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

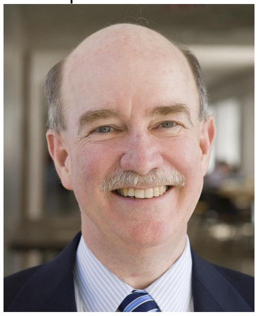
Dr. CJ Guo joined the Office of Corporate Relations as a Senior Industrial Liaison Officer in July, 2015. CJ comes to OCR with 25 years of extensive global experience in technology innovations, portfolio management and business development in emerging and conventional energy sectors with leading multinational 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
Director, MIT Energy Initiative (MITEI)
Chevron Professor of Chemical Engineering
MIT Department of Chemical Engineering



Robert Armstrong
Director, MIT Energy Initiative (MITEI)
Chevron Professor of Chemical Engineering
MIT Department of Chemical Engineering

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 of Chemical Engineering, MIT

?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
Professor of Nuclear Science and Engineering
Professor of Materials Science and Engineering
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Bilge Yildiz is a 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. She received her PhD degree at MIT in 2003 and her BSc degree from Hacettepe University in Turkey in 1999. After working at Argonne National Laboratory as research staff, she returned to MIT as an assistant professor in 2007. Her leadership responsibilities at MIT include one of the Integrated Research Groups of MIT's NSF sponsored Materials Research Science and Engineering Center, and the Low Carbon Energy Center on Materials in Energy and Extreme Environments.

She is a member of the Basic Science and Electronics Divisions of the ACerS. Her research focuses on laying the scientific groundwork and proof-of-principle material systems for the next generation of high-efficiency devices for energy conversion and information processing, based on solid state mixed ionic-electronic conducting (MIEC) materials, by combining in situ surface sensitive experiments with first-principles calculations and novel atomistic simulations. Her work has made significant con-tri-bu-tions to advancing the molecular-level understanding of oxygen reduction and oxidation kinetics on MIEC solid surfaces, and of ion and electron transport, under electro-chemo-mechanical conditions. The scientific insights derived from her research guide the design of novel surface chemistries for efficient and durable solid oxide fuel cells, thermo-/electro-chemical splitting of H_2O and CO_2, corrosion resistant films, high energy density solid state batteries, and red-ox based memristive information storage and processing.

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

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.*

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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.