Zr-doped Indium Oxide as transparent electrodes for photovoltaics

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Transparent conductive oxide (TCO) thin films play an important role as transparent electrodes (TE) for photovoltaic applications and flexible electronics that requires long-term stability, high conductivity, and selected high optical transparency. It is important to improve conventional TCOs as Indium Tin Oxide (ITO), the most used TCO, and other Indium-based TE taking advantage of their already consolidate good electrical and optical properties. Reducing the amount of In and optimizing the process parameters to obtain good performance at room temperature with low post-deposition thermal annealing is still one of the major challenges. This work, we present an ultra-thin, highly conductive, and transparent TCO based on In_2O_3 doped with low Zr concentration (IZrO). Films with reduced thickness (down to 15nm) compared to those standardly used in solar cells, were deposited by co-sputtering of In_2O_3 and Zr targets, at room temperature followed by low-temperature thermal annealing (T=200 °C). RBS has been performed to measure the elements at% and film thickness, while SEM and AFM were employed for morphological analysis. Optical bandgap and work function values were obtained by Tauc analysis and KPFM measurements, while the crystalline structure was detected by XRD technique. The improvement of the crystalline quality leads to very good optical and electrical properties: resistivity as low as 10^{-4} Ωcm and optical transmittance up to 80%. IZrO electrode performances have been tested through EQE measurements on a semi-finite HJT bi-facial silicon solar cell manufactured by Enel Green Power. The cell was taken from the production line just after the deposition of the n+ and p+ hydrogenated amorphous

silicon layers deposited on the front and on the back surfaces respectively. Our studies report EQE comparable to that of standard ITO. Those results suggest that ultra-thin IZrO may successfully be employed to reduce costs and the amount of critical materials for In-based TCO.