

2D/3D Hybrid Perovskites for Stable and Efficient Solar Cells

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Three-dimensional (3D) methylammonium lead iodide perovskite solar cells are undoubtedly leading the photovoltaic scene with their power conversion efficiency (PCE) >22%, holding the promise to be the near future solution to harness solar energy[1]. Tuning the material composition, i.e. by cations and anions substitution, and functionalization of the device interfaces have been the successful routes for a real breakthrough in the device performances[2]. However, poor stability (= device lifetime), mainly due to material decomposition upon contact with water, is now the bottleneck for the widespread of this technology. Diverse technological approaches have been proposed delivering appreciable improvements, but still failing by far the market requirements demanding 25-years lifetime. In this talk, I will show a new concept by using a different class of perovskites, arranging into a two-dimensional (2D) structure, i.e. resembling natural quantum wells. 2D perovskites have demonstrated high stability, far above their 3D counterparts. However, their narrow band gap limits their light-harvesting ability, compromising their photovoltaic action. Combining 2D and 3D into a new hybrid 2D/3D heterostructure will be discussed as a new way to boost device efficiency and stability, together. The 2D/3D composite self-assembles into an exceptional gradually organized interface where the 2D perovskite anchors on the TiO₂ substrate, templating the growth of a highly ordered 3D perovskite on top. This results in mesoporous solar cells leading to 12.9% PCE[3]. Aiming at the up-scaling of this technology, we realize 10x10 cm² large-area solar modules using a fully printable, hole conductor free device configuration (i.e. where a carbon

electrode is used to replace the organic hole transporter and gold). The module delivers 11.2% efficiency stable for more than 10,000 hours with no degradation under accelerated testing conditions, leading to a record one-year stability (see result in Figure 1). On the other side a 3D/2D interface will be also presented, where 2D layer lies on top of the 3D as a mean to physically protect the 3D underneath while also blocking the electron hole recombination at the perovskite/hole transporter interface. This results in enhanced stability without compromising the efficiency, leading to PCE=20% stable for 1000 h[4].

References

- [1] http://www.nrel.gov/ncpv/images/efficiency_chart.jpg.
- [2] J.-P. Correa-Baena et al., *Science*, 358 (2017), 739–744.
- [3] G. Grancini et al., *Nat. Commun.*, 8 (2017), ncomms15684, Jun. 2017.
- [4] K. Taek Cho et al., "Energy Environ. Sci.", (2018) doi:10.1039/C7EE03513F.

Figures

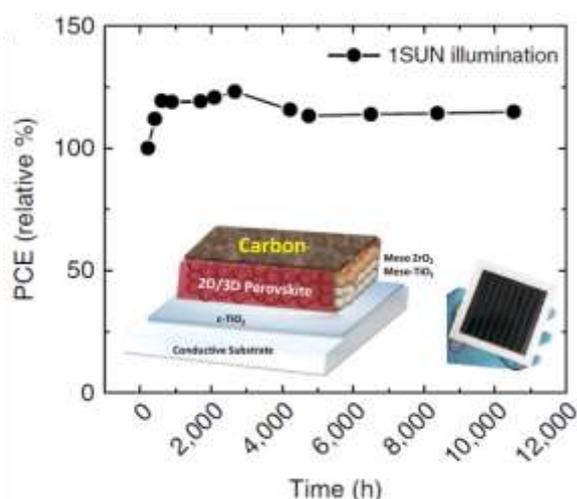


Figure 1: Stability of a 10x10 cm² module tested for 10000 hours. In the inset device structure and a picture of the solar module.