Abstract submitted to the 37th EU PVSEC 2020, Lisbon, Portugal

Topic 3: Perovskites and Other Non-Silicon Materials
3.1 Perovskites

Optical and electrical characterization of perovskites

R. Ebner[1], B. Kubicek[1], G. Ujvari[1], A. Mittal[1], N. Bansal[1], T. Dimopoulos[1], M. Hadjipanayi[2], V. Paraskeva[2], M. Hadjikypris[2], G. E. Georghiou[2], A. Hadipour[3]
[1]AIT Austrian Institute of Technology, Center for Energy, Giefinggasse 2, 1210 Vienna,
Austria, T +43 50550-6628, F +43 50550-6390, rita.ebner@ait.ac.at, www.ait.ac.at
[2]University of Cyprus, 1 Panepistimiou Avenue, 2109 Aglantzia, Nicosia, Cyprus, www.foss.ucy.ac.cy
[3]imec, Kapeldreef 75, 3001 Leuven, Belgium, www.imec.be

1. Aim

New and emerging photovoltaics technologies such as single-junction perovskites and 4 and 2 terminal tandem structures based on perovskite in combination with perovskite, silicon and CIGS as sub-cells demand more advanced characterization methods for understanding degradation mechanisms occurring therein and subsequently contributing to improvement of their properties. Therefore, here, degradation in perovskites and perovskites on silicon tandem were investigated through the use of advanced optical and electrical characterization methods. Methods of Dark Lock-In Thermography (DLIT), Electroluminescence (EL) and Photoluminescence (PL) were applied beside power output (IV) and external quantum efficiency (EQE) measurements.

These optical and electrical measurement methods are applied effectively in quality control and development support and are important characterization tools in industry and research. EL, PL and DLIT imaging are non-destructive measurement techniques. These types of optical measurement provide fast, real-time and high resolution images and will give a two-dimensional distribution of the characteristic features of PV cells and allow the investigation of cracks, defects, shunts and stacking faults in the cells. IV- and EQE-measurements help to get a complete picture of the power conversion efficiency of solar cells. IV-measurements give the current generated by the cell under simulated solar irradiation conditions and EQE-measurements provide a quantification of the generated current at each wavelength.

2. Experiments

Perovskite solar cells (PIN and NIP) were characterized by means of power output determination (IV), EQE, EL (FIG.4), PL and (DLIT). FIG.1 shows the PIN and NIP device structure. FIG.2 shows the front and back of one PIN test sample with 12 cells (active areas). FIG.3 shows a sketch of the device.

For example, the measurement results of one cell, D11, which is marked with a red rectangle in FIG.3, are the following: Current-voltage measurements supplied an open circuit voltage (Voc) of 1V and a short circuit current density (Jsc) of 16.3mA/cm^2. The results of the EQE measurement are given in FIG.4, where the ratio of extracted free charge carriers to incident photons was determined. In FIG.5 the EL-image of the cell D11 shows some small defects (marked with a yellow rectangle) and an increase of defects (marked with a blue rectangle) after degradation (a short increase of the current during EL-measurement).

3. Conclusion and outlook

By means of the optical and electrical measurement tools the perovskite solar cells could be characterized. First defects and shunts were identified by means of EL, PL and DLIT measurements (for example see the bright spots in the EL-image of FIG.5). The EQE-measurement supplied very high values (about 90% for cell D11, see FIG.4). The short circuit current density of the cells was also very satisfying (Jsc=16.3mA/cm^2 for D11).

It is planned to perform further indoor tests and also outdoor tests of different structured perovskite samples and also perovskite tandem cells. In addition, the aim is to develop protocols for indoor and outdoor testing of perovskites.

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Explanatory page 1:

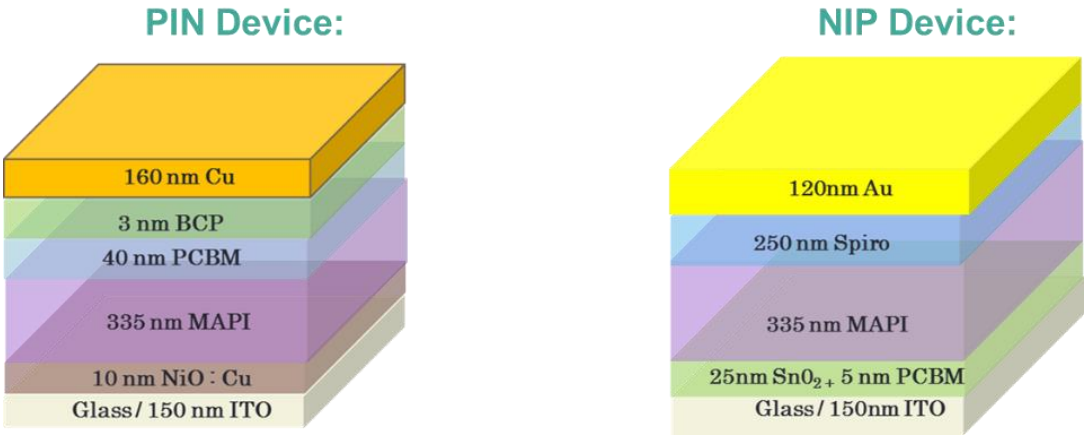

FIG.1 PIN and NIP device.

