Ho Soonmin,
Centre for Green Chemistry and Applied Chemistry,
INTI International University, Negeri Sembilan, Malaysia
E-mail: soonmin.ho@newinti.edu.my

A SHORT REVIEW ON METAL OXIDE THIN FILMS

Abstract. Preparation and characterization of metal oxide thin films were extensively discussed by many researchers. In this work, nickel oxide, tin oxide, cuprous oxide and cupric oxide films were characterized by using various tools. The obtained band gap values are in the range of 1.75 to 4.4 eV.

Keywords: band gap, copper oxide, nickel oxide, thin films, tin oxide.

Introduction

Over the last decade, thin films were successfully deposited onto substrate by using various deposition techniques [1; 2]. These films have been considered attractive for utilizing in solar cell [3; 4], laser device, sensor device, switching device, Schottky barrier and IR detectors. Generally, deposition technique could be broadly divided into two groups, namely physical and chemical method [5; 6]. Selection of deposition technique is highly dependent on many factors such as easiest setup [7; 8], cheap equipment [9, 10], convenient for large area deposition [11; 12], controllable growth rate [13] and film thickness.

In this work, several metal oxides were prepared by using different techniques and obtained films were characterized by using various tools.

Literature survey

Nickel oxide thin films:

Spray pyrolysis technique has been used to produce nickel oxide (NiO) films [14]. X-ray diffraction (XRD) data indicated that amorphous structure at 280 °C, while cubic structure at 320–400 °C. Broad peak and polycrystalline structure could be observed in as-deposited NiO films and annealed films, prepared using sol gel technique [15]. Furthermore, XRD data showed intensity was increased with annealing temperature (300–600 °C). The band gap value (2.1 to 3.9 eV) was increased with increasing annealing temperature (300–473 K) for the chemical bath deposited NiO films [16]. The D. C. reactive magnetron sputtering method was used to prepare NiO films [17]. Irregular shape grains, uniform grain size distribution, worm like structure, and smooth structure could be seen when the thickness is 150, 250, 350, and 550 nm, respectively.

Tin oxide thin films:

The tin oxide films deposited onto glass substrate using atmospheric pressure chemical vapour deposition method [18] indicated major orientation along (110) plane. The films deposited onto fluorine doped tin oxide glass via electro deposition method [19] at different concentrations of butyl rhodamine B (BRhB) were studied. There are different morphologies could be observed including irregularly connected

nanoparticles (absence of BRhB), loose surface structure (100 μ M BRhB) and porous structure (150 μ M BRhB). The films prepared using pulsed laser deposition indicated pure polycrystalline phase, and almost stoichiometric [20]. Magnetron sputtering technique was used to prepare films [21] and, resistivity increases with reduce of oxygen pressure from 10 to 1%. The crystallite size (29.8 to 6.5 nm) reduced as the substrate temperature was reduced from 800 to 400 °C for the films prepared using spray pyrolysis [22]. Higher band gap value could be observed under higher anneal temperature for the films produced using thermal evaporation [23]. The annealed chemical bath deposited SnO₂ films are highly transparent, highly stoichiometric [24] with a band gap of 4.4 eV.

Cuprous oxide and cupric oxide thin films:

The cupric oxide (CuO) with monoclinic structure was produced using reactive radio frequency magnetron sputtering method [25]. Spray pyrolysis technique was used to synthesis CuO film. Its thickness (660–1250 nm) increased as the deposition time was increased from 30 to 80 minutes [26]. Sol-gel spin coating was used to prepare Cu₂O films [27] in the presence of ethylene glycol. These films showed irregular morphology, band gap of 1.75 eV, film thickness of 59 nm and lower absorption value. XRD data supported the existence of Cu₂O at 250 °C, while formation of CuO at 350, 450 °C for the films prepared using thermal evaporation [28]. The obtained electro deposited Cu₂O films [29] show cubic structure, crystal size about 210 nm and band gap is 1.98 eV. There are three peaks (627, 503 and 540 nm) could be observed in photoluminescence spectra for the chemical bath deposited Cu₂O films [30]. The higher growth rate is achieved when using higher pressure during the preparation of Cu₂O via magnetron sputtering [31].

