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Magnetron Sputtering of Electronically Active and Passive Layers for Thin Film Solar Cells

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Thin film solar cells are large-area photodiodes consisting of at least a metal layer (back contact), an oxide layer (transparent front electrode) and a semiconducting layer, which is the active film, that absorbs the sun light converting it into electron-hole pairs. Though simple in principle, the challenges of the film preparation are to deposit the above mentioned films compact, homogeneously and defect free on m2/module and on km2/year in a production fab.

Magnetron sputtering is a well-established large-area, plasma-assisted deposition technology since more than 30 years, mostly used in fields like architectural and low emissivity glass coatings, mirrors and absorbers for solar concentrators, magnetic films for hard disks or hard coatings for tools, i.e., mainly for metals, oxides and nitrides.

In the rising thin film photovoltaics industry, magnetron sputtering is only used for the deposition of metallic back contacts (Ag, Mo) and transparent, conductive window layers (ITO, ZnO) or for metallic precursor films. However, it is not yet applied on a technical scale for the absorber layers in thin film solar cells, i.e., for the active semiconductors.

In this review, obstacles are outlined, which delayed the use of magnetron sputtering for active semiconducting layers. The energies of species (sputtered atoms, positive and negative ions, energetic neutrals) are discussed and its influence on the film growth, especially of reflected neutral argon atoms (Ar0) and negative ions (O-, S-, Se-). Due to the low defect formation energies of semiconductors, tailoring the discharge conditions (low particle energies) is mandatory for the preparation of semiconducting films of high electronic quality.

The possibilities of reactive magnetron sputtering (RMS) are demonstrated for the deposition of active sulfidic absorber films (CuInS2) for efficient thin film solar cells.

The deposition process optimization for the passive films is explained with respect to intrinsic stress, film morphology and adherence.

Keywords
thin film solar cells
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plasma assistance