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BENJAMIN M. STATLER COLLEGE OF ENGINEERING AND MINERAL RESOURCES

MATERIALS SCIENCE AND ENGINEERING (MS&E) SEMINAR SERIES

Friday, November 6, 2020 at 3:00 pm via Zoom

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"Dynamic Electrochemical Control of Oxide Thin Film Oxygen Stoichiometry: Applications to In-situ Defect and Transport Analysis, Mechanical Actuation, and ElectroOptical Tuning"

Professor Harry L. Tuller, Department of Materials Science and Engineering, Massachusetts Institute of Technology, Cambridge, MA, 02139

Abstract: Dynamic electrochemical control of oxide thin film oxygen stoichiometry provides the opportunity to not only rapidly and controllably vary the defect and transport properties of thin film oxides, but also to access oxygen activities not normally accessible by chemical means. In-situ stoichiometry control of mixed ionic-electronic conductors $Pr_{0.1}Ce_{0.9}O_{2-\delta}$, $La_{1.85}Ce_{0.15}CuO_{4+\delta}$ and the metal-insulator transition material VO_2 demonstrated abilities to investigate changes in defect thermodynamics induced in supported thin films, correlate defect properties with SOFC cathode performance and optical properties, as well as inducing phase transformations. Dynamic stoichiometry induced chemical expansion (DCX) also provides a direct method for probing defect induced dilation (chemical expansion) of thin films during voltage driven changes in defect concentration, as illustrated below. The response is modeled in the frequency domain, by approximating the mechanical response as linear, resulting in an electro-chemo-mechanical admittance spectroscopy interpretation of the system. The resultant mechanical actuator produces strains at 1000th the voltage as piezoelectric actuators.

BIO: Harry L. Tuller is R.P. Simmons Professor of Ceramics and Electronic Materials; Department of Materials Science and Engineering and Head of the Crystal Physics and Electroceramics Laboratory at MIT He received B.S. and M.S. degrees in Electrical Engineering and Eng.Sc.D. in Solid State Science & Engineering from Columbia University, NY; served as Postdoctoral Research Associate; Physics, Technion, Israel, following which he joined the faculty at MIT. His research focuses on defects, diffusion, and the electrical, electrochemical and optical properties of metal oxides with applications to sensors, fuel cells, photoelectrochemistry, thin film oxides, MEMS and memristive devices. He has published over 490 articles, coedited 15 books and was awarded 34 patents. He is Editor-in-Chief of the Journal of Electroceramics; Series Editor of Electronic Materials: Science and Technology published by Springer-Nature; co-founder of Boston MicroSystems, a pioneer in silicon carbide-based MEMS technology and devices and Past President of the International Society of Solid State Ionics (2015-17). His honors include: Fellow of the American Ceramic Society – ACERS- (1984); recipient of Fulbright (1989-1990), and von Humboldt Awards (Germany) (1997-2002); Docteur Honoris Causa, University Provence, Marseilles (2004); ACERS F.H. Norton Award (2005); elected to World Academy of Ceramics (2006); ACERS Edward Orton Jr. award (2007); Technices Doctor Honoris Causa, University of Oulu, Finland (2009); Outstanding Achievement Award - High Temperature Division, The Electrochemical Society (2010); Somiya Award for International Collaboration in Materials Research, International Union Materials Research Societies, Japan (2012); Helmholtz International Fellow Award (Germany) (2013); Fellow of The Electrochemical Society (2014); President, International Society of Solid State Ionics (2015-17); Life Senior member IEEE; Distinguished Life Member, American Ceramic Society [2016]; R.P. Simmons Chair-MIT (2017-present); Thomas Egleston Medal – Columbia University School of Engineering (2019)

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