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Toward greener and inexpensive perovskite solar cells

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The ever-growing energy demand of the world necessitates the research and development of alternative sustainable energy sources that are cheaper and greener. Organometalhalide perovskites have attained an unprecedented growth from 3.8% to 22.1% in a short span of 8 years. In spite of favorable properties and high efficiencies, there are a few factors which hinder their commercialization. They are toxicity of lead, instability in air and moisture, use of fullerenes. PCBM, a fullerene derivative, which is the commonly used electron transport layer (ETL) has the following disadvantages- high production costs, photochemical instability, the tendency to aggregate at high temperatures leading to morphological instability, post-fabrication crystallisation, and synthetic inflexibility. N-type conjugated Perylene diimide based molecules are chemically robust, resistant to photodegradation, relatively easy to manipulate synthetically, possess tunable energy levels, cheaper and they are in industrial use as pigments. We propose the use of n-type conjugated perylene diimide based molecules as alternative materials for PCBM ETL and achieved a PCE of 11 %. Later, we studied the use of benzo[ghi]perylenetriimide (BPTI) derivatives as novel ETL materials in a series of PSCs. The BPTI is expanded on the π-conjugated plane by a five-membered imide ring along the short axis on the original PDI backbone. Compared to PDI, BPTI shows straightforward access to chemical functionality through substituted groups attached to the five-membered imide position. This inspired us to explore possible strategies on making new non-planar π-conjugated electron acceptors. We achieved an efficiency of about 11.6% with the used twisted-BPTI as the alternate ETL. Another major concern regarding the commercialization of lead-based perovskite solar cells is the presence of environmentally toxic lead (Pb) and its chemical instability. To replace lead-based perovskites, we propose the use of antimony-based perovskite materials, which forms A3B2X9 type perovskites by heterogeneous substitution of Pb. Our work is one of the pioneer reports on Sb-based perovskite solar cells. We introduced an additive to enhance the film quality, anti-solvent treatment with Chlorobenzene to enhance the crystallinity and a hydrophobic underlayer for perovskite resulting in 2.8% PCE, which is one of the highest PCEs reported for this material until now.

Biography

Priyadharsini Karuppuswamy completed her Bachelor's degree in nanotechnology from SRM University (2010-2014), India. Later, she worked at Center for Nano-fibers and Nanotechnology at National University of Singapore (2014). She was then enrolled under Taiwan International Graduate Program (2014-present) and is currently pursuing Ph.D. at Academia Sinica, Taiwan. Her research interests include Perovskite solar cells (PSCs), Lead-free PSCs, thin-film PVs, and nanofibers. She is currently working on replacing fullerene in PSCs and improving the Perovskite/carrier transport layer interface to enhance the device efficiency and stability. Her interests also lie in the fabrication of low-toxic, Lead-free perovskite solar cells aiming towards commercialization.

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