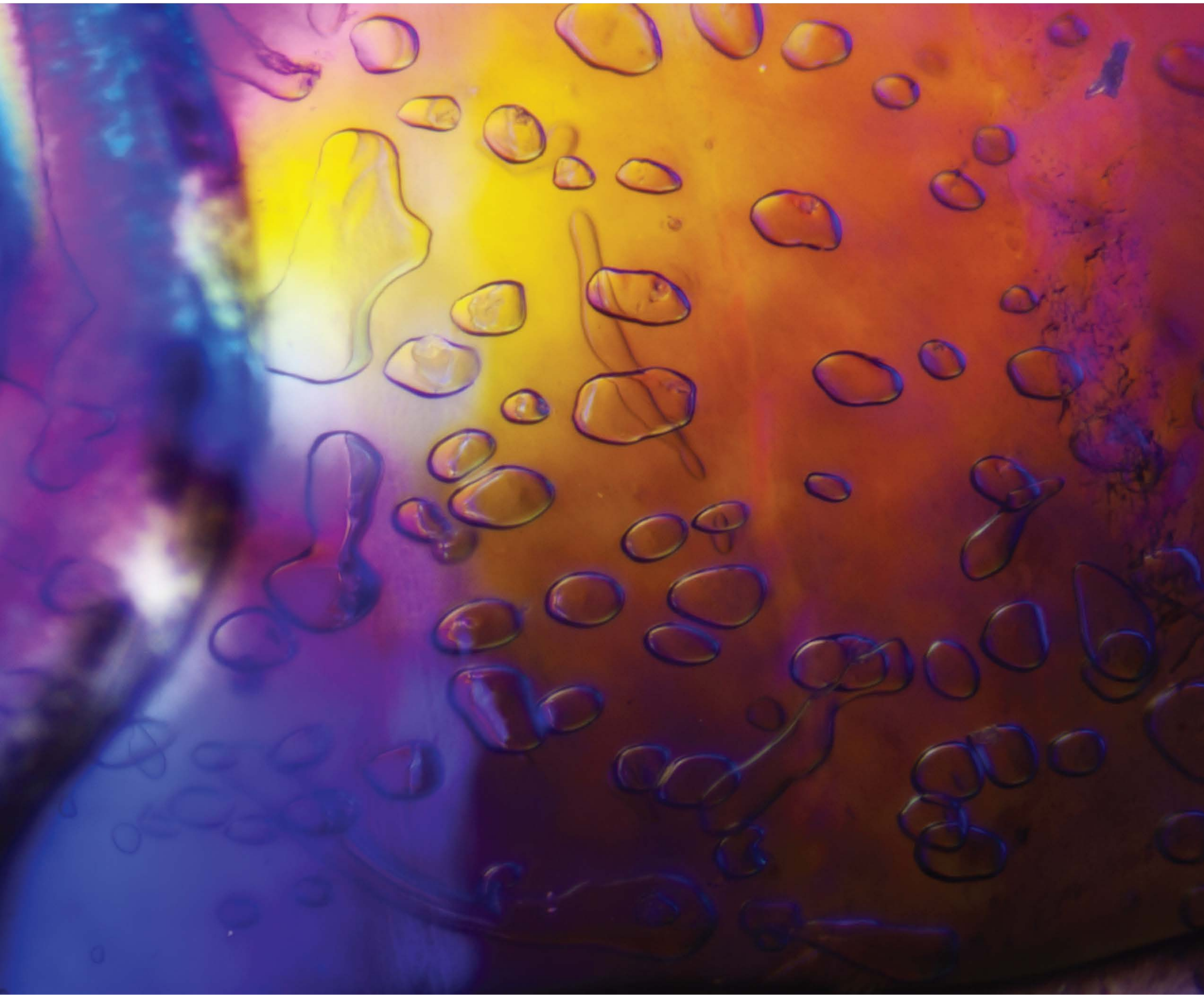
MPC
Making Matter, Matter ®

Materials Day

Materials for Electrochemical Energy Storage



Materials Resources:

