. Penner
UC Irvine

Wolfgang J. Parak
U. Hamburg

Yury Gogotsi
Drexel

KAIST
Korea Advanced Institute of Science and Technology

2nd KAIST Emerging Materials e-Symposium

CV & Abstract Book – Table of Contents

Nov. 16 (09:45-10:30)

Edward H. Sargent

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Prof. Edward H. Sargent received the B.Sc.Eng. (Engineering Physics) from Queen's University in 1995 and the Ph.D. in Electrical and Computer Engineering (Photonics) from the University of Toronto in 1998. He holds the rank of University Professor in the Edward S. Rogers Sr. Department of Electrical and Computer Engineering at the University of Toronto. He holds the Canada Research Chair in Nanotechnology and also serves as Vice President – Research for the University of Toronto. His publications have been cited 68,000 times. Recently it was announced that he will start a research laboratory in Chemistry and ECE at Northwestern University.

Nanomaterials for Consumer Electronics and for Energy Decarbonization

Edward H. Sargent *

University of Toronto
**ted.sargent@utoronto.ca*

Materials such as quantum dots, perovskites, and metal nanoparticles have seen rapid advancements in their synthesis and the understanding of their physicochemical properties. I will discuss ways in which the community is levering this control over properties in applications such as optical sensors (including fast ones for LIDAR), light-emitting diodes for displays, photovoltaics, and electrocatalysts for energy and chemicals decarbonization.

Nov. 16 (10:30-11:15)

Gleb Yushin

Professor and Professor and a Mifflin Hood Chair
in the Department of Materials Science and Engineering
at Georgia Institute of Technology
Email: yushin@gatech.edu
Website: http://energymatlab.kaist.ac.kr

Prof. Gleb Yushin is a Professor and a Mifflin Hood Chair in the School of Materials Science and Engineering at the Georgia Institute of Technology and an Editor-in-Chief of Materials Today, the flagship journal of the Materials Today family (100+ journals) dedicated to covering the most innovative, cutting edge and influential work of broad interest to the materials science community. Prof. Yushin is also a co-founder and CTO of a Georgia Tech startup Sila Nanotechnologies, Inc., advanced battery materials company currently employing nearly 300 people and valued at over $3B. Prof. Yushin pioneered transformative developments of advanced materials for next generation rechargeable batteries for clean energy and transportation. Prof. Yushin was selected to become a recipient of the Outstanding Achievement in Research Innovation Award by Georgia Tech (2019), a finalist and Honoree of the Blavatnik Award for Young Scientists by the New York Academy of Sciences (2017, 2018), distinguished as one of the "Leading and Most Cited Researchers in Sciences Around the World" by Clarivate Analytics (2017-2021) and was elected to the Hall of Fame of his alma mater (NCSU, College of Engineering, MSE, 2018). Prof. Yushin is a Fellow of the EU Academy of Sciences, a Fellow of the National Academy of Inventors (NAI), a Fellow of the Materials Research Society (MRS) and a Fellow of The Electrochemical Society (ECS). Prof. Yushin holds over 140 US and international patents and patent applications (all licensed or assigned to companies), has given over 130 invited and keynote presentations, and has published over 160 highly impactful papers that have been cited by over 35 thousand times.

Conversion Materials and Solid Electrolytes for Next Generation Lithium-Ion Batteries

Gleb Yushin*

School of Materials Science & Engineering, Georgia Institute of Technology
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During the last 30 years the evolutionary improvements in lithium-ion battery (LIB) technologies increased LIB volumetric and gravimetric energy densities by over 3 times and reduced cell price by up to 50 times. As a result, LIBs mostly replaced other rechargeable battery technologies for most portable applications.[1] Very large future demand is projected based on the gradual cost reduction in LIB cells from the current $100-250 kWh-1 to below $70 kWh-1. To accelerate the transition to renewable energy economy and electric transportation the cost of LIBs should be reduced rapidly and drastically. This can become feasible if traditional intercalation-type active electrode materials in LIB construction are replaced with low-cost, broadly available, high-capacity conversion-type active materials, such as silicon (Si)-based anodes and metal fluoride (e.g., 3LiF/Fe)-based or sulfide (Li_2S)-based cathodes. A transition to conversion-type LIB chemistries should enable cost reduction down to $30 kWh^{-1}. However, conversion active materials suffer from multiple limitations, such as large volume changes, low conductivity, and unfavorable interactions with liquid electrolytes, commonly leading to low attainable energy density, significant impedance growth, rapid capacity decay and premature cell failure. The use of nanostructured composite materials or solid electrolytes may overcome such limitations.[2-5] Material and nanocomposite engineering proved to be capable of (i) improving kinetics of electrochemical reactions, (ii) preventing localized mechanical failure and degradation of the solid electrolyte interphases, and (iii) preventing dissolution of active materials during cycling. Precise control over nanocomposite chemistry and dimensions is commonly needed to attain the desirable material characteristics. However, for practical applications, synthesis methods need to additionally be inexpensive at scale and rely on the use of low-cost, broadly available precursors. In addition, it is important that novel materials remain fully compatible with currently operating and planned LIB factories.

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[4] F. Wu and G. Yushin, "Conversion Cathodes for Rechargeable Lithium and Lithium-Ion Batteries", ***Energy & Environmental Science***, 10 (2), 435-459, 2017.
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Nov. 16 (11:15-12:00)

M. Stanley Whittingham FRS

Distinguished Professor in the Department of Chemistry and Materials Science and Engineering at Binghamton University
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Website: https://www.binghamton.edu/centers/necces/people/

Prof. Stanley Whittingham is is a SUNY distinguished professor of chemistry and materials science and engineering at Binghamton University and the 2019 Chemistry Nobel Laureate. He received his BA and D Phil degrees in chemistry from Oxford University, where he is an honorary Fellow of New College. He has been active in Li-batteries since 1971 when he won the Young Author Award of the Electrochemical Society for his work on beta-alumina. In 1972, he joined Exxon and discovered the role of intercalation in battery reactions, which resulted in the first commercial lithium rechargeable batteries that were built by Exxon Enterprises. In 1988 he returned to academia at SUNY Binghamton to initiate a program in materials chemistry. In 2018 he was elected a member of the National Academy of Engineering and received the Turnbull Award from MRS. He is a Fellow of the Royal Society, of MRS, ECS, ISE and ICDD.

The Lithium Battery, from a Dream to Readiness to take on Climate Change – Opportunities and Challenges

M. Stanley Whittingham*

Chemistry Department, Binghamton University
**E-mail: stanwhit@binghamton.edu*

The current global climate challenges call for serious attention to carbon-free renewable energy technologies such as solar and wind, in addition to hydro and nuclear. The former two are intermittent producers of energy, so storage is essential. Batteries provide the most flexible means of storing electrical energy, varying in size from milliWatthours to gigaWatthours and being portable or fixed. Lithium-ion batteries dominate this storage. I will discuss their origins,[1] their present status and the challenges facing us if we are to further increase their energy density and reduce their cost whilst increasing safety and lifetime. I will place emphasis on the challenges of pushing the limits of the high nickel layered oxides,[2-4] and on the opportunity to use cathodes that have redox couples over at least three oxidation states, such as ε-$VOPO_4$.[5,6]

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Nov. 16 (13:00-13:45)

Xin Li

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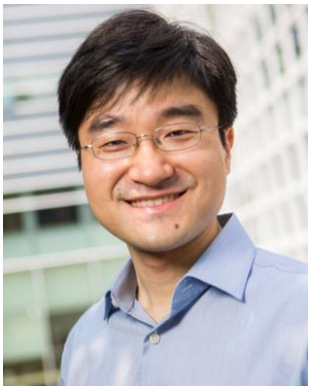

Prof. Xin Li is an associate professor of materials science at the School of Engineering and Applied Sciences, Harvard University. Xin Li's research group designs new energy-related materials and systems through advanced synthesis, characterization, and simulation, with the current focus on solid-state batteries and unconventional superconductors. Xin Li received his B.S. degree in physics from Nanjing University, China, his Ph.D. degree in materials science and engineering from Prof. Dickey's group at Pennsylvania State University and performed postdoctoral research in Prof. Zewail's group at CalTech and Prof. Ceder's group at MIT before joining Harvard in 2015.

