CHEMICAL SCIENCES ROUNDTABLE

Advances, Challenges, and Long-Term Opportunities of Electrochemistry: Addressing Societal Needs

Planning Committe Biographies

Héctor D. Abruña, NAS, is Émile M. Chamot Professor in the Department of Chemistry and Chemical Biology at Cornell University. His research group focuses on the development and characterization of new materials and architectures for fuel cells and batteries, and molecular assemblies for molecular electronics and sensor applications. He uses electrochemical techniques as probes for an array of chemical systems and uses other techniques to address problems of electrochemical interest. His group has pioneered the development and use of operando methods for the study of electrochemical interfaces with emphasis on X-rays, TEM and DEMS (differential electrochemical mass spectrometry). Dr. Abruna was inducted into the National Academy of Sciences in 2018 for his leadership in electrochemistry. He received his PhD in analytical chemistry from the University of North Carolina, Chapel Hill.

Phil Baran, NAS, is Darlene Shiley Professor in the Department of Chemistry at the Scripps Research Institute. His research focuses on the field of chemical synthesis of complicated organic molecules. He has developed remarkably short, efficient and practical synthetic pathways to many biologically active compounds, and has invented new strategies and methods of synthesis which have advanced both academic and industrial research. The Baran laboratory identifies areas of chemical synthesis that can have a dramatic impact on the rate of drug discovery and development. Baran was elected into the National Academies in 2017. He received his PhD in chemistry in 2001 from the Scripps Research Institute.

Carol A. Bessel is the Acting Division Director for Chemistry at the National Science Foundation (NSF). She was awarded a National Research Council Postdoctoral Research Fellowship at the Naval Research Laboratory in Washington, DC before becoming a faculty member in the Department of Chemistry at Villanova University. While a professor, she received a Bunting Fellowship at the Radcliffe Institute of Advanced Studies at Harvard University to study the use of carbon nanofibers in fuel cell applications. She also took sabbatical leave to study dissolution of copper interconnects for microchip manufacturing at the University of North Carolina at Chapel Hill. Dr. Bessel started as a rotator at the NSF in August 2005 and converted to permanent federal employment in 2007. She is committed to promoting discovery in the chemical sciences, enhancing undergraduate and graduate education and broadening participation, and improving society through science and engineering. She earned her PhD in chemistry from the State University of New York at Buffalo.

Yet-Ming Chiang, NAE, is Kyocera Professor in the Department of Materials Science and Engineering at Massachusetts Institute of Technology. Dr. Chiang's research focuses on the design, synthesis, and characterization of advanced inorganic materials and related devices. His current topics of interest include new cathode and anode materials for lithium ion batteries, phase transformations in electroactive materials, electrochemical device design, electrochemical-to-

mechanical energy conversion, self-assembling colloids, and the stability and defect chemical properties of interfaces in inorganic materials. Dr. Chiang was elected to the National Academy of Engineering in 2009 for his contributions to the understanding of new energy-storage materials and their commercialization. He received his ScD in ceramics from Massachusetts Institute of Technology.

Anne Co is Associate Professor of Chemistry and Biochemistry in the Department of Chemistry at The Ohio State University. Her current research interest is in investigating the properties of electrocatalytic materials and processes for energy conversion and storage. She is Associate Editor of American Chemical Society Applied Energy Materials. Dr. Co obtained her PhD in chemistry with a specialization in electrochemistry from the University of Calgary, Canada.

Raul Miranda is the lead for the chemical transformations team and a program manager at the US Department of Energy, Basic Energy Sciences. Before joining DOE in 2001, he was program director for the Kinetics, Catalysis and Molecular Processes program at the National Science Foundation (1996-2000). He was also a tenured professor of chemical engineering at the University of Louisville (1983-2000), where he directed the Materials Research Laboratory. His previous teaching experience encompassed traditional chemical engineering courses and specialized in kinetics and reaction engineering, heterogeneous catalysis, engineering mathematics, solid-state chemical processing, and computational condensed-matter chemistry. His previous research experience focused on heterogeneous catalysis, solid state and surface chemistry, and reaction mechanisms. He developed synthesis methods for non-metallic catalysts, molecular sieves, and materials for chemical sensing and microelectronics applications. Dr. Miranda received his PhD at the University of Connecticut in Storrs.

