

Special Lecture by Prof. Nicola Perry (University of Illinois Urbana-Champaign)

Date: March 18th, 2024, 15:00-16:30 (Tentative)

Place: Institute of Multidisciplinary Research for Advanced Materials, Tohoku University

Title:

Solid-State Ionics for Energy Applications: Design and Discovery Through the Lens of Defect Chemistry

Abstract:

Point defect-mediated properties in oxides, particularly chemical expansivity, catalytic activity, and ionic conductivity, govern performance of solid-state electrochemical energy devices. This presentation will demonstrate both systematic experiments on model compositions and high-throughput screening methods to uncover design principles and materials that can extend the efficiency or lifetime of fuel cells, electrolyzers, and all-solid-state batteries. In one example, we have developed near-zero-chemical-strain electrodes and membranes for enhanced durability by tailoring the location of redox (anion vs. cation) and crystal symmetry. In a second example, we have dramatically increased the oxygen surface exchange coefficient of fuel cell/electrolyzer electrodes - critical for efficiency - by orders of magnitude through a new in-situ crystallization route that preserves a pristine surface chemistry and produces a beneficial defect chemistry for charge transfer. Lastly, for Li-ion batteries, we have developed a defect-focused descriptor filter to identify (from ~20,000 candidates in the Materials Project database) air-stable superionic solid electrolytes with intrinsic Li sublattice disorder and compatibility with high/low voltage electrodes. High-throughput characterization methods and low-thermal-budget processing routes for solid-state ionic materials developed in the course of the work will be addressed.



Nicola H. Perry received her Ph.D. in Materials Science and Engineering from Northwestern University in 2009, for investigating interfacial transport behavior in nano-ionics with Thomas O. Mason. After this, she joined the Energy Frontier Research Center for Inverse Design as a postdoctoral fellow, developing p-type transparent conducting oxides and synthesizing missing materials. From 2012-2014 she was a postdoctoral researcher at the International Institute for Carbon-Neutral Energy Research (I2CNER) at Kyushu University, Japan, and a visiting scholar at MIT, working with Harry L. Tuller. From 2014-2017 she served as a World Premier Initiative Assistant Professor at I2CNER and as a Research Affiliate at MIT, where her research focused on mixed ionic and electronic conducting oxides for high-temperature electrochemical energy conversion and storage. She joined UIUC in

January 2018, where she leads a group in tailoring and understanding point defect-mediated properties in electro-chemo-mechanically active oxides and halides. Her research has been recognized with the NSF CAREER Award, DOE Early Career Award, JSPS Kakehni Awards, UIUC Dean's Award for Excellence in Research, and IUMRS Award for Encouragement of Research, J. Bruce Wagner Jr. Award from the Electrochemical Society, and the Edward C. Henry and Richard M. Fulrath Awards from the American Ceramic Society.

Her research seeks to understand and design dynamic behavior in a class of inorganic materials called "solid state ionics." These materials enable carbon-neutral energy technologies, including fuel/electrolysis cells and batteries, to store and convert energy between chemical and electrical forms cleanly. She has developed a scientific foundation that enables the engineering of key material properties that control the energy conversion/storage efficiency and lifetime: 1) chemical expansivity, 2) ionic/electronic conductivity, and 3) interfacial reaction kinetics. Her recent work has sought to uncover and leverage the operando coupling among electrical, chemical, mechanical, and optical states of solid-state-ionic materials, which is essential for tailoring the key properties for improved device performance.

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This special lecture is co-organized by Tohoku Ionics Research Group, The Electrochemical Society of Japan TOHOKU Branch, and SOFC/SOEC Social Implementation Center at Tohoku University.