Industrially Viable Rear Surface Passivation Approach for Cu(In,Ga)Se_2 Solar Cells

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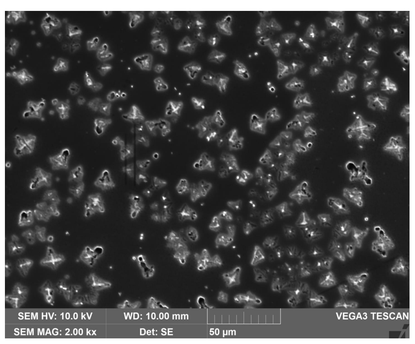
Purpose:
Reducing the thickness of Cu(In,Ga)Se_2 (CIGS) absorber layers has potential to decrease its costs significantly, but has drawbacks like incomplete absorption and increased rear surface recombination, both resulting in power conversion efficiency losses. One solution is to implement a rear surface passivation layer, which has potential to reduce rear surface recombination velocity and increase rear internal reflection.

Strategy : 'Atomic-layer-deposited-alumina (Al_2O_3) layer as the passivation layer, and NaF spin coating on top of this layer to make point contact openings.'

Characterization Results: SEM, EDS, PL-TRPL & Solar Simulator

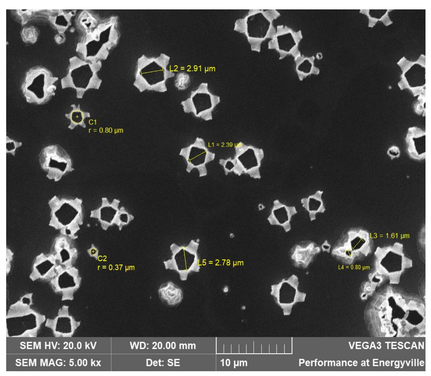
a-

b-



Intermediate step;
'Selenization at 540°C'

c-



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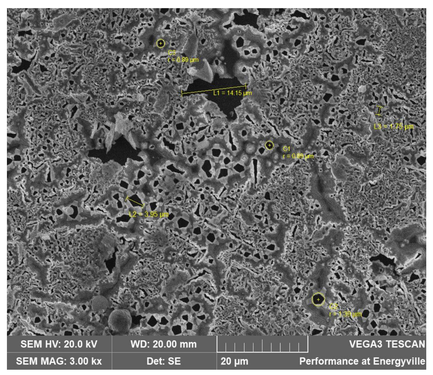

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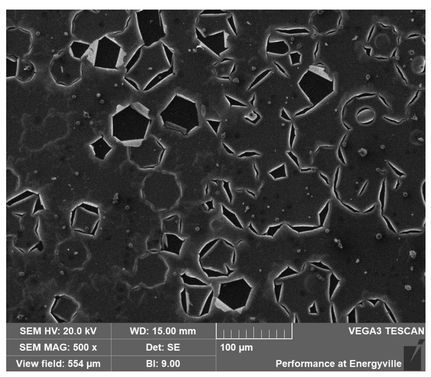

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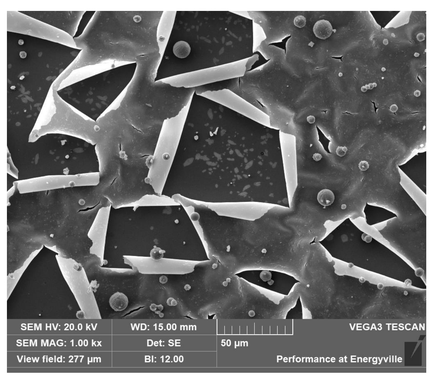

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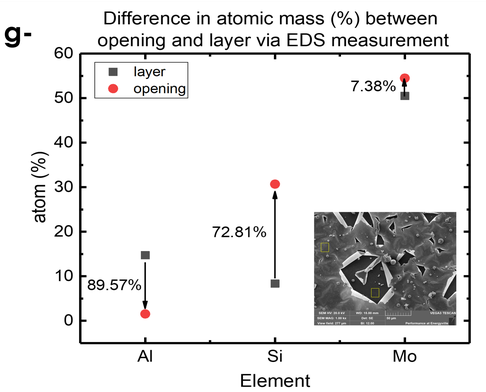

