MIT Industrial Liaison Program Faculty Knowledgebase Report

Decarbonizing the Industrial Sector

December 7, 2020 10:00 am - 12:00 pm

10:00am - 10:05am	Opening Remarks CJ (Changjie) Guo Program Director, MIT Corporate Relations

CJ (Changjie) Guo
Program Director
MIT Corporate Relations

Dr. CJ Guo joined the Office of Corporate Relations as a Senior Industrial Liaison Officer in July, 2015. CJ comes to OCR with 25 years of extensive global experience in technology innovations, portfolio management and business development in emerging and conventional energy sectors with leading multinational corporations in the US, China and Canada.

CJ is a leading expert in emerging energy technologies and energy system transitions. With Shell, he was the Emerging Technology Theme Leader in China/Beijing (2011 to 2015), worked extensively with the Chinese energy communities on the country's future energy landscape, and the Senior Technology Advisor in alternative transportation fuels in the US / Houston (2006-2010), and served during 2010 as Chairman of the Fuel Operations Group for the US DOE FreedomCar Partnership. Prior to joining Shell, CJ has held technology development, commercialization and management positions with Air Liquide (2002-2006) and The BOC Group (1995-2001) after working as a research scientist in oil-sands upgrading with CANMET in Canada (1992-1994).

CJ earned his Ph.D., Chemical Engineering, at CSU, Ohio, his M.S. and B.S., Chemical Engineering at TYUT, China. He has earned various awards from Shell, Air Liquide, BOC, Shanxi Province (China). He holds many patents and has sat on the board of Shenzhen Sanmu Battery Technology Company as an independent board member during 2009-2010.

10:05am - 10:15am

Introduction and framing
Robert Armstrong
Chevron Professor of Chemical Engineering
Director, MIT Energy Initiative (MITEI)

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Professor Robert C. Armstrong directs the MIT Energy Initiative, an Institute-wide effort at MIT linking science, technology, and policy to transform the world's energy systems. A member of the MIT faculty since 1973, Armstrong served as head of the Department of Chemical Engineering from 1996 to 2007. His research interests include polymer fluid mechanics, rheology of complex materials, and energy.

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

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

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10:15am - 12:00pm

Decarbonizing the Industrial Sector
Yuriy Román
Professor of Chemical Engineering, MIT
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?Professor Yuriy Román ?is from Mexico City, Mexico. He earned his B.S.E. in Chemical Engineering from the University of Pennsylvania in 2002. After working in industry for a year, Prof. Román moved to Madison, WI to pursue graduate studies. He received his Ph.D. in Chemical and Biological Engineering from the University of Wisconsin-Madison in 2008, working under the supervision of Professor James A. Dumesic. His thesis work involved the catalytic conversion of carbohydrates obtained from lignocellulosic biomass into chemical intermediates used for the production of biofuels and biomaterials. He then moved to the California Institute of Technology to do postdoctoral research in the synthesis and characterization of microporous and mesoporous materials in the group of Professor Mark E. Davis. There, he investigated the synthesis and implementation of microporous Lewis and Brønsted solid acids for the isomerization of carbohydrates and production of acetic acid from methanol.

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Bilge Yildiz

Breene M. Kerr (1951) Professor, Professor of Materials Science and Engineering
Professor of Nuclear Science and Engineering

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Bilge Yildiz is the Breene M. Kerr (1951) Professor in the Nuclear Science and Engineering and the Materials Science and Engineering Departments at Massachusetts Institute of Technology (MIT), where she leads the Laboratory for Electrochemical Interfaces. Yildiz's research focuses on laying the scientific groundwork to enable next generation electrochemical devices for energy conversion and information processing. The scientific insights derived from her research guide the design of novel materials and interfaces for efficient and durable solid oxide fuel cells, electrolytic water splitting, brain-inspired computing, and solid state batteries. Yildiz laboratory has made significant contributions in advancing the molecular-level understanding of ion diffusion, oxygen reduction, water splitting and charge transfer mechanisms in mixed ionic-electronic conducting oxides. Yildiz's research has uncovered the effects of surface chemistry, elastic strain, dislocations, and strong electric fields on the reactivity, efficiency, and degradation in these applications. Her approach combines computational and experimental analyses at the atomic and electronic level, using in situ scanning tunneling and X-ray spectroscopy together with first-principles calculations and novel atomistic simulations. Yildiz's teaching and research efforts have been recognized by the Argonne Pace Setter (2006), ANS Outstanding Teaching (2008), NSF CAREER (2011), IU-MRS Somiya (2012), the ECS Charles Tobias Young Investigator (2012), the ACerS Ross Coffin Purdy (2018) and the LG Chem Global Innovation Contest (2020) awards. She is a Fellow of the American Physical Society (2021), the Royal Society of Chemistry (2022), and the Electrochemical Society (2023) and an elected member of the Austrian Academy of Science (2023).

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Electrification and Decarbonization of Chemical Synthesis
Karthish Manthiram
Theodore Miller Career Development Chair and Assistant Professor, Chemical Engineering

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Karthish Manthiram is the Theodore T. Miller Career Development Chair and Assistant Professor in Chemical Engineering at MIT. The Manthiram Lab at MIT is focused on the molecular engineering of electrocatalysts for the synthesis of organic molecules, including pharmaceuticals, fuels, and commodity chemicals, using renewable feedstocks. Karthish received his bachelor's degree in Chemical Engineering from Stanford University and his Ph.D. in Chemical Engineering from UC Berkeley, where his dissertation research was focused on the development of nanoscale materials for storing solar energy in chemical bonds. Most recently, he was a postdoctoral researcher at the California Institute of Technology, where he worked on developing new ionically-conductive polymers using olefin metathesis. Karthish's research has been recognized with several awards, including the NSF CAREER Award, DOE Early Career Award, 3M Nontenured Faculty Award, American Chemical Society PRF New Investigator Award, Dan Cubicciotti Award of the Electrochemical Society, and Forbes 30 Under 30 in Science. Karthish's teaching has been recognized with the C. Michael Mohr Outstanding Undergraduate Teaching Award, the MIT ChemE Outstanding Graduate Teaching Award, and the MIT Teaching with Digital Technology Award. He serves on the Early Career Advisory Board for *ACS Catalysis* and on the Advisory Board for both *Trends in Chemistry* and the *MIT Science Policy Review.*

Chemical synthesis is responsible for significant emissions of carbon dioxide worldwide. These emissions arise not only due to the energy requirements of chemical synthesis, but since hydrocarbon feedstocks can be overoxidized or used as hydrogen sources. Using renewable electricity to drive chemical synthesis may provide a route to overcoming these challenges, enabling synthetic routes which operate at benign conditions and utilize sustainable inputs. We are developing an electrosynthetic toolkit in which distributed feedstocks, including carbon dioxide, dinitrogen, water, and renewable electricity, can be converted into diverse fuels, chemicals, and materials.

In this presentation, we will first share recent advances made in our laboratory on nitrogen fixation to synthesize ammonia at ambient conditions. We will then discuss how to drive selective and sustainable carboxylation reactions for chain extension. Finally, we will examine how water can be used as a sustainable oxygen-atom source for epoxidation of olefins, providing a route to utilize oxidative equivalents in a water electrolyzer. These example reactions will illustrate how the modularity of chemical manufacturing could be enhanced through electrochemical routes which open up local and on-demand production of critical chemicals and materials.