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| **Title:** | Conductive and optically transparent sol–gel spin coated Al3+ and Sn4+ doped ZnO nano-crystalline thin-films | | | |
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| **Abstract:** |  |
| This study investigates the structural, morphological, optical, and electrical  characteristics of Al3+ and Sn4+ doped ZnO nano-crystalline thin flms fabricated  using a sol–gel spin coating technique. The thin-flms, with a uniform thickness of  200 nm (2% fabrication tolerance), were analyzed using scanning electron microscopy (SEM) and x-ray difractometry (XRD) to evaluate surface proflometry, uniformity, and material compositions. The structural analysis revealed gradual improved crystalline properties up to 6 at.% Al doping and 4 at.% Sn doping, beyond which crystallinity deteriorated. Optical parameters, including optical conductivity, bandgaps, absorption index, and dielectric indices, were determined using an ultraviolet–visible (UV–Vis) spectrophotometer. The absorption indices (higher range in 0.0043–0.0046 mm for 2 at.% AZO) exhibited a non-linear relationship with bandgap energies in both types of flms. The flms demonstrated high mean transmitance (96%) and small grain size (~ 20 nm), indicating their suitability for various optoelectronic applications. The flms also exhibited low carrier concentration rates, with specifc concentrations showing optimal mobility and resistivity values. The highest and lowest FoM values were identifed as 850 (10–6 Ω−1) for 6 at.% Sn and 1.06 (10–6 Ω−1) respectively. The study provides a rare comparison between AZO and SZO thin flms, providing valuable insights into the enhanced properties of Al3+ and Sn4+ doped ZnO thin flms, emphasizing their potential for diverse technological applications (e.g. optoelectronic devices and organic solar cells) used as conductive oxides and optically transparent electrode | |