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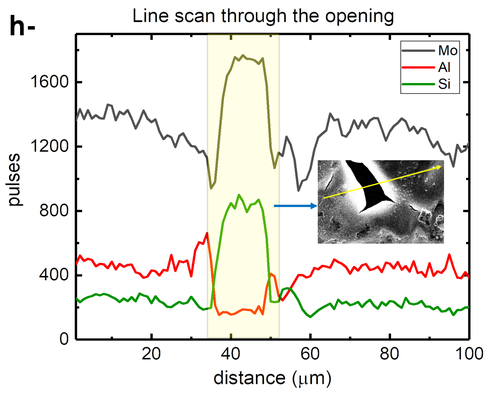
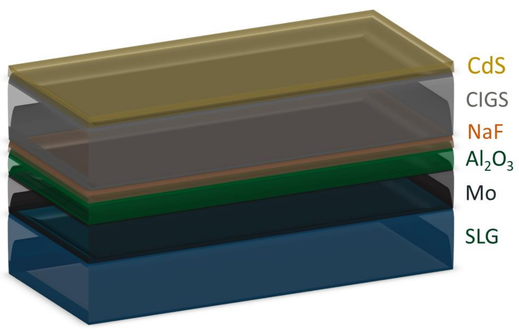


Figure 1: a- Spin coating NaF on Al_2O_3 deposited ultra-thin CIGS solar cell, **b-** SEM picture of *characterization sample* before selenization, **c, d, e and f-** SEM pictures of characterization sample after selenization to depict the point openings inside the dielectric layer, **g-** EDX analysis to depict the difference between the amount of elements, for the layer and the contact-opening (inset: SEM picture of the analyzed sample) **and h-** EDX line scan to prove the existence of the openings in dielectric layer (inset: SEM picture of the analyzed sample).

a-



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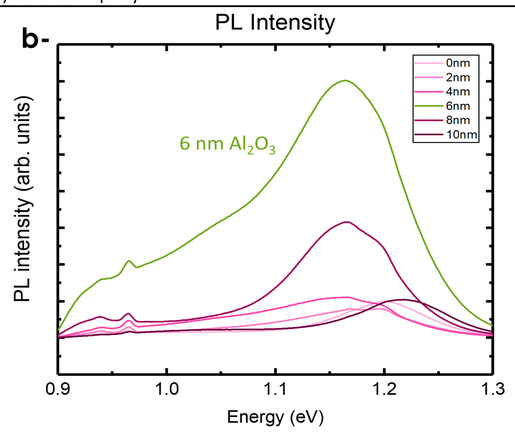

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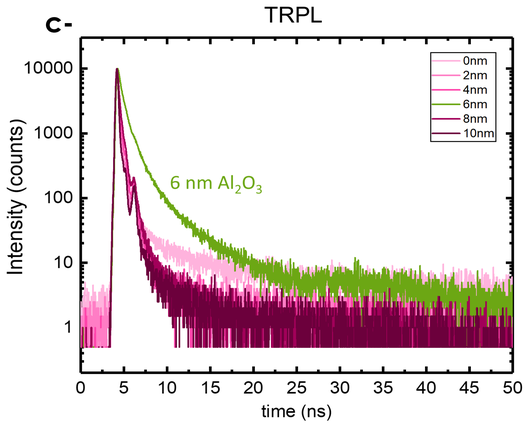
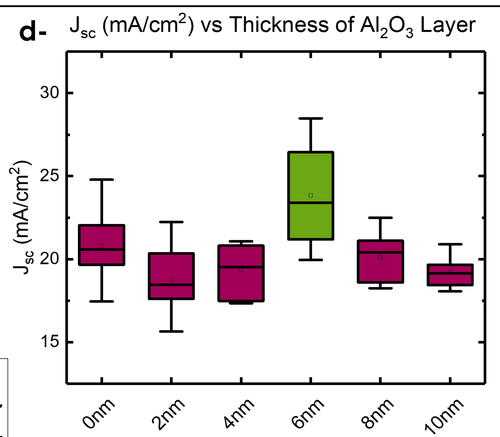


