Perovskite Morphology and Coverage Ratio Control to $CH_3NH_3PbI_3$ Solar Cells

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Introduction:

Perovskite solar cells have remarkably marched since it originated from DSSCs and the power conversion efficiency (PCE) has been elevated from 3.8% in 2009, 15.4% in 2013, to 20.1% in April 2014 [1, 2]. The perovskite solar cells are now approaching large-scale application for their cost-effective, solution processibility, abundance in raw material sources and applicability in flexible substrates. Among the components of all-state solid thin film perovskite solar cells, the morphology of the perovskite layer have dominantly controlled final PCEs of the cells. [3, 4] Therefore we had conducted series of investigations for perovskite morphology and coverage ratio control to $CH_3NH_3PbI_3$ solar cells

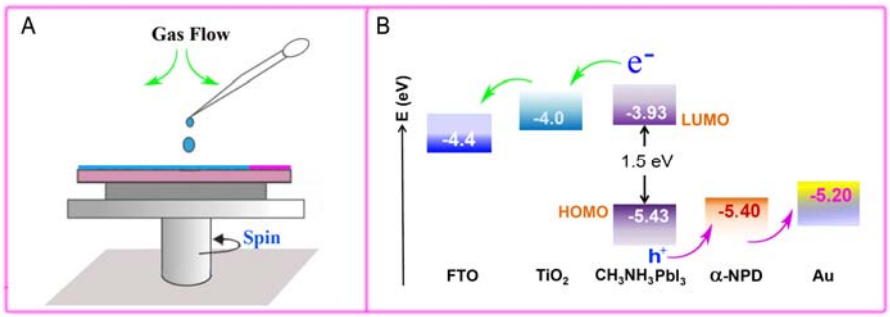

Fig.1 Modified GFA setups for spin-coating (A) and component energy alignment diagram (B)

Results and discussion:

We have applied such a TiO_2 mesoporic solar cell sturcture as FTO glass/dense TiO_2/ mesoporic TiO_2/ $CH_3NH_3PbI_3$/α-NPD (MoO_3)/Gold. The α-NPD doped by MoO_3 as HTM is initially employed and its HOMO of 5.4 eV is comptible with the cells (Fig.1B). Series of $CH_3NH_3PbI_3$ perovskite solar cells are fabricated by routes of gas-flowing assisting (GFA, Fig.1A), twice spin-coating of PbI_2 and thermally-dipping in CH_3NH_3I solution, by which some undesirable perovskite morphologies are well avoided. The $CH_3NH_3PbI_3$ crystal morphology have dramatically improved and the coverage ratio (α) of perovskite on the underneath TiO_2 mesoporic layer are elevated from 86.5% to 100% (Fig.2 A, B, C). Higher homogeneity and coverage ratio of the $CH_3NH_3PbI_3$ layer have directly contributed to the solar cells' performance. Fig.2 D has depicted the equivalent circuit and the shunting path can be suppressed to significantly elevate the shor-circuit J_{sc} as shown in Formula (1).

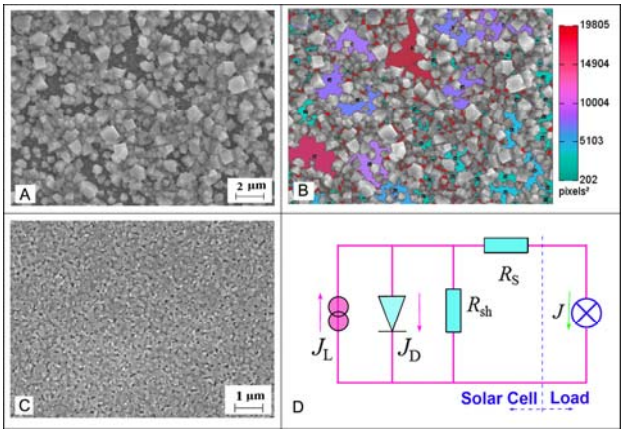

Fig.2 Different perovskite-covered layers (A, C), α calculation by ImageJ (B, The color scale denotes area size) and the interpretation by equivalent circuit (D)

$$J = J_L - J_0\left[\exp\left(\frac{e(V + J\times R_s)}{AK_BT}\right) - 1\right] - \frac{V + J\times R_s}{R_{sh}} \quad \cdots\cdots(1)$$

Reference

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[2] Research Cell Efficiency Records, http://www.nrel.gov/ncpv (2014).

[3] J. You, Y. M. Yang, Z. Hong, T.-B. Song, *et al. Appl. Phys. Lett.*, **105** (2014) 1-5.

[4] P. Docampo, F. Hanusch, S. D. Stranks, M. Döblinger, *et al. Adv. Energy Mater.*, **4** (2014) 5-10.