Conclusion

Metal oxide thin films have been successfully prepared using various deposition techniques. The properties of nickel oxide, tin oxide, cuprous oxide and cupric oxide have been reported. Scanning electron microscopy studies indicate that a strong dependence of the surface texture, film thickness and grain size on the various experimental conditions.

Acknowledgement:

INTI INTERNATIONAL UNIVERSITY is gratefully acknowledged for the financial support of this work.

References:

1. Gwee S. Y., Ho S. M., Anuar K., Tan W. T., Abdullah D. K., Atan M. S., Saravanan N. Preparation and characterization of iron sulphide thin films by chemical bath deposition method. *Indonesian Journal of Chemistry*. 2010–10. – P. 8–11.
2. Shanthi M., Saravanan N., Ho S. M., Anuar K., Tan W. T. Effect of bath temperature on the chemical bath deposition of PbSe thin films. *Kathmandu University Journal of Science, Engineering and Technology*. 2010–6. – P. 126–132.
3. Saravanan N., Ho S. M., Anuar K., Noraini K., Abdul H. A. Influence of the deposition time on the structure and morphology of the ZnS thin films electro deposited on indium tin oxide substrates. *Digest Journal of Nanomaterials and Biostructures*. 2010. – 5. – P. 975–980.
4. Haron J., Kuang Z., Atan S., Ho S. M., Anuar K., Saravanan N., Tan W. T. Effects of electrolytes concentration on the chemically deposited Cu_4SnS_4 thin films. *Asian Journal of Chemistry*. 2010. – 22. – P. 222–232.
5. Mohd Y. R., Ho S. M., Anuar K., Mohd J. H., Abdul H. A., Saravanan N. Chemical bath deposition of NiSe thin films from aqueous solution. *Kuwait Journal of Science and Engineering*. 2010. – 37. – P. 63–73.
6. Lim K. S., Anuar K., Ho S. M., Saravanan N. Investigation of morphological properties of the copper sulfide films in acidic media based on atomic force microscopy. *International Research Journal of Chemistry*. 2013. – 3. – P. 62–68.
7. Ho S. M. Metal chalcogenide thin films for photoelectrochemical cell applications: a review. *Middle East Journal of Scientific Research*. 2016. – 24. – P. 1232–1235.
8. Ho S. M. Power conversion efficiency in thin film solar cell: review. *International Journal of Chemical Sciences*. 2016. – 14. – P. 143–151.
9. Kassim A., Ho S. M., Gwee S. Y., Tan W. T., Saravanan N. Influence of pH values on chemical bath deposited FeS_2 thin films. *Pacific Journal of Science and Technology*. 2009. – 10. – P. 801–805.
10. Haron M. J., Atan S., Ho S. M., Anuar K. The effect of the pH value on the growth and properties of chemical bath deposited SnS thin films. *Research Journal of Chemistry and Environment*. 2011. – 15. – P. 45–48.
11. Tan W. T., Kassim A., Ho S. M. The role of bath temperature in aqueous acidic chemically PbS films. *Journal of Basic and Applied Scientific Research*. 2013–3–P. 353–357.
12. Ho S. M. Influence of complexing agent on the growth of chemically deposited $\text{Ni}_3\text{Pb}_2\text{S}_2$ thin films. *Oriental Journal of Chemistry*. 2014. – 30. – P. 1009–1012.
13. Noraini K., Ho S. M., Anuar K., Saravanan N. XRD and AFM studies of ZnS thin films produced by electro deposition method. *Arabian Journal of Chemistry*. 2010. – 3. – P. 243–249.
14. Ismail R. A., Ghafori S., Kadhim G. A. Preparation and characterization of nanostructured nickel oxide thin films by spray pyrolysis. *Applied Nanoscience*. 2013. – 3. – P. 509–514.
15. Jlassi M., Sta I., Hajji M., Ezzaouia H. Optical and electrical properties of nickel oxide thin films synthesized by sol–gel spin coating. *Materials Science in Semiconductor Processing*. 2014. – 21. – P. 7–13.
16. Ezema F. I., Ekwealor A. B. C., Osuji R. U. Optical properties of chemical bath deposited nickel oxide (NiO_x) thin films. *Superficies Vacio*. 2008. – 21. – P. 6–10.
17. Reddy A. M., Reddy A. S., Reddy P. S. Thickness dependent properties of nickel oxide thin films deposited by dc reactive magnetron sputtering. *Vacuum*. 2011. – 85. – P. 949–954.
18. Saikia P., Borthakur A., Saikia P. K. Structural, optical and electrical properties of tin oxide thin film deposited by APCVD method. *Indian Journal of Physics*. 2011. – 85. – P. 551–558.
19. Yang J., Li X., Bai S. L., Luo R. X., Chen A. F., Lin Y., Zhang J. B. Electrodeposition and electro catalytic characteristics of porous crystalline SnO_2 thin film using butyl rhodamine B as a structure directing agent. *Thin Solid Films*. 2011. – 529. – P. 6241–6245.
20. Dolbec R., El K. M. A., Serventi A. M., Trudeau M., Saint J. R. G. Microstructure and physical properties of nanostructured tin oxide thin films grown by means of pulsed laser deposition. *Thin Solid Films*. 2002–419–P. 230–236.
21. Leng D., Wu L., Jiang H., Zhao Y., Zhang J., Li W., Feng L. Preparation and properties of SnO_2 film deposited by magnetron sputtering. *International Journal of Photoenergy*. 2012. – Doi:10.1155/2012/235971.

