I²CNER Seminar Series

International Institute for Carbon-Neutral Energy Research (WPI-I²CNER)
Kyushu University

Title **Coupled Behavior in Solid State Ionic Materials for Electrochemical Energy Applications**

Speaker ***Professor Nicola Helen Perry***
Department of Materials Science and Engineering, University of Illinois, Urbana-Champaign, US

Time & Date 4:00 PM (JST), Wednesday, March 4th, 2026

Venue Hybrid format (I²CNER Hall C, I²CNER Bldg. 1, Ito Campus, Zoom)

Abstract

Links between dynamic chemical, mechanical, electrical, and optical properties of solid-state ionic materials can be leveraged to monitor or control behavior relevant for energy applications (fuel cells, electrolyzers, batteries, etc.). In this talk I will describe recent results that highlight two types of coupled behaviors: "photo-ionics" and "chemo-mechanics."

Regarding photo-ionics, time-dependent light absorption can be used to monitor changes in defect populations, for example surface exchange reaction kinetics that govern efficiency of electrodes in fuel and electrolysis cells. In this case the relevant gas partial pressure (pO_2 or pH_2O) is stepped around a thin film electrode material and its optical relaxation over time is fit to determine a surface exchange coefficient. I will describe our recent extension of this method to evaluate oxygen exchange kinetics of combinatorial libraries and proton exchange kinetics of new triple conducting oxides. However, light absorption is also a means to control ion fluxes in materials; I will provide an example of how shining UV light onto electrode thin films can induce oxygen surface exchange and oxygen incorporation at intermediate temperatures. Understanding and leveraging such phenomena lays the foundation for a new generation of opto-ionic technologies and lies at the heart of the UIUC MRSEC Interdisciplinary Research Group on photo-ionics – the first center-wide effort in the world dedicated to this topic.

Regarding chemo-mechanics, strains/stresses accompanying defect concentration changes can be deleterious for device lifetime. To improve electrolyte and electrode stability we have been uncovering descriptors for near-zero-strain materials. Our previous work focused on crystal chemical design principles for low-strain perovskites, while our latest efforts have instead turned to the role of morphology in other crystal structures. I will discuss the effects of nanostructuring on chemical expansivity of fluorite-structured electrode candidates, where modifications to defect chemistry in the proximity of interfaces alter the macroscopic chemical strains and transport behavior. Stress/strain can also be leveraged to modify ion dynamics; one example from our work is mechano-electro-chemically driven exsolution of catalytic nanoparticles on electrode surfaces to improve fuel electrode activity and device efficiency in all-fluorite cells.

About the Speaker

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 in 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 a NSF CAREER Award, DOE Early Career Award, JSPS Kakenhi Awards, UIUC Dean's Award for Excellence in Research, IUMRS Award for Encouragement of Research, J. Bruce Wagner Jr. Award from the Electrochemical Society, Principal Investigator Development in Sustainability Award from the American Chemical Society, and the Edward C. Henry and Richard M. Fulrath Awards from the American Ceramic Society.

Registration https://forms.office.com/r/y3bbmf62fT

Host Prof. Tatsumi Ishihara

Contact I²CNER・Q-PIT Office of Research Support Services, Research Support and Public Relations
Tel.: +81 92 802-6935
Email: iq-kenkyu@jimu.kyushu-u.ac.jp

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