Ultrathin CdSeTe solar cells with optimized rear side contact

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Polycrystalline Cadmium Telluride (CdTe) thin-film solar cells have a very low levelized cost of energy and provide an attractive alternative to Si cells. Indeed, state-of-the-art CdTe solar cells have reached a remarkable efficiency of 22.1% [1] thanks to several key improvements over the years. First, annealing under $CdCl_2$ atmosphere resulted in huge efficiency increase as compared to as-grown CdTe through grain interior and grain boundary passivation. Second, the CdS buffer layer was replaced by a more transparent material MgZnO. Finally, the incorporation of Selenium has shown a significant rise of the short circuit current and a decrease of the open-circuit voltage deficiency [2].

Reducing the CdTe absorber thickness, usually 3-4 µm, would decrease even more the fabrication cost and possibly reduce the relatively high bandgap-voltage offset. Nonetheless, it usually comes at the expense of light absorption. Thus, it requires light trapping combined with a highly reflective mirror such as silver to preserve the Jsc. However, because of CdTe high electron affinity and low doping, replacing the gold contact while keeping high performances is not trivial.

In this contribution, we will introduce our investigations of novel back contacts for ultrathin CdTe solar cells. The aim of this work is to explore alternative contacts compatible with highly reflective, nanostructured back mirrors. This study is carried out with solar cells supplied by the NREL (US), with two different thicknesses: 3.45 µm and 0.65 µm. We first apply a strategy we already successfully implemented for ultrathin CIGS solar cells with flat back mirrors [3]. Then, we try to further enhance light trapping using nano-structured mirrors at the rear side of the devices, a highly efficient method introduced in our 200 nm-thick GaAs solar cells [4].
We will present our latest experimental results where several back contacts are investigated and compared. EQE measurement for gold back contact display high and homogeneous Jsc values around 28 mA/cm^2 with 650 nm-thick absorber (fig1), with V_{oc}=0.67 V and FF=66 %. Using the Rigorous Coupled Wave Analysis (RCWA) method, we model the optical properties of ultrathin CdTe solar cells with various nanostructured back contacts (fig2). Finally, we will propose optimized architectures and perspectives for ultra-thin CdTe solar cells.

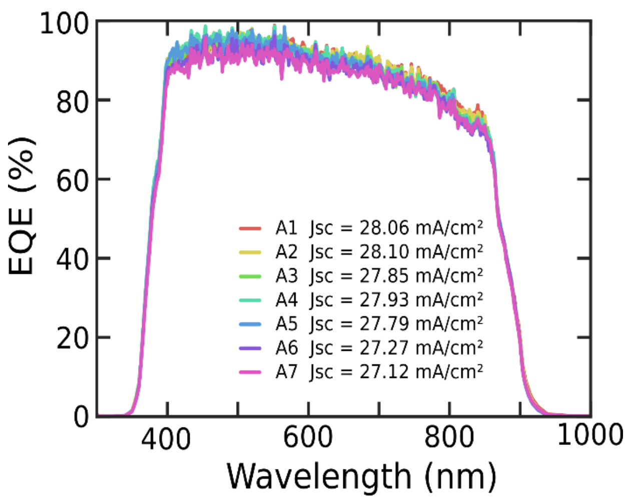

Figure 1: External Quantum Efficiency measured for seven solar cells with 650 nm-thick absorber and Au back contact

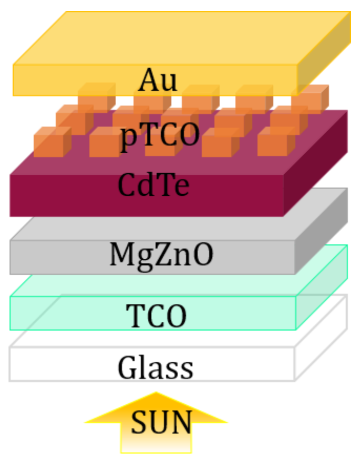

Figure 2: Ultrathin CdTe solar cell with a nanostructured back mirror

[1] M. A. Green *et al.*, “Solar cell efficiency tables (Version **58**),” 2021.
[2] J. D. Poplawsky *et al.*, *Nat. Commun.*, **7**, 1–10, 2016.
[3] L. Gouillart *et al.*, *Prog. Photovoltaics Res. Appl.*, **29**, 212–221, 2021.
[4] H. Chen *et al.*, *Nat. Energy*, **4**, 761–767, 2019