Perovskite solar cells based on layered materials

Dr George Kakavelakis
Cambridge Graphene Centre, University of Cambridge, 9 JJ Thomson Avenue, Cambridge CB3 0FA, UK.
Current affiliation: Laboratory of Photonics and Interfaces, Institute of Chemical Sciences and Engineering, École Polytechnique Fédérale de Lausanne, Lausanne, 1015 Switzerland.
georgios.kakavelakis@epfl.ch

Metal halide perovskite solar cells (PSCs) are promising for low-cost (~50% price compared to Si-based PV) [1] solar power generation, due to their high efficiencies (~25%) [2] and their solution processability [3]. However, these highly efficient PSCs have low (<1000hours) continuous operational lifetimes in high temperature/humidity conditions (e.g. 85 ^{o}C and 85% R.H.) [4] and rely on metal current collectors (CCs) and expensive hole transporting layers (HTMs) [5]. Replacing the metal CCs with a solution processed material and avoiding the use of expensive HTMs can increase stability and throughput and further reduce cost and manufacturing complexity. In the first part of the talk, I will summarize the state of the art reports on the development of fully printable Carbon-based PSCs (CPSCs), while in the second part I will present our recent progress on fully printable CPSCs where we first reported the use of graphene ink based current collectors in CPSCs. We report a low temperature (<80 oC) curable perovskite-compatible high-pressure homogenized graphene ink with sheet resistance, R_S<5 Ohm/sq at 10μm and long-term stability in ambient conditions (>12 months). Fully printed PSCs are fabricated using this ink to print the CC. By optimizing the halide perovskite/HTMs/CC interface we get PSCs with average power conversion efficiency~16% %. Our devices satisfy ISOS-D1 and ISOS-D2 [6] long-term stability tests for >100 hours without any encapsulation layer to prevent oxygen/moisture diffusion, outperforming PSCs based on metallic CC [5,7]. This demonstrates that low-cost (due to the replacement of metallic CC and use of low cost HTMs and passivation layers), efficient, stable and fully printable devices can be achieved using high-pressure homogenized graphene.

REFERENCES

[1] H. J. Snaith, J. Phys. Chem. Lett., 4 (2013) 3623.
[2] https://www.nrel.gov/pv/cell-efficiency.html
[3] J. You et al. ACS Nano, 8 (2014) 1674.
[4] T. Leijtens, et al. Adv. Energy Mater., 5 (2015) 1500963.
[5] K. Domanski et al. ACS Nano, 10 (2016) 6306−6314.
[6] A. Mei et al. Science, 345 (2014) 295; G. Grancini et al. Nat. Commun. 8 (2017) 15684.
[7] M. O. Reese et al. Sol. Energy Mater Sol. Cells, 95 (2011) 1253.