Photovoltaic and Optical Characteristics of Layered and 3D mixed Halide Perovskites

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Abstract

The halide perovskites materials have received exceptional attention for various photonics applications due to their unique materials characteristics. In this presentation, we will show halide perovskites thin film made of low-dimensional/3D mixed structure. Low-pressure vapor-assisted solution process (LP-VASP) which is demonstrated for the first to synthesis Low-dimensional and 3D mixed perovskite. Their performances in photovoltaic and non-linear optical properties will be presented and discussed. Such families of hybrid organic-inorganic halide perovskite semiconductors are promising candidates for next generation photonic and applications such as solar cells, light-emitting diode, and lasing devices. The slightly 2D doped perovskite showed larger grain size and better photovoltaic performances in both power conversion efficiency and stability. For highly 2D doped perovskite thin film, we observed multiple PL emission spectra with significant multiphoton absorption characteristics, which implies the co-existence of multiple n-layered perovskites domains in one film. The nonlinear optical effects and materials properties are characterized in detail by multiphoton spectroscopy, KPFM, TR-PL, and PL mapping.

LP-VASP method and device architecture

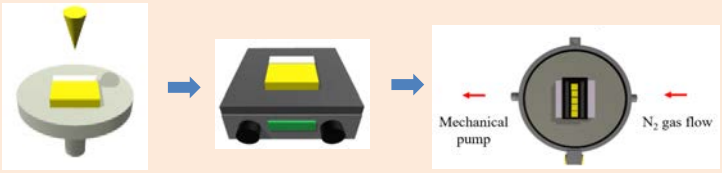

Fig. 1 The fabrication process of perovskite film: (a) spin coating of PEAI-doped PbI_2 precursor on the FTO/cp-TiO_2/mp-TiO_2 substrate, (b) annealing the sample and (c) undergoing MAI vapor-solid reaction at 1 torr, 135 ° C with 2 hr.

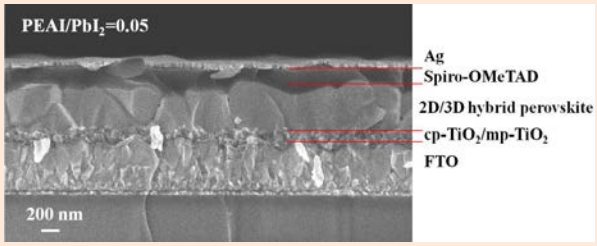

Fig. 2 Cross-sectional SEM of perovskite solar cells prepared by PEAI/PbI_2 = 0.05.

Photovoltaic performances

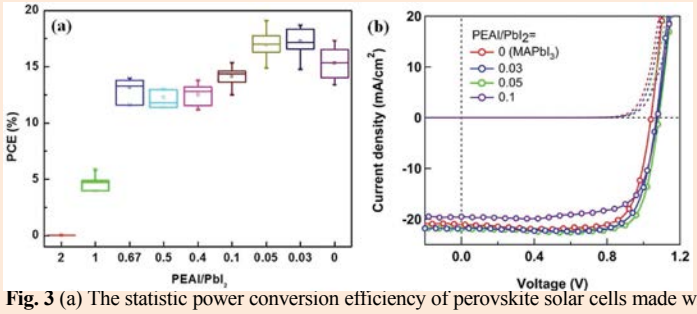

Fig. 3 (a) The statistic power conversion efficiency of perovskite solar cells made with variant doping level of PEAI/PbI_2. (b) The J-V curves of perovskite solar cells with PEAI/PbI2 = 0.1, 0.05, 0.03 and 0. [Adv. Mater., 2018, 30, 1801401]

