Learning curves from long-term outdoor testing and indoor optoelectronic characterization of perovskite mini-modules

Vasiliki Paraskeva[1], Maria Hadjipanayi[1], Matthew Norton[1], Aranzazu Aguirre[2,3,4], Anurag Krishna[2,3,4], Tom Aernouts[2,3,4], Sabrina Penchmann[5,6], Silke Christiansen[5,6], Marios Sergides[7], Andreas Othonos[7], Rita Ebner[8] and George E.Georghiou[1]

[1 1]University of Cyprus, PV Technology Laboratory, Department of Electrical & Computer Engineering, Nicosia, Cyprus

[2]Imec, imo-imomec, Thin Film PV Technology – partner in Solliance, Thor Park 8320, 3600 Genk, Belgium

[3]EnergyVille, imo-imomec, Thor Park 8320, 3600 Genk, Belgium

[4]Hasselt University, imo-imomec, Martelarenlaan 42, 3500 Hasselt, Belgium

[5]Fraunhofer IKTS, Fraunhofer Institute for Ceramic Technologies and Systems, Äußere Nürnberger Str. 62, 91301 Forchheim, Germany

[6]Max-Planck-Institut für die Physik des Lichts, 91058 Erlangen, Germany

[7]Laboratory of Ultrafast Science, Department of Physics, University of Cyprus, Nicosia, 1678, Cyprus

[8]AIT Austrian Institute of Technology, Center for Energy, Giefinggasse 2, 1210 Vienna, Austria

e-mail: vparas01@ucy.ac.cy

Improving the performance of perovskite devices is key to increasing their competitiveness against conventional sources of energy. Several perovskite and perovskite on Silicon tandems were extensively investigated both outdoors at real environmental conditions and indoors using a range of advanced optoelectronic methods (Spatially-Resolved Electroluminescence/Photoluminescence, Lock-In-Thermography, Light-Beam Induced Current, Raman and Ultrafast spectroscopy, etc.) to set-up a complete optical and electrical characterization of perovskite devices. The devices demonstrated the impact of irradiance and temperature on their major electrical parameters during outdoor testing conducted over several months in the field. Significant discrepancies on degradation rate were obtained for same perovskite architectures demonstrating the impact of material quality on long-term performance of perovskites. Exponential degradation of performance was obtained in the majority of samples under test during the first hours of light application. Performance recovery overnight and diurnal performance degradation of several perovskite samples were calculated for each day in the field demonstrating the dominant values for diurnal degradation and recovery for each perovskite structure and at different degradation stages. Seasonal dependence of the overall performance degradation is discussed and the diurnal performance degradation-to-recovery ratio is analysed.

Spatially-resolved Electroluminescence and Lock-In-Thermography methods demonstrated hotspot and shunts evolution in perovskite mini-modules after outdoor exposure. Raman spectroscopy measurements revealed the differences in chemical properties of perovskite mini-modules after outdoor exposure while Ultrafast spectroscopy demonstrated the carrier relaxation processes in the devices which are correlated with diurnal performance degradation and recovery processes.

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