Investigation of $ZnSnN_2$ deposition by reactive High-Power Impulse Magnetron Sputtering

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Tandem solar cells are considered a viable solution to foster the performance of photovoltaics (PV), since silicon efficiency (26,7% at lab scale [1]) is approaching the theoretical one (29,4%). Tandem devices are based on top semi-transparent cells, absorbing a portion of the solar spectrum and transmitting the leftover to the silicon bottom cell, to have several PV junctions – typically 2. Simulations indicate efficiency of an ideal Si-based tandem solar cell is over 40% [2], with several prototypal devices already overcoming the 30% threshold [3].
As absorber material of top cell for Si-based tandems, mature PV materials as III-V, CIGS, CdTe and the more recent perovskites have been tested. Unfortunately, their commercial usage is hindered by different issues – including rare, polluting and/or toxic elements, high fabrication cost, lower energy gap than ideal top material, limited efficiency, or reduced stability over time. Hence, innovative semiconductors with wide band gap (close to 2eV [4]) and low-cost (thin film approach) are needed. Among novel materials proposed as top semiconductor, ternary nitride Zn-IV-N_2 (IV=Sn, Ge, Si) has attracted interest because of (i) wide and tuneable band gap; (ii) large absorption coefficient; (iii) earth-abundant and non-toxic elements; (iv) it can be deposited in thin films by low-cost methods [5].
Here, we investigate the deposition of $ZnSnN_2$ (ZTN) by High-Power Impulse Magnetron Sputtering (HiPIMS) – a technique with high degree of ionisation of sputtered species and improved gas dissociation, to grow high-quality films [6]. HiPIMS deposition from Zn and Sn targets are studied, both in Ar and N_2 reactive atmosphere. Several parameters are investigated, such as pressure, gas mixture and substrate bias. HiPIMS discharge dynamics are analysed, as well as process gas ionisation by optical emission spectroscopy (OES). Thin films are characterised by scanning electron microscopy (SEM) – to determine morphology and grain features – and X-ray diffraction (XRD) – to detect amorphous and crystalline phases. The results are the bases for further research on HiPIMS reactive co-sputtering to deposit high-quality films of ZTN and tune its properties for advanced PV applications, as tandem solar cells.

References

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