Area: Area 2 Thin-Film Compound Semiconductor PV

OPTIMIZATION OF THE RECOMBINATION JUNCTION IN MONOLITHIC TWO-TERMINAL HYBRID CIGS TANDEM DEVICES

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Multijunction solar cell devices offer some fundamental benefits in the potential of fabricating solar cells with higher efficiencies, due to their better utilization of the solar spectrum and generation of higher voltages per current, leading to lower resistive losses. These devices can be fabricated in two-terminal and four-terminal configurations. While four-terminal configurations obtain the most challenges in implementation in modules and pv systems, two-terminal devices need to overcome technological challenges on cell level, such as current-matching, proper recombination junctions, and compatibility between different technologies.

In this work, we present a monolithic configuration of two-terminal CIGS/a-Si:H tandem cells. We previously demonstrated the first working devices and in this work we focus more on the quality of the recombination junction, which should recombine the electrons of the CIGS bottom cell with the holes generated in the amorphous silicon top cell. The most important parameters of these layers lay in the conductivity of these layers (will it allow transport of the charge carriers), the activation energy (will there be any transport barriers), and the recombination rate. In complete devices, the JV curves will help to identify the quality of the recombination junctions. The V_{oc} should be a lossless summation of the potentials of the subcells, and there should be an absence of an S-shape (indicator for a transport barrier) in the JV-curves.

Various methodologies have been applied to determine the quality of these recombination junctions. The configuration of these devices is SLG/ Mo/ CIGS/ CdS/ X_1/ X_2/ X_3/ p-SiO_x/ a-Si:H/ n-SiO_x/ AZO. In all cases X_1 corresponds either to (conventional) i-ZnO or phosphorus-doped (n-doped) SiO_x. Where applied, X_2 refers to a material with a high n-doping and X_3 to a material with a high p-doping. Different thicknesses and materials were investigated. In all cases X_2 and X_3 refer to silicon based materials.

Firstly, we characterized individual layers, which enabled us to run simulations to determine the band alignment between the different materials. In addition, configurations with stand-alone recombination junctions (so without any absorber layers) have been fabricated and JV curves, spectral response and activation energy have been measured (see Figure 1a for the activation energy results). Finally, we also fabricated complete devices to (de)validate the various stand-alone approaches (see the various JV curves in Figure 1b). Using the best recombination junctions, we have been able to fabricate monolithic tandem cells with a V_{oc} of 1.45V, which is close to the summation of their single junction reference cells (with V_{oc} of ±850 mV for a-Si:H and ±620 mV for the CIGS).

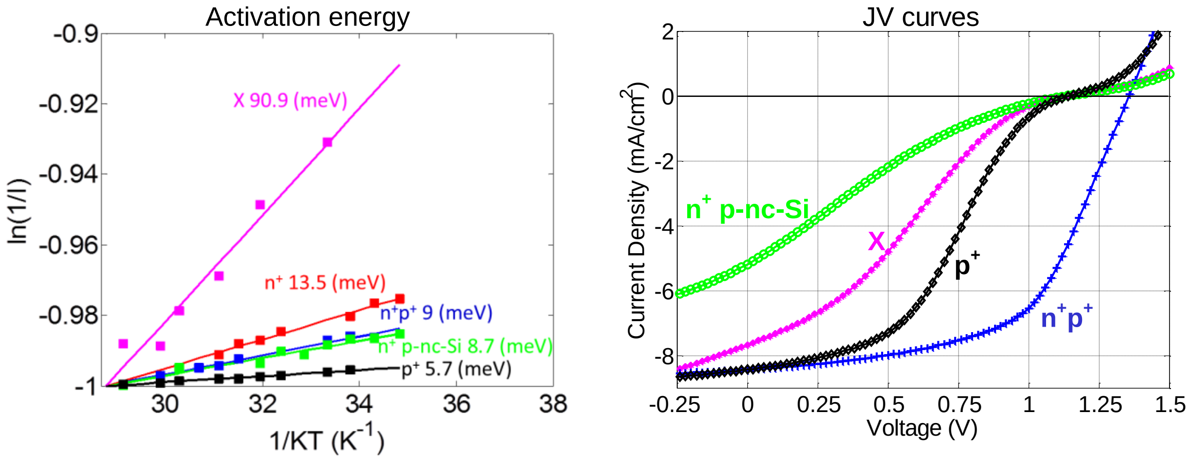

Figure 1 X refers to no recombination junction at all, in all other cases, the fabricated recombination junctions (X_2 & X_3) are indicated in the figures.

Figure 1 a) Activation energy of a stand-alone recombination junction, lower values indicate a lower transport barrier, which can be correlated to a better recombination junction;

Figure 1 b) The same recombination junctions implemented in full devices, showing significant barriers appearing in the most of the devices.