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Professor

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Photo-electro-chemistry of Perovskites for Solar Energy Conversion

ABSTRACT:

The development of advanced materials and technologies to efficiently convert energy directly into electricity is of urgent importance due to increasing energy demands of an ever-growing world population and the emerging need to diversify to renewable energy alternatives. However, tremendous scientific challenges remain before successful implementation of any number of competing energy technologies such beyond silicon based solar cells. The materials, interfaces and device architectures currently being explored are very challenging to interrogate by ensemble-averaging, bulk experimental methods since they do not exhibit long-range order or homogeneity, contain unique nano-morphological features and possess non-uniform chemical compositions and defect chemistry. Additionally, these materials and interfaces are dynamically "reactive" and their performance degrades significantly during use that limits their cycle life and their ultimate commercialization prospects. This presentation will highlight our efforts to develop high-resolution, spatially resolved methods to study perovskite solar cells. Some methods are developed to study the buried interface in different levels of depth in a functional device. These experiments reveal lots of mixing between various layers [1-3]. Another design parameter is bandgap tuning of the perovskite chemistry by partial substitution of I^- with Br^- to expand their application to tandem solar cells and LEDs. The only critical issue remaining to solve is their poor long-term stability under operation conditions, specifically photochemical degradation by splitting into I- and Br-rich phases. Sufficient suppression of this process requires a thorough understanding of the underlying phenomena. In this talk, we report the detailed investigations of electric field induced and photoinduced phase transformation in stoichiometric and non-stoichiometric mixed halides, $CsPbI_{3-x}Br_x$. Using both ToF-SIMs and in-situ Atomic Force Microscopy, the real-time kinetics of halide phase segregation under illumination is visualized. The I-rich phase segregated predominantly along grain boundaries while the grain bulk remained enriched with Br. We propose that photogenerated Pb^0 and I_3^- species are selectively expelled from grain bulk into grain boundary interfaces as realized by spatially resolved imaging methods.

BIO:

Professor Stevenson received his Ph.D. in 1997 from the University of Utah under the supervision of Professor Henry White. Subsequently, he held a postdoctoral appointment at Northwestern University (1997-2000); and a professorial appointment from 2000-2015 at the University of Texas at Austin. Currently, he is leading the development of a new graduate level university (Skolkovo Institute for Science and Technology) in Moscow, Russia where he was the Provost, Full Faculty and founder of the Center for Energy Science and Technology (CEST). In 2019, Skoltech became the youngest university in the world and only university in the Russian Federation to be ranked in top 100 Nature Index of Top Young Universities.

Stevenson's research interests are aimed at elucidating and controlling chemistry at solid/liquid interfaces vital to many emerging energy storage and energy conversion technologies. To date he has published over 350 peer-reviewed publications, 13 patents, and six book chapters in this field**.** He is a recipient of a NSF CAREER award (2002), the Conference of Southern Graduate Schools New Scholar Award (2004), the Society of Electroanalytical Chemistry Young Investigator Award (2006), Kavli Fellow (2012), the Society of Electroanalytical Chemistry Charles N. Reilley Award (2021), and the Electrochemical Society David C. Grahame award (2023).

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