Materials Processing Center provides an environment where students and professionals from industry, government and academia collaborate to identify and address pivotal multidisciplinary issues in materials processing and manufacturing at MIT.
http://mpc-www.mit.edu

Microphotonics Center @ MIT builds interdisciplinary teams, focused on collaborative research for the advancement of basic science and emerging technology pertaining to integrated photonic systems.
http://mphotonics.mit.edu

The Communications Technology Roadmap (CTR) is a project under the Microphotonics Industry Consortium, which in turn is part of the MIT Microphotonics Center. The purpose of this Roadmap is to understand the interaction between technology, industry, and policy dynamics and from there, formulate a vision for the future of the microphotonics industry.
http://mph-roadmap.mit.edu/

The Crystal Physics and Electroceramics Laboratory is devoted to the modeling, processing, characterization and optimization of energy related devices (sensors, batteries, fuel cells, solar/photolysis cells) and the integration of sensor, actuator and photonic materials into microelectromechanical (MEMS) systems.
http://electroceramics.scripts.mit.edu/

The Skoltech Center for Electrochemical Energy Storage (CEES) is an inter-university/interdepartmental center with three major goals; development of advanced lithium ion and multivalent ion batteries, the development of rechargeable metal-air batteries, and the development of reversible low and elevated temperature fuel cells.
http://cees-www.mit.edu/

Center for Materials Science & Engineering is devoted to the design, creation, and fundamental understanding of materials that are capable of enhancing the human experience.
http://mit.edu/cmse

Department of Materials Science & Engineering is known as the world-wide leader in its field, pioneering advances in engineering sciences and technologies.
http://dmse.mit.edu

Dates for future Materials Day events:

Wednesday, October 11, 2017

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
MATERIALS PROCESSING CENTER

Materials Day at MIT

Materials for Electrochemical Energy Storage

October 18, 2016

Hosted annually by the Materials Processing Center, Materials Day features emerging research and applications in materials science & engineering for products and processes across the industrial spectrum. The theme for this year's symposium is "Materials for Electrochemical Energy Storage." Topics will include: advanced metal-ion, metal-air and flow batteries for applications ranging from consumer electronics to transportation and grid level energy management. Materials Day activities include conference speakers from both MIT and Industry. The student poster session immediately follows the technical symposium and showcases the latest results from the diverse materials research communities in MIT's Schools of Science and Engineering.

Materials Processing Center
Massachusetts Institute of Technology
77 Massachusetts Avenue
Room 24-517
Cambridge, MA 02139
http://mpc-www.mit.edu
email: mpc@mit.edu

Materials Day Agenda

8:00 am	**Registration** Kresge Lobby, W16
8:45 am	**Welcome and Overview** Professor Carl V. Thompson Director, Materials Processing Center Department of Materials Science & Engineering MIT
Session I:	
9:00 am	**3M's Battery Materials - Still Room for More Energy in Li-ion** Dr. Kevin Eberman Product Development Manager 3M
9:40 am	**Evaluating Storage Technologies for Solar and Wind Energy** Professor Jessika Trancik Associate Professor in Energy Studies Institute for Data, Systems and Society MIT
10:20 am	**Break**
Session II:	
10:40 am	**Materials Challenges for Next-Generation Batteries and Opportunities Using Computational Design** Dr. Boris Kozinsky Principal Scientist Research & Technology Center Bosch
11:20 am	**Activating Oxygen Chemistry for Sustainable Energy** Professor Yang Shao-Horn Departments of Mechanical Engineering & Materials Science & Engineering MIT
12:00 - 1:00 pm	**Lunch** Student Center, 3rd floor, Twenty Chimneys/Mezzanine Lounge (Bldg. W20)
Session III:	

1:10 pm **Capturing the Value of Energy Storage**
Dr. Glen D. Merfeld
Product Science Leader
GE Global Research

