Journal of Physics: Conference Series

PAPER • OPEN ACCESS

p-ZnO Thin Films Deposited by RF-Magnetron Sputtering

To cite this article: L S Zambom and R D Mansano 2015 *J. Phys.: Conf. Ser.* **591** 012040

Journal of Physics: Conference Series **591** (2015) 012040 doi:10.1088/1742-6596/591/1/012040

p-ZnO Thin Films Deposited by RF-Magnetron Sputtering

L S Zambom[1] and R D Mansano[2]

1DSE -Faculdade de Tecnologia de São Paulo – CEETEPS, Brasil
2DEE-PSI-LSI-Escola Politécnica da Universidade de São Paulo, Brasil

Email: zambom@fatecsp.br, mansano@lsi.usp.br

Abstract. In this work, we study ZnO thin films deposited onto silicon substrate by RF-magnetron sputtering for semiconductor applications. For this, we analyses resistivity, photoconduction, composition and semiconducting characteristics, in these films. The results indicate that the films are nearly stoichiometric, p-type, with relative high resistivity and some samples shown photocurrent when exposed to white light.

1. Introduction

Undoped ZnO thin films are a promising optoelectronic and gas sensing material because of its band gap (3.37 eV) and have n-type conductivity. ZnO can be obtained by various techniques such as spray pyrolysis [1], chemical vapor deposition [2], pulsed laser deposition [3], sputtering [4,5] and sol-gel process [6,7]. Its semiconducting property is function of the native defects oxygen vacancies and zinc interstitials [7]. On the other hand, is difficult to produce stable p-ZnO and this conductivity is obtained with N doping [8].

2. Experimental

Undoped p-ZnO thin films deposited onto p-type silicon substrate (100) from a pure zinc metal target (99.99%) and oxygen (99.999%) atmosphere using a home building RF-magnetron sputtering. Previous of the deposition, the silicon wafers were cleaned using 1:H_2O_2 + 4:H_2SO_4 solution (Piranha clean) followed by dip in 10 % HF solution to remove the silicon oxide formed in the H_2SO_4 solution. The pressure was maintained at 10 mTorr, the target-substrate distance was 10 cm, the substrate temperature was maintained constant at about 90 ^{o}C and the ZnO thin films were deposited at different RF power (13.56 MHz) of 50 W, 100 W, 150 W and 200 W. The oxygen flow was kept at 70 sccm and process time was 30 and 60 minutes. The thicknesses measurements obtained by spectral reflectance at 632.8 nm wavelength light source. The ZnO stoichiometry analysed using Rutherford Back Scattering measurements. Conduction induced by white light were obtained from metal (Al)/dielectric/Si 700 μm x 700 μm capacitors that were built at the front side of the wafers. The bottom contact in the wafers backside is 500 nm thickness aluminium films. We use I-V measurements for the resistivity analysis and hot probe measurement for obtain the semiconducting type.

3. Results and Discussion

The sputtering process of Zinc oxide p-type thin films has a relatively high deposition rate, (Figure 1). Ndong [9], in similar process pressure and temperature conditions, obtained deposition rate values from 5.8 nm/min to 8.8 nm/min to 50 W sputtering power. However, Xiong [10] obtained ZnO n-type with deposition rate changing from 33.3 nm/min to 166.6 nm/min at 30 mTorr and 350 ^{O}C. Our results show that is possible to deposit ZnO thin films with reasonable deposition rate in extremely low temperature using different substrates as polymeric ones.