Cynthia Zoski is the Associate Director of the Center for Electrochemistry and Research Professor of Chemistry at the University of Texas at Austin. Her research interests involve the application of electrochemical methods to the study of chemical problems and include investigations that involve scanning electrochemical microscopy, ultramicroelectrodes, and electrocatalysis at metal nanoparticles and atomic clusters. She has published over 80 peer-reviewed papers, book chapters, and other publications. She has co-authored Electrochemical Methods, 2nd ed. Instructor's and Student's Solution Manuals and is the editor of the Handbook of Electrochemistry. She is the co-editor of the Electroanalytical Chemistry series with Allen J. Bard. Dr. Zoski received her PhD in electrochemistry from Queen's University, Canada.

Workshop Participant Biographies

Veronica Augustyn is an Assistant Professor of Materials Science & Engineering and a University Faculty Scholar at North Carolina State University. Prior to this appointment, she was a postdoctoral fellow at the University of Texas at Austin. Her research focuses on the design, synthesis, and characterization of materials for electrochemical energy technologies. In particular, she is interested in the relationships between material structure, composition, and morphology, and the resulting electrochemical mechanisms. A prominent area of research is the fundamental understanding of electrochemical redox and ion transport under nanoconfinement. She also leads an award-winning international project at NC State, SciBridge, which develops renewable energy research and education collaborations between universities in Africa and the U.S. Among other

honors, she is the recipient of a 2019 Department of Energy Early Career Award, a 2019 Sloan Research Fellowship in Chemistry, and a 2017 NSF CAREER Award, and is a Scialog Fellow in Advanced Energy Storage from the Research Corporation for Science Advancement. She received her B.S. at the University of Arizona, both in materials science and engineering and her Ph.D. from the University of California, Los Angeles.

Ismaila Dabo is an associate professor in the Department of Materials Science and Engineering at the Pennsylvania State University. He joined Pennsylvania State University in 2013 as an assistant professor. After obtaining his PhD, he became a postdoctoral fellow at the French Institute of Computer Science and a permanent researcher at University of Paris Est. His research focuses on the development of molecular and submolecular models to understand and optimize the performance of materials for energy conversion and storage, specifically in the areas of electrochemistry to produce electricity from fuels and of photochemistry to produce fuels from sunlight. His awards include the *Corning Chair in Materials Science and Engineering* (2019), *Montgomery Teaching Award* (2019), *National Science Foundation CAREER Award* (2017), and *Oak Ridge Ralph E. Powe Junior Faculty Award* (2014). He received B.Sc. and M.Sc. degrees in Mechanical Engineering from Ecole Polytechnique (France) and graduated with a Ph.D. in Materials Science and Engineering from the Massachusetts Institute of Technology in 2008.

Jeffrey E. Dick is an assistant professor at the University of North Carolina at Chapel Hill. At UNC, Jeffrey's research program uses electrochemistry for the following pursuits: answering fundamental questions regarding single mitochondria and enzyme behavior, developing methods to electrogenerate radical species to destroy micropollutants, developing nanoelectrochemical tools for single cell metabolomics, and studying the nucleation and growth kinetics of single nanoparticles. He earned a Bachelor of Science from Ball State University in 2013 and graduated with a PhD in Analytical Chemistry from the University of Texas at Austin in 2017 under the guidance of Allen J. Bard.