1:50 pm **Ultralow Cost Electrochemical Storage to Turn Renewable Energy into Reliable Energy**
Professor Yet-Ming Chiang
Department of Materials Science & Engineering
MIT

2:30 pm **Control of Phase Transformations in Rechargeable Batteries**
Professor Martin Z. Bazant
Departments of Chemical Engineering and Mathematics
MIT

3:10 pm **Wrap-up and Discussion**

Materials Research Review Poster Session

3:30 pm **Poster Session and Social**
La Sala De Puerto Rico
2nd Floor Stratton Student Center
(Bldg. W20)

5:30 pm **Poster Awards**

5:45 pm **Adjourn**

Professor Carl V. Thompson

Director
Materials Processing Center
Stavros Salapatas Professor of Materials Science and Engineering
Department of Materials Science and Engineering
Massachusetts Institute of Technology

Biography

Professor Thompson received his S.B. in Materials Science and Engineering from MIT, and his S.M. and Ph.D. in Applied Physics from Harvard University. He was an IBM postdoctoral Fellow in the Research Laboratory of Electronics at MIT before joining the faculty of the Department of Materials Science and Engineering in 1983. Professor Thompson spent the 1990-91 academic year at Cambridge University, the 1997-98 academic year at the Max Planck Institut fur Metallforschung, and 2012 at the Karlsruhe Institute of Technology. He has been active in MIT's programs with Singapore, including twelve years leading the program for Advanced Materials for Micro- and Nano-Systems of the Singapore-MIT Alliance. He served as the President of the Materials Research Society in 1996. He is currently the Director of MIT's Materials Processing Center and Co-Director of the Skoltech Center for Electrochemical Energy Storage. Professor Thompson has been a consultant with over thirty companies, including Intel, IBM, DEC, and a number of start-ups involved in development of microelectromechanical devices and systems.

Professor Thompson's research interests include processing of thin films and nanostructures; the mechanical and electrical properties of nanostructures; and the incorporation of thin films and nanostructures in electronic, electromechanical, and electrochemical devices and systems.

Dr. Kevin Eberman
Product Development Manager
3M

3M's Battery Materials - Still Room for More Energy in Li-ion

Abstract

In the context of the state of the art of Li-ion battery technology, the remaining opportunities for increasing energy-density will be discussed, including current and developmental battery material products from 3M. Focus will be on the technical aspect of what makes the materials work well and also what challenges still remain. These materials include electrolyte, Si-anode, cathode, current-collector, and thermal solutions. A goal of the talk will be to find new ways to collaborate in future development of these or other battery materials.

Biography

Kevin Eberman finished his Ph.D. in Materials Science at the Massachusetts Institute of Technology in 1998. After that he had a post-doc appointment at the Max Planck Institute for Solid-State Research, where he had a paper published in Nature. Next he started in the Li-ion battery (LIB) group at 3M in 1999 developing anode and cathode materials for LIBs. He was the technical lead in launching a new class of the cathode materials called "NMC" and in building that business. Then he worked at Medtronic from 2006 to 2010 as a Principal Scientist in the battery research group, where he contributed to Li-ion and primary battery research, development, and production. In 2010 he re-joined 3M and moved to the management role for LIB research group. Now Kevin provides technical leadership for the development of improved materials for batteries. He has 22 publications and 11 patents or patent-applications. The LIB laboratory in EMSD develops advanced materials for LIBs with higher energy, better safety and lower cost. 3M is a leading materials supplier in LIB market. EMSD is part of 3M's Electronics and Energy Business Group, enabling technologies for reliable battery performance by creating materials for more powerful, smaller, safer and longer-lasting batteries.

