PO4042

Pretreatment of glass substrates by low energy ion beam for as-sputtered textured zinc oxide thin films

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The morphology of the zinc oxide films which are widely used as TCO layers in silicon thin films solar cells is important since it influences to a large extent the light trapping in the thin absorber layer. One way to prepare textured zinc oxide films is magnetron sputtering and post deposition wet chemical etching in HCl solution. Other methods utilize special deposition conditions to achieve as grown texture in ZnO films. In this work, we report on a new method that facilitates direct growth of nano-textured ZnO:Al films by sputtering. The rough growth is initiated by a pretreatment of the glass substrate by low energy (500 eV) Ar and O_2 mixed ion beam. Afterwards zinc oxide films (650 nm) are deposited by magnetron sputtering. The lateral sizes are around 500 nm and rms roughness is around 35 nm. The resistivity is below 5×10^{-4} Ω·cm while the transparency in the near-infrared spectral range is high (> 82% at 1000 nm). The microcrystalline silicon thin-film solar cells based on this type of ZnO:Al films demonstrate the suitability of these film as front contact.
The growth of the zinc oxide films on the ion beam treated glass substrates were investigated by AFM, XRD and TEM. Both the vertical and the lateral size of the surface features increase with increasing film thickness. The as-grown textured zinc oxide films show strong c-axis orientation like the zinc oxide films sputtered on untreated glass substrate. However, when the film is thicker than 600 nm, additional growth orientations with very low intensity show up. Furthermore, the as-grown textured zinc oxide films exhibit strong conical growth, instead of the mainly columnar growth for the zinc oxide films sputtered on untreated glass substrates. The conical growth of the zinc oxide film is related to the alteration of the glass surface by ion beam treatment. XPS and SEM of the glass surface were carried out before and after ion beam treatment. Additional iron, zinc and argon atoms were found on the treated glass surface. These contaminations which originate either from the ion source or the process chamber can obviously influences the nucleation of the sputtered zinc oxide film.

Keywords
ZnO films, ion beam treatment