What Makes Solid-State Batteries Special? -Principles, Progress and Challenges

Xin Li

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Solid-state batteries pose new challenges to the battery design due to the unique solid-solid interfaces at battery cathode and anode. However, these interfaces, upon critical understanding and design, also form a special opportunity to unlock advanced battery performances. We design solid state batteries based on our unique mechanical constriction principle and the constrained ensemble computational platform, for a stable cycling toward performance relevant conditions. More challenges to the design of all-solid-state batteries are also discussed within the constrained ensemble framework.

Nov. 16 (13:45-14:30)

Jun Lu

Senior Scientist
Chemical Sciences and Engineering Division
Argonne National Laborotory
Email: junlu@anl.gov

Dr. Jun Lu is a chemist at Argonne National Laboratory. His research interests focus on the electrochemical energy storage and conversion technology, with main focus on beyond Li-ion battery technology. Dr. Lu earned his bachelor degree in Chemistry Physics from University of Science and Technology of China (USTC) in 2000. He completed his Ph.D. from the Department of Metallurgical Engineering at University of Utah in 2009 with a major research on metal hydrides for reversible hydrogen storage application. He is the awardee of the first DOE-EERE postdoctoral fellow under Vehicles Technology Program from 2011-2013. He is also the first awardee of IAOEES Award for Research Excellence in Electrochemistry Energy in 2016. He is the associate editor of ACS Applied Materials and Interfaces. Dr. Lu has authored/co-authored more than 450 peer-reviewed research articles, including Nature, Science, Nature Energy, Nature Nanotechnology; Chem. Rev.; Nature Commun.; PANS, JACS; etc, and has filed over 20 patents and patent applications.

Li-oxygen Battery: From Open System to Close System

Jun Lu

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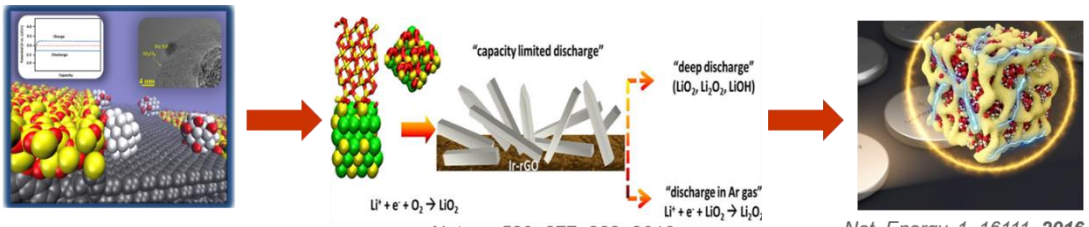
To meet the high-energy requirement that can enable the 40-miles electric drive Plug in Hybrid Electric Vehicle (P-HEVs), long range electric vehicle (EV) and smart grid, it is necessary to develop very high energy and high power cathodes and anodes that when combined in a battery system must offer 5,000 charge-depleting cycles, 15 years calendar life as well as excellent safety characteristics. These challenging requirements make it difficult for conventional cathode materials to be adopted in P-HEVs and EVs. Metal-air batteries, specifically Li-air battery, have large theoretical energy density about 2-10 times higher than those of lithium-ion batteries, and are frequently advocated as the solution toward next-generation electrochemical energy storage for applications including electric vehicles or grid energy storage. In this talk, I summarize the recent discovery on developing the Li-O2 battery, particularly highlighting the strategy how to move this system from an open to a close configuration.



Nat. Commun. 4, 2383, **2013** *Nature, 529, 377–382, 2016* *Nat. Energy. 1, 16111,* ***2016***

Nov. 16 (14:30-15:15)

Chongmin Wang

Laboratory Fellow in Pacific Northwest National Laboratory, Richland, USA
Email: Chongmin.wang@pnnl.gov
Website: https://www.pnnl.gov/people/chongmin-wang

Dr. Chongmin Wang is a Laboratory Fellow at Pacific Northwest National Laboratory (PNNL). He received his B.Sc. and M.Sc. in physics from Lanzhou University in China and Ph.D. in Materials Science and Engineering from University of Leeds, UK. Before Joining PNNL, he worked at the Max Planck Institute for Metals Research, Germany, NIMS, Japan, and Lehigh University. His research focuses on advanced microscopy, specifically *in situ* electron microscopy for energy materials. He has published 400 journal papers and several book chapters and has delivered 100 invited talks. Wang's awards include the Materials Research Society (MRS) Innovation in Materials Characterization Award, the *Microscopy Today* Innovation Award, the Roland B. Snow Award (The American Ceramic Society), the R&D 100 Award, a *Journal of Materials Research (JMR)* Paper of the Year Award (MRS), the Outstanding Invention Award (Japan), and the PNNL Director's Awards for Exceptional Scientific Achievement, and PNNL Director's Awards for Lifetime Achievement. He currently serves as the principal editor of *JMR.* He is a Fellow of the Materials Research Society and Fellow of Microscopy Society of America.

Advanced Electron Microscopy and Spectroscopy Diagnosis Guided Design of Materials for Better Batteries

Chongmin Wang*

Pacific Northwest National Laboratory, Richland, WA 99352, USA
**E-mail: Chongmin.wang@pnnl.gov*

Diagnosis techniques based on advanced microscopy and spectroscopy have been realized to be one of the essential approaches for gaining insights as how an electrode material failure, therefore feeding back for optimized designing and creating of new electrode materials with enhanced battery performances. In this presentation, I will focus on recent progress on using ex-situ, in-situ, operando and cryo-scanning transmission electron microscopy for probing into the structural and chemical evolution of electrode materials for lithium ion batteries, representatively such as layer structured cathode, Li and Si anode. I will highlight several recent key observations, which even appear to be well documented, while essentially are poorly understood, therefore limiting the advances of both cathode and anode for better batteries. It would be expected that this presentation can stimulate new ideas as how to attack the bottlenecks to advance the electrode materials design for better batteries.

Nov. 16 (15:15-16:00)

Sung-Yoon Chung

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Prof. Sung-Yoon Chung received his BS (with *highest honors*) degree from the Department of Materials Science and Engineering at Inha University in 1995 and MS and PhD degrees from the Department of Materials Science and Engineering at KAIST in 1997 and 2001, respectively. He also conducted post-doctoral research at MIT in Prof. Yet-Ming Chiang's group from 2001 to 2003. The main research at MIT focused on the development of new cathode materials based on metal-phosphate nanocrystals for high-power Li-ion batteries. Prof. Chung started his career as an independent principal investigator in the Department of Materials Science and Engineering at Inha University in 2003. He then moved to the Graduate School of EEWS (Energy, Environment, Water, and Sustainability) at KAIST in 2012, served for the department as a department head (2017–2020), and currently work in the Department of Materials Science and Engineering. He also has worked as a Principal Editor of the *Journal of Materials Research* (JMR) since 2016. His research interests encompass materials physics and chemistry of complex oxides for electrocatalysis, materials design and synthesis for energy storage and conversion, and nanostructure control of materials interfaces, covering atomic-scale direct characterization with STEM and EELS.

Correlation of Local Crystal/Electronic Structures with Activity and Durability of Oxygen Electrocatalysis in Complex Oxides

Sung-Yoon Chung*

Department of Materials Science and Engineering, KAIST, Korea
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A great deal of research has been carried out over the last two decades to achieve better efficiency in energy storage and conversion. As many actual devices based on electrochemical reactions for energy conversion and production operate at room temperature, the utilization of adequate electrocatalysts is imperative to significantly lower the activation barrier during the redox reactions. Hydrogen-evolution/oxygen-evolution reactions (HER/OER) are key electrochemical processes at the cathode and anode sides, respectively, in electrolyzers for hydrogen production *via* water splitting. It is generally accepted that the activation barrier of the OER associated with transfer of multiple electrons and protons is very large, resulting in a comparatively higher anodic overpotential to split water. Therefore, the OER is a predominant pathway that can notably affect the overall efficiency of electrolysis.[1] Furthermore, as acidic solutions are utilized in proton-exchange-membrane (PEM) electrolyzers usually showing high OER current at lower overpotentials, the durability of catalysts at the anode side is another significant issue in addition to the high catalytic activity.[2,3] In this presentation, in addition to briefly summarizing the basic background and important descriptors of the OER, we focus on the correlation among the atomic structure, the electronic states, and the resulting OER in complex oxides to offer key insights toward achieving better catalytic activity and stability of oxide catalysts. In particular, advances in direct imaging and chemical analysis in scanning transmission electron microscopy (STEM) during the last two decades enabled atomic-level identification and visualization of the active sites.[4,5] We thus demonstrate notable atomic-scale examples clarifying the strong relation between the local structure and the electronic states to achieve better OER performance.

