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Study and improvement of aluminium doped ZnO thin films: Limits and advantages

Albert C. Aragonès A. Palacios-Padrós F. Caballero-Briones, Fausto Sanz

ZnO: Al films were deposited at 70◦C at a fixed −1.1 V potentialonto ITO substrates from a 0.01 MZn(NO3)2+ x Al(NO3)3·9H2O electrochemical bath, with Al3+concentrations between 0 and 2 mM. Elec-trodeposition conditions were optimized to remove bubbles, increase grain size homogeneity and ensure adherence. Films were characterized by field emission scanning electron microscopy, X-ray diffraction, X-ray photoelectron spectroscopy, UV–vis transmittance, electrochemical impedance spectroscopy and photocurrent spectroscopy. Films were crystalline with the wurtzite structure and present a morphology made of hexagonal nano-pillars. It was found that Al incorporation increases gradually up to ∼11 at% forsamples prepared within the concentration range 0.0–0.3 mM Al3+in the bath. For higher Al3+contents(>0.4 mM) an amorphous Al2O3-like compound develops on top of the films. In the grown films with Alcontents up to 11 at%, changes in the optical band gap from 2.88 eV to 3.45 eV and in the carrier densi-ties from 1019to 1020cm−3were observed. The blue shift in the band gap energy was attributed to the Burstein-Moss effect. Changes in the photocurrent response and the electronic disorder were also dis-cussed in the light of Al doping. Optical transmittances up to 60% at 550 nm were obtained, thus making these films suitable as transparent and conductive oxide films.