The impact of novel high-performance substrates in ultrathin solar cells

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Silicon wafer-based technology dominated the photovoltaic market, with only a significantly smaller market share belonging to thin films. Ultrathin solar cells, using sub-µm absorbers are gaining relevance, due to their potential for savings in material resources and processing time, and potential for performance increase. The use of ultrathin absorbers to fabricate solar cells moves thin film technology to a relevant competitor status. The reduction of the absorber thickness down to the ultrathin range, raises two inherent intrinsic issues: increased rear interface recombination and decreased light absorption. These issues may be tackled through the incorporation of a dielectric passivation layer between the rear contact and the absorber [1]. Moreover, by having a very high percentage of the rear contact covered in a transparent dielectric layer for passivation in the contact structure [2], there is freedom to add extra functionality between the passivation and rear contact, leading to high-performance substrates (HPS). We will use $Cu(In,Ga)Se_2$ (CIGS) based ultrathin technology to showcase the optoelectronic potential of the HPS, and review some of the novel substrates architectures developed by the Nanofabrication for Optoelectronic Applications - NOA - group at INL. Optical simulations allow for accurate descriptions of the optical gains, providing a guideline to the passivation schemes. The NOA group has been focusing its investigation in: dielectric materials, innovative contacting approaches and industrially-friendly microelectronics-based nanofabrication (deposition, lithography, and etching) processes. The morphology, structure and optoelectronic properties of HPS and final devices are evaluated through advanced characterization techniques. We will discuss how the implementation of HPS can lead to increased figures of merit values over conventional ultrathin CIGS based devices. We will review the impact of lines vs. points contacts; the use of different dielectric materials and its impact on interface active defects density and built-in electrical field; and how highly reflective metals and nanostructures can be incorporated in HPS architectures to increase device's performance. Figure 1 shows three CIGS ultrathin solar cells, (a) with a conventional substrate and with a HPS based on two innovative contacting approaches schemes: (b) line and (c) point contacts. The implementation of novel SiO_x line contacts HPS in CIGS based devices, lead to improvements up to 5 % (abs) in the power conversion efficiency values over the conventional architecture.

REFERENCES

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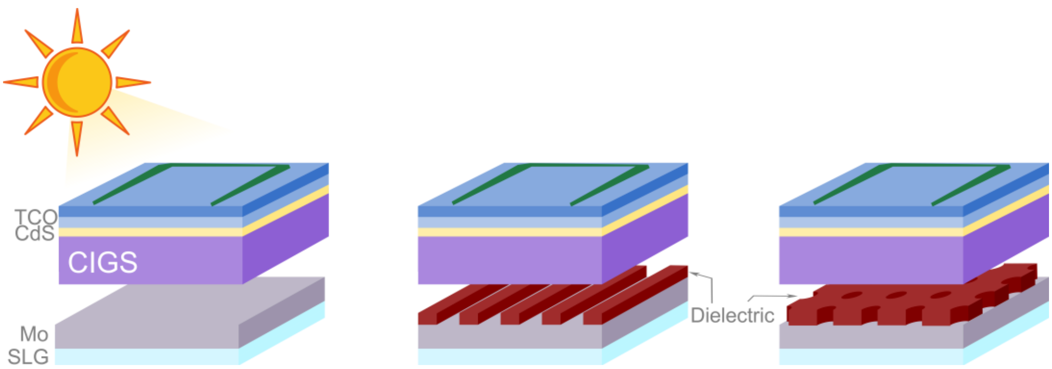

Figure 1: CIGS ultrathin solar cells with a (a) conventional substrate, (b) HPS based line contacts, and (c) HPS based point contacts.