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Nov. 16 (18:30-19:15)

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Dr. Alexis Grimaud is CNRS Researcher in the Solid-State Chemistry and Energy laboratory, at Collège de France, Paris, France. Dr. Grimaud received in 2011 his Ph.D from the University of Bordeaux, at the Institute of Condensed Matter Chemistry of Bordeaux (ICMCB). From 2012 to 2014, he was a postdoctoral researcher at the Massachusetts Institute of Technology (MIT). His research efforts focus on understanding complex interfacial processes at the heart of electrochemical systems, including water electrolyzers and Li-ion batteries. His emphasis on the development of novel water splitting electrocatalysts is guided by the interplay existing between physical properties of heterogeneous catalysts, and more specifically transition metal oxides, and kinetics of reactions. He is also pursuing fundamental understanding for interfacial reactions occuring in rechargeable batteries, for which he is developing and studying novel liquid electrolytes with tailored reactivity that he is using to allow intercalation into novel classes of materials. To date, he has published more than 75 articles. He is the recipient of the French Young Researcher award as well as the Young Researcher award from the Energy Division of the French Chemical Society.

Designing Novel Intercalation Materials Using an Electrolyte Engineering Approach

Alexis Grimaud*

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The quest for new electro-active materials led to the rapid development of energy storage and conversion devices, including water electrolyzers and Li-ion batteries. However, their realization into practical devices relies in mastering properties at the electrode/electrolyte interface. When studying solid/liquid interfaces, difficulties arise. Among them, controlling the surface chemistry of electro-active materials is challenging, owing to the dynamics of the charge transfer at the interface which often leads to surface degradation and reconstruction phenomena. Recently, we have demonstrating that an electrolyte engineering strategies can stabilize novel materials for electrochemical applications, including water splitting catalysts and Li-ion battery materials. A first example will be given on the control of a novel oxygen evolution reaction (OER) reactions relying on the reversible exchange of hydrated cations into transition metal oxides catalysts, simultaneously enhancing the OER kinetics while avoiding detrimental surface degradation.[2] Then, we will describe the utilization of superconcentrated electrolytes to unlock reversible Li^+ intercalation into transition metal halides previously believed to be too unstable to be used as Li-ion battery materials.[2] Through this talk, emphasis will be placed on how physical and chemical properties of liquid electrolytes control the interfacial phenomena on the surface of transition metal-based electrode materials.[3]

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[2] N. Dubouis et al., "Superconcentrated electrolytes widens insertion electrochemistry to soluble layered halides", ***Nature Materials*** 368, p. 155 (2021).
[3] D. Degoulange et al., "Towards the understanding of Water-in-Salt electrolytes: individual ion activities and liquid junction potentials in highly concentrated aqueous solutions", ***J. Chem. Phys.*** 155, 064701 (2021).

Nov. 16 (19:15-20:00)

Jennifer L. M. Rupp

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Prof. Jennifer Rupp is the Thomas Lord Associate Professor of Electrochemical Materials at the Department of Materials Science and Engineering, and Associate Professor at the Department of Electrical Engineering and Computer Science at MIT. Prior she was a non-tenure track assistant professor at ETH Zurich Switzerland where she held two prestigious externally funded career grants, namely an ERC Starting Grant (SNSF) and Swiss National Science Foundation (SNF) professorship.

She previously was affiliated as a visiting and senior scientist at MIT (2012-2011), the National Institute of Materials Science (NIMS) in Tsukuba, Japan (2011), and was working as a postdoc at ETH Zurich (2010-2006). Rupp team`s current research interests are on processing of ceramic and glass materials, solid state material design and tuning of structure-property relations for novel energy and information devices and operation schemes. This ranges from alternative energy storage via solid state batteries, solar-to-synthetic fuel conversion or novel types of neuromorphic memories and computing logic entities for data storage and transfer beyond transistors and new sensing functions to track chemicals in the environment. Here, her team goes the whole way from material design, novel processing techniques to make ceramics, cermets or glassy-type ceramic structures up to novel device prototypes, their operation and characteristics.

She has published more than 110 papers, holds more 20 patents, and, being a frequent speaker and panel member of the World Economic Forum, enjoys discussing material tech trends on the theme of energy with the public, economists and policy makers. Rupp also enjoys engaging with companies all around the world through both consultancy and collaborations focused either on material processing business or electrochemical device & product engineering (e.g. battery, oil & fuel processing, sensing, electronic companies). Rupp currently serves as elected board member at ceramic and battery companies since 2021. Currently, she holds a position as associate editor at Journal of Materials Chemistry A and is also on the advisory board member for Matter, Energy & Environmental Science, Advanced Functional Materials and other journals.

Rupp and team received several honors and awards such as the Displaying Future Award by the company Merck KGaA 2018 for a glucose converting fuel cell chip, BASF and Volkswagen Science Award 2017 for battery research, "Top 40 international scientist under the age of 40" by World Economic Forum 2015, Spark Award for the most innovative and economically important invention of the year 2014 at ETH Zurich, Kepler award “new materials in energy technology” by the European Academy of Science 2012 or Young Scientist Award by the Solid State Ionic Society. In 2021, Rupp was invited to become a Fellow of the Royal Society of Chemistry (FRSC). She gave keynote lectures at Royal Society UK 2018, Nature Energy and Sustainability conferences, is a frequent Gordon Research lecturer for ceramics and electrochemistry and many others, also she presented on battery and energy technologies at the World Economic Forum.

Design and Manufacture of Solid State Batteries towards Low Cost

Jennifer L.M. Rupp*

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Next generation of energy storage devices may largely benefit from fast and solid Li+ ceramic electrolyte conductors to allow for safe and efficient batteries and fast data calculation. For those applications, the ability of Li-oxides to be processed as thin film structures and with high control over Lithiation and phases at low temperature is of essence to control conductivity. Through this presentation we review the field from a new angle, not only focused on the classics such as Li-ionic transport and electrochemical stability window for Li-solid state battery electrolytes, but focusing on opportunities and challenges routes in thermal and ceramic processing of the components and their assemblies with electrodes. Also, we will carefully review and give perspectives on the role of solid state battery ceramic strategies for the electrolyte on the electrode interfaces and towards charge transfer and vs. current densities. In other words, it will be a little ceramicist (own) love story on the good and the evil we can design by smart ceramic design at the interfaces originating by the very first choices made in the electrolyte ceramic structure and material design. In the second part of the talk we will discuss new opportunities on low temperature processing of solid state electrolyte ceramics that do not technically require "classic sintering" and avoid prior particle calcination; instead demonstrating opportunities to use liquid based direct densification routes and vacuum techniques to design solid electrolytes and grafting interfaces to new hybrid and solid state battery prototypes targeted at processing below 700C for all parts. Collectively, the insights on solid state energy storage provide evidence for the functionalities that those Li-solid state material designs can have for cost and mass manufacturable solid state and hybrid battery prototypes.

