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Effect of Thermal Annealing on the Optical Band Gap of NiO Thin Film

P MALLICK

Department of Physics, North Orissa University, Baripada 757003, India

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Abstract. NiO thin films grown on Si(100) substrate by low cost sol-gel spin coating method were subjected to thermal annealing at different temperature. All the annealed films were characterized by UV-Visible spectrophotometer in order to effect of thermal annealing on the optical band gap of NiO. NiO film annealed at 400 ^{0}C showed the optical band gap of 3.52eV and the films annealed at and above 600 ^{0}C showed the optical band gap of 3.62 eV. The increased optical band for the films annealed at higher temperature may be due to better crystallization of NiO films.

Keywords: Thin film; sol-gel; optical band gap; NiO

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1. Introduction

Nickel oxide (NiO) has attracted much research attention due to its numerous technological applications, such as p-type transparent conductor [1], solar cell [2], gas sensor [3], electrochromic display device [4], resistive random access memory [5] etc. For better performance, almost all of these applications demand NiO in thin film form with well controlled microstructure. The evolution of film microstructure is closely related to its preparation techniques [6]. It is therefore essential to prepare good quality NiO thin films by using low cost method. Sol-gel technique is one of the cost effective and it ensures a potentially higher purity, homogeneity, low processing temperature and makes possible deposition on a large area [7].

It is worth mentioning here that in some cases the post deposition modifications of the films require for better phase formation and stability [6]. In this paper, we have synthesized NiO thin films by low cost sol-gel route. Our aim

is to study the effect of thermal annealing on the optical band gap of NiO thin film.

2. Experimental

The aqueous solution of $Ni(NO_3)_2$ $6H_2O$ (0.1M) was prepared using magnetic stirrer. During stirring process, polyvinyl alcohol (PVA) was added to the solution such that the ratio of $Ni(NO_3)_2$ $6H_2O$ to PVA will be 1:2. The resultant gel formed in this process is used for the synthesis of NiO thin films on Si(100) substrate by using spin coating method [6].

The asdeposited films were annealed at 400, 600, 800, 900 and 1000 ^{0}C for 1 hour in a programmable tubular furnace. The optical absorption characterization of the films was done using Shimadzu UV–VIS 2450 spectrophotometer.

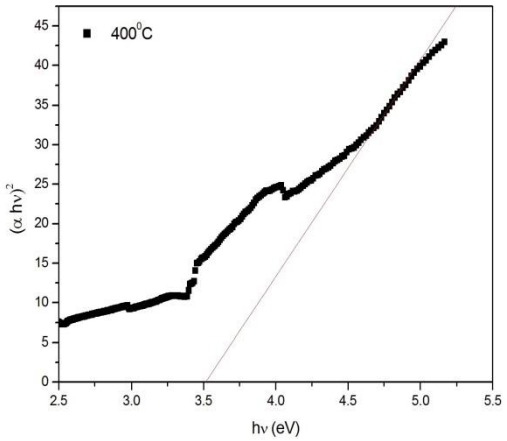

Fig. 1: Variation of $(\alpha h\nu)^2$ vs. photon energy, $h\nu$ for NiO thin film annealed at 400 ^{0}C.

3. Results and Discussion

The absorption coefficient (α) and optical band gap (E_g) are related by the following expression [8]:

$$\alpha = \frac{B(h\nu - E_g)^n}{h\nu} \qquad (1)$$

where $h\nu$ is the incident photon energy and B is a materials dependent constant. The value of n is ½ for direct inter-band transitions and/or 2 for indirect inter-

band transitions [9]. The usual method to estimate the optical band gap is to extrapolate the linear portion of the $(\alpha h\nu)^2$ vs. $h\nu$ plot to α = 0. The value of E_g for the film annealed at 400 ^{0}C is 3.52 eV (Fig. 1) which closely matches with the reported value of optical band gap of NiO nanoparticles (3.51 eV) [10]. The optical band gap increased to 3.62 eV when the annealing temperature increased from 400 to 600 ^{0}C (Fig. 2). Further annealing does not influence the band gap i.e. the band gap remains constant (~ 3.62 eV) in the all annealed temperature except 400 ^{0}C. Since the reported values of band gap for NiO in most cases vary from 3.6 to 4.0 eV [11], the increased optical band for the film annealed at higher temperature may be due to better crystallization of NiO films.

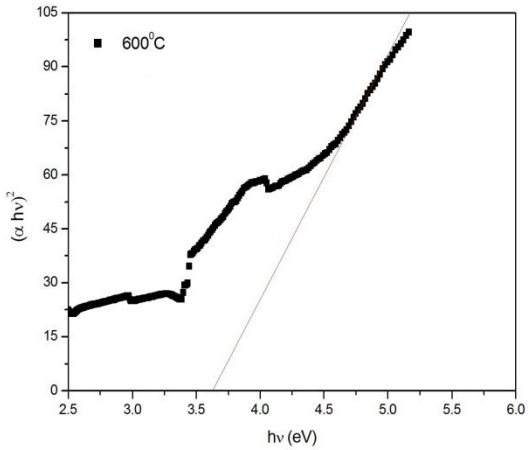

Fig. 2. Variation of $(\alpha h\nu)^2$ vs. photon energy, $h\nu$ for NiO thin film annealed at 600 ^{0}C.

4. Conclusion

We report the evolution of optical band gap of NiO thin films with annealing temperature. NiO film annealed at 400 ^{0}C showed the optical band gap of 3.52eV which increased to 3.62 eV with increasing annealing temperature ≥ 600 ^{0}C. The increased optical band for the film annealed at higher temperature may be due to better crystallization of NiO films.

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References

[1] I M Chan, T Y Hsu and F C Hong, *Appl. Phys. Lett.* **81**, 1899 (2002)

[2] J Bandara and H Weerasinghe, *Sol. Energy Mater. Sol. Cells* **85**, 385 (2005)

[3] I Hotovy, J Huran, P Siciliano, S Capone, L Spiessand and V Rehacek, *Sens. Actuators B* **78**, 126 (2001)

[4] C G Granqvist, E Avendano and A Azens, *Thin Solid Films* **442**, 201 (2003)

[5] J F Gibbons and W E Beadle, *Solid State Electron.* **7**, 785 (1964)

[6] P Mallick, B N Dash, V Solanki, S Varma and N C Mishra, *Adv. Sci. Eng. Med.* **6(10)**, 1118 (2014)

[7] L L Hench and J K West, *Chem. Rev.* **90**, 33 (1990)

[8] N F Mott and E A Davies, *Electronic Processes in Non-Crystalline Materials* (Clarendon Press, Oxford, 1979)

[9] A N Banerjee and K K Chattopadhyay. In D Depla and S Maheiu S (Eds.), Reactive sputter deposition (Springer-Verlag Berlin Heidelberg, 2008, p.465)

[10] X Li, X Zhang, Z Li and Y Qian, *Solid State Commun.* **137**, 581 (2006)

[11] M Zöllner, S Kipp and K D Becker, *Cryst. Res. Technol.* **35**, 299 (2000)