Abstract

The development of metal oxide-based semiconductors for solar water splitting has been the focus of many researchers in the past 5-10 years. Despite the poor intrinsic properties of metal oxides (e.g., low carrier mobility due to small polaron transport), relatively large photocurrents (> 4 mA/cm²) have been shown under simulated sunlight. Modest solar-to-hydrogen (STH) efficiencies (up to 8%) have also been demonstrated with metal oxide-based solar water splitting devices. In this talk, the progress in developing BiVO₄—one of the highest performing metal oxide photoanodes—will be outlined. This includes efforts in increasing the fundamental understanding of metal oxide photoelectrodes, determining the performance limiting factors, and designing strategies to overcome these limitations. A combination of advanced spectroscopic investigations (e.g., time-resolved microwave and terahertz conductivity, ambient pressure x-ray photoelectron spectroscopy, intensity modulated photocurrent spectroscopy) will be presented. Next, the scalability of metal oxide photoelectrodes was shown in the fabrication of large area (50-100 cm² active area) BiVO₄ photoelectrodes via spray pyrolysis. In such a large scale, different factors were found to be limiting (e.g., substrate and electrolyte conductivity, pH gradient). Strategies to overcome these limitations will be outlined. Finally, efforts in pushing the STH efficiency will be described. These include the modification of the bandgap of BiVO₄ through anion incorporation and the development of novel small bandgap (< 2.0 eV) complex metal oxides (e.g., CuBi₂O₄, FeVO₄, Fe₂WO₆). The interplay between theoretical and experimental combinatorial chemistry to expedite material discovery will be discussed.

About the Speaker

Fatwa F. Abdi is a staff scientist at the Institute for Solar Fuels, Helmholtz-Zentrum Berlin für Materialien und Energie (HZB). He obtained his undergraduate degree in 2005 from Nanyang Technological University and masters’ degree in 2006 from National University of Singapore and Massachusetts Institute of Technology, all in Materials Science and Engineering. After a short stint in the semiconductor industry, he pursued a PhD at TU Delft, the Netherlands, and graduated cum laude in 2013 with a dissertation on “Towards Highly Efficient Bias-Free Solar Water Splitting”. He was the recipient of Singapore-MIT Alliance fellowship (2005-2006) for his master education and Martinus van Marum prize (2014) from the Royal Dutch Society of Sciences and Humanities (KNHW) for the best thesis in chemistry in the past 5 years. His research interests at HZB include the development of metal oxide semiconductors for photoelectrochemical energy conversion, and the understanding of the semiconductor-catalyst-electrolyte interface.