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Sam H Y Hsu

City University of Hong Kong, China

Electrochemical properties of Pb-based hybrid perovskite materials for renewable energy applications

The organometallic halide perovskite materials have attracted tremendous attention due to impressive features, including its direct bandgap of ~1.55 eV, high absorption coefficient, ambipolar charge-carrier mobilities, long exciton lifetimes/diffusion length and low exciton binding energy. A liquid junction Photoelectrochemical (PEC) cell with methylammonium lead iodide ($MeNH_3PbI_3$) is of interest for several reasons. A liquid junction system produces a photoactive junction simply upon immersing the semiconductor in solution, which simplifies the assembly of the cell. It also allows one to do the rapid synthesis and combinatorial screening for novel hybrid materials with different dopants on them. A liquid junction PEC cell based on p-type $MeNH_3PbI_3$-based perovskites with large open-circuit voltage is developed. $MeNH_3PbI_3$ perovskite is readily soluble or decomposed in many common solvents. However, the solvent, dichloromethane (CH_2Cl_2), can be employed to form stable liquid junctions. These were characterized with photoelectrochemical cells with several redox couples, including I3-/I-, Fc/Fc+, DMFc/DMFc+ and BQ/BQ•- (where Fc is ferrocene, DMFc is decamethylferrocene, BQ is benzoquinone.) in CH_2Cl_2. The solution-processed $MeNH_3PbI_3$ shows cathodic photocurrents and hence p-type behavior. The difference between the photocurrent onset potential and the standard potential for BQ/BQ•- is 1.25V, which is especially large for a semiconductor with a band gap of 1.55 eV 1, 2 A PEC photovoltaic cell, with a configuration of p-$MeNH_3PbI_3$/CH_2Cl_2, BQ (2 mM), BQ•- (2 mM)/carbon, shows an open-circuit photovoltage of 1.05 V and a short-circuit current density of 7.8 mA/cm^2 under 100 mW/cm^2 irradiations. Overall optical-to-electrical energy conversion efficiency is 6.1%. The PEC cell shows good stability for over 5.0 hours under irradiation.

Biography

Sam H. Y. Hsu obtained his PhD degree under supervision of Prof. Kirk S. SCHANZE at University of Florida with focusing on photophysical behaviors of functional metallopolymer materials for solar energy applications. After that, he received the two-year postdoctoral and research associate's appointments respectively with Prof. Allen J. BARD and Prof. Edward T. YU in Center for Electrochemistry and Department of Electrical and Computer Engineering at University of Texas at Austin. During the period of his postdoc and research associate, he completed many outstanding multidisciplinary projects. The area of his expertise stretches from multistep synthesis of organic-inorganic semiconductors to new related disciplines involving diverse areas of applications and material characterization, including solar fuels, organic and inorganic photovoltaic cells, ultrafast laser spectroscopy, and scanning photoelectrochemical microscopy imaging.

sam.hyhsu@cityu.edu.hk

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