学術講演会



Prof. Kyle S. Brinkman

Department of Materials Science and Engineering,
Clemson University

Defect Engineering and Multi-Species Transport in BCFZY Triple-Conducting Oxides for Protonic Ceramic Electrochemical Devices

日時：令和8年12月10日（木）15：00～16：00
場所：マテリアル・開発系教育研究棟 講義室2

米国クレムソン大学Department of Materials Science and EngineeringのBrinkman教授は，Department Chairでもあり、固体イオニクスを基盤として、燃料電池や全固体電池用のイオン伝導材料、核関連材料、材料熱力学の研究に取り組んでいる。博士号取得後には日本の産業技術総合研究所で博士研究員を務めた経歴も有する。この度、東北大学への来訪にあわせて学術講演会を企画しました。皆様のお越しをお待ちしております。

連絡先：東北大学・大学院工学研究科　石井 (022-795-3939)

Defect Engineering and Multi-Species Transport in BCFZY Triple-Conducting Oxides for Protonic Ceramic Electrochemical Devices

Triple ionic-electronic conducting (TIEC) oxides represent a transformative class of electrode materials for protonic ceramic fuel cells (PCFCs), protonic ceramic electrolysis cells (PCECs), and hydrogen separation technologies because they simultaneously transport electrons, oxygen ions, and protons. Among these materials, $BaCo_{0.4}Fe_{0.4}Zr_{0.2-x}Y_xO_{3-\delta}$ (BCFZY) has emerged as one of the most promising electrode systems due to its exceptional oxygen reduction activity and its ability to support coupled ionic transport processes. This presentation summarizes a comprehensive experimental and computational investigation of the BCFZY compositional series, spanning crystal chemistry, thermodynamics, oxygen transport, proton transport, atomistic modeling, and device-level validation. Neutron diffraction, X-ray diffraction, and high-temperature calorimetry reveal that Y substitution increases oxygen vacancy concentration while simultaneously destabilizing the perovskite lattice. Direct measurements of oxygen transport demonstrate that increasing Y content decreases bulk oxygen conductivity and oxygen permeation flux while dramatically enhancing oxygen surface-exchange kinetics. Conductivity relaxation experiments reveal nearly an order-of-magnitude improvement in surface reaction rates, highlighting a critical tradeoff between bulk transport and catalytic activity. To complement these findings, hydrogen permeation and hydration relaxation studies provide some of the first direct measurements of proton transport kinetics within the BCFZY system. Ab initio molecular dynamics calculations show that increasing Y concentration generally decreases both oxygen and proton diffusivities, while defect-equilibrium calculations indicate that changes in carrier concentration partially compensate for reduced mobility. The combined experimental and computational oxygen and proton kinetic analyses provide new mechanistic insight into defect chemistry, transport processes, and electrode design strategies for advanced protonic ceramic fuel cells, electrolysis cells, and hydrogen separation membranes.

Kyle Brinkman, Biography and Photo

Kyle Brinkman is the Steven H. (’77) and Mary K. Sigmon Family Endowed Professor and Department Chair of Materials Science and Engineering at Clemson University in Clemson, SC. Brinkman received a Bachelor of Science in chemical engineering and a Master of Science in materials science and engineering both from Clemson. He graduated from the Swiss Federal Institute of Technology in Lausanne, Switzerland with a Ph.D. in materials science and engineering. Brinkman then served as a postdoctoral fellow at the Advanced Industrial Science and Technology Institute in Tsukuba, Japan and later worked as a principal engineer in the Science and Technology Directorate of the U.S. Department of Energy’s Savannah River National Laboratory.

He is a Fellow of the American Ceramic Society (FACErS), a Fellow of the Royal Society of Chemistry in the UK (FRSC), an Academician of the World Academy of Ceramics, a NETL ORISE Faculty Fellow, received the Brimacombe Medalist Award, the Navrotsky Award for Experimental Thermodynamics and the Karl Schwartzwalder-Professional Achievement in Ceramic Engineering (PACE) Award from the American Ceramic Society.