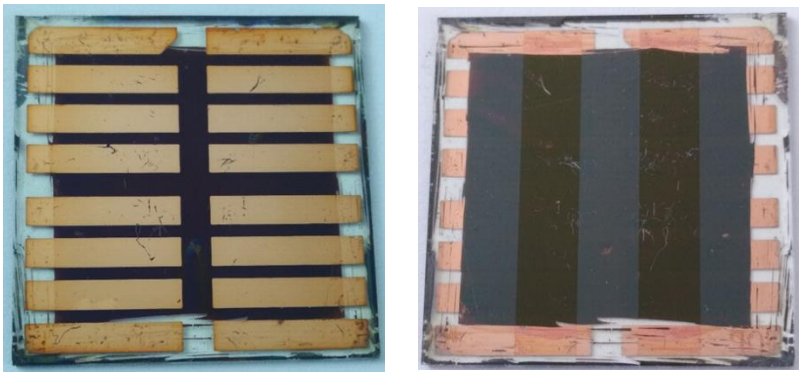

FIG.2 PIN device (left: front, right: back),

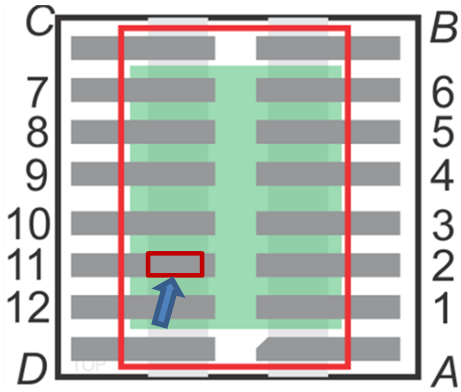

FIG.3 Sketch of the device: ITO connections are: A, B, C and D; metallic electrodes (Cu) are: 1 until 12 (12 active areas); each active area = 0.13 cm^2, D11 is marked with a red rectangle.

Explanatory page 2:

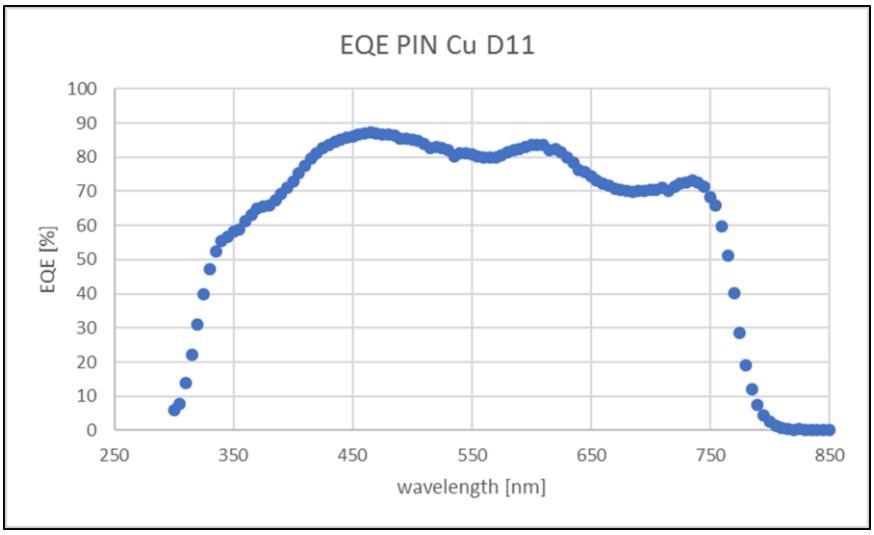

FIG.4 External quantum efficiency of D11 (PIN device)

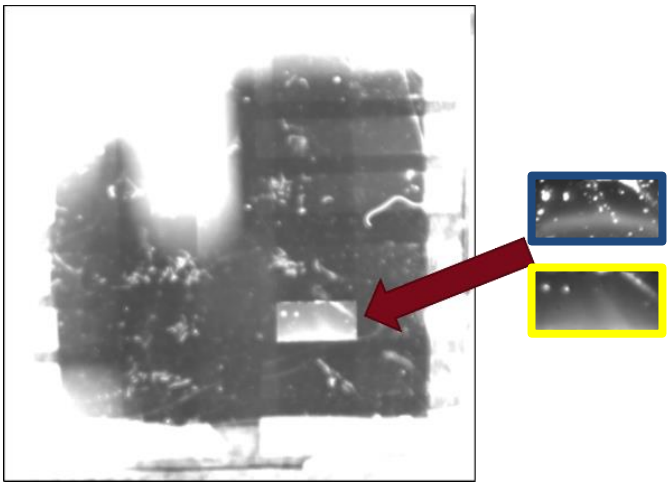

FIG.5 Electroluminescence of D11 (PIN device)

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