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   JLM Rupp, R Pfenninger, M. Struzik, A Nenning, I Garbayo, *US 62/718,838* (2018)
3. Methods of Fabricating Thin Films Comprising Lithium-Containing Materials
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4. Glass-Type Polyamorphism in Li-Garnet Thin Film Solid State Battery Conductors
   I Garbayo, M Struzik, WJ Bowman, R Pfenninger, JLM Rupp, *Advanced Energy Materials,* 1702265 (2018)
5. Solid-state Electrolyte and Method of Manufacture Thereof.
   ZD Hood, Y Zhu, L Miara, JLM Rupp. *US 62/713,366* (2018)
6. Solution-Processed Solid-state Electrolyte and Method of Manufacture Thereof.
   Y Zhu, ZD Hood, L Miara, JLM Rupp *US 62/713,428* (2018)
7. Processing thin but robust electrolytes for solid-state batteries
   M. Balaish, J.C. Gonzalez-Rosillo, K.J. Kim, Y. Zhu, Z.D. Hood, J.L.M. Rupp, Nature Energy, 6, 227–239 (2021)
8. Solid-State Li–Metal Batteries: Challenges and Horizons of Oxide and Sulfide Solid Electrolytes and Their Interfaces
   K.J. Kim, M. Balaish, M. Wadaguchi, L. Kong, J.L.M Rupp, Advanced Energy Materials, 202002689 (2021)
9. Lithium-film ceramics for solid-state lithionic devices
   Y. Zhu, J.C. Gonzalez-Rosillo, M. Balaish, Z.D. Hood, K.J. Kim, J.L.M. Rupp, Nature Review Materials, 6, 313–331 (2020)

Nov. 16 (20:00-20:45)

Clare P. Grey

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Prof. Clare P. Grey received a BA and D. Phil. (1991) in Chemistry from the University of Oxford. After post-doctoral fellowships in the Netherlands and at DuPont CR&D in Wilmington, DE, she joined the faculty at Stony Brook University (SBU) in 1994. She moved to Cambridge in 2009, maintaining an adjunct position at SBU, becoming a Fellow of Pembroke College in 2011. She was the founding director of the NorthEast Center for Chemical Energy Storage, a Department of Energy, Energy Frontier Research Center. She is currently the director of the EPSRC Centre for Advanced Materials for Integrated Energy Systems (CAM-IES) and an Expert Panel member of the Faraday Institution. Recent honours/awards include the RSC John Goodenough Award (2019), the Richard R. Ernst Prize in Magnetic Resonance (2020), the RS Hughes Award (2020) and the Körber European Science Award (2021) for her contributions to the optimization of batteries using NMR spectroscopy. She is a Fellow of the Royal Society and foreign member of the American Academy of Arts and Sciences. Her current research interests include the use of solid-state NMR and diffraction-based methods to determine structure-function relationships in materials for energy storage (batteries and supercapacitors), conversion (fuel cells) and carbon capture. She is a cofounder of the company Nyobolt, which seeks to develop batteries for fast charge applications.

Operando Magnetic Resonance, Diffraction and Optical Scattering Measurements of Function and Failure in Layered Cathode Materials

Clare P. Grey*

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Ni-rich layered cathode materials are among the most promising candidates for high energy density Li-ion batteries for EV applications, yet improvements in their capacity retention – particularly under conditions of stress (high/low temperature, fast charging) – are still required for their more widespread use. This talk focuses on describing how operando methods can be used to probe thermodynamic and metastable phase transitions and intercalation mechanisms in these and related battery electrodes. Recent studies aimed at understanding the initial first cycle capacity loss and capacity loss over more extended cycling in half and full cells will be described. Ex-situ nuclear magnetic resonance (NMR) is first used to track local environment and lithium mobility. Operando x-ray diffraction (XRD) and NMR spectroscopy of $Li_xNi_{0.8}Co_{0.15}Al_{0.05}O_2$ is then employed to demonstrate that the apparent first cycle capacity loss is a kinetic effect linked to limited Li mobility at $x > 0.88$.[1] XRD and NMR[2] experiments for NMC811 ($LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$) show the emergence and growth of a "fatigued" phase with cycle number, which cannot be fully delithiatied. We discuss the origins of this phenomena – which is not solely due to kinetic limitations or inter-granular cracking - and its relationship to the growth of the rock-salt surface phase.[3] Finally the use of a novel operando optical spectroscopy method to study intercalation processes, phase transitions and lithium-vacancy ordering processes will be described.[4]

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[1] "Intrinsic Kinetic Limitations in Substituted Lithium Layered Transition-Metal Oxide Electrodes", A. Grenier, P.J. Reeves, H. Liu, I.D. Seymour, K. Märker, K.M. Wiaderek, P.J. Chupas, C.P. Grey, K.W. Chapman, *J. Am. Chem. Soc.*, **142**, 7001-7011 (2020).

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Nov.17 (10:00-10:45)

Reginald Penner

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Reginald Penner is Chancellor's in the Department of Chemistry at the University of California, Irvine (UCI). Professor Penner attended Gustavus Adolphus College in Saint Peter, Minnesota where he obtained B.A. degrees in Chemistry and Biology in 1983. He studied at Texas A&M University beginning in 1983 with Professor Charles R. Martin and he received a Ph.D. in Chemistry in 1987. He proceeded to postdoctoral appointments at Stanford University and Caltech working with Professor Nate Lewis, before being appointed at UCI in 1990. Professor Penner is an electrochemist whose research group develops methods based upon electro-deposition for making nanomaterials, such as nanowires, composed of metals and semiconductors. With his students, he has more than 190 research publications to date. He is an A.P. Sloan Fellow, a Camille and Henry Dreyfus Teacher-Scholar, an NSF and ONR Young Investigator, and a Fellow of the American Association for the Advancement of Science (AAAS). He received the 2009 Faraday Medal from the Royal Society of Chemistry of the UK. He is the 2016 recipient of the Charles N. Reilley Award of the Society for Electroanalytical Chemistry and the 2016 American Chemical Society Division of Analytical Chemistry Award in Electrochemistry. He is an Assoc. Editor of *ACS Nano*.

Introducing the Virus Bioresistor: A New Electrochemical Biosensing Paradigm

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Viruses are infamous for making us sick. That's their dark side. But they don't receive enough credit for the good they can do. Specifically, viruses can be convinced to collaborate with us to acquire information from bodily fluids about early stage diseases – and in particular, cancers. You already know that for many cancers, early detection means a cure is possible, even likely. Together with a chemical biologist at UCI, Professor Greg Weiss and his team, our research group is designing a new type of biosensor that communicates electrically with viruses in order to diagnose bladder cancer, and to detect its recurrence in patients who have had it in the past. These biosensors are called Virus BioResistors or "VBRs". A VBR will be capable of detecting early stage bladder cancer in a routine urinalysis test, in 5 min. or less, in a doctor's office. This transformational capability has the potential to save lives. Bladder cancer is the "low hanging fruit" for this technology because it is the easiest cancer to detect in urine. But the possibility exists to develop VBRs capable of detecting several other cancers using urinalysis including cancers of the prostate, kidney, and possibly even pancreas.

The VBR depends upon an electrodeposited bioaffinity layer, ≈100 nm in total thickness, that is a composite of PEDOT (poly(3,4-ethylenedioxythiophene)) and the M13 virus particles that serve as receptors. At low frequencies, this impedance of this layer increases when target protein molecules are bound within the PEDOT-virus layer. The high frequency impedance measures only the electrical conductivity of the solution, providing information on the hydration state of the patient undergoing testing. The orthogonality of the VBR response at low and high frequencies allows accurate measurement of target protein, without influence from the salt concentration of urine, an important capability for clinical applications of this technology.

