Promising TCO based on Silicon doped Zinc Oxide

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ABSTRACT

Transparent Conductive Oxides (TCO) are components of numerous devices, as flat panel displays or photovoltaic cells. In particular in electrochromic devices the TCO layer is a key for faster switching time. The most common TCO used are ITO (Indium Tin Oxide) and FTO (Fluorine Tin Oxide). However, the cost and scarcity of indium and the high temperature deposition required for FTO impede the development of low cost devices on flexible substrate (i.e. PET, PMMA...). In that respect, Zinc oxide has received an increase of interest as an alternative for new TCO. Herein, we investigate the substitution of Zn^{2+} by trivalent and tetravalent elements aiming at further increasing the performances of n-type semiconductor doped ZnO thin films.

Doped ZnO thin films were grown by the Pulsed Laser Deposition technique. In terms of optical transmittance and electrical conductivity, among various dopants (Al, Ga, Si...), Silicon doped Zinc oxide thin films, SZO, exhibit the highest performances with an optical transmittance higher than 80% in the visible domain (400-800nm), and a relatively low resistivity ($\rho \approx 10^{-3}\Omega$.cm) for thin films deposited at low substrate temperature $T \leq 150°C$. Such behavior was correlated to an increase of carrier concentration (estimated by optical modelling) for ZnO:Si thin films in comparison with ZnO:Al or ZnO:Ga thin films (For instance, $N_{ZnO:Si} = 15x10^{20}cm^{-3} > N_{ZnO:Al} = 11x10^{20}cm^{-3}$). Herein, combining various complementary characterizations (XRD, RBS, XPS, MEB...) the relationship between the structure, composition, morphology, optical and electrical properties of doped ZnO thin films will be further discussed, using both experimental and simulation approaches.

Keywords: Transparent Conducting Oxide – Zinc Oxide – Pulsed Laser Deposition – Simulation – Optical measurement – Electrical measurement