Electrical characterization of recombination junctions for Perovskites/Crystalline Silicon tandem solar cells

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Combining perovskites (PK) and crystalline silicon (c-Si) materials is a promising approach towards highly efficient tandem devices [1]. In this work, we study different recombination junctions (RJ) between the c-Si bottom cell and the SnO_2 Electron Transport Layer (ETL) of the PK top cell (NIP configuration). The bottom cells use poly-Si/SiO_x passivated contacts technology and we compare RJ based on a Transparent Conductive Oxide (TCO) or a thin Si-based layer. For the solar cells fabrication, we use n-type wafers and (n^+) rear poly-Si layers, whereas for RJ characterization p-type substrates and (p^+) rear poly-Si layers are needed. After a wet chemical treatment (HF dip) to clean the doped poly-Si layers surface, we deposited either a 12nm-thick Indium Tin Oxide recombination (ITO rec.) layer or a 25nm-thick Phosphorus-doped microcrystalline Si (µc-Si) layer on the front (p^+) poly-Si layer. By contacting these RJ stacks with varying ITO/Ag contact dots sizes, we can measure dark I(V) curves (Fig. 1 a/ and b/) and then extract specific contact resistivity (ρ_c) values using Cox and Stack Method (CSM) [2]. Our previous results [3] showed that without using ETL, both RJ approaches allow specific contact resistivity values below 100 mΩ.cm^2, suitable for further tandem solar cell integration. Here, we observe resistive losses for the (n^+) µc-Si / SnO_2 contact, whereas better transport properties are obtained using ITO rec. at the top/bottom cell interface. On tandem devices (Fig. 1 c/), not only Fill Factor (FF) but also Open Circuit Voltage (V_{OC}) losses are caused by the poor (n^+) µc-Si / SnO_2 contact properties.

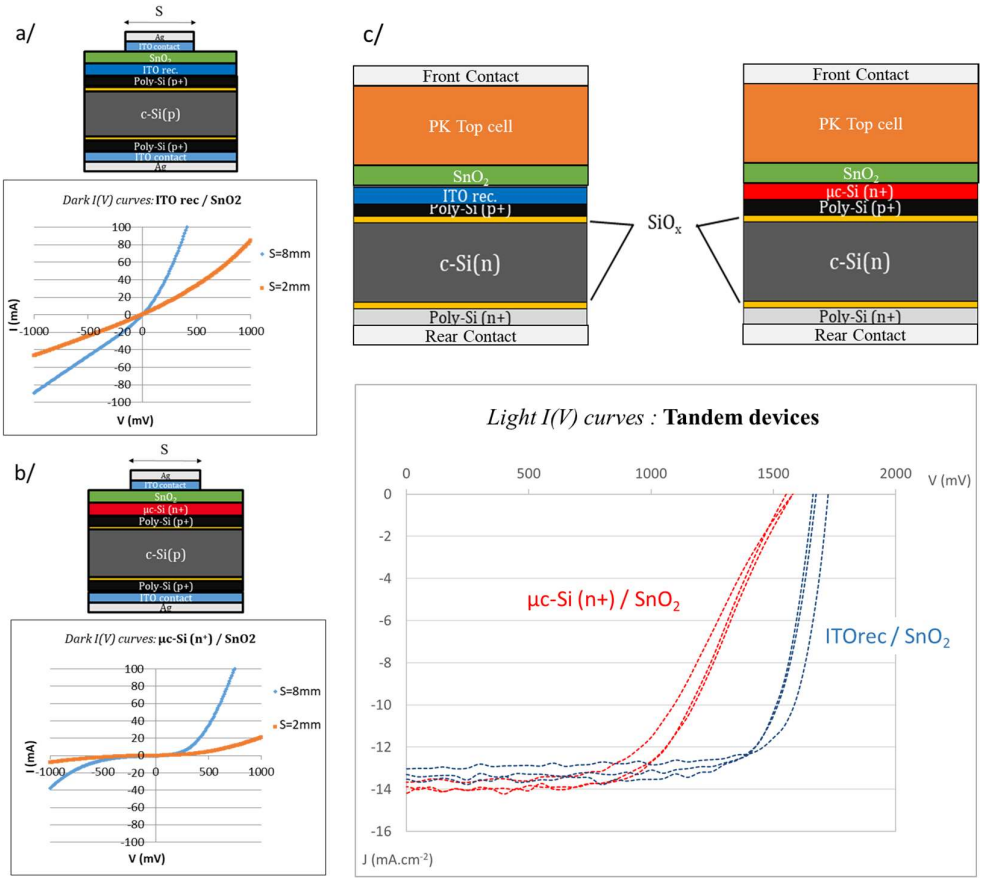

Figure 1 *: RJ test structures and dark I(V) curves obtained on different circular top contact sizes (S) for a/ITO rec.-based RJ and b/ µc-Si-based RJ. c/ Cells structures and light I(V) curves measured on tandem devices using both RJ approaches.*

[1] https://www.pv-magazine.com/2022/07/07/csem-epfl-achieve-31-25-efficiency-for-tandem-perovskite-silicon-solar-cell/
[2] R.H. Cox, H. Strack, Ohmic contacts for GaAs devices, Solid State Electron. 10 (1967) 1213–1218
[3] B. Marteau et al, "From Silicon Based TRJ Developments on Poly-Si Passivated Contacts to Tandem Integration into Perovskite / Silicon Devices", Tandem Workshop 2022