Nov.17 (10:45-11:30)

Raymond E. Schaak

DuPont Professor of Materials Chemistry
Department of Chemistry
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Professor of Chemical Engineering
Department of Chemical Engineering
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Dr. Raymond Schaak is the DuPont Professor of Materials Chemistry in the Chemistry Department at Penn State University. Dr. Schaak also has a Courtesy appointment in the Chemical Engineering Department at Penn State and is part of the Penn State Materials Research Institute. Dr. Schaak received a B.S. degree in chemistry from Lebanon Valley College in 1998. In 2001, he received a Ph.D. in materials chemistry from Penn State University under the direction of Professor Thomas Mallouk. From 2001–2003, he was a postdoctoral research associate with Professor Robert Cava at Princeton University. In 2003, Dr. Schaak began his independent career as an Assistant Professor in the Department of Chemistry at Texas A&M University. In 2007, he moved to Penn State University as an Associate Professor of Chemistry, was promoted to Professor in 2011, and was appointed as the DuPont Professor of Materials Chemistry in 2013. His research group focuses on developing new chemical strategies for the synthesis of nanoscale solid-state materials and applying these materials to problems at the forefront of modern materials research. Dr. Schaak has received several awards, including most recently the National Fresenius Award (2011), the ACS Inorganic Nanoscience Award (2016), and the ACS Akron Section Award (2020). In 2017, Dr. Schaak was elected as a Fellow of the American Association for the Advancement of Science (AAAS). He serves as an Associate Editor of *ACS Nano* (since 2010) and as the inaugural Deputy Editor of *ACS Nanoscience Au*, which launched in 2021.

A Designer's Toolkit for Constructing Complex Nanoparticle Libraries

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Multi-component nanoparticles offer unique opportunities to combine different properties in a single construct, enabling both multi-functionality and the emergence of new synergistic functions. Synthesizing such multi-component nanoparticles requires simultaneous control over size, shape, composition, and structure, as well as interfaces and spatial arrangements. One way of achieving these requirements is to use sequential partial cation exchange reactions, where interfaces and asymmetry are introduced by compositional modifications that are made within an existing nanoparticle. For example, by applying to copper sulfide nanorods up to seven sequential cation exchange reactions using mix-and-match combinations of five distinct cations, we can map out synthetically feasible pathways to more than 65,000 distinct heterostructured metal sulfide nanorods that contain up to six materials, eight segments, and eleven internal interfaces. Using simultaneous instead of sequential multi-cation exchange, analogous reactions produce high entropy metal sulfide nanoparticles. A growing library of complex heterostructured metal sulfide nanoparticles can now be rationally designed and then readily synthesized using simple nanochemical reactions.

Nov.17 (11:30-12:15)

Cherie R. Kagan

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Cherie R. Kagan is the Stephen J. Angello Professor of Electrical and Systems Engineering, Professor of Materials Science and Engineering, and Professor of Chemistry at the University of Pennsylvania. She is Penn Engineering's Associate Dean for Research, the 2021 President of the Materials Research Society, and an Associate Editor of ACS Nano. Kagan is also the Director of the newly awarded National Science Foundation Engineering Research Center for the Internet of Things for Precision Agriculture. She graduated from the University of Pennsylvania in 1991 with a BSE in Materials Science and Engineering and a BA Mathematics and earned her PhD in Materials Science and Engineering from the Massachusetts Institute of Technology in 1996. In 1996, she went to Bell Labs as a postdoctoral fellow and in 1998, she joined IBM's T. J. Watson Research Center, where she most recently managed the "Molecular Assemblies and Devices Group." In 2007, she joined the faculty of the University of Pennsylvania. Kagan's research is focused on studying the chemical and physical properties of nanostructured materials and in integrating materials with optical, electrical, magnetic, mechanical, and thermal properties in (multi-)functional devices with applications in optoelectronics, photonics, and sensing.

Designing Optical Metamaterials from Colloidal Noble Metal Nanocrystal Assemblies

Cherie R. Kagan *

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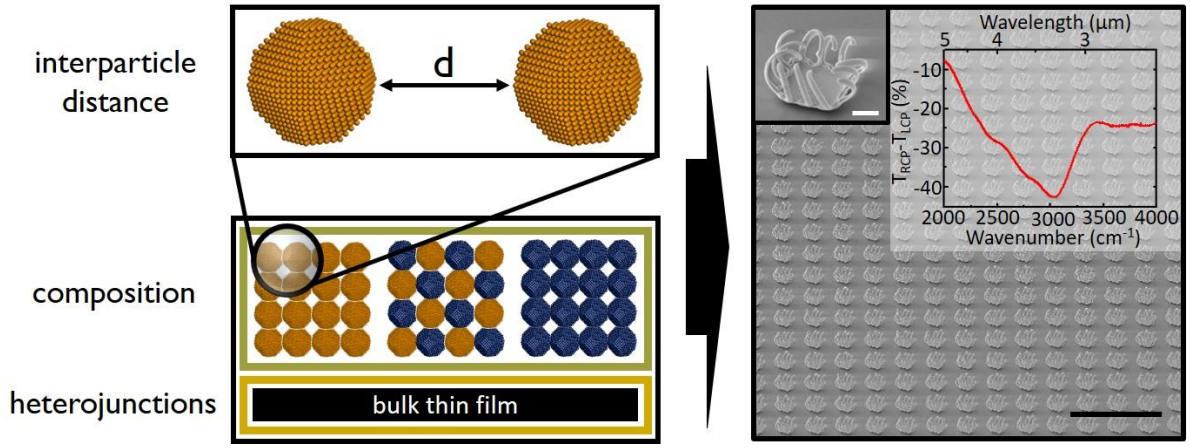
Colloidal noble metal nanocrystals (NCs) have metal cores and organic or inorganic ligand shells and are known for their size- and shape-dependent localized surface plasmon resonances. In this talk, I will describe the use of these NCs as building blocks of assemblies with designer optical properties for 2D and 3D metamaterials. Chemical exchange of the long ligands used in NC synthesis with more compact ligand chemistries reduces the interparticle distance (d) and increases interparticle coupling. This ligand-controlled coupling allows us to tune through a dielectric-to-metal phase transition, seen by a 1010 range in DC conductivity and a dielectric permittivity ranging from everywhere positive to everywhere negative across the whole range of optical frequencies, and design assemblies that are strong optical absorbers or scatterers. We harness the solution-processability and physical properties of colloidal NCs to pattern NC superstructures for large-area metamaterials, demonstrating 2D extreme bandwidth quarter-wave plates and optical sensors. By exploiting the different chemical and physical properties of NC assemblies from bulk thin films, we construct NC/bulk bilayer heterostructures that, upon ligand exchange, fold into three-dimensional structures providing a simple route to 3D metamaterials, demonstrating chiral structures that form broadband circular polarizers. Combining superparamagnetic NCs and plasmonic NCs, we fabricate multifunctional, smart superparticles, that in suspensions, switch their polarization-dependent transmission in the infrared in response to an external magnetic field.



Nov. 17 (13:00-13:45)

Deji Akinwande

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Deji Akinwande is an Endowed Full Professor at the University of Texas at Austin, and a Fellow of the IEEE and APS. He received the PhD degree from Stanford University in 2009. His research focuses on 2D materials and nanoelectronics/technology, pioneering device innovations from lab towards applications. Prof. Akinwande has been honored with the 2019 Fulbright Specialist Award, 2017 Bessel-Humboldt Research Award, the U.S Presidential PECASE award, the inaugural Gordon Moore Inventor Fellow award, the inaugural IEEE Nano Geim and Novoselov Graphene Prize, the IEEE "Early Career Award" in Nanotechnology, the NSF CAREER award, several DoD Young Investigator awards, and was a past recipient of fellowships from the Kilby/TI, Ford Foundation, Alfred P. Sloan Foundation, 3M, and Stanford DARE Initiative. His research achievements have been featured by Nature news, Time and Forbes magazine, BBC, Discover magazine, Wall Street Journal, and many media outlets. He serves as an Editor for the IEEE Electron Device Letters and Nature NPJ 2D Materials and Applications. He Chairs the 2022 Gordon Research Conference on 2D materials, and was the past chair of the 2019 Device Research Conference (DRC), and the 2018 Nano-device committee of IEEE IEDM Conference.

Novel Applications of 2D Materials from Wearable Health to Memory Devices and 5G Switches

Deji Akinwande *

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This talk will present our latest research adventures on 2D nanomaterials towards greater scientific understanding and advanced engineering applications. In particular, the talk will highlight our work on flexible electronics, zero-power devices, single-atom monolayer memory, non-volatile RF/5G/6G switches, and wearable tattoo sensors for mobile health. Non-volatile memory devices based on 2D materials are an application of defects and is a rapidly advancing field with rich physics that can be attributed to metal adsorption into vacancies. The memory devices can be used for neuromorphic computing and operate as switches up to 500GHz. Likewise, from a practical point, electronic tattoos based on graphene have ushered a new material platform that has highly desirable practical attributes including optical transparency, mechanical imperceptibility, and is the thinnest conductive electrode sensor that can be integrated on skin for physiological measurements including blood pressure monitoring with Class A performance. Much of these research achievements have been published in leading journals.

