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Characterization of Surfaces and Interfaces in Solar Devices - Magic Treatments, Alternative Materials, and What They Do to the Electronic Structure

CLEMENS HESKE, University of Nevada Las Vegas (UNLV) and Karlsruhe Institute of Technology (KIT)

Thin-film photovoltaic (PV) cells have reached conversion efficiencies well above 20%, just like high-quality silicon devices. At first glance, then, one would think that "we are done". However, the opposite is true: the real challenges of renewable energy conversion lie ahead, in particular when "magic" treatments or "alternative" materials are to be employed. Even more so, solar water splitting ("Photoelectrochemistry" or "PEC") is just at the beginning of its development towards a viable energy technology of the future. Making it all happen will require a detailed understanding of the electronic and chemical properties of materials and interfaces, and that's where high-end characterization approaches come into play. Using a tool chest of electron and soft x-ray spectroscopic methods, it is possible to unravel (some of) the secrets of candidate materials and their interfaces. Our tool chest includes lab-based photoelectron and Auger electron spectroscopy (in Las Vegas), and soft x-ray emission and absorption spectroscopy using high-brilliance synchrotron radiation (in Berkeley). While the electron-based techniques are very surface-sensitive, the two synchrotron methods are photon-in-photon-out techniques that probe the bulk region near the surface. Using $Cu(In,Ga)(S,Se)_2$ (CIGSSe) as an efficient model material for PV and PEC devices alike, the talk will present experiments that gain insights into surface treatments, alternative materials, and their interfaces, in particular in view of the chemical and electronic structure, and, ultimately, the device performance (and stability, and cost, and ...). And while the main focus will be on specific solar materials, attempts will be made to convince the esteemed listeners that these characterization techniques can be applied to a wide variety of different materials and their surfaces/interfaces, regardless of application.