Long-term outdoor monitoring of perovskite modules

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Perovskite-based solar cells are very promising devices due to their excellent optical and electronic properties[1]. However, their long-term performance stability under real operating conditions remains in question since those devices are sensitive to moisture, illumination, temperature, etc [2] Due to the relative novelty of perovskite PV, experience of continuous outdoor exposure of modules with perovskite cells is limited. Two laminated semi-transparent perovskite mini-modules have been tested outside with the main purpose to study their outdoor performance stability and to study power conversion efficiency differences attributed to their different encapsulation. The perovskite mini-modules layer stack is glass /Polyoleofine/glass/ITO/NiO/perovskite/C60/BCP/ITO/5XPolyolefine/glass with perovskite active layer to be. Different thickness in front glass encapsulant was used in the modules.

A well-defined methodology has been followed to establish the long-term performance trend of the modules. The current-voltage characteristics of the modules have been collected at regular time intervals during field testing. Alongside electrical parameters, environmental sensors that record solar irradiance in the plane of array, ambient and device temperatures, humidity/precipitation levels have been used.

Results from almost four (4) months of outdoor testing demonstrate efficiency degradation for the modules up to 30%. Similar degradation rates have been obtained for the two types of modules. The efficiency degradation is mainly attributed to current losses while voltage losses were found to be low. Spatially-resolved Electroluminescence and Dark Lock-In-Thermography techniques have been applied before outdoor testing in an attempt to detect changes in defect and hotspot evolution respectively.

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[1] H. Liu, H. Zhang, X. Xu, and L. Zhang, “The opto-electronic functional devices based on three-dimensional lead halide perovskites,” *Appl. Sci.*, vol. 11, no. 4, pp. 1–22, 2021, doi: 10.3390/app11041453.

[2] K. Domanski, E. Alharbi, A. Hagfeldt, M. Gratzel, and W. Tress, “Systematic Investigation of the Impact of Operation Conditions on the Degradation Behaviour of Perovskite Solar Cells.,” *Nat. Energy*, vol. 3, pp. 61–67, 2018.

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