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2D materials to make perovskite-based photovoltaics competitive with the exiting PV technologies

The winning future of the emerging perovskite solar cells is closely linked to the dimension scalability and the possibility to boost the existing photovoltaic (PV) technology in tandem configuration. Indeed, on one hand, the main limit to the perovskite technology commercialization consists in a drop in power conversion efficiency (PCE) when dimensions are scaled from prototype small-area cell to module configuration. On the other hand, the well-established silicon PV technologies can overcome the Shockley-Queisser limit only when combined in tandem configuration. The synergetic development of large area perovskite devices fitting the standard silicon wafer dimensions and the optimization of perovskite/silicon tandem architectures can definitively open up new horizons for winning the commercialization challenges. To this end, bi-dimensional (2D) materials recently demonstrated their effectiveness in boosting the perovskite PV device efficiency and stability by mitigating the performance drop when scaling the cell dimensions up to module size.[1] Here, the use of interface engineering based on materials is proposed as an efficient tool for trap passivation and energy level alignment, by mitigating the performance losses induced by the scaling-up process.[2] In particular, the successful application of 2D materials, i.e., graphene,[3][4][5] functionalized MoS_2,[6][7] and MXenes[8][9] in perovskite solar modules (PSMs) allowed to achieve PCE overcoming 17% and 14.5% over 121 and 210 cm^2 substrate area respectively.[10] Moreover, an ad-hoc lamination procedure employing low temperature cross linking EVA (at 80°C-85°C) allowed to fabricate several 0.5 m^2 panels, finally assembled in Crete Island, in the first worldwide fully operating 2D material-perovskite solar farm. The 2D material optimization developed for opaque device can be easily transferred on semitransparent ones for feasible application in tandem 2T mechanically stacked configuration when coupled with crystalline Silicon (c-Si) technology. Indeed, the possibility to separately optimize the two sub-cells allows to carefully choose the most promising device structure for both top and bottom cells.[11] More in detail, semi-transparent perovskite top cell performance is boosted through a rational use of additives and bi-dimensional materials to tune the device interfaces and to optimize the light management within the device structure. In addition, a protective buffer layer (PBL) based on MoO_3 thin film is used to prevent damages induced by the transparent electrode sputtering deposition over the hole transporting layer. At the same time, a textured amorphous/crystalline silicon heterojunction (c-Si HTJ) cell fabricated with an in-line production process is used as state of art bottom cell. The tandem perovskite/Si tandem device demonstrates remarkable PCE above 28%. Finally, the scale up of this new tandem configuration is now calling for clever strategies inspired by the already exiting PV technology.

References

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