Electrospun 3D composite nano-flowers for high performance triplication perovskite solar cells

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ABSTRACT

Three dimensional (3-D) flower-shaped SnO_2-TiO_2 nano-structure has been synthesized by electro-spinning and incorporated on top of sol-gel ZnO ETL to fabricate highly efficient (highest efficiency: 17.25%) triple-cation (methyl ammonium, formamidinium and rubidium cations) based perovskite solar cell (PSC). The flower-based PSCs demonstrate superior photovoltaic performance compared to control ZnO or one-dimensional (1-D) fiber-shaped nano-structure ETL based devices. Nano-structured ETLs passivate the interstitial trap sites in pristine ZnO by intercalation of metal atoms in host ZnO lattice matrix and increase the n-type conductivity of the (nano-structured) ETL films by reducing the functional groups on ZnO surface. The accumulated ions at the perovskite/ETL interface are also well-distributed and hence the accumulation capacitance is significantly reduced in nano-structured ETL based PSCs, due to the branch-structured ETL network. Moreover, the nano-flower based PSC demonstrates superior charge transfer property, compared to nano-fiber based PSC owing to enhanced material crystallinity and higher effective surface area of 3-D nano-flower network, with respect to 1-D nano-fiber structure. The photo-current hysteretic phenomena are also most suppressed in nano-flower based PSC, due to mitigated electrode polarization mechanism in it. Adding to the merits, PSCs incorporating nano-flower ETL demonstrate enhanced device stability compared to the control devices, retaining about 92% of its initial efficiency even after a month. The enhanced device stability with nano-flower based PSC is contributed by the lower hydrophilicity, lower extent of functional surface hydroxyl group and lower content of vacant interstitial trap sites of the respective ETL film.

KEYWORDS: SnO_2-TiO_2 composite nano-flower**;** ZnO ETL**;** Perovskite solar cell**;** Low temperature**;** Interstitial sites**;** Accumulation capacitance**;** Recombination lifetime**;** Impedance spectroscopy