Advanced Light Management and Passivation Strategies in Ultrathin CIGS Solar Cells

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This work is based on $Cu(In,Ga)Se_2$ (CIGS) polycrystalline material as light absorber in thin films solar cells. In order to reduce costs and save materials, we are aiming to reduce the absorber thickness from 2.5 µm to 0.5 µm, while increasing efficiency. CIGS is usually deposited by co-evaporation on Molybdenum back contacts which withstands the high (up to 500°C) deposition temperature. However, the CIGS/Mo interface has a low reflectivity and is prone to charge recombination, resulting in poor performances in ultrathin CIGS solar cells. This poses the challenge of finding a stable, highly reflective and passivating material for the back contact. Here, we present novel back contacts with two purposes: passivation of the back interface and increase of light absorption.

Our approach aims to enhance photon absorption in ultrathin CIGS absorbers (~0.5 µm) by integrating tailored light-scattering nanostructures at the substrate level. These nanopatterns are designed using computational modeling and fabricated via nanoimprint lithography. They are combined with an optimized transparent conductive back contact (ITO) and/or thermally stable reflective mirrors, which maintain up to 90% reflectance under the high-temperature conditions typical of CIGS deposition [1].

Our recent results demonstrate the effectiveness of our approach made of an ITO back contact covered by a nano-imprinted SiO_2 layer with periodic openings (Fig. 1). It leads to improvements in both Voc (+60 mV) and Jsc (+5 mA/cm^2) with respect to conventional Mo back contacts, thereby enhancing overall cell performances. The Voc improvement is attributed to a reduction in the contact area with the conductive oxide (localized CIGS/ITO contacts) and a low recombination velocity at the CIGS/SiO_2 interface. The Jsc improvement is due to the combination of a reflective mirror and the diffractive effect of the periodic holes [2].

A thin (<60 nm) SiO_2 layer was used in these experiments. According to optical simulations, further improvements can be obtained with optimized period, width and thickness of the patterned layer. Ongoing experiments should also provide additional insights on the remarkable passivation properties of this localized back contacts.

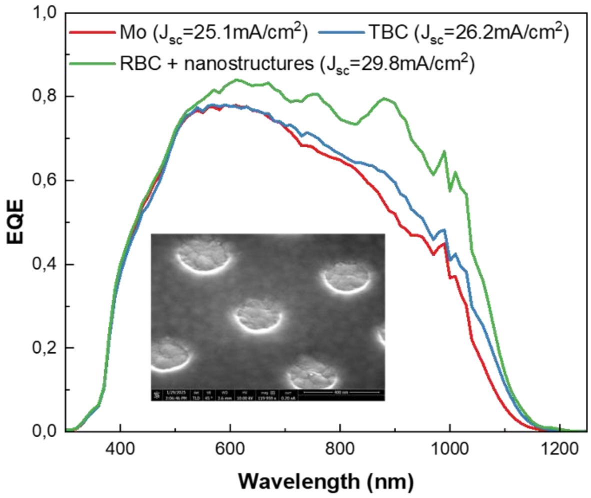

Figure 1 : External Quantum Efficiency measurements for 0.5µm CIGS cells on Mo, Transparent Back Contact (TBC) and Reflective Back Contact (RBC) with nanostructures. Inset: SEM image of the nanostructures (holes in a SiO_2 layer on ITO).

References

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[2] Inès Massiot, Andrea Cattoni, and Stéphane Collin, "Progress and prospects for ultrathin solar cells" **Nature Energy 5**, 959-972, 2020.