Highly Efficient Perovskite Solar Cells for Light Harvesting under Indoor Illumination via Solution Processed Composite Electron Transport Layers

Janardan Dagar,[1] Sergio Castro-Hermosa[1], Giulia Lucarelli[1], Franco Cacialli[2], Thomas M. Brown[3]

[1]CHOSE (Centre for Hybrid and Organic Solar Energy), Department of Electronic Engineering, University of Rome Tor Vergata, Via del Politecnico 1, 00133 Rome, Italy
[2]Department Physics and Astronomy and London Centre for Nanotechnology, University College London, London, WC1H 0AH, UK

Email: Janardan.Dagar@helmholtz-berlin.de

We present planar perovskite solar cells incorporating solution processed SnO_2/MgO composite electron transport layers that show the highest power outputs ever reported under typical 200-400 lx indoor illumination conditions. When measured under white OSRAM LED lamp (200, 400 lx), the maximum power density values were 20.2 μW/cm^2 (estimated PCE = 25.0%) at 200 lx and 41.6 μW/cm^2 (PCE = 26.9%) at 400 lx which correspond to a ∼ 20% increment compared to solar cells with a SnO_2 layer only. The thin MgO overlayer leads to more uniform films, reduces interfacial carrier recombination, and leads to better stability. The maximum power conversion efficiency was 19.0% under 1 sun illumination of the best cell with a stabilized value of 18.1%. The MgO layer not only lead to higher rectification ratios but led to devices with considerably less hysteresis at low illuminance as well as better shelf life stability. All layers of the cells, except for the two electrodes, are solution processed at low temperatures, thus low cost processing. Furthermore, ambient indoor conditions represent a milder environment compared to stringent outdoor conditions for a technology that is still looking for a commercial outlet also due to stability concerns. The unparalleled performance here demonstrated, paves the way for perovskite solar cells to contribute strongly to the powering of the indoor electronics of the future (e.g. smart autonomous indoor wireless sensor networks, internet of things etc). The PCE was 19.0% under 1 sun illumination of the best cell with a stabilized value of 18.1%. We also introduced Al_2O_3 nanoparticles over SnO_2 layer to get the PCE (20.1%) under 1 sun illumination.
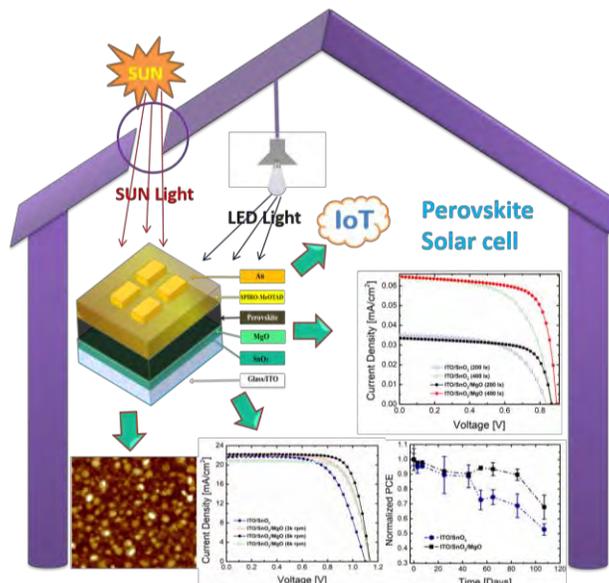

Figure 1 Graphical image of the perovskite cell testing under both 1sun and indoor illumination