Highly Stable and Efficient Perovskite Solar Cells with Metal Oxide and Graphene Based Functional Composites

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For practical use of perovskite solar cells (PSCs) the instability issues of devices, attributed to degradation of perovskite molecules by moisture, ions migration, and thermal- and light-instability, have to be solved. To solve such issues, we developed simple methods for production of metal oxide and graphene based functional composites such as Ag-rGO, perovskite-NiO, perovskite/Ag-rGO, NiO-carbon-graphite and Al_2O_3/graphene, and utilized them for PSCs. We reported highly efficient and stable PSCs based on perovskite/Ag-reduced graphene oxide (Ag-rGO) and mesoporous Al_2O_3/graphene (mp-AG) composites. The mp-AG composite was conductive with one-order of magnitude higher mobility than mp-TiO_2 and used for electron transport layer (ETL). Compared to the mp-TiO_2 ETL based cells, the champion device based on perovskite/Ag-rGO and $SrTiO_3$/mp-AG composites showed overall a best performance. More importantly, the champion device without encapsulation exhibited not only remarkable thermal- and photo-stability but also long-term stability with retaining 97-99 % of the initial values of photovoltaic parameters with sustaining ~ 93% of initial PCE over 300 days under ambient conditions.