Larry R. Faulkner is President Emeritus of The University of Texas at Austin and is the retired president of Houston Endowment, a private philanthropy established by Jesse H. and Mary Gibbs Jones. He also served as Chancellor *ad interim* of The University of Texas System. Over four decades, Dr. Faulkner was on the chemistry faculties of Harvard University, the University of Illinois, and the University of Texas. At Illinois he was also Head of the Department of Chemistry, Dean of the College of Liberal Arts and Sciences, and Provost and Vice Chancellor for Academic Affairs. In 1998, he returned to the University of Texas at Austin as the 27th president and served into 2006. Faulkner became President of Houston Endowment immediately thereafter and retired in February 2012. He has served on the boards of Exxon Mobil Corporation, Temple-Inland, Sandia National Laboratories, Southern Methodist University, Internet2, Houston Grand Opera, Discovery Green Conservancy, the Lyndon Baines Johnson Foundation, and Reasoning Mind. He is currently on the boards of Al Akhawayn University in Ifrane, Somaiya Viyavihar University in Mumbai, the O'Donnell Foundation, and the Philosophical Society of Texas. From 2006 into 2008, he chaired the National Mathematics Advisory Panel by designation of the President and the Secretary of Education. He also chaired the recent National Academies Committee on Federal Regulation of Research (2015-2016). He is a member of the American Academy of Arts and Sciences and has been recognized with the Electrochemical Society's Edward Goodrich Acheson Medal, the American Chemical Society Award in Analytical Chemistry, the Charles N. Reilly

Award of the Society for Electroanalytical Chemistry, and the U.S. Department of Energy Award for Outstanding Scientific Achievement in Materials Chemistry. In 1969, he received his PhD in chemistry from the University of Texas at Austin.

Thomas Francisco Jaramillo is an Associate Professor of Chemical Engineering and Director of the SUNCAT Center for Interface Science and Catalysis at Stanford University. Thomas conducted his post-doctoral research in the Department of Physics at the Technical University of Denmark as a Hans Christian Ørsted Post-doctoral Fellow prior to returning to Stanford to embark on his independent research career. Thomas's research efforts are aimed at developing materials and processes that can accelerate important chemical transformations related to energy conversion with improved efficiency and durability. The overarching theme is the development of cost-effective, clean energy technologies that can benefit societal and economic growth while minimizing impacts to the environment. In pursuit of these goals, Professor Jaramillo conducts fundamental studies into semiconductors and catalyst materials to understand the physical and chemical factors that govern their performance, insights which he then leverages to engineer improved materials and devices for sustainable energy. Thomas Jaramillo has won a number of awards, including the Volkswagen/BASF Science Award Electrochemistry (2014), the Resonate Award from the Resnick Institute (2014), the Presidential Early Career Award for Scientists & Engineers (PECASE, 2011), the U.S. Dept. of Energy Hydrogen and Fuel Cell Program Research & Development Award (2011), the NSF CAREER Award (2011), and the Mohr-Davidow Ventures Innovator Award (2009). A native of Puerto Rico, Thomas first came to Stanford University to pursue his B.S. in Chemical Engineering, followed by graduate school at the University of California at Santa Barbara where he earned his M.S. and Ph.D. in Chemical Engineering.

Marc Koper is Professor of Surface Chemistry and Catalysis at Leiden University, The Netherlands. He was an EU Marie Curie postdoctoral fellow at the University of Ulm (Germany) and a Fellow of Royal Netherlands Academy of Arts and Sciences (KNAW) at Eindhoven University of Technology, before moving to Leiden University in 2005. His research in Leiden focuses on fundamental aspects of electrocatalysis, theoretical electrochemistry, and electrochemical surface science, in relation to renewable energy and chemistry. He received his PhD degree (1994) from Utrecht University (The Netherlands) with a thesis on nonlinear dynamics and oscillations in electrochemistry.

Song Lin grew up in Tianjin, China and is currently a Howard Milstein Faculty Fellow and Assistant Professor of Chemistry at Cornell University. His doctoral research was focused on the development and mechanistic understanding of enantioselective reactions catalyzed by multifunctional hydrogen-bond donors. His postdoctoral research at UC Berkeley was focused on using molecularly tunable materials, such as covalent organic frameworks, as catalysts for electrochemical reduction of CO_2. In the summer of 2016, Song moved to Ithaca to start his independent career at Cornell University. The Lin Laboratory is interested in developing new catalytic strategies for organic reaction discovery with a particular emphasis on electrochemistry and radical catalysis. Song has received several early career awards, including Alfred P. Sloan Fellowship, ONR Young Investigator Award, Lilly Research Award, NSF CAREER Award, and 3M Nontenure Faculty Award. He obtained his B.S. degree from Peking University in 2008, where

he carried out undergraduate research with Zhangjie Shi on Pd-catalyzed C–H alkylation. In 2013, he received his PhD at Harvard University working under the direction of Eric Jacobsen.

