The 2016 World Congress on
Advances in Civil, Environmental, and Materials Research (ACEM16)
Jeju Island, Korea, August 28-September 1, 2016

Synthesis and characterization of Ni_2O_3 Thin Films

*Zohra N. Kayani[1)], Saira Riaz[2)], Shahzad Naseem[2)] and Rehana Zia[1)]

[1)]*Lahore College for Women University, Lahore, Pakistan*
[2)]*Centre of Excellence in Solid state Physics, University of the Punjab, Lahore, Pakistan.*
**Telephone: 0092-42-99203801-9 (248) Fax: 0092-42-99203877*
**E-mail:zohrakayani@yahoo.com*

Abstract

Nickel oxide thin films have been prepared by sol-gel dip-coating technique on glass substrate. These films have been characterized by using Fourier Transform Infra-Red Spectroscopy (FTIR), X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM) and UV-visible spectro-photometry. It is shown that Ni_2O_3 thin films have single crystalline nature. Ni_2O_3 thin films high transmission in the wave length range of 300–900 nm and decrease of band gap with increase in withdrawal speed. The SEM micrograph shows cubic crystallites.

1. INTRODUCTION

Nickel oxide (NiO) is a useful material preferably required for catalysis, battery cathodes (Yoshio 1998), gas sensors, electro-chromic films (Alcantara 1998; Wu 2007). The nickel oxide thin films were deposited using numerous methods i.e. thermal evaporation (Patel 2011), organic solvent method (Velevska 2011) chemical vapor deposition , electro-chemical deposition, sol–gel (Nalage 2012), sputtering (Miller 1997), chemical solution deposition (Vidales-Hurtado 2008). Among all these deposition routes sol-gel dip coating is an advantageous technique owing to be inexpensive, low-temperature synthesis and liberty to deposit materials on various substrate.
In this project, Ni_2O_3 thin films were deposited by sol–gel dip coating route and their structural, optical and surface properties were studied.

2. EXPERIMENTAL DETAILS

Ni_2O_3 thin films are synthesized by a sol–gel dip coating route using nickel chloride $NiCl_2.6H_2O$, de-ionized water and NH_4OH. After one day of aging Ni_2O_3 sol was deposited on to a glass substrate at withdrawal speed of 70 and 80 mm/sec and dried on a hot plate at 60 °C for 20min.

The structural properties were studied by Bruker XRD model D8 Discover (Germany) in the 2θ range of 20-60 degree. Surface was investigated by SEM (S-3400N, Hitachi) and transmission curves of films were measured by UV-Vis spectrophotometer (UV-Vis, HITACHI U-2800). Transmission-wavenumber relation was studied by FTIR Model M 2000 Midac USA.

3. RESULTS AND DISCUSSION

3.1. FTIR

FTIR spectra of Figure 1 indicate the formation of Ni_2O_3 by the sol–gel method and thermal annealing treatment. The absorption bands raised due to the nickel oxide were observed between 400 and 850 cm^1 (Teoh 2012). Peak at 454 cm^{-1} represents Ni_2O_3 bonds.

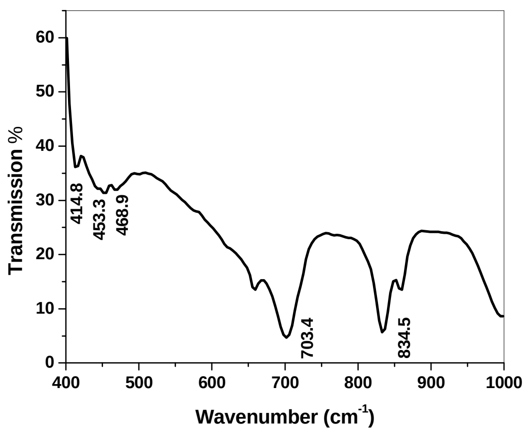

Fig. 1 FTIR of Ni_2O_3

3.2. STRUCTURAL PRPPERTIES

The X-Ray Diffraction curves of the thin films showed diffraction peak (Fig. 2). Thin films are found to be single crystalline with a peak at (002) plane. Same diffraction peak is found for films at withdrawal speed of 70 and 80 mm/s.

