The Role of Graphene in Perovskite Solar Cells

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The impressive power conversion efficiency (PCE=22.1% [1]) reported for perovskite solar cells (PSCs) has been reached thanks to the tremendous efforts made in improving the growth process, the morphology of the active film and the energy level matching between the cell's constituent layers. Despite that, record PCE is yet far from the theoretical predicted efficiency limit (approaching 31%). Notably, losses due to interfacial recombination negatively affect the charge injection at perovskite/transporting layer interface. Similarly, poor charge transport in electron (ETL) and hole (HTL) transporting layers severely limits charge collection at the electrodes. Moreover, the stability of PSCs still remains an open issue to be addressed. In fact, the poor air (H_2O and O_2 adsorption), photo, and thermal stability could dramatically restrict the future commercial exploitation of PSCs.

In this work, graphene and related two-dimensional materials (GRMs) have been introduced in the device structure in order to improve the charge injection and/or collection at the electrodes and the device's long-term stability under real working conditions [2].

On one hand, the insertion of graphene flakes into the mesoporous-TiO_2 layer ($mTiO_2$) and of lithium-neutralized graphene oxide (GO-Li) as interlayer (see Fig.1) showed enhanced conversion efficiency and stability on both small and large area devices, by demonstrating the crucial role of graphene interface engineering (GIE) at $mTiO_2$/perovskite interface [3]. In particular, GIE is here demonstrated as an effective way to control the crystalline quality of the perovskite active material by means of continuous wave and picosecond time-resolved optical spectroscopy. More in detail, by exciting the graphene-based sample with a low-intensity radiation (2.06 eV) at T=11K, we point-out that the densities of traps at $mTiO_2$/perovskite interface are lower with respect to the reference substrate. The observed behaviour proves the high quality of the perovskite film when graphene-modified ETL is employed as substrate

On the other hand, the application of graphene-based oxides (GBOs) at PSC counter-electrode is here demonstrated as an effective way to prevent the ions diffusion from perovskite into the hole transporting material. The ions blocking capability of GBOs has been verified by intensity modulated photocurrent spectroscopy (IMPS). The stability improvement gained by the application of GIE in PSCs opens a promising route for further scale-up and stabilize the PSC technology, towards its commercialization.

References

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