Expanding the Material Space in Semiconductor Photoelectrochemistry

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Abstract: Semiconductor photoelectrochemistry is a highly exciting and dynamic field bringing together material science, interfacial electrochemistry and solar energy conversion. Photoelectrochemical (PEC) water splitting have been the main motivation behind this research for decades, since the seminal work by Fujishima and Honda.[1] Soon after the concept was published in 197x, it became clear TiO_2 photoelectrodes are unsuitable for such application due to its large band gap. More recently, record performance of over 14% solar-to-hydrogen conversion efficiency have been reported with monolithic integrated III-V tandem photoelectrodes passivated by ultrathin conformal oxide layers.[2] These developments demonstrate that the PEC concept is feasible and competitive in comparison to integrating mature technologies such as PV and electrolyzers. It is also clear that absorbers such as TiO_2, Fe_2O_3, WO_3 and $BiVO_4$, which still dominate the photoelectrochemical literature, are unsuitable as solar absorbers. Thus, we need to match the high opto-electronic properties offered by III-V semiconductors with Earth abundant materials with low-cost processing.

In this contribution, I will introduce some of our studies on photoelectrodes based on a variety of materials including PbI_2,[3] $BiPS_4$,[4] $LaFeO_3$,[5] and $GaFeO_3$.[6] We investigate how key material properties such as defect-tolerance and covalency manifest themselves in photoelectrochemical responses. I will strongly emphasize in the need for combining detailed structural and electronic material characterization with carefully conducted photoelectrochemical experiments, which can provide a wealth of information beyond photocurrent magnitude under simulated solar irradiation.

References

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Biography: David J. Fermín (PhD, FRSC) is the Professor of Electrochemistry and Head of the Bristol Electrochemistry and Solar Team. He completed his first degree in Chemistry at The Universidad Simon Bolivar (Venezuela) in 1991, where he entered the wonderful world of electrochemistry for good. Back then, he assisted in the Spanish translation of the book by John Bockris entitled *Solar Hydrogen Energy: The Power to Save Earth*. That inspired him to work on semiconductor photoelectrochemistry for his PhD at the University Bath (1993 – 1997). He continued his career in Switzerland (Swiss Federal Institute Lausanne) investigating how to harvest solar energy employing molecular interfaces. In 2001, he was awarded the Tajima Prize by the International Society of Electrochemistry for his contributions to the field of photoelectrochemistry. In 2003, he obtained a Swiss National Science Foundation Professorial Fellowship joining the University of Berne, before moving to the University Bristol in 2007. He currently leads activity on active materials and prototype devices for photovoltaic solar cells as well as electrochemical and photoelectrochemical hydrogen generation.