The role of nanostructured metal halide perovskite materials in solar energy harvesting

Sayantani Ghosh,
Department of Physics,
University of California, Merced, CA, USA
http://ghoshlab.ucmerced.edu/

Research in nanostructured devices for solar energy harvesting and storage are driven primarily by the design and development of new materials. In my group, we focus on investigating the ramifications of different active materials and architectures on photovoltaic (PV) performance, especially device efficiency and stability. In the past decade, organic–inorganic metal halide perovskites (MHPs) have emerged as the most prominent new PV material, combining a very competitive power conversion efficiency that rivals crystalline silicon with the added benefits of solution processability, high specific power, and excellent defect tolerance. However, without significant and complicated structural and chemical modifications, MHPs degrade under ambient humidity and long-term photo exposure. Here, I will discuss two specific applications of nanostructured MHPs which allow circumventing of these problematic issues. The leverages MHPs' stable performance in vacuum under AM0 solar radiation and as part of a collaboration with the National Aeronautics and Space Administration (NASA), demonstrates the long-term viability of using MHP PVs in space, following a 10-month flight on the International Space Station. The second, leading from some findings in the first study, focuses on the interaction between MHP thin films and metal halide perovskite quantum dots (PQDs). Mapping static and dynamic MHP emission as functions of temperature, excitation energy, and excitation power revealed that a low density of PQDs improved thin film properties, while increasing PQD density further had detrimental effects. This complex modulation of MHP properties by PQDs indicate an intricate interplay between different factors that need to be considered in optimizing such heterostructures for optoelectronic applications.

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