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Spectral Response of Indium Oxynitride Thin Films

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In this work we study the electrical properties as spectral response, resistivity and quantum efficiency of nanostructured indium oxynitride deposited by reactive RF magnetron sputtering. This material shows multi-functionality in electrical and photonic applications. It shows transparency in visible range, wide band gap, high resistivity, low linkage current and response for light. The deposition processes were performed in a home build magnetron sputtering system, using a four-inch pure In (99.999 %) target, nitrogen and oxygen as process gases. The pressure was kept constant in 1.33 Pa and the RF power (13.56 MHz) was constant 250 W. The spectral response was estimated for samples deposited with 0 %, 10 %, 20 %, 50 %, 80 % and 85 % of oxygen concentration in the gas mixture.

Keywords: Thin films, Indium oxynitride.

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1. INTRODUCTION

In the past decade, InN has attracted much attention in the nitride semiconductors scientific community. This material is promising for a wide range of applications including terahertz, as well as solar cells [1].

The indium oxynitride is a new class of materials with optical, mechanical and electrical properties potentially interesting for industrial applications. Numerous properties of the InNO, such as the refractive index and the photoelectric effect intensity, vary according to the proportion of oxygen and nitrogen contained in the formed film.

It is visible that there is influence of oxygen incorporation in the film: the pure InN has a dark brown coloration, it is not transparent, with low resistivity (this material is almost a conductor), high carrier density around 10^{21} cm^{-3} and with photoelectric effect lower than the seen for indium oxynitride. The InNO is transparent, it has a wider band gap (around 3.4 eV) and nearest indium oxide, which makes it an excellent candidate to be employed in sensors [2].

This work main objective is to study the influence of deposition process on the optical and electrical properties of RF reactive-sputtered InNO films using nitrogen and oxygen.

2. EXPERIMENTAL

Initially, a cleaning process ($4H_2SO_4 + 1H_2O_2$) followed by HF dipping (2 %), was performed. The deposition processes were performed in a home build magnetron sputtering system, using a four-inch pure in target (99.999 %), nitrogen (99.995 %) and oxygen (99.998 %) as plasma precursors.

The pressure was kept constant in 1.33 Pa and the RF power (13.56 MHz) was constant 250 W. The sub-strate was silicon (75 mm, *p*-type, 1-10 Ω·cm). Six dif-ferent oxygen gas concentrations were used in deposi-tion processes.

3. RESULTS

The results obtained from the Hall effect measurements show that, in general, the resistivity of the InNO films deposited on Si is very high (using InN as reference). The band gap of InN is nearly 8×10^{-3} Ω·cm and 1×10^{1} Ω·cm.

An analysis of the spectral response was performed for each sample (Fig. 1). There is a higher current intensity in the near infrared region.

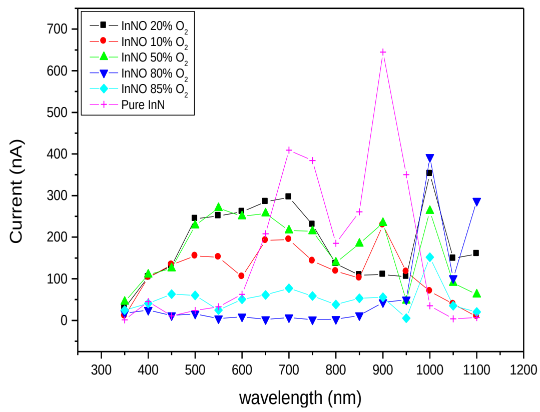

Fig. 1 – Indium oxynitride and indium nitride samples Spectral Response

As a function of spectral response can be calculated quantum efficiency.

The quantum efficiency describes the response of the sensor to different wavelengths of the electromagnetic spectrum.

In the case of measurements of quantum efficiency, the greater response is seen for the wavelength of 1050 nm in the near infrared. The sensors fabricated in this work have a higher sensitivity between 950 and 1050 nm. InNO thin film with 20 % oxygen has higher response.

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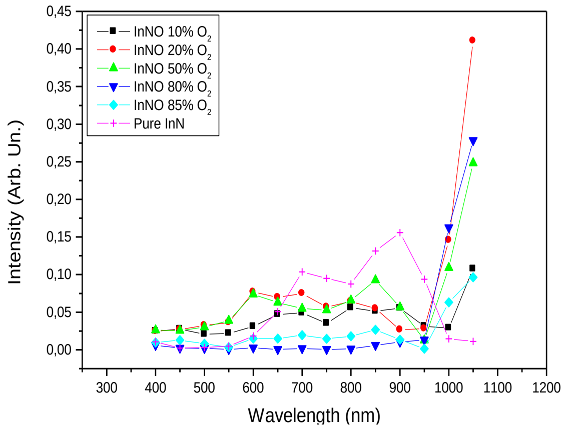

Fig. 2 – Indium oxynitride and indium nitride samples quantum efficiency

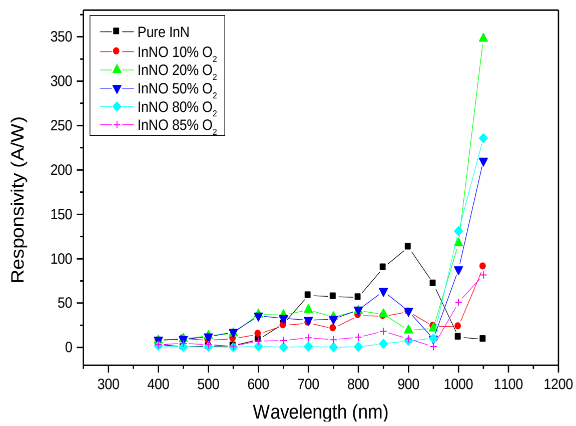

Fig. 3 – Indium oxynitride and indium nitride samples responsivity

These sensors can be used in medicine, climate measures, astronomical measurements, among others.

In the specific case of a photodetector, responsivity measures the electrical output per optical input. In addition, the responsivity of the detector increases with increasing the wavelength, corresponding to the equation $R = (\eta\lambda) / 1.24$, where R is the responsivity of photodetector, η is the quantum efficiency of the black silicon material, λ is the wavelength of received irradiation.

4. CONCLUSIONS

By studying these electrical properties is possible to reach conclusions about the application of these materials in sensors in the infrared region as well as solar cells.

These materials could also be used in the medical field for construction of equipment.

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