Karthish Manthiram is the Warren K. Lewis Career Development Professor in Chemical Engineering at the Massachusetts Institute of Technology. His lab is focused on the electrification and decarbonization of chemical manufacturing, so that air, water, and renewable electricity can be used to synthesize and functionalize diverse chemicals. Beginning with carbon dioxide, dinitrogen, and water, his lab has developed efficient electrocatalytic pathways to key commodity chemicals including monomers for plastics and fertilizers. This is driven by tight integration of perspectives from the chemical sciences regarding catalyst synthesis and design with understanding of coupled transport-kinetics from chemical engineering. Karthish's research and teaching have been recognized with several awards, including Forbes 30 Under 30 in Science, Dan Cubicciotti Award of the Electrochemical Society, 3M Nontenured Faculty Award, Young Innovators Award in NanoEnergy, and the C. Michael Mohr Outstanding Undergraduate Teaching Award. Most recently, he was a postdoctoral researcher at the California Institute of Technology with R. H. Grubbs. Karthish received his bachelor's degree in Chemical Engineering from Stanford University in 2010 and his Ph.D. in Chemical Engineering from UC Berkeley with A. Paul Alivisatos in 2015.

Shelley Minteer is the Dale and Susan Poulter Endowed Chair of Biological Chemistry in the Department of Chemistry at the University of Utah. Her research interests are focused on electrocatalysis, bioelectrochemistry, and electroanalytical chemistry. She has expertise in energy storage, energy conversion, and electrosynthesis. After receiving her PhD, she spent 11 years as a faculty in the Department of Chemistry at Saint Louis University before moving to the University of Utah in 2011. She has published greater than 350 publications and greater than 450 presentations at national and international conferences and universities. She has won several awards including the Luigi Galvani Prize of the Bioelectrochemical Society, International Society of Electrochemistry Tajima Prize, Fellow of the Electrochemical Society and the International Society of Electrochemistry, Award for Electrochemistry of the American Chemical Society, Grahame Award of the Electrochemical Society, and the Society of Electroanalytical Chemists' Young Investigator Award and Reilley Award. She received her PhD in Analytical Chemistry at the University of Iowa in 2000 under the direction of Professor Johna Leddy.

Miguel A. Modestino is an Assistant Professor in the Department of Chemical and Biomolecular Engineering of New York University (NYU). From 2013-2016, he was a post-doctoral fellow at the École Polytechnique Fédérale de Lausanne in Switzerland where he served as project manager for the Solar Hydrogen Integrated Nano-electrolysis (SHINE) project. He is a winner of the 2016 Global Change Award from the H&M Foundation, 2017 MIT Technology Review Innovators Under 35 Latam Award and the 2018 ACS Petroleum Research Fund Doctoral New Investigator Award. He is the director of the Multifunctionals Materials Systems Laboratory at NYU which focusses on the development of advanced electrochemical technologies for the incorporation of renewable energy into chemical manufacturing. He is also co-founder of Sunthetics Inc., a startup developing a sustainable process for the production of Nylon 6,6 intermediates. Miguel obtained his B.S in Chemical Engineering (2007) and M.S. in Chemical Engineering Practice (2008) from the Massachusetts Institute of Technology, and his Ph.D. in from the University of California, Berkeley (2013).

Kevin D. Moeller joined the chemistry faculty at Washington University in St. Louis in 1987, and he has been Professor of Chemistry since 1999. He was an NIH Postdoctoral Fellow at the University of Wisconsin – Madison (Professor Barry M. Trost) from 1985 to 1987. Many of his long standing research interests center on the interplay between electrochemistry and organic synthesis, efforts that have ranged from the use of electrochemical methods for probing the chemistry of reactive radical cation intermediates and synthesizing complex molecular structures to the use of electrochemically directed synthetic methods for constructing complex molecular surfaces and expanding the utility of bioanalytical devices. In addition to these efforts, the Moeller group has worked to develop chemical probes for examining the chemistry and structural features of protein active sites. In 2016, he received the Manuel M. Baizer Award in Organic Electrochemistry from the Electrochemical Society. He is also a recipient of the ACS St. Louis Section Award, the ACS Midwest Award, and he will receive the ACS Cope Scholar Late-Stage Career Award in 2020. He earned a BA degree in Chemistry from the University of California – Santa Barbara in 1980, and then his Ph.D. degree in Organic Chemistry (Professor R. Daniel Little) from the same institution in 1985.