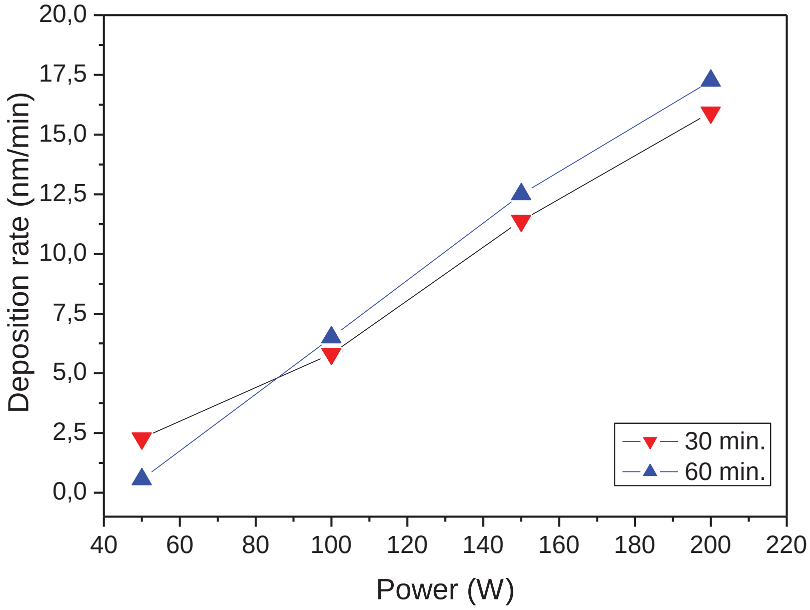

Figure 1 – Zinc oxide deposition rate versus RF power

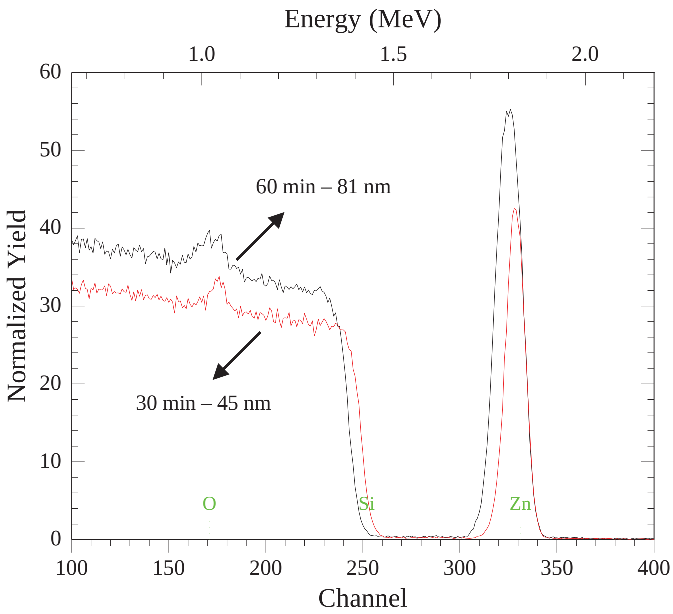

Figure 2 - Zinc oxide RBS spectra for different oxidation times – 100 W

The Zn/O ratio, calculated from RBS spectra, figure 2, changed from 1.03 to 1.12 near to stoichiometric one. Unfortunately, RBS technique was not able to detect any impurities in the samples from the metallic chamber. The intrinsic defects as Frenkel vacancy and Schottky by the zinc excess in the thin films promote the p-type semiconductor characteristics in the ZnO thin films obtained by reactive sputtering, the propriety were observed by hot point probe, all samples shows p type semiconductor characteristics.

Through I-V (current – voltage), and considering breakdown electric field as 1.0 $MVcm^{-1}$, resistivity was calculated, Figure 3. These values are relatively low when compared with thermal silicon oxide (10^{14} to 10^{16} Ω.cm) a common dielectric in silicon technology for transistor devices. Our films shown high resistivity, decreasing which the RF power, the value in the same observed in the literature [11], for undoped ZnO thin films sputtering deposited.

