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Clarification of the relationship between electrical properties and the columnar structure of sputtered Al-doped zinc oxide films

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Fabrication of inorganic transparent conductive oxides (TCOs) on polymer substrates has been of increasing interest due to their potential applications in the field of flexible electronics. Nevertheless, the brittleness of inorganic thin films often results in a failure of the flexible electronic devices caused by strains formed during stretching, folding or bending. The higher the film thickness, the lower is the strain required to initiate cracks in the film. Thus, achieving the appropriate characteristics at the lowest possible film thickness is very important.

Aluminum doped zinc oxide (AZO) has attained prominence as being a very good transparent conducting oxide for optoelectronics and photovoltaic applications. It is considered a cheap and non-toxic alternative to preferably used Indium tin oxide films. Nevertheless, the reduction in the AZO film thickness leads to a significant increase in its resistivity. The present work deals with the investigation of the thickness dependence of electrical properties of AZO films prepared at substrate temperature 100℃.

The AZO films were prepared by magnetron sputtering using deposition system BOC Edwards TF 600. The structure was characterized by electron microscopy. The film resistivity, Hall mobility and carrier concentration were measured on square samples (8 × 8 mm2) at room temperature by the Van der Pauw method. We have proposed an extended one-dimensional mathematical model based on the trapping states related to the grain boundaries. The experimentally determined parameters together with the model allow to identify electrical properties at individual thickness layers and correlate them with the film structure observed at a given distance from the substrate. The presented approach describes very well the inferior electrical conductivity of very thin films, as well as the conductivity saturation for larger film thickness.

Author: NOVÁK, Petr (University of West Bohemia)

Co-authors: OČENÁŠEK, Jan (New Technologies –Research Centre, University of West Bohemia); MEDLÍN, Rostislav (New Technologies –Research Centre, University of West Bohemia); KOZÁK, Tomáš (Department of Physics and NTIS - European Centre of Excellence, University of West Bohemia)

Presenter: NOVÁK, Petr (University of West Bohemia)

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