David Muller is the Samuel B. Eckert Professor of Engineering in the School of Applied and Engineering Physics at Cornell University, and the co-director of the Kavli Institute at Cornell for Nanoscale Science. His current research interests include the atomic-scale control and characterization of matter for applications in energy storage and conversion, with a focus on battery and fuel cell electric vehicles. As a research scientist at Bell Labs, he applied his research on imaging single atoms and atomic-scale spectroscopy to determine the physical limits on how small a transistor can be made. He has developed quantitative and operando imaging and characterization methods to explore the chemistry, electronic structure and bonding inside objects as diverse as fuel cells, batteries, transistors, and two-dimensional superconductors. David is a fellow of both the American Physical Society and the Microscopy Society of America, and recipient of the MSA Burton Medal and MAS Duncumb Award. He is a graduate of the University of Sydney and received a Ph.D. from Cornell University.

Andrew M. Rappe is Blanchard Professor of Chemistry and Professor of Materials Science and Engineering at the University of Pennsylvania. Andrew has published more than 300 peer-reviewed articles. In recent years, he has become a leader in the theory of hybrid organic-inorganic perovskites and of topological materials. He has championed the use of the bulk photovoltaic effect for solar energy harvesting, and he has made seminal contributions to the theory of ferroelectric materials and to topological physics. In the field of electrochemistry, Rappe studies how nonstoichiometric surfaces, smart material substrates, and anomalous light-matter interactions yield electrocatalysts with breakthrough activity and selectivity for hydrogen evolution, oxygen evolution, and CO_2 reduction reactions. Andrew received an NSF CAREER award in 1997, an Alfred P. Sloan Research Fellowship in 1998, and a Camille Dreyfus Teacher-Scholar Award in 1999. He was named a Fellow of the American Physical Society in 2006. Rappe was named Weston Visiting Professors at the Weizmann Institute of Science in 2014, and Ziqiang Professor at Shanghai University in 2016. He was awarded the Humboldt Research Award in 2017 and the Cheney Fellowship at University of Leeds in 2018. Andrew is one of two founding co-directors of the VIPER honors program at Penn, the Vagelos Integrated Program in Energy Research. He

received his A.B. in "Chemistry and Physics" *summa cum laude* from Harvard University in 1986, and his Ph.D. in "Physics and Chemistry" from MIT in 1992.

Matt Sigman is currently is the Peter J. Christine S. Stang Presidential Endowed Chair of Chemistry at the rank of Distinguished Professor and is the department chair. His research program explores the broad areas of oxidation catalysis, asymmetric catalysis, and the relationship between structure and function in complex reactions. After earning his PhD, he moved to Harvard University to complete an NIH funded postdoctoral stint with Professor Eric Jacobsen. In 1999, he joined the faculty of the University of Utah where his research group has focused on the development of new synthetic methodology with an underlying interest in reaction mechanism. Sigman's research efforts have been recognized by several awards including the Pfizer Award for Creativity in Organic Chemistry (2004), the Camille and Henry Dreyfus Teacher Scholar Award (2004), the Arthur C. Cope Scholar Award (2010), the University of Utah Distinguished Research Award (2011) and ACS Award for Creative Work in Synthetic Organic Chemistry (2017). Additionally, he has been recognized for outstanding teaching at the University of Utah as highlighted by being named the University of Utah Distinguished Honors Professor (2008) and the Robert W. Parry Award (2009). He received a B.S. in chemistry from Sonoma State University in 1992 before obtaining his Ph.D. at Washington State University with Professor Bruce Eaton in 1996 in organometallic chemistry.