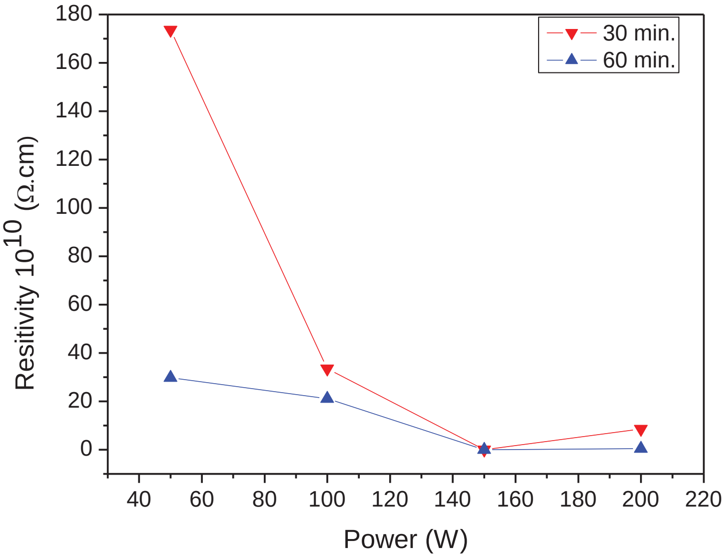

Figure 3– Zinc oxide resistivity versus RF power

Some ZnO films shows sensitivity to white light (Figure 4). When exposed to white light films had increase in their conduction up to 12 times, its suggest the possible application of ZnO thin films as light sensing material in photonics devices. The ZnO samples did not shown any photocurrent characteristic above zero volts.

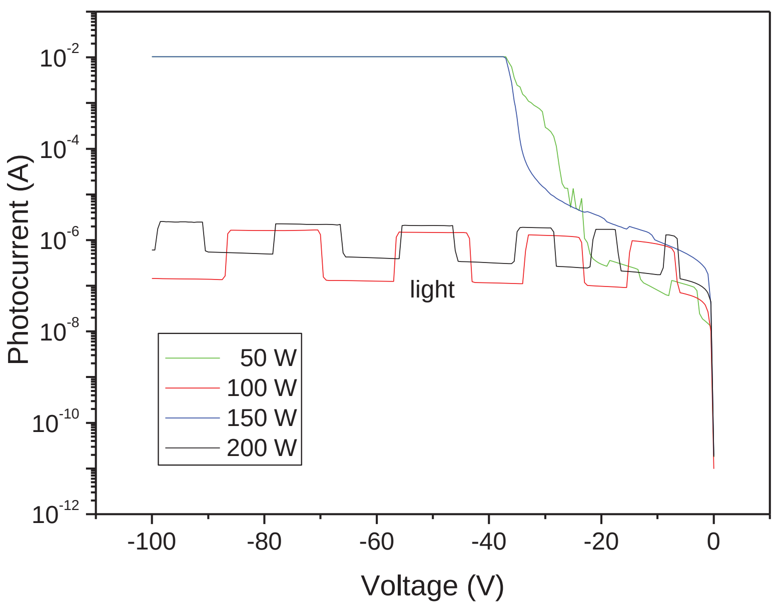

Figure 4 – Zinc oxide photocurrent for different RF power

4. Conclusion

In this work, we deposit nearly stoichiometric p-type ZnO thin films in low temperature by RF-magnetron sputtering for microelectronics and photonics applications. We observe the semiconductor characteristics by the photoelectric effect and p-type characteristics in undoped ZnO thin films. The main influences in semiconductor characteristics of these films were the defects in their structures, native defects and vacancies. The films showed a relative high resistivity and semiconductor characteristics, some samples show photocurrent when exposed to white light , its suggest the possible application of ZnO thin films as light sensing material in photonics devices.

Acknowledgements

The authors acknowledge CNPq for financial support and the Instituto de Fisica da Universidade de São Paulo for the RBS analyses.

References

[1] Godbole B et *al* 2011 *Mater Sci* Appl **2** 643
[2] Nicolay S et *al* 2012 *Sol Energ Mat Sol C* **105** 46
[3] Wenckstern H *et al* 2004 *Appl Phys Lett* **84** 79
[4] Lee J L *et al* 2002 *Thin Solid Films* **420** 112
[5] Jiang M, Tang K andYan X 2012 *J Photonics Energy* **2** 028502-1
[6] Ilican S, Caglar Y and Caglar M 2008 *J Optoelectron Adv M* **10** 2578
[7] Kashif M *et al* 2012 *Microelectron Int* **29** 131
[8] Chavillon B *et al* 2012 *J Am Chem Soc* **134** 464
[9] Ndong R O *et al* 2003 *Microelectron J* **34** 1087
[10] Xiong G L *et al* 2002 *Appl Phys Lett* **80** 1195
[11] Jeong W J , *et al* 2003 *Thin Solid Films* **426** 94