KNE101

Energetic Tailoring of Magnetron Sputtering Deposition Processes for Defect-sensitive Materials: Transparent Conductive Oxides and other Semiconductors

Klaus Ellmer, Stefan Seeger

Optotransmitter-Umweltschutz-Technologie, Berlin, Germany

ellmer@out-ev.de

Since more than 40 years, magnetron sputteringis a widely used large-area, plasma-assisted deposition method for many industrial applications, especially 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 thin film photovoltaics industry, magnetron sputtering is the established technology 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 active semiconductors.
In this review, obstacles are outlined, which postpone the use of reactive magnetron sputter deposition 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 (Ar^0) and negative ions (O^-, S^-, Se^-). Due to the low defect formation energies of semiconductors, tailoring of the discharge conditions (sufficiently low particle energies) is mandatory for the preparation of defect-poor semiconducting films of high electronic quality by reactive magnetron sputtering (RMS).
We present some highlighting results for the deposition of active chalcopyrite absorber films for efficient thin film solar cells ($Cu(In,Ga)Se_2$), as well as for transparent conducting oxides (ZnO) and discuss the challenges of epitaxial film growth for active nitride semiconductors (GaN etc.).

Keywords
reactive magnetron sputtering
defect generation
active semiconductors
energetic particles