Esther S. Takeuchi, NAE, is a SUNY Distinguished Professor and the William and Jane Knapp Chair in Energy and the Environment in the Departments of Materials Science and Chemical Engineering and Chemistry at Stony Brook University. She holds a joint appointment at Brookhaven National Laboratory. Prior to her academic appointment, she was employed at Greatbatch, Inc., where her research focused on lithium battery research for implantable applications. She was instrumental in the success of the lithium/silver vanadium oxide (Li/SVO) battery, the power source enabling the widespread adoption of life-saving implantable cardiac defibrillators (ICDs). She began her academic career at the University at Buffalo and relocated to Stony Brook University and Brookhaven National Laboratory in 2012. Dr. Takeuchi is a member of National Academy of Engineering, was awarded the National Medal of Technology and Innovation, inducted into the National Inventors Hall of Fame and is a Charter Member of the National Academy of Innovation. She received the E. V Murphree and Astellas Awards from the American Chemical Society and the Electrochemical Society Battery Division Technology award. She is a Fellow of the Electrochemical Society the American Institute of Medical and Biological Engineering and American Association for the Advancement of Science. Dr. Takeuchi is inventor of > 150 patents and received the 2018 European Inventor Award in the category in the category of non-EPO countries. Dr. Takeuchi received a bachelor's degree from the University of Pennsylvania with a double major in chemistry and history and completed a Ph.D. in chemistry at the Ohio State University.

Bill Tumas is the Associate Laboratory Director for Materials and Chemical Science and Technology at the National Renewable Energy Laboratory (NREL). NREL carries out fundamental and applied R&D for renewable energy and energy efficiency including photovoltaics and solar energy conversion; solar fuels; hydrogen production, storage and utilization; materials discovery, synthesis and development; chemistry and nanoscience; electrochemistry; fuel cells; energy storage and reliability/durability. Bill is also the Director of the Center for Next Generation

of Materials Design Energy Frontier Research Center which integrates high-throughput theory, experiment, and data mining to discover new functional semiconductor materials, including metastable systems, relevant to energy applications. Prior to joining NREL in 2009, Bill was at Los Alamos National Laboratory for 17 years where his last position was Program Director for Applied Energy Programs. He started his career at DuPont Central Research where he was a project leader for environmental and oxidation catalysis. His research activities have included materials design, solar energy conversion, homogeneous and phase-separable catalysis, supercritical fluids, green chemistry, chemical hydrogen storage, and wastewater treatment technology development and assessment. Bill has over 60 peer-reviewed publications, 12 patents, and has given over 125 invited presentations and seminars. He carried out postdoctoral research at Caltech as an NIH and a Chaim Weizmann Postdoctoral Fellow. Bill received his B.A. in Chemistry, *summa cum laude*, from Ithaca College and his Ph.D. in Organic Chemistry from Stanford as an NSF and Hertz Fellow.

Stanley Whittingham, NAE, is a SUNY distinguished professor of chemistry and materials science and engineering at SUNY Binghamton. He has been active in Li-batteries since 1971 when he won the Young Author Award of the Electrochemical Society for his work on the solid electrolyte beta-alumina. In 1972, he discovered the role of intercalation in battery reactions, which resulted in the first commercial lithium rechargeable batteries that were built by Exxon. In 1988 he returned to academia at SUNY Binghamton to initiate a program in materials chemistry. He was awarded a JSPS Fellowship in the Physics Department of the University of Tokyo in 1993. In 2004 he received the Battery Division Research Award. He is presently Director of the NECCES EFRC based at Binghamton. In 2012 he received the Yeager Award of the International Battery Association for his lifetime contributions to battery research; in 2015 he received the Lifetime Contributions to Battery Technology award from NAATBaaT, in 2017 the Senior Research Award from Solid State Ionics, and in 2018 was elected a member of the National Academy of Engineering and received the Turnbull Award from MRS. He is a Fellow of both the Electrochemical Society and the Materials Research Society. He is Vice-Chair, Board of Directors of the New York Battery and Energy Storage Technology Consortium (NYBEST). In 2019, he earned the Nobel Prize in Chemistry. He received his BA and PhD degrees in chemistry from Oxford University.