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ELECTRICAL AND OPTICAL PROPERTIES OF ZINC OXIDE THIN FILMS

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Abstract

Zinc oxide films have been prepared by high temperature oxidation of thermally evaporated zinc films on glass substrates. The resulting films are characterized using X-ray diffraction, optical absorption and electrical conductivity measurements. These zinc oxide films are very transparent and photoconductive.

Introduction

Zinc oxide is a n-type semiconductor with a large bandgap of about 4 eV. It is also photoconductive and its electrical conductivity varies over a large range [8]. Thus zinc oxide thin films can be used as transparent conductive coatings and infra-red reflective coatings. Zinc oxide have been prepared by various techniques such as sputtering [4], ionised-cluster beam deposition [7], spray pyrolysis [1, 2], chemical deposition [5] and reactive sputtering [8]

This paper reports on the preparation of zinc oxide films by high temperature oxidation of zinc metal films. The structural, electrical and optical properties of the deposited films are also investigated.

Experimental

Zinc metal films are deposited onto glass substrates inside a vacuum chamber. Zinc metal powder is heated in a molybdenum boat inside a vacuum chamber with a pressure of about 10^{-5} mbar. The metal films are deposited onto glass substrates held at room temperature.

The metal films are then transferred into a furnace heated to between 450°C and 500°C. They are left in the furnace with oxygen ambient for various time periods. The various oxidation conditions carried out are given in Table 1.

Sample	Oxidation conditions
S1	1 hour at 500°C
S2	2 hours at 500°C
S3	3 hours at 500°C
S4	4 hours at 500°C
S5	6 hours at 400°C
S6	4 hours at 400°C
S7	49 hours at 400°C

Table 1. Oxidation conditions for various samples

Structural characterisations are carried out using a Shimadzu XD5 diffractometer with Cu k_{α} radiation ($\lambda = 1.5408$)

Results and Discussions

Figure 1 shows the XRD patterns for the as deposited zinc film and film after oxidation for 1 hour at 500°C. It shows that both samples are polycrystalline. All oxidised films investigated are found to be polycrystalline. There is no preferred orientation for the oxide films obtained by this method.

Variation of dark resistance with oxidation time is shown in Figure 2. The sample resistance increases with time and approaches saturation above about 6 hours. Saturation resistance is dependent on oxidation temperature. Thus conductivity

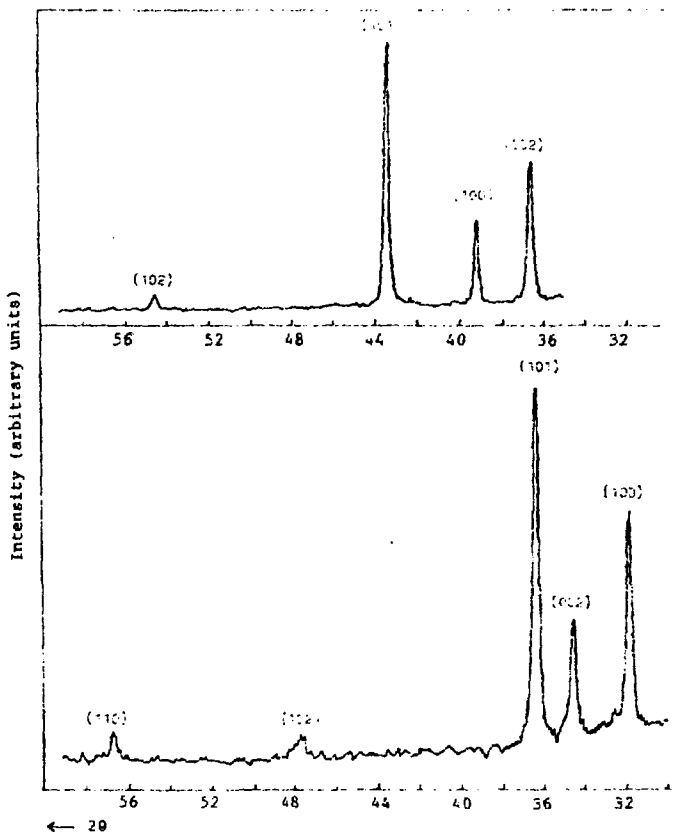


Figure 1: XRD pattern of (a) as prepared zinc film (b) after 1 hour oxidation at 500°C .

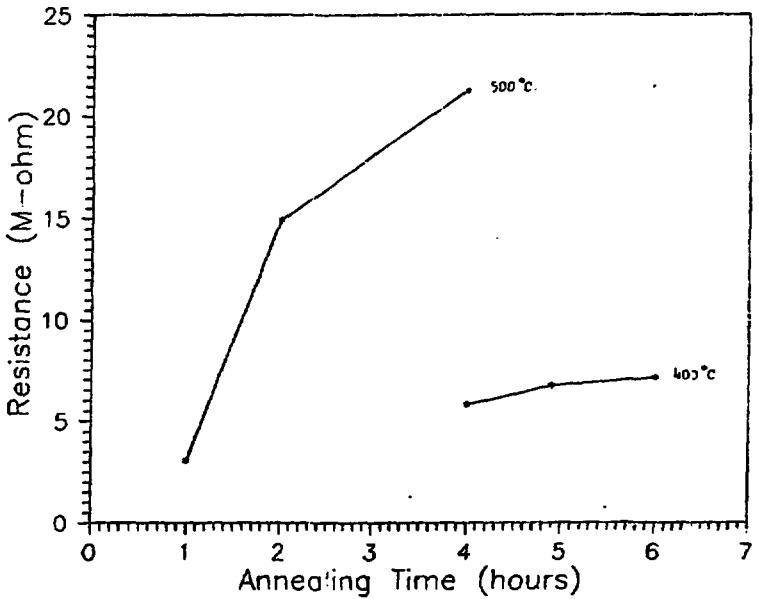