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Nov. 17 (13:45-14:30)

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ACS Nano

EDUCATION

B.S.	Harvard University, Cambridge, MA	1990
Ph.D.	Université Louis Pasteur/Université de Strasbourg	1995

APPOINTMENTS

Postdoctoral Fellow	Scripps Research Institute, La Jolla, CA	1995-1997
Assistant Professor	Purdue University 1997-2001	
Associate Professor	Purdue University (with tenure)	2001-2003
Professor/Canada	University of Alberta	2003-present

RESEARCH INTERESTS

(1) Materials for renewable energy applications
(2) Self-assembly on surfaces
(3) Surface chemistry of nanomaterials

Soft van der Waals Epitaxy with Block Copolymers

Jillian M. Buriak *

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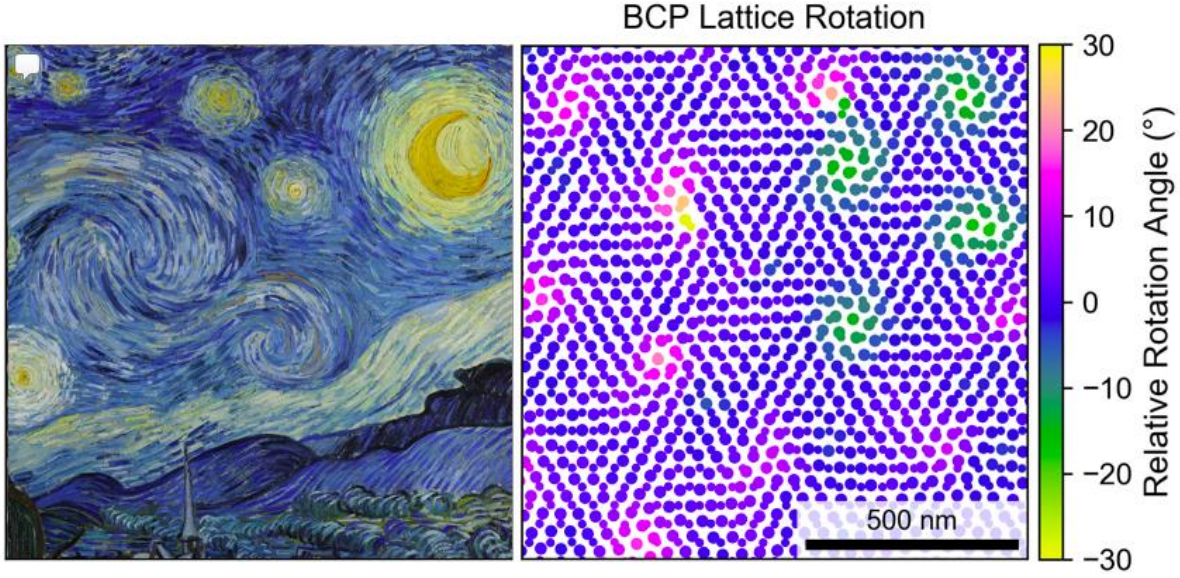
Nanopatterned surfaces are of central importance to a variety of areas and applications, such as computer chip architectures, tissue interfacing, biosensors, light management and plasmonics, among others. Since lithography is the single most expensive step in computer chip manufacturing, having the molecules 'do the hard work' is the basis for using self-assembled block copolymers (BCPs) templates to pattern sub-10 nm features on silicon, a process termed directed self-assembly, or DSA. Here, we will describe the remarkable versatility of using BCPs, polymers that contain sufficient chemical information to form highly ordered templates over large areas. Recently, the experimental observation of what are termed static distortion waves (SDWs) [also referred to as mass distortion waves (MDWs)] that are local chiral twisting of lattices, has become a topic of extreme interest in the area of 2D-based materials - perfect timing as the discovery of SDWs/MDWs in incommensurate block copolymer-based self-assembled structures that are at least an order of magnitude larger in scale serve as an easily studied and tailored model for these motifs on 2D materials.



Scheme 1. Left: van Gogh's Starry Night. Right: Chiral twists. Standing/mass distortion waves produced via self-assembly of block copolymers to form incommensurate lattices of Moiré superstructures.

Nov. 17 (14:30-15:15)

Ali Javey

Lam Research Distinguished Chair in Semiconductor Processing
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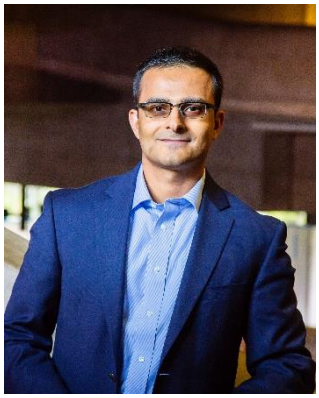

Ali Javey received a Ph.D. degree in chemistry from Stanford University in 2005, and was a Junior Fellow of the Harvard Society of Fellows from 2005 to 2006. He then joined the faculty of the University of California at Berkeley where he is currently a professor of Electrical Engineering and Computer Sciences. He is also a senior faculty scientist at the Lawrence Berkeley National Laboratory where he serves as the program leader of Electronic Materials (E-Mat). He is a co-director of Berkeley Sensor and Actuator Center (BSAC). He is an associate editor of ACS Nano.

Javey's research interests encompass the fields of chemistry, materials science, and electrical engineering. His work focuses on the integration of nanoscale electronic materials for various technological applications, including low power electronics, flexible circuits and sensors, and energy generation and harvesting. He is the recipient of MRS Outstanding Young Investigator Award (2015), Nano Letters Young Investigator Lectureship (2014); UC Berkeley Electrical Engineering Outstanding Teaching Award (2012); APEC Science Prize for Innovation, Research and Education (2011); Netexplorateur of the Year Award (2011); IEEE Nanotechnology Early Career Award (2010); Alfred P. Sloan Fellow (2010); Mohr Davidow Ventures Innovators Award (2010); National Academy of Sciences Award for Initiatives in Research (2009); Technology Review TR35 (2009); NSF Early CAREER Award (2008); U.S. Frontiers of Engineering by National Academy of Engineering (2008); and Peter Verhofstadt Fellowship from the Semiconductor Research Corporation (2003).

Wearable Sweat Sensors - Towards big data for human health

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Wearable sensor technologies play a significant role in realizing personalized medicine through continuously monitoring an individual's health state. To this end, human sweat is an excellent candidate for non-invasive monitoring as it contains physiologically rich information. In this talk, I will present our recent advancements on fully-integrated perspiration analysis system that can simultaneously measure sweat rate, metabolites, electrolytes, drugs and heavy metals, as well as the skin temperature to calibrate the sensors' response. Our work bridges the technological gap in wearable biosensors by merging plastic-based sensors that interface with the skin, and silicon integrated circuits consolidated on a flexible circuit board for complex signal processing. This wearable system is used to measure the detailed sweat profile of subjects at rest and engaged in prolonged physical activities, and infer real-time assessment of physiological state of the subjects. Case studies on the correlation of sweat analytes with those of blood and various physiological conditions will be presented, including for applications in dehydration studies, diabetes monitoring, drug metabolism rate studies, and detection and monitoring of cystic fibrosis. Finally, a general roadmap for the technology will be presented, with focus on opportunities and challenges.