Professor Jessika Trancik
Atlantic Richfield Associate Professor in Energy Studies
Institute for Data, Systems and Society (IDSS)
Massachusetts Institute of Technology

Evaluating Storage Technologies for Solar and Wind Energy

Abstract

Wind and solar industries have grown rapidly in recent years but still supply only a small fraction of global electricity. The continued growth of these industries, to levels that significantly contribute to climate change mitigation, will depend on whether they can compete against alternatives that provide energy on demand. Energy storage can transform intermittent renewables for this purpose but evaluating diverse storage technologies on a common scale has proved a major challenge, due to widely varying performance along multiple cost dimensions and no dominant technology option. Here we clear a hurdle in energy storage research by devising a method to evaluate storage technologies against patterns of energy demand. Some storage technologies today are shown to add value to solar and wind energy, but cost reduction is needed to reach widespread profitability. The optimal cost improvement trajectories are found to be location invariant due to emergent characteristics of electricity prices and energy resource availability. The resulting cost targets can be used to inform the development of energy storage materials and devices.

Biography

Jessika Trancik is the Atlantic Richfield Career Development Associate Professor in Energy Studies at the Institute for Data, Systems and Society (IDSS) at the Massachusetts Institute of Technology. She is also an external professor at the Santa Fe Institute. She received her B.S. in materials science and engineering from Cornell University and her Ph.D. in materials science from the University of Oxford as a Rhodes Scholar. Before MIT, she spent several years at the Santa Fe Institute as an Omidyar Fellow, and at Columbia University as an Earth Institute Fellow, where her research focused on energy systems modeling. Her research group studies the dynamic costs and environmental impacts of energy technologies to inform technology design and policy.

Dr. Boris Kozinsky
Principal Scientist
Research & Technology Center
Bosch

Materials Challenges for Next-Generation Batteries and Opportunities Using Computational Design

Abstract

Lithium-ion batteries have revolutionized energy storage for portable electronic devices, however their high cost is still an obstacle for wide commercialization of electric vehicles. Significant improvement of today's batteries can be obtained by inventing new combinations of materials that will allow for better safety and higher energy density on the cell level. Some of the most active areas of research today are aimed at developing Li-metal anodes and solid-state electrolyte technologies. This talk will give an overview of different constraints and innovation opportunities in the space of new materials, taking into account their intrinsic properties as well as their interactions in the complex coupled battery system. In the quest for designing new materials systems, we need to achieve deep atomic-level understanding of the mechanisms controlling electrochemistry and transport, as well as degradation. An important research tool emerging in this context is computational materials modeling, that is capable of yielding insights that are not available from experimental characterization alone. I will illustrate this approach with examples of our work in the areas of electrolyte transport and electrochemical stability, and show how computation can accelerate the path towards new materials and higher-energy batteries.

Biography

Dr. Boris Kozinsky is a principal scientist at Bosch Research, leading the Research and Technology Center North America branch in Cambridge MA. His work is at the intersection between condensed matter physics, computational methods, and data informatics. His main interest is in the design of novel compositions and optimization of their properties derived from quantum and atomistic understanding using first-principles computations, specifically targeting ionic, electronic and phonon transport, and determining design rules across the wide space of structures. In addition to scientific publications, he has co-authored close to 50 granted and pending patent applications. His team works closely with experimental groups worldwide, both at Bosch and at leading universities, in diverse technology areas that include energy storage, thermoelectrics, piezoelectrics, and low-dimensional materials.

Before joining Bosch, Dr. Kozinsky earned his PhD in Physics from MIT, working in the Department of Materials Science and Engineering. Prior to that he received undergraduate degrees from MIT in Physics, Mathematics, and Electrical Engineering and Computer Science. He is closely involved with academic research, establishing collaborations and managing multiple sponsored university projects. He also serves on the scientific advisory boards of several US and European academic centers on computational and experimental materials design.