Intermediate step;
'Finalization of the solar cells with window layer and grids'

d-



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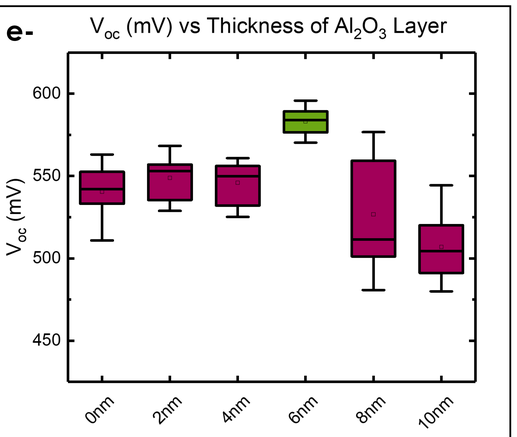

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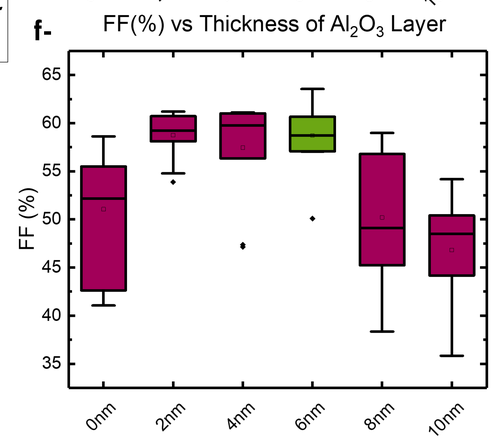

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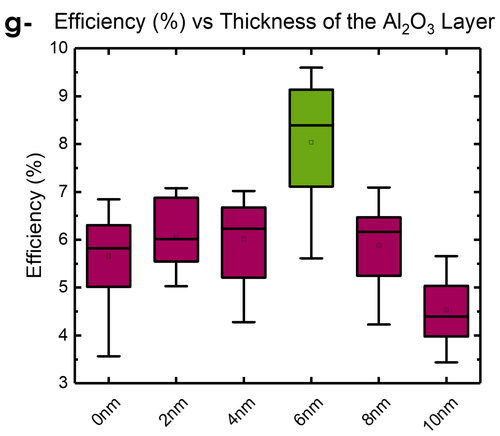

Figure 2: a- Uncomplete (without window layer and grids) CIGS structure with alumina passivation layer and NaF spin coating interlayer for PL measurement, **b and c-** Photoluminescence (PL) and time-resolved PL (TRPL) measurements of CIGS solar cells with various alumina thicknesses , **d, e, f and g-** Solar simulator measurements for ultra-thin CIGS solar cells with various thicknesses of alumina at rear surface in combination with NaF spin coating; current density, open circuit voltage, fill factor and efficiency versus thickness of the alumina layer, respectively.

Comments and Further Studies:

- ✓ According to TR-PL results, a 6 nm thick passivation layer gave the slowest decay time and PL response in all sets of samples.
- ✓ Significant increase in power conversion efficiency and gain in open-circuit voltage, current density, and fill-factor values were measured for the 6 nm Al_2O_3 rear passivated CIGS cells.
- ✓ It can be concluded that by using a simple, cost-effective and fast way, we succeeded to make point contact openings to passivate the back surface of ultra-thin CIGS solar cells.

The ongoing work focuses on different aspects like;

- *Trying to make the openings in nano-scale range and control the density of the these openings.*
- *Investigation of the different metal oxides as passivation layers in combination with the same contact opening approach.*

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https://www.uhasselt.be/UH/IMO/Visit-the-groups/Chalcogenide-thin-film-photovolataics.html
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