Chemical and Electrochemical Stability of Perovskite Oxide Surfaces in Energy Conversion: Mechanisms and Improvements

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Abstract: A broad range of highly active doped ternary oxides, including perovskites, are desirable materials in electrochemical energy conversion, catalysis and information processing applications. At elevated temperatures related to synthesis or operation, however, the structure and chemistry of their surfaces can deviate from the bulk. This can give rise to large variations in the kinetics of reactions taking place at their surfaces, including oxygen reduction, oxygen evolution, and splitting of H₂O and CO₂. In particular, aliovalent dopants introduced for improving the electronic and ionic conductivity enrich and phase separate at the surface perovskide oxides. This gives rise to detrimental effects on surface reaction kinetics in energy conversion devices such as fuel cells, electrolyzers and thermochemical H₂O and CO₂ splitting. This talk will have three parts. First, the mechanisms behind such near-surface chemical evolution will be discussed. Second, the dependence of surface chemistry on environmental conditions, including temperature, gas composition, electrochemical potential and crystal orientation will be described. Third, modifications of the surface chemistry that improve electrochemical stability and activity, designed based on the governing mechanisms, will be presented. Guidelines for enabling high performance perovskite oxides in energy conversion technologies will be presented.

Biography

Bilge Yildiz is a professor in the Nuclear Science and Engineering and the Materials Science and Engineering Departments at Massachusetts Institute of Technology (MIT), where she leads the Laboratory for Electrochemical Interfaces. She received her PhD degree at MIT in 2003 and her BSc degree from Hacettepe University in Turkey in 1999. After working at Argonne National Laboratory as research staff, she returned to MIT as an assistant professor in 2007. Her leadership responsibilities at MIT include the Low Carbon Energy Center on Materials in Energy and Extreme Environments, and one of the Integrated Research Groups of MIT’s NSF sponsored Materials Research Science and Engineering Center. Her research focuses on laying the scientific groundwork and proof-of-principle material systems for the next generation of high-efficiency devices for energy conversion and information processing, based on solid state mixed ionic-electronic conducting (MIEC) material, by combining in situ surface sensitive experiments with first-principles calculations and novel atomistic simulations. Her work has made significant contributions to advancing the molecular-level understanding of oxygen reduction and oxidation kinetics on MIEC solid surfaces, and of ion and electron transport, under electro-chemo-mechanical conditions. The scientific insights derived from her research guide the design of novel surface chemistries for efficient and durable solid oxide fuel cells, thermo-/electro-chemical splitting of H₂O and CO₂, corrosion resistant films, high energy density solid state batteries, and red-ox based memristive information storage. Her teaching and research efforts have been recognized by the Argonne Pace Setter (2016), ANS Outstanding Teaching (2008), NSF CAREER (2011), IU-MRS Somiya (2012) and the ECS Charles Tobias Young Investigator (2012) Awards.