2D and 3D composition evolution in the perovskite film

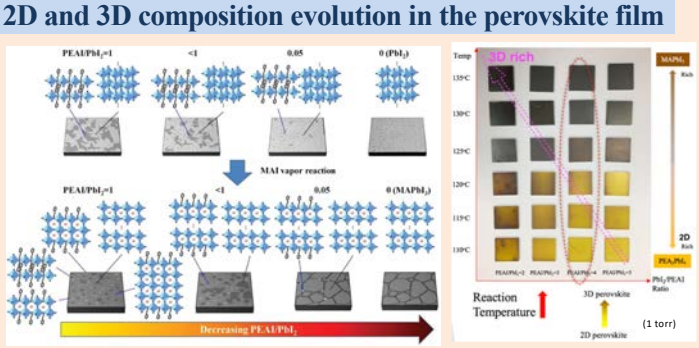

Fig. 4 Composition evolution of 2D and 3D mixed perovskite film with variant doping level of PEAI/PbI_2.

Material Characteristics of highly 2D doped perovskite film

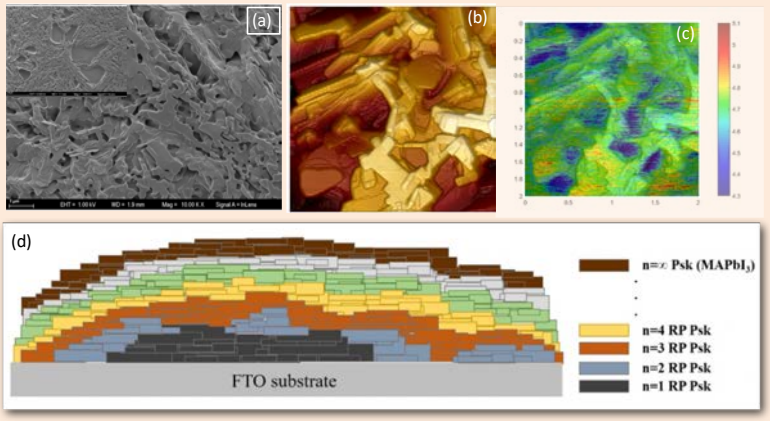

Fig. 5 (a) SEM image, (b) AFM morphology, (c) KPFM work function mapping and (d) proposed film structure of PEAI-doped PbI_2 film (PEAI/PbI_2=4, 1 torr, 125 c)

Optical properties of highly 2D doped perovskite film

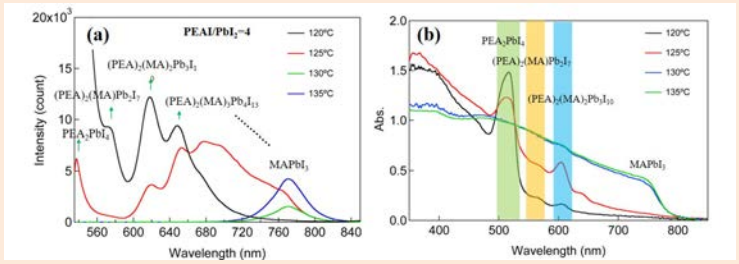

Fig. 6 (a) PL and (b) UV-Vis spectra of PEAI-doped PbI_2 film (PEAI/PbI_2=4) with variant reaction temperature via LP-VASP treatment.

Confocal and multiphoton PL mapping of highly doped film

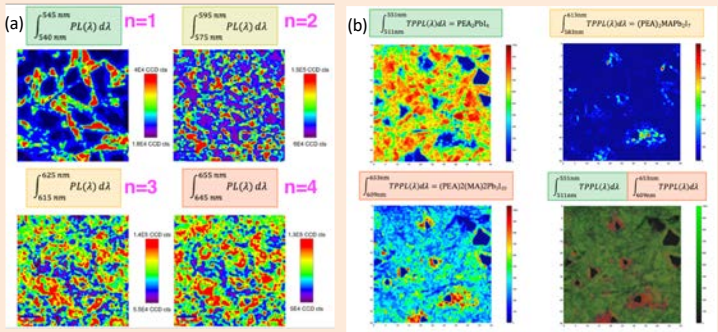

Fig. 7 (a) PL and (b) multiphoton PL mapping of PEAI-contained perovskite film by receiving different wavelength range. The film is excited by a laser with a wavelength of 532 nm in (a) and 800 nm in (b).

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