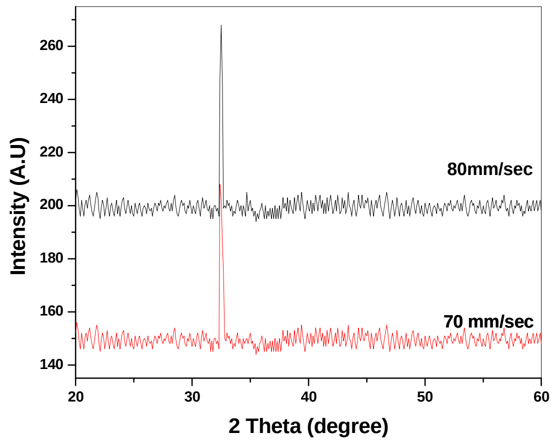

Fig. 2 XRD pattern of Nickel oxide thin films

The diffraction peak was utilized to evaluate the crystallite size using the Scherrer equation

$$D=0.9\lambda/ \beta\cos \theta$$

The crystallite size is found to decrease from 9.46 to 8.57 nm with enhancement in withdrawal speed from 70-80 mm/s.

3.3. OPTICAL CHARACTERSTICS

The transmission spectra of Ni_2O_3 thin films deposited on glass substrates at 70 and 80 mm/sec are presented in Figure 3. The increase in the withdrawal speed of the substrate results in decrease in the transmission.

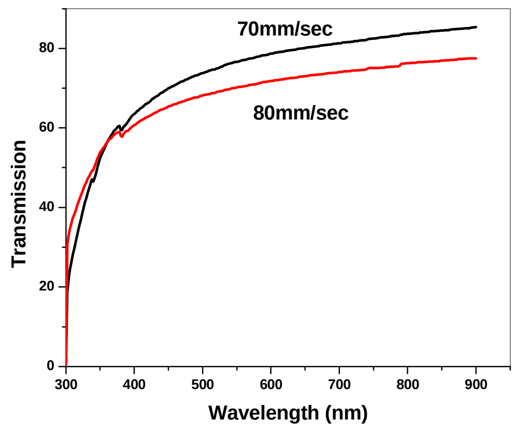

Fig. 3 Transmission Spectra of nickel oxide thin films

Figure 4 shows plot of $(ahv)^2$ versus the photon energy (*hv*) for both, films deposited at 70 and mm/s withdrawal speed. A band gap is obtained from the intersection of the fitted straight line and the abscissa. The band gap values decreased with increase in withdrawal speed from 3.66 eV to 3.46 eV.

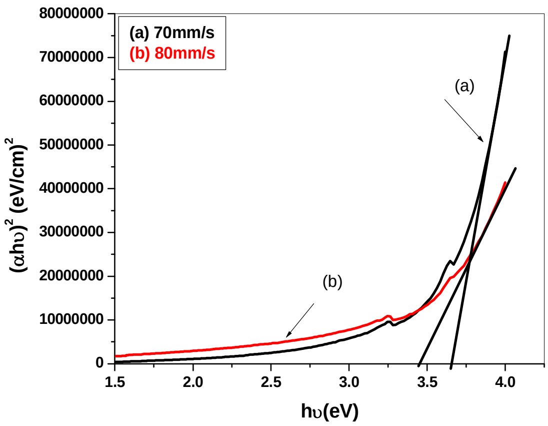

Fig. 4 $(ahv)^2$ versus the photon energe

3.4. Surface study

The SEM micrograph of the films prepared at 70mm/sec indicates uniform distribution of closely packed grains in certain regions as shown in Fig. 5a. With the increase of withdrawal speed to 80mm/sec nucleation of grains took place (Fig. 5b). The nucleation of grains is determined by the driving force for nucleation.