Nov. 17 (15:15-16:00)

Paul S. Weiss

UC Presidential Chair and Distinguished Professor of Chemistry & Biochemistry, Bioengineering, and Materials Science & Engineering at UCLA
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Prof. Paul S. Weiss graduated from MIT with S.B. and S.M. degrees in chemistry in 1980 and from the University of California at Berkeley with a Ph.D. in chemistry in 1986. He is a nanoscientist and holds a UC Presidential Chair and is a distinguished professor of chemistry & biochemistry, bioengineering, and materials science & engineering at UCLA, where he was previously director of the California NanoSystems Institute. He also currently holds visiting appointments at Harvard's Wyss Institute and several universities in Australia, China, India, and South Korea. He studies the ultimate limits of miniaturization, developing and applying new tools and methods for atomic-resolution and spectroscopic imaging and patterning of chemical functionality. He and his group apply these advances in other areas including neuroscience, microbiome studies, tissue engineering, and high-throughput gene editing. He led, coauthored, and published the technology roadmaps for the BRAIN Initiative and the U.S. Microbiome Initiative. He has won awards in science, engineering, teaching, publishing, and communications, including the American Chemical Society (ACS) Award in Colloid and Surface Chemistry, ACS Tolman Medal, te ACS Patterson-Crane Award in Chemical Information, and IEEE Nanotechnology Pioneer Award. He is a fellow of the American Academy of Arts and Sciences, American Association for the Advancement of Science, ACS, American Institute for Medical and Biological Engineering, American Physical Society, American Vacuum Society, Canadian Academy of Engineering, IEEE, Materials Research Society, and an honorary fellow of the Chinese Chemical Society and Chemical Research Society of India. He is the founding and current editor-in-chief of *ACS Nano*. He has published over 500 papers, holds over 40 patents, and has given over 800 invited, plenary, keynote, and named lectures.

Nanotechnology Approaches to Biology and Medicine

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Biology functions at the nanoscale. Thus, there are special opportunities not only to make biological measurements using nanotechnology, but also to interact directly in order to influence biological outcomes. I describe how we fabricate and use nanostructures to advance high-throughput gene editing for cellular therapies targeting genetic diseases and cancer immunotherapy.[1] We also use microfluidics and functionalized nanostructured features in the selective capture, probing, and release of single circulating tumor cells in liquid biopsies in order to diagnose cancers and to assess the efficacy of treatments.[2] We exploit supramolecular assembly, acoustofluidics, specific surface functionalization, and plasmonics to enable these processes.[3-5] Nanoscience and nanotechnology developed from chemistry, physics, biology, engineering, medicine, toxicology, and a host of other fields. Along the way, we taught each other our problems, challenges, and approaches. The interdisciplinary communication skills that were developed and are now part of our training remain unique to the field. As a result, nanoscience contributes to a wide range of other fields, such as neuroscience and the microbiome.[6],[7]

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Nov. 17 (18:30-19:15)

Wolfgang Parak

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Wolfgang Parak is Professor at the University of Hamburg. He has studied physics and obtained his PhD in Munich. After a postdoctoral fellowship at Berkeley he returned 2003 to Munich to start his own group. Before moving to the University of Hamburg in 2017 he spent 10 years as professor at the Philipps University Marburg. The research of Wolfgang Parak is dedicated towards the development of new surface chemistries of inorganic nanoparticles and towards the characterization of their physicochemical properties. In particular, the development of an amphiphilic polymer coating is nowadays used by many different groups worldwide. Nanoparticles with such high colloidal stability are the bases of experimentally correlating their physicochemical properties with their interaction will cells (involving uptake and cytotoxicity), which has been the research topic of the Parak group for the 2 decades. The group also uses polymeric polyelectrolyte capsules fabricated by layer-by-layer assembly for biological applications (in vitro sensing and delivery). Wolfgang Parak is also Associate Editor of ACS Nano and ACS Nanoscience Au.

Quantitative considerations about the cellular entry and excretion of colloidal nanoparticles

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Nanomaterials play a promising role in the advancements of technology and health care. Their nanometric size combined with particular optoelectronic, magnetic, or plasmonic properties makes them suitable candidates for theranostics, biosensing, and bioimaging applications. This led to intensive investigation of the interaction of nanoparticles (NPs) with cells. Whereas most studies are focused on how the physicochemical properties of NPs will influence their uptake by cells, much less is known about their potential excretion from cells. However, to control and manipulate the number of NPs in a cell both, cellular uptake and excretion need to be studied quantitatively. Monitoring the intracellular and extracellular amount of NPs, after residual non-internalized NPs have been removed, over time enables to disentangle the influence of cell proliferation and exocytosis, which are the major pathways for the reduction of NPs per cell. Proliferation depends on the type of cells, and exocytosis depends on the size of the NPs. Examples are given on the role of these two different processes for different cells and NPs.

Nov. 17 (19:15-20:00)

Yury Gogotsi

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Biography:

Yury Gogotsi is Distinguished University Professor and Charles T. and Ruth M. Bach Professor of Materials Science and Engineering at Drexel University. He also serves as Director of the A.J. Drexel Nanomaterials Institute. His research group works on 2D carbides, nanostructured carbons, and other nanomaterials for energy, water and biomedical applications. He is recognized as Highly Cited Researcher in Materials Science and Chemistry, and Citations Laureate by Thomson-Reuters/Clarivate Analytics. He has received numerous awards for his research including the ACS Award in the Chemistry of Materials, Gamow Prize, European Carbon Association Award, and S. Somiya Award from IUMRS. He has been elected a Fellow of the World Academy of Ceramics, the European Academy of Sciences, American Association for Advancement of Science, Materials Research Society, American Ceramic Society, the Electrochemical Society, Royal Society of Chemistry, and the International Society of Electrochemistry. He holds honorary doctorates from several Universities in France and Ukraine. He served on the MRS Board of Directors and is acting as Associate Editor of *ACS Nano*.

Electrochemistry and Energy Storage Applications of MXenes

Yury Gogotsi

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2D carbides and nitrides, known as MXenes, are among the most recent, but quickly expanding material families. The field is experiencing very fast growth with the number of papers on MXenes exceeding 1000/year. Major breakthroughs have been achieved in the past 3-4 years, including synthesis of dozens of computationally predicted MXenes, demonstration of superconductivity in Nb_2C MXene with specific surface terminations and stronger interactions with electromagnetic waves compared to metals. Valuable ad unique properties of MXenes, such as metallic conductivity combined with hydrophilicity and redox activity, led to numerous applications. MXenes, especially $Ti_3C_2T_x$ and V_2CT_x, have shown promise for energy storage applications. However, a narrow voltage window and degradation of these MXenes in their delaminated form, particularly in water containing environments, has been a limiting factor for widening their use in electrochemical applications. This presentation will first discuss new approaches to synthesis, stoichiometry, and surface chemistry control that result in materials with greatly improved chemical and electrochemical stability and having a shelf life of several months without degradation. Second, I'll discuss electrochemical properties and energy storage applications of these MXenes in general. Finally, the electrochemistry of $Ti_3C_2T_x$ in water-in-salt electrolytes will be discussed. Water-in-salt electrolytes, which can provide a wide potential window, are a safer alternative to organic electrolytes. Our recent studies showed that $Ti_3C_2T_x$ MXene shows an electrochemical anomaly in these highly concentrated electrolytes (19.8M LiCl, 19.2M LiBr, 15M LiTFSI), exhibiting distinct and separated anodic and cathodic peaks related to insertion and disinsertion of solvated cations in an expanded voltage window of 1.6 V.

Nov. 17 (20:00-20:45)

Patrice Simon

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Prof. Patrice Simon is Distinguished Professor of Material Science at the Université Paul Sabatier. His research deals with the synthesis and characterization of nanostructured materials for electrochemical energy storage sources, including electrochemical capacitors and Li-ion batteries. He is a specialist of interfacial electrochemistry and is more specifically interested in modification of the material / electrolyte interface for improving kinetics of ion adsorption and charge transfer in electrodes for energy storage applications.
P. Simon is Deputy Director of the French network on Electrochemical Energy Storage (RS2E, www.energie-rs2e.com) and former director of the Alistore European Research Institute (www.alistore.eu). He is member of the French Academy of Sciences since 2019.

He received several awards for his scientific contribution including grants from the European Research Council (Advanced Grant 2012 and Synergy Grant 2020), the Horizon Prize from the Royal Society of Chemistry (2021), Conway Prize in Electrochemistry from ISE (2018. He is Fellow of the International Society of Electrochemistry (2017), member of the French Academy of Technologies (2018) and Senior Member of the Institut Universitaire de France (2017).

