Perovskite solar panels: an innovative highlight achieved by 2D materials

Sara Pescetelli
Antonio Agresti, Stefano Razza, Paolo Mariani, Sebastiano Bellani, Francesco Bonaccorso, Enrico Leonardi, Marco Pierro, Cristina Cornaro, Aldo Di Carlo
C.H.O.S.E., Electronic Engineering Department, University of Rome Tor Vergata, Via del Politecnico 1, 00133, Rome, Italy.
sara.pescetelli@uniroma2.it

Perovskite solar cells (PSCs) represent nowadays the forefront of innovative photovoltaic technologies due to their high efficiency and low fabrication costs. At the same time, during the last few years, 2D layered materials have attracted a great deal of interest due to their fascinating optoelectronic, chemical, and mechanical properties and unique structure. Recently, the exploration of a wide range of novel 2D materials for use in PSCs has seen considerable progress, but despite the rapid development of this cutting-edge technology still a lot remains to be done regarding scalability.
Herein, we combine the use of graphene and emerging 2D layered materials in large area perovskite solar modules (PSMs) and in perovskite solar panel (PSPs) by retaining good power conversion efficiency (PCE) and stability. In fact, passing from solar cell to module i) the increasing of contact series resistance, ii) the difficulty in controlling perovskite morphology and uniformity, iii) the interfacial charge recombination strongly limits the final PCE and the stability. Moreover, passing from module to panel, the main constrain is represented by the organic selective layer, degrading at standard lamination temperatures (140°C), even for a limited time. In this work we demonstrate highly efficient large area perovskite solar module (11x11 cm^2) by employing 2D interface engineering strategy together with the use of stable polymeric hole transporting material (HTM).[1] Indeed, the addition of graphene within the electron transporting layer (ETL) as well the insertion of functionalized MoS_2 interlayer at perovskite/HTM interface allowed to achieve PCE exceeding 15.7% over more than 80 cm^2 active area and an excellent stability at 85°C after 1000 h of prolonged stress test.[2] Finally, we developed a standardized procedure for the high-throughput and large number production processes suitable for the fabrication of large-area modules. In this way, 40 perovskite-2D materials modules based on the structure FTO/$cTiO_2$+graphene/$mTiO_2$+graphene/perovskite/fMoS_2/PTAA/gold have been realized and laminated in a 0.5 m^2 panel. The outdoor measurements performed at STC demonstrated power conversion efficiency output above 10%. Moreover, the performance ratio (PR) was computed by showing higher values under overcast conditions than those measured under clear sky conditions, proving that 2D material-perovskite solar panels working are efficient even in case of diffuse irradiance.

REFERENCES

[1] A. Agresti, S. Pescetelli, A. L. Palma, B. Martin-Garcia, L. Najafi, S. Bellani, I. Moreels, M. Prato, F. Bonaccorso, A. Di Carlo, *ACS Energy Lett.* **2019**, *4*, 1862.
[2] S. Pescetelli, L. A. Castriotta, A. Agresti, A. Di Carlo, *2019 Int. Symp. Adv. Electr. Commun. Technol.* **2019**, 1.

FIGURES

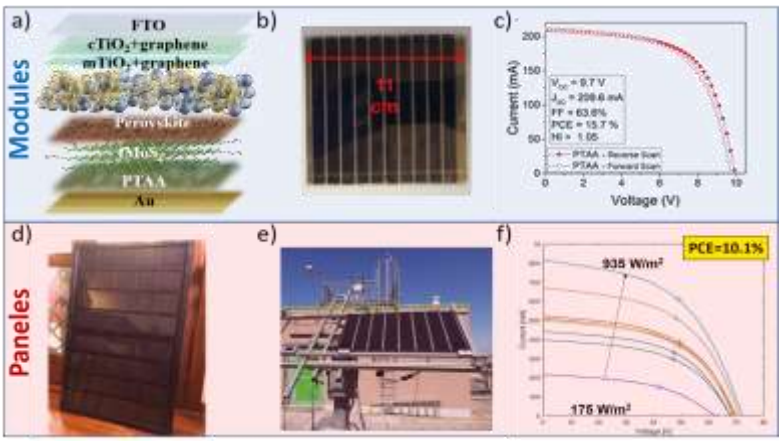

Figure 1: a) 2D interface engineering structure; b) module 11x11 cm^2 picture; c) I-V curve of best module under 1 SUN illumination; d) Perovskite-2D material solar panel; e) panel on the tracker station of ESTER laboratory of Tor Vergata University; f) I-V curve of tested panel at different outdoor irradiance conditions.