ABSTRACT

Designing a transparent conductor for specific applications may require fundamental understanding of the microstructure and the thus correlated optoelectronic properties with respect to a number of experimental parameters. To this end, the present study introduced varying concentration of boron into the undoped and the Al-doped ZnO films by using co-deposition route in RF magnetron sputtering on soda lime glass substrates. A wide range of experimental techniques are then used to characterize these films. The films are found to demonstrate a high optical transmittance of > 83%, and showed blue shift as a result of boron doping with E_g being as high as 3.98 eV. For the B^{3+}-doped ZnO films, an increase in carrier concentration with increasing boron content is related to the cumulative effects of increased boron substitution in the zinc lattice positions and an increase in the intrinsic shallow donor level defects, caused by zinc interstitials and oxygen vacancies. An inverse effect is seen for the (B^{3+}, Al^{3+})-doped ZnO films with increasing boron introduction, caused by reduced Al substitution in zinc lattice positions because of higher B-O bond strength as well as reduced doping efficiencies of B^{3+} and/or Al^{3+} ions due to decreasing crystallinity in these films. Finally, very high boron content in both these films is found to develop B_2O_3 and/or B_7O phases, thereby not contributing entirely to the carrier generation and also reducing the carrier mobility of these films. Understanding developed through this study may be used to design a transparent conductor by tuning its microstructure and optoelectronic properties through controlling the dopant type and its concentration in ZnO.