Electrochemistry under Confinement in 2-D metal carbide (MXene) electrodes for energy storage applications

Patrice Simon

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Growing demand for fast charging electrochemical energy storage devices with long cycle lifetimes for portable electronics has led to a desire for alternatives to current battery systems, which store energy via slow, diffusion-limited faradaic reactions. The closest devices that fit these demands are Electrochemical Double Layer Capacitors (EDLCs) which can be fully charged within minutes, with almost unlimited cyclability. However, although EDLCs are now used in several applications including for the ever-growing electric mobility market (trams and hybrid electric vehicles), they suffer from limited energy density and this is why high-rate performance redox materials are extensively investigated in the literature.

In this talk, we will present our work on high-rate redox (pseudocapacitive) materials, with a focus on MXenes. MXenes are two-dimensional (2D) early transition metal carbides and nitrides which are usually produced by selective etching of the A group element from MAX phases in F-containing electrolytes [1,2]. We recently proposed a new synthetic method to prepare MXenes from molten salt route, where the MXene surface groups can be tuned [3,4]. The careful control of the electrode architecture and surface composition have led to drastic improvement of the performance of these materials during Li-ion insertion, associated with the partial desolvation of Li ions during the intercalation process. Those results offer interesting perspectives to design high energy and high power energy storage devices.

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Nov. 18 (9:30–10:15)

Omar M. Yaghi

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Omar M. Yaghi pioneered several extensive classes of new materials and a new branch of chemistry, reticular chemistry. This chemistry has yielded materials with applications in hydrogen storage, carbon capture and harvesting water from desert air. Reticular chemistry is being practiced in hundreds of research labs in over 100 countries.

Professor Yaghi has published over 300 scientific articles and has received over 180,000 citations for which he is listed among the very top most cited chemists. He is a member of the US National Academy of Sciences, and has been honored with many awards for his scientific accomplishments, including King Faisal International Prize in Science (2015), Mustafa Prize in Nanoscience and Nanotechnology (2015), TÜBA Academy Prize in Basic and Engineering Sciences (2016), the Medal of Excellence of the First Order bestowed by the King of Jordan His Majesty King Abdullah II (2017), Albert Einstein World Award of Science (2017), BBVA Foundation Frontiers of Knowledge Award in Basic Sciences (2017), Kuwait Prize in Basic Sciences (2017), Wolf Prize in Chemistry (2018), Prince Sultan bin Abdulaziz International Prize for Water (2018), ENI Award for Excellence in Energy (2018), the Mohammed bin Rashid Medal of Science of United Arab Emirates (2019), Gregori Aminoff Prize by the Royal Swedish Academy of Sciences awarded by the King of Sweden His Majesty Carl XVI Gustaf (2019), August-Wilhelm-von-Hofmann-Denkmünze of the German Chemical Society (2020), and Royal Society of Chemistry Sustainable Water Award, United Kingdom (2020).

Envisioning the 'Air Economy' *Powered by Reticular Chemistry*

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Addressing the three major stresses facing our planet, clean air, clean energy, and clean water, is within our reach. At present, new materials such as metal-organic frameworks and covalent organic frameworks, produced by reticular chemistry, are at the forefront of efforts to capture carbon dioxide from air and harvest water from air. We envision that the products of these two capture processes (carbon dioxide and water) can be fed into a conversion cycle in which they are used to produce fuels and chemicals via artificial photosynthesis. The use of air as a nonpolluting, cyclable, and sustainable resource for carbon and water can be powered by sunlight. We describe how the scientific basis for realizing this vision is either already achieved or being established, and that in the fullness of time this paradigm may lead to new global industries and a thriving 'air economy.' Specifically, progress towards harvesting water from air and capture of carbon dioxide from air will be presented.

Nov. 18 (10:15-11:00)

Jiwoong Park

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Jiwoong Park a professor in Chemistry and Molecular Engineering at the University of Chicago. His research group is working on the science and technology of atomically thin crystalline materials and recently showed how to chemically synthesize and control 2D van der Waals crystals and molecular structures to produce high-quality large-scale materials useful for future applications.
He received a B.S. degree from Seoul National University (1996) and a Ph.D. from the University of California, Berkeley. Before coming to the University of Chicago in 2016, he was a faculty member at Cornell University for ten years. Park currently serves as an associate editor of Nano Letters.

New 2D with Atomically Thin Crystals

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Two dimensional (2D) electron transport has been one of the most important topics in science and technology for decades. It was originally studied in 3D semiconductors and then continued in 2D van der Waals (vdW) crystals. In this talk, I will start with the large-scale processes for generating 2D crystalline semiconductor films and superlattices that could be used to fabricate atomically thin integrated circuits. Then we will discuss more recent directions, where we use these 2D materials to realize non-electronic 2D transport phenomena, for example, observed from phonons, photons, and mass. These new approaches could empower the development of 2D phononics, 2D photonics, and 2D mechanics.

Nov. 18 (11:00-11:45)

Mark C. Hersam

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Mark C. Hersam is the Walter P. Murphy Professor of Materials Science and Engineering and Director of the Materials Research Center at Northwestern University. He also holds faculty appointments in the Departments of Chemistry, Applied Physics, Medicine, and Electrical Engineering. He earned a B.S. in Electrical Engineering from the University of Illinois at Urbana-Champaign (UIUC) in 1996, M.Phil. in Physics from the University of Cambridge (UK) in 1997, and a Ph.D. in Electrical Engineering from UIUC in 2000. His research interests include nanomaterials, nanomanufacturing, nanoelectronics, scanning probe microscopy, renewable energy, and quantum information science. Dr. Hersam has received several honors including the Presidential Early Career Award for Scientists and Engineers, TMS Robert Lansing Hardy Award, AVS Peter Mark Award, MRS Outstanding Young Investigator, U.S. Science Envoy, MacArthur Fellowship, AVS Medard W. Welch Award, and eight Teacher of the Year Awards. Dr. Hersam has been repeatedly named a Clarivate Analytics Highly Cited Researcher with over 600 peer-reviewed publications that have been cited more than 50,000 times with an h-index of 109. An elected member of the National Academy of Inventors, Dr. Hersam has founded two companies, NanoIntegris and Volexion, which are commercial suppliers of nanoelectronic and battery materials, respectively. Dr. Hersam is a Fellow of MRS, ACS, AVS, APS, AAAS, SPIE, and IEEE, and also serves as an Associate Editor of ACS Nano.

Chemically Tailored 2D Materials for Electronic and Energy Technologies

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Layered two-dimensional (2D) materials interact primarily via van der Waals bonding, which has created new opportunities for heterostructures that are not constrained by epitaxial growth. However, it is important to acknowledge that van der Waals interactions are not limited to interplanar interactions in 2D materials. In principle, any passivated, dangling bond-free surface interacts with another via non-covalent forces. Consequently, layered 2D materials can be integrated with a diverse range of other materials, including those of different dimensionality, to form van der Waals heterostructures [1]. Furthermore, chemical functionalization provides additional opportunities for tailoring the properties of 2D materials [2] and the degree of coupling across heterointerfaces [3]. In order to efficiently explore the vast phase space for van der Waals heterostructures, our laboratory employs solution-based additive assembly. In particular, constituent nanomaterials (e.g., carbon nanotubes, graphene, transition metal dichalcogenides, black phosphorus, boron nitride, and indium selenide) are isolated in solution, and then deposited into thin films with scalable additive manufacturing methods (e.g., inkjet, gravure, and screen printing) [4]. By achieving high levels of nanomaterial monodispersity and printing fidelity, a variety of electronic and energy applications can be enhanced including photodetectors, optical emitters, supercapacitors, and batteries [5-7]. Furthermore, by integrating multiple nanomaterials into heterostructures, unprecedented device function can be realized including anti-ambipolar transistors, gate-tunable Gaussian heterojunction transistors, and neuromorphic memtransistors [8-10]. In addition to technological implications for electronic and energy technologies, this talk will explore several fundamental issues including band alignment, doping, trap states, and charge/energy transfer across van der Waals heterointerfaces.

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