Professor Yang Shao-Horn
Department of Mechanical Engineering &
Department of Materials Science & Engineering
Massachusetts Institute of Technology

Activating Oxygen Chemistry for Sustainable Energy

Abstract

Efficient energy storage enables the use of sustainable energy. Activating oxygen chemistry is central to enable efficient redox of small molecules of energy consequence, including photoelectrochemical and electrochemical water-splitting, regenerative fuel cells, and metal-air batteries. Probing a fundamental catalyst "design principle" that links surface structure and chemistry to the catalytic activity can guide the search for highly active catalysts that are cost effective and abundant in nature. Recent advances in identifying the design principles and activity descriptors of transition metal oxides will be presented. We will show that these fundamental concepts can be used to tune transition metal oxide surfaces with much enhanced activities for oxygen electrocatalysis. We will also discuss how oxide bulk electronic structures can influence oxygen electrocatalysis, from which proton-coupled and -decoupled electron transfer mechanisms are discussed. Lastly, connecting bulk to surface electronic structures is challenging but much needed to provide mechanistic insights, and some in-situ synchrotron X-ray measurements to this end will be discussed.

Biography

Yang Shao-Horn is W.M. Keck Professor of Energy, Professor of Materials Science and Engineering, and Professor of Mechanical Engineering at MIT. Her research is centered on the chemical physics of surfaces with emphasis on metal oxides, searching for descriptors of catalytic activity, wetting properties and ion transport, and design materials for electrochemical/photoelectrochemical water splitting and CO2 reduction, ion/electron storage, and ion conductors.

Professor Shao-Horn has been the recipient of several awards and honors recognizing her teaching/mentoring and research contributions, including the Charles Tobias Young Investigator Award from the Electrochemical Society, the Tajima Prize from the International Society of Electrochemistry, the Research Award by the International Battery Materials Association, the Battery Research Award of the Electrochemical Society, and Royal Society of Chemistry Fellow and AAAS Fellow.

Dr. Glen D. Merfeld
Product Science Leader
GE Global Research

Capturing the Value of Energy Storage

Abstract

There has been tremendous growth and investment in the energy storage industry with the goal of enabling better use of our constrained energy resources. We'll review macro drivers that are exciting change in energy consumption and explore trends that signal a nascent grid storage market primed for rapid growth. We'll also look at how advances in technology are fueling progress. Creation of real, sustainable value with energy storage requires integrated, scalable, and economic solutions. A value analytics methodology will be illustrated that maps physics-based storage performance against application specific requirements and local market constructs. This analysis reveals, by market segment, what storage type, amount, and mode of use will create the greatest customer value. This type of informed design and intelligent dispatch of grid storage will enable higher levels of performance, create new value streams, and open new markets.

Biography

With the goal of linking the physics from our labs to value for our customers, Glen is the Product Science Leader at GE Global Research. His team builds methods, tools, and models to inject scientific method and statistical rigor into product management, helping GE balance market needs with engineering and supply chain capabilities. Turning Product Management into a science includes creating models of our key Industry Ecosystems – Energy, Transportation, and Healthcare. These let us see the whole industry landscape, help us maximize product margins, and allow us to anticipate and plan disruptive innovation. Glen's team is a resource for the entire company to advance world leading product analytics while providing a hub to create, foster and share product management excellence. Product Management Science is transforming how we prioritize our core research investments and how we create ground breaking research.

Glen is a Chemical Engineer with a B.S. from Northwestern University and a Ph.D. from the University of Texas at Austin and has been part of GE's research community since 1998 working across several GE businesses on the adoption of advanced technologies.