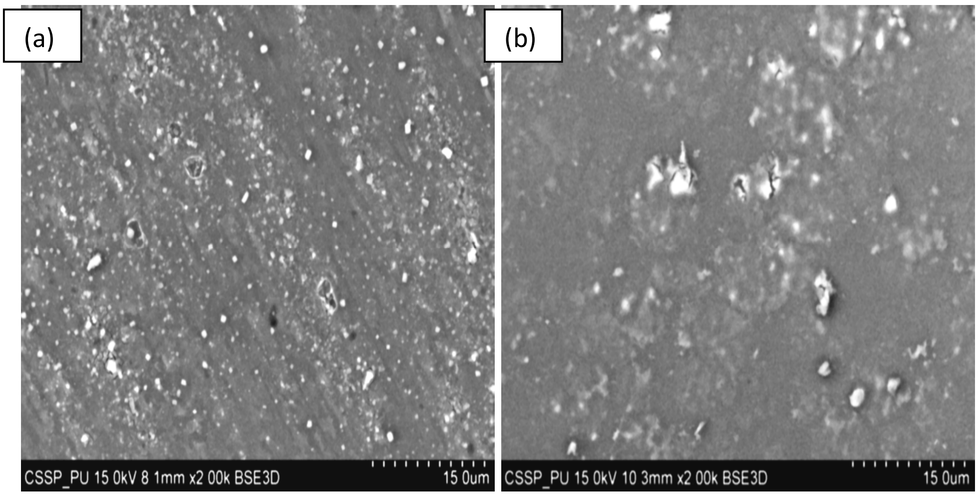

Fig. 5 SEM micrographs of nickle oxide thin films deposited at (a) 70 and (b) 80mm/sec

4. CONCLUSION

Preparation of nickel oxide films using sol-gel dip coating route is reported. Films are found to be single crystalline. The band gap of the films is found to be dependent on the withdrawal speed of substrate. The film prepared at a withdrawal speed of 70mm/sec, in this study show large band gap and high transmission. Surface study shows that with increase in withdrawal speed nucleation of grains took place.

REFERENCES

Alcantara R, Lavela P, Tirado JL, Stoyanova R, Zhecheva E (1998), "Recent advances in the study of layered lithium transition metal oxides and their application as intercalation electrodes," *J. Solid. State. Electrochem*., **3(3):** 121-134.

Miller EL, Rocheleau RE (1997), "Electrochemical behavior of reactively Bull sputtered iron-doped nickel oxide," *J. Electrochem. Soc*., *144(9*): 3072-3077.

Nalage R S, Chougule A M, Sen S , Joshi B P, Patil B V (2012), "Sol–gel synthesis of nickel oxide thin films and their characterization," *Thin Solid Films,* **520** :4835–4840.

Patel J K, Desai S M, Panchal J C, Rehan B (2011), "P-type transparent NiO thin films by e-beam evaporation techniques," *J. Nano- Electron. Phys.*, **3 (1)**: 376-382

Teoh, G. L., and Li, K-D., (2012), "Synthesis and Characterization of NiO Nanoparticles by Sol-Gel Method,"*Mater. Trans*., **53 (12):** 2135 – 2140.

Velevska J, Pecovska-Gjorgjevich M, Najdoski M and Stojanov N., (2011), "Studies on Electrochromism of Chemically Deposited Nickel Oxide Thin Films," *Silpakorn U Science & Tech J*., **5 (1)**: 34-42.

Vidales-Hurtado, A. M., Mendoza-Galván, A., (2008), "Electrochromism in nickel oxide-based thin films obtained by chemical-bath deposition," *Solid State Ionics,* **179**: 2065–2068.

Wu, Y., He, Y., Wu, T., Chen, T., Weng, W., Wan, H., (2007), "Influence of some parameters on the synthesis of nanosized NiO material by modified sol-gel method," *J. Mater. Lett*., **61(14-15):** 3174-3178.

Yoshio, M., Todorov, Y., Yamato, K., Nogochi, H., Itoh, J., Okada, M., Mouri, T., (1998), "Preparation of LiyNi1-xMnxO2 as a Cathode for Lithium-ion Battery," *J. Power. Sources*, **74(1)**: 46-53.