Materials and devices for solar energy conversion and storage – Research update

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Our research interests are focused towards the development of materials and devices for sustainable solar energy conversion and storage using low cost processing. Reducing the cost of manufacture includes both the monetary cost as well as the energy investment required for production, as well as extending the lifetime of materials and devices for such applications.

The main research in our group is focused on studying the stability of perovksite photovoltaic materials and devices. Phovotovoltaics (PV) based on organic-inorganic hybrid metal halide perovskites have recently attracted much attention, mainly due to the rapid improvement of their power conversion efficiency (PCE) from 3.8% to over 22.1%. Their advantages include ease of fabrication, high light absorption, good charge carrier mobility, tunable bandgap, and low cost. Despite these advantages, their poor operational stability remains a major obstacle for their commercialization. Concentrated natural sunlight was suggested for accelerated studies of lifetime and light-induced degradation. We recently demonstrated an experimental methodology with independent control of sunlight intensity, the sample temperature and environment during the exposure. Our studies of perovskite PV materials showed a strong dependence of the stability on the materials composition, correlated with chemical bond strength, crystalline structures and defect density. Furthermore, the synthesis sequence of the perovskite deposition process was found to affect its stability, due to the effect of PbI_2 residue in the film. Accelerated testing using concentrated sunlight is therefore a powerful tool for material screening and advanced PV material development. These methods are also used for testing strategies for improving the stability of perovskite PV materials.

Other research projects in the lab include: 1. Semiconductor-sensitized solar cells for IR absorption, based on wet-chemistry deposited bulk- and nanoparticle absorbers; 2. Characterizing the effect of the ordered electric double layer in ionic liquids on the electrochemical charge transfer and transport, for applications in fuel cells and energy storage in batteries; 3. Optimizing the performance of hematite photoelectrodes for the production of solar fuels by water oxidation, via engineering of structural and spatiotemporal heterogeneities.

The experimental infrastructure at the Department of Solar Energy and Environmental Physics has recently expanded significantly and include sample and device preparation labs, a plethora of optoelectronic characterization tools, and an advanced sunlight concentration and characterization lab. The Hybrid Evaporation System PVD-4H purchased from Vinci Technologies, France, complements this effort via vapor phase deposition of metals as electrical contacts to our manufactured devices, and of organic materials as low-cost sunlight harvesting materials. Such capabilities allow us to hire high-quality international graduate students and post-doctoral fellows, perform top-notch research, publish highly-cited papers in highly ranked professional journals, develop local and international collaborations, and advance solar energy research in Israel.

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