Light-Trapping in Ultrathin CIGS Solar Cells with Nanostructured Back Mirrors

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Ultrathin $Cu(In,Ga)Se_2$ (CIGS) solar cells technology (CIGS layer thickness <500 nm) is developed nowadays as an alternative to the conventional 2-3 µm-thick cells in order to reduce the manufacturing costs. However, ultrathin absorbers lead to poor light absorption and increased back contact recombination [1]. Here, we investigate new architectures to improve light trapping and increase absorption in the CIGS layer, in order to achieve efficiencies higher than 20%, in the frame of the European project ARCIGS-M.

The novel architecture consists of replacing the usual Molybdenum back contact with a flat silver mirror encapsulated in TCO and combined with a nanostructured dielectric layer. It is compatible with the direct deposition of CIGS [2] and it can be implemented at the industrial scale (dielectric and metallic deposition, nanoimprint lithography). The light-trapping mechanism is based on multiple overlapping resonances, similar to the recent demonstration of ultrathin GaAs solar cells [3]. The geometrical parameters were optimized based on the overall short-circuit current and using both a systematic approach and a genetic algorithm, for effective CIGS thicknesses comprised between 200 and 300 nm. We demonstrated a short-circuit current density of 36.4 mA/cm^2 for a 292 nm effective CIGS thickness and a nanostructured silver back mirror, as compared to 31.89 mA/cm^2 for a flat mirror assuming the same effective CIGS thickness.

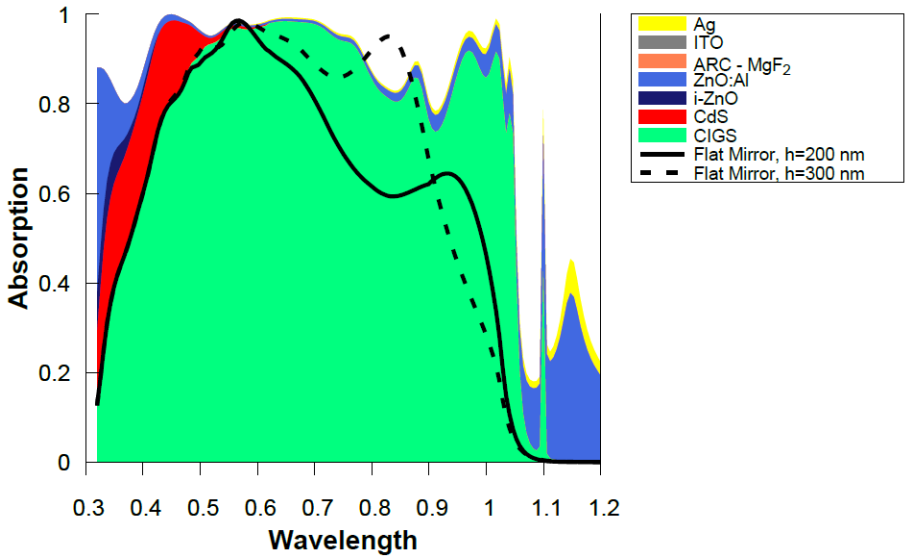

Fig. 1. Absorption in each layer of an optimized solar cell with a 292 nm effective CIGS thickness and a nanostructured back mirror. The solid (resp. dotted) line represents absorption in a 200 nm (resp. 300 nm) CIGS layer with a flat mirror.

[1] Mollica, F. et al., Thin Solid Films 633, 202–207, 2017.
[2] Louis Gouillart et al., Thin Solid Films 672, 1-6, 2019.
[3] H.-L. Chen et al., Nature Energy 4, 761-767, 2019.