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Air-stable high efficiency perovskite solar cells fabricated with graphene and metal oxide based nanocomposites

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The poor air-stability and reproducibility of hybrid solar cells have prevented the practical applications of the devices that can withstand sustained operation under ambient air conditions. To solve this issue, we developed simple methods for the production of silver nanoparticles (AgNPs) and reduced graphene oxide (rGO) in the form of Ag-rGO composites by one-step microwave-assisted reduction (MWAR) for bulk-heterojunction solar cells (BHJ-SCs) and the synthesis of perovskite-metal oxide composite for perovskite solar cells (PSCs). The field-effect transistor fabricated with the Ag-rGO composite showed p-type behavior with a high mobility of 3.3x105 cm2V-1s-1 and conductivity of 9x106 S/m which is one-order of magnitude greater than pristine graphene (1.59x105 S/m). As-synthesized Ag-rGO composite was introduced into the active layer of bulk heterojunction solar cell based on P3HT:PCBM. Compared to the P3HT:PCBM only device, the Ag-rGO implemented device showed 33% increase in photocurrent density and 42% increase of power conversion efficiency (PCE) due to enhancement of the charge carrier generation and fast extraction of holes to the electrode. By introducing the perovskite-metal oxide composite into PSCs with Al2O3/NiO interface engineering, we obtained a high efficiency of 18.14% for a champion device and excellent reproducibility of average 16-18% PCE for 35 devices which were all fabricated under ambient-air conditions, not in a glove box. More importantly, the devices without encapsulation showed a significant enhancement in long-term air-stability; the device photovoltaic parameters stabilized after 20 days and sustained its stability over 210 days with retaining ~100% of its original Voc, ~94% of Jsc, ~91% of FF and ~86% of PCE in an ambient environment.

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