

2012 Dow Lecture

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"Transport-Induced Instability in Electrochemical Devices: Fuel Cells, Batteries, Electrolyzers"

Many electrochemical devices such as batteries, fuel cells, electrolyzers, etc. degrade over time and under various operating conditions. In batteries, it is known that in series-connected cells, degradation often occurs if one or more cells exhibit different characteristics than the rest of the cells. Also, batteries are more prone to degradation during charging. Problems with laptop batteries are well known. Fuel cells (especially stacks) also undergo degradation during operation. There is considerable literature on solid oxide electrolyzers, which too degrade under certain operating conditions. Degradation in these devices may manifest as increase in resistance, loss of capacity, or both. In some instances, complete electrode delamination has been observed. In some cases, electrolyte instability may occur. While there are several reasons for degradation, and many may depend upon the specifics of any given system, the observation that many electrochemical devices degrade suggests that there may be a common underlying reason which is applicable to all such electrochemical systems. This talk is on a mechanism of degradation which is based on coupled multi-species, and is applicable to virtually all electrochemical systems. A key conclusion of the study is that the chemical potential of an electrically neutral species within the electrolyte corresponding to the mobile ion, may lie outside the range covered by the values at the electrodes (reservoirs), and this can lead to transport-induced instability. That is, membrane may become thermodynamically (or mechanically) unstable even when exposed to stable conditions at the two electrodes. Specific examples of solid oxide fuel cells, solid oxide electrolyzers, mixed proton-oxygen ion-electron (hole) conductors and lithium ion batteries will be addressed.

Bio: Anil Virkar is Distinguished Professor in the Department of Materials Science & Engineering at the University of Utah. He is also the Director of NSF MRSEC at Utah. He is a cofounder and Vice President of Materials and Systems Research, Inc. (MSRI) (www.msrihome.com), a small company based in Salt Lake City, Utah; a cofounder of Versa Power Systems, (VPS) (www.versa-power.com), a Colorado-based company with operations in Calgary and serves on its board. He also was a founding member of Ceramatec, Inc., based in Salt Lake City, Utah.

He received B.Tech. (Hons.) in Metallurgical Engineering from Indian Institute of Technology, Mumbai, India (1967); M.S. in Engineering Mechanics from Louisiana State University in (1969); and Ph.D. from Northwestern University in Materials Science in (1973). He is a Fellow of the American Ceramic Society, a Fellow of The Electrochemical Society, a Fellow of ASM International, and a member of the American Chemical Society, the Materials Research Society and the American Society of Mechanical Engineers. He has received awards for research from the American Ceramic Society (Ross Coffin Purdy Award-1992), the University of Utah (Distinguished Research Award-1994), DOE Basic Science Division's Chunky Bullets Competition Award (2002), Alkyl Amines Distinguished Speaker Award of the Indian Chemical Engineering Society (2003), Outstanding Achievement Award of The Electrochemical Society (2006), and was awarded the State of Utah Governor's Medal of Science and Technology (2006), and was elected to the National Academy of Engineering, NAE (2007). He has been listed in 'Highly Cited Researchers' database since 2001 in the Materials Science category as one of the most highly cited researchers (one of 290 worldwide) compiled by www.ISIHighlyCited.com. He has supervised Ph.D. thesis work of >25 students and M.S. thesis work of > 20 students over the years, in addition to guiding the work of several postdoctoral fellows. He has five PhD students currently conducting research under his direction. He is an author or co-author of ~250 research articles, and an inventor or co-inventor on more than 40 patents.

Tuesday, February 21, 2012
Tech L211, 4:00pm
Reception: Cook Hall Atrium