1.15 Volt V_{OC} $CuGaSe_2$ / c-Si tandem solar cell with ITO or tunnel junction at the interface

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The photovoltaic (PV) conversion efficiency of crystalline silicon (c-Si) solar cells is close to the theoretical limit (around 29%). To overcome this limitation, without drastically changing the pre-existing industrial tools, the solution of a monolithic tandem solar cell with a c-Si bottom cell is currently a hot topic in the PV community. A top cell with a $CuGaSe_2$ (CGSe) absorber has the advantage of being based on a material (i.e. CIGS), already industrialized and which has reached efficiencies above 23%[1] with single-junction devices. To obtain an ideal top cell bandgap around 1.7eV[2], pure-gallium CGSe is an obvious candidate with its bandgap of 1.68eV. The record efficiency of CGSe-based single-junction solar cell is 11.9%[3] and therefore the technology needs to be improved to make a relevant CGSe / c-Si tandem structure. A first monolithic CGSe / c-Si tandem cell with two-terminals has already been elaborated[4], but this structure is based on a recombination layer with ITO at the interface which on the one hand causes chemical reactions with the CGSe absorber and on the other hand requires the use of indium, an element considered as critical.

In this study, we elaborate a CGSe / c-Si tandem cell with an interfacial ITO as reference (thereafter this tandem will be called ITO) and we propose an alternative tandem architecture which does not require an ITO-based recombination layer at the interface between the two sub-cells. A passivating tunnel junction made with a thin layer of highly doped polycrystalline silicon (poly-Si) formed on an ultra-thin silicon oxide (SiO_x) is used at the interface between the c-Si and the CGSe solar cells (thereafter this tandem cell will be called tunnel). This structure, which is, to the best of our knowledge, the first to use a Si-based tunnel junction for a chalcogenide / c-Si tandem solar cell, still needs to be optimized. Electrical measurements were realized and we performed TEM analyses of the CGSe / ITO interface to correlate electrical tandem cell performances and chemical and structural properties. The two kinds of tandem cells exhibit V_{OC} values of 1.15V.

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