Professor Yet-Ming Chiang
Department of Materials Science & Engineering
Massachusetts Institute of Technology

Ultralow Cost Electrochemical Storage to Turn Renewable Energy into Reliable Energy

Abstract

The rapidly dropping cost of wind and solar electricity generation, illustrated by levelized costs of electricity (LCOE) that are now competitive with fossil fuel generation, only highlights the need for electrical storage that can turn renewable power into predictable, dispatchable, and even baseload power. Such a revolutionary outcome requires energy storage with costs well below the trajectory of current technology, and which is in addition safe, scalable, and sufficiently energy-dense for widespread deployment, including in space-constrained environments. Although pumped hydroelectric storage (PHS) and underground compressed air energy storage (CAES) today have the lowest costs (U.S. \$100/kWh installed cost), each faces geographical and environmental constraints that may limit widespread deployment. Here we demonstrate an ambient-temperature aqueous rechargeable flow battery that uses low-cost polysulfide chemistry in conjunction with lithium or sodium as the working ion, and an air- or oxygen-breathing cathode. The solution energy density is 40-125 Wh/L, exceeding current solution-based flow batteries; using sodium polysulfide, the chemical cost of stored energy is exceptionally low at U.S. \$1/kWh. Projected to system-level, this new approach has energy and power costs comparable to that of PHS and CAES, but is achieved at higher energy density and with minimal locational constraints.

Biography

Yet-Ming Chiang is Kyocera Professor in the Department of Materials Science and Engineering at the Massachusetts Institute of Technology (MIT). He holds S.B. and Sc.D. degrees from MIT, where he has been a faculty member since 1984. His work focuses primarily on advanced materials and their role in clean energy. He is a member of the U.S. National Academy of Engineering, and a Fellow of the American Ceramic Society and the Materials Research Society. He has published over 200 scientific articles, one textbook, and holds about 35 issued patents and a similar number of pending patent applications. In addition to his academic research, Chiang has co-founded four companies based on research from his MIT laboratory: American Superconductor Corporation (NASDAQ: AMSC), A123 Systems (NASDAQ: AONE), SpringLeaf Therapeutics, and 24M Technologies. Of these, three are in the area of energy technology (Am. Super., A123, and 24M) and three grew out of research in batteries (A123, SpringLeaf and 24M). Chiang also serves on numerous government and private advisory committees and study panels, including the U.S. Department of Energy's Energy Efficiency and Renewable Energy Advisory Committee (ERAC) and Basic Energy Sciences Advisory Committee (BESAC), the Basic Energy Sciences' Materials Science Division's Materials Council, Princeton University's Andlinger Center for Energy and Environment, and the Stanford Institute for Materials and Energy Sciences (SIMES).

Professor Martin Z. Bazant
Department of Chemical Engineering
Department of Mathematics
Massachusetts Institute of Technology

