Effect of Substrate Temperature on Electrical and Structural Properties Al-doped Zinc Oxide Films Deposited by Magnetron Sputtering

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Transparent conductive oxides (TCO) with a wide band gap, high transparency and low resistance are popular material for photovoltaic heterostructure solar energy cells, transparent conducting electrodes, window materials, displays.

Today, the most widely used TCO are indium tin oxide $(In_2O_3)_{0,9}$-$(SnO_2)_{0,1}$ (ITO), which has suitable characteristics. However, ITO has some negative factors such as the limited deposits of indium in the Earth's crust, causes constant increase in the cost indium, and also high toxicity and environmental hazard ITO industrial-scale production. These factors are the reason to replacement this material on more safe, economically profitable and affordable.

Doped by donor impurities zinc oxide is a promising material for future technologies of electronics and optoelectronics. In economic terms, aluminum is the most favorable donor impurity.

Al-doped zinc oxide (ZnO:Al) satisfies all the above mentioned conditions: non-toxic (on the stage of the production and application), the prevalence of raw materials in the Earth's crust, high stability to hydrogen plasma and temperature changes [1], has a wide band gap (~3,34 eV) that allows the material to be highly transparent (~85-95%) in a wide range of wavelengths (300-1000 nm), and low resistivity ($\sim 2 \cdot 10^{-4}$ Ω·cm) [2].

ZnO:Al thin films were grown on Si and glass substrates by reactive magnetron sputtering. The composite target of zinc with aluminum inserts have been used for films deposition. To improve the crystalline perfection of the ZnO:Al films and to maintain a constant growth rate we used a new approach in ZnO:Al magnetron sputtering, namely, the layer-by-layer growth method [3]. It is shown that our method allows to grow high quality ZnO:Al films on different crystalline and amorphous substrates. In our experiment, we changed the substrate temperature within the limits 100 - 400°C. The characterization of ZnO:Al films was carried out by XRD, Fourier transform infrared spectroscopy, EDX analysis, Transmittance measurements, SIMS and AFM.

Temperature dependences of electrical resistivity and Hall coefficient were investigated. It was established that the substrate temperature at films deposition influence essentially on the electron concentration and mobility.

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