22. Achour R., Atmane B., Mohamed J., Boubaker B. Structural, optical and electrical properties studies of ultrasonically deposited tin oxide (SnO_2) thin films with different substrate temperatures. *Superlattices and Microstructures*. 2015.– 86.– P. 403–411.
23. Jahnvi V. S., Tripathy S. K. Study of optical characteristics of doped SnO_2 by thermal evaporation method. *Indian Journal of Research in Pharmacy and Biotechnology*. 2014.– Special issue 1.– P. 78–82.
24. Khallaf H., Chen C., Chang L., Lupan O., Dutta A., Heinrich H., Haque F., Barco E. D., Chow L. Chemical bath deposition of SnO_2 and Cd_2SnO_4 thin films. *Applied Surface Science*. 2012.– 258.– P. 6069–6074.
25. Cho S. Optical and electrical properties of CuO thin films deposited at several growth temperatures by reactive RF magnetron sputtering. *Metals and Materials International*. 2013.– 19.– P. 1327–1331.
26. Morales J., Sanchez L., Martin F., Ramos-Barrado J. R., Sanchez M. Use of low temperature nanostructured CuO thin films deposited by spray pyrolysis in lithium cells. *Thin Solid Films*. 2005.– 474.– P. 133–140.
27. Halin D. S. C., Talib I. A., Daud A. R., Hamid M. Characterizations of cuprous oxide thin films prepared by sol-gel spin coating technique with different additives for the photoelectrochemical solar cell. *International Journal of Photoenergy*. 2014.– URL: <http://dx.doi.org/10.1155/2014/352156>.
28. Kasim U. I., Muhammad B. M., Umar A., Uno E. U., Mohammed I. K., Jibrin A. Y. Effect of oxidation temperature on the properties of copper oxide thin films prepared from thermally oxidized evaporated copper thin films. *IOSR Journal of Applied Physics*. 2013.– 3.– P. 61–66.
29. Mahalingam T., Chitra J. S., Chu J. P., Moon H., Kwon H. J., Kim Y. D. Photoelectrochemical solar cell studies on electroplated cuprous oxide thin films. *Journal of Materials Science: Materials in Electronics*. 2006.– 17.– P. 519–523.
30. Ahirrao P. B., Gosavi S. R., Patil D. R., Shinde M. S., Patil R. S. Photoluminescence properties of modified chemical bath deposited copper oxide thin film. *Archives of Applied Science Research*. 2011.– 3.– P. 288–291.
31. Rastkar A. R., Niknam A. R., Shokri B. Characterization of copper oxide nanolayers deposited by direct current magnetron sputtering. *Thin Solid Films*. 2009.– 517.– P. 5464–5467.