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Study of the properties of magnetron sputtered indium-tin oxide thin films

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Abstract – Indium-tin oxide thin films were deposited in low temperature over silicon and glass substrates by RF magnetron sputtering, with various deposition times. The optical, electrical, chemical and structural properties of the samples were studied, considering their thickness dependance. The samples deposited over silicon substrates showed better electrical properties, with resistivities in the order of 10^{-4} Ω.cm, while the ones deposited over glass showed resistivities in the order of 10^{-3} Ω.cm. The transmittance spectra of the samples showed that optical properties are improved for thinner films.

Transparent conductive oxide thin films play an important role as transparent electrodes in several types of devices. [1] ITO is currently the most used transparent conducting oxide (TCO), due to its satisfactory performance related to transparency, conductivity and transmittance. [2] Among the available methods for fabricating ITO films, magnetron sputtering is one of the more versatile techniques for the ITO film preparation.

In this work, RF magnetron sputtering was used for the deposition of the ITO thin layers over silicon and optical glass substrates, using a 6" high-purity ITO target (90% In_2O_3 – 10% SnO_2). The process is initiated in a glow discharge, produced in the vacuum chamber, under 5mTorr of process pressure (controlled by argon flow of 24 sccm) and 75W of RF power. The duration of the process varied over the range 30 - 120 minutes. The thicknesses of the samples were obtained by a high step meter, and the deposition rate of the process was found to be around 5.3nm/min.

Sheet resistance and resistivity values for silicon samples were found to be lower than the results obtained for glass samples (Fig. 1). The difference is due to the high roughness and low purity of optical glass substrates. Although the resistivity tends to remain constant with the increase of thickness, it shows a slight linear decrease behavior, attributed to the improvement of the cristallinity of the films.

The trasmittance spectra of the ITO/glass samples were obtained by a UV-Vis-NIR spectrometer (Fig. 2). The samples showed absorption in the UV region, transmission in the visible range and started reflecting in the NIR region. This reflection tends to improve as film thickness become higher. The average transmittance of the transparent samples was calculated considering the visible range of the transmittance spectra, showing that higher thicknesses make the films less transparent.

Best results of electrical measurements were found for higher thicknesses probably due to the improvement of the cristallinity of the films. Best results of optical measurements were found for lower thicknesses because of the higher visible transmission.

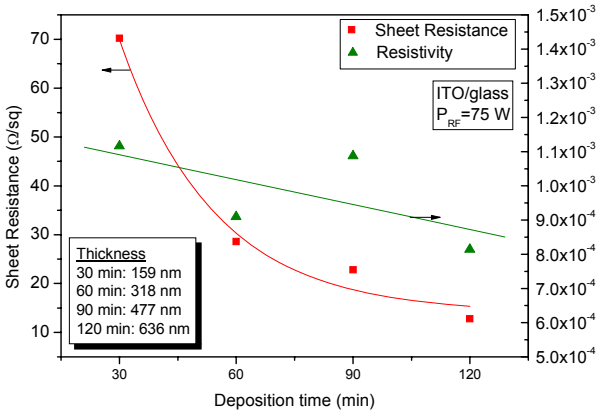

Figure 1: Sheet resistance and resistivity of the samples obtained over glass substrates.

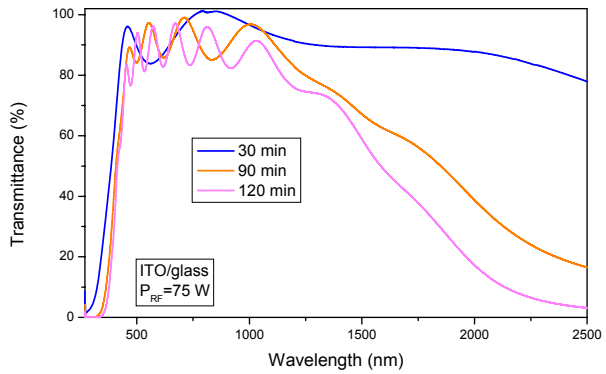

Figure 2: Transmittance spectra of the tranparent samples, not considering the substrate optical absorption.

[1] H. Hosono, H. Ohta, M. Orita, K. Ueda and M. Hirano, Vacuum 66 (2002) 419–425.
[2] S. Schoemaker and M. Willert-Porada,Thin Solid Films 517 (2009) 3053–3056.