Control of Phase Transformations in Rechargeable Batteries

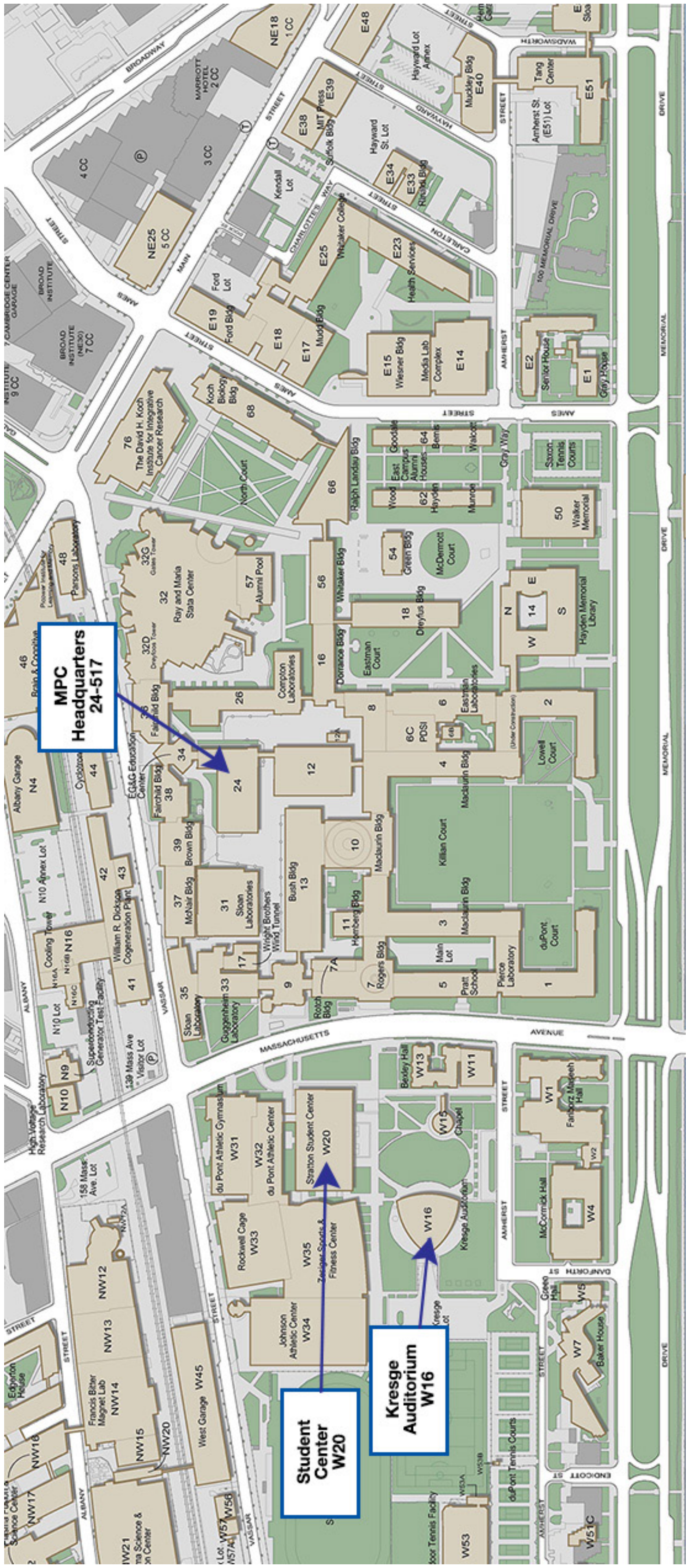
Abstract

The rapid, stable cycling of rechargeable batteries requires well-controlled phase transformations of the redox active materials in each electrode, between the charged and discharged states. Three examples will be discussed: 1) In Li-ion batteries, common intercalation materials, such as iron phosphate and graphite, undergo phase separation (into Li-rich and Li-poor phases), which limits the power density and leads to degradation. A general mathematical theory, supported by recent X-ray imaging experiments, will be presented that shows how phase separation can be suppressed by concentration-dependent reaction resistance. 2) In Li-air batteries, the same theory, applied to electrodeposition of Li2O2, reveals a fundamental rate limitation, unfortunately far below the needs of electric vehicles. 3) Finally, in Li-metal batteries, theoretical and experimental results will be presented regarding the control of morphological instabilities in lithium electrodeposition, which must be achieved to ensure safety and long cycle life.

Biography

Martin Z. Bazant is the E. G. Roos (1944) Professor of Chemical Engineering and Mathematics at the Massachusetts Institute of Technology. After a PhD in Physics at Harvard University (1997), he joined the MIT faculty in Mathematics (1998) and then Chemical Engineering (2008), where he currently serves as Executive Officer. His research combines theory, computation and experiments in diverse fields, with emphasis on electrochemistry and electrokinetics. His contributions have been recognized by the Alexander Kuznetsov Prize in Theoretical Electrochemistry (ISE), Global Climate and Energy Project Chair (Stanford), Paris Sciences Chair (ESPCI), Brilliant Ten (Popular Science), Lighthill Lecture in Applied Mathematics (IMA), Winchell Lecture in Materials Science (Purdue), and Corrsin Lecture in Fluid Dynamics (Johns Hopkins). He serves on the editorial board of SIAM Journal of Applied Mathematics and Scientific Reports and is the Chief Scientific Advisor for Saint Gobain Ceramics and Plastics, Northboro R&D Center.

Notes


MPC Headquarters 24-517
Student Center W20
Kresge Auditorium W16