Graphene Interface Engineering: a new paradigm for improving Perovskite Solar Cell/Module performances

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The dramatic development exhibited in the last few years by perovskite solar cells (PSC) technology has triggered the scientific community efforts in findings more efficient and stable PSC structures [1] for both small and large area cells and modules.[2] To achieve these goals, a particular attention should be given to interfaces between layers forming the PSC. In fact, processes occurring at the interface such as recombination, charge transfer and intermixing master the performance and the stability of the solar cell. Recently, we introduced a new paradigm to engineer the interface, namely the use of Graphene and related 2D materials (GRM)[3] to tailor the interface properties, with the aim to both increase power conversion efficiency (PCE) and stability of PSCs. [4-9]
By dispersing Graphene flakes, produced by liquid phase exfoliation of pristine graphite,[10] into the mesoporous TiO_2 layer and by inserting graphene oxide (GO) as interlayer between perovskite and Spiro-OMeTAD layers, we demonstrate a PCE of 18.2% with the two-step deposition procedure, carried out in air.[5] The obtained PCE value is due mainly to improved charge carriers injection and collection processes with respect to conventional PSCs. Although the addition of GRMs does not influence the shelf-life, it is instead beneficial for the stability of PSC under several aging conditions. In particular, mTiO2+G PSCs retain more than 88% of the initial PCE after 16 hours of prolonged 1 SUN illumination at maximum power point. Moreover, when subjected to prolonged heating at 60°C, the GO based structures show enhanced stability with respect to the mTiO2+G one, which shows thermal induced modification at mTiO2+G perovskite interface.
The as-proposed interface engineering strategy based on GRM has been exploited for the fabrication of state-of-the-art large area perovskite modules. We indeed demonstrated a PCE of 12.6% on a monolithic module with an active area exceeding 50 cm2. The use of GRM is beneficial to increase the PCE by more than 10% with respect to "conventional" modules, i.e. without GRM interfaces.[9]

References

[*] Work performed in collaboration with Istituto Italiano di Tecnologia (F. Bonaccorso) and TEI of Crete (E. Kymakis)

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