Understanding of degradation mechanism of perovskite solar cells

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Organic-inorganic hybrid halide perovskites have emerged as an interesting class of materials that have excellent photovoltaic properties for application to solar cells. In the last five years, the power conversion efficiency of perovskite solar cells (PSCs) over 20% has recently been realized through systematic optimization of materials and fabrication processes. In addition to high efficiency, good operational stability under continuous solar illumination is another key requirement for industrial and commercial application of PSCs. However, the stability of PSCs is just beginning to be studied, and the actual degradation mechanisms of PSCs are not well understand.

Carrier traps (in other words, defect states or gap states) are well known to impede carrier collection by the electrodes and act as carrier recombination centers, which are detrimental to solar cell performance. Firstly, to undersand carrier traps effects on the device lifetime, we investigate the degradation mechanisms of $CH_3NH_3PbI_3$-based PSCs using a thermally stimulated current technique, which is a versatile technique used to analyze carrier traps in inorganic and organic materials. We show that a large density of hole traps is formed in PSCs degraded by continuous solar illumination and that the formation of hole traps is strongly related to the stability. This is the first report describing the trap-induced degradation of PSC performance as shown in Figure 1.[1] Furthermore, we proved that one intrinsic source of the traps is metallic lead, which is resulting from photodegradation of $CH_3NH_3PbI_3$. Based on these findings, we greatly extended the lifetime of PSCs under standard laboratory weathering testing (ISOS-L-1 Laboratory) with a light intensity of 100 mW cm^{-2} without using a UV filter from 150 hours to 4000 hours by suppressing the formation of carrier traps using a mutifuctional additive, which is longest device lifetime reported so far.[2]

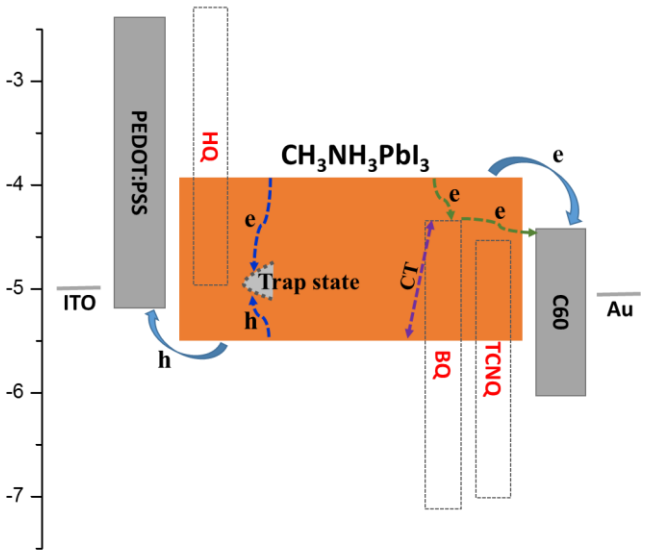

Fig.1 Proposed mechanism of carrier traps induced degradation of PSC device.

Reference:

[1] C. Qin, T. Matsushima, T. Fujihara, W. J. Potscavage, Jr., and C. Adachi, *Advanced Materials*, 28 (2016), 466-471.

[2] C. Qin, T. Matsushima, T. Fujihara, and C. Adachi, under review.