Optimization Of The Electrical Properties Of Magnetron Sputtered Aluminium Doped Zinc Oxide Films For Opto-Electronic Applications

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Transparent conducting oxides (TCOs) based on SnO_2, In_2O_3, ZnO possess a wide range of applications in a variety of opto-electronic devices [1,2,3,4,5]. Recently magnetron sputtered ZnO:Al films have acquired high potential as front electrode in CIS [3] and silicon thin film solar cells [2,6,7]. Here we report on efforts to obtain highly conductive and transparent ZnO:Al films using different deposition conditions for RF, DC and MF (mid frequency) sputtering.

Since the electrical and optical properties are controlled through the material parameters like carrier mobility and concentration [4,5,8], we concentrated our efforts to optimize the deposition conditions for them. Investigations were made to see the effect of target doping concentration (TDC), film thickness, sputter pressure and deposition temperature. RF sputtering from ceramic targets yields low resistivities between 3-5 x 10^{-4} Ωcm by lowering the target doping concentrations from 2 % to 0.5 % *(Fig. 1)*.

With decreasing TDC to 0.5 % carrier mobilities up to 44 cm^2/Vs were obtained, accompanied by the extension of the region of high transmission to the near infrared, due to a reduction in free carrier absorption and corresponding shift in plasma wavelength *(Fig. 2)*.

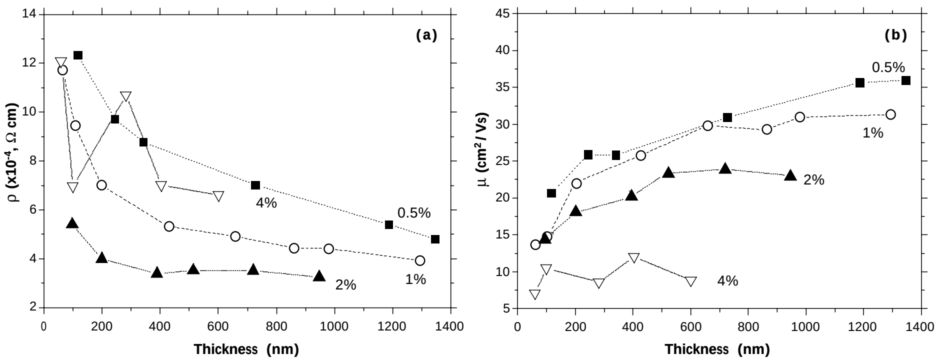

Figure 1

Resistivity ρ *(a) and mobility* μ *(b) of differently doped ZnO:Al films as a function of film thickness.*

DC and MF sputtering from metallic targets yielded similar low resistivities. An analysis of mobility (μ) data of all films as function of the corresponding carrier densities (N) showed that the μ-N values obtained in this study are in vicinity to the limits suggested in the literature [9,10] *(Fig. 3)*.

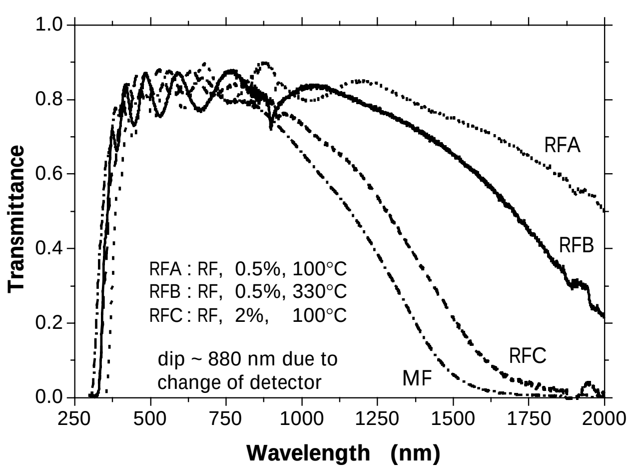

Figure 2

Spectral transmittance of RF and MF films with low electrical resistivity.

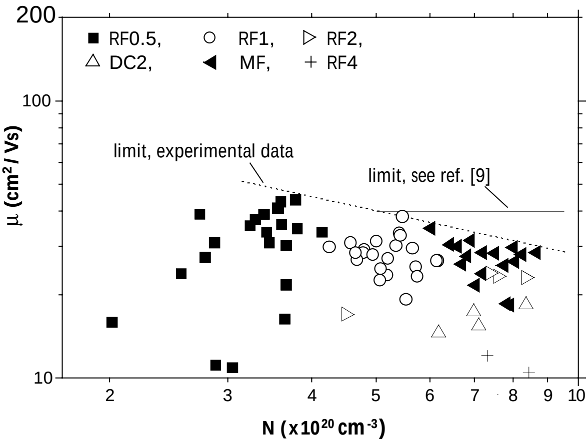

Figure 3

Carrier mobility μ versus carrier concentration N (μ-N) dependence for films deposited using different sputter techniques and conditions. The numerical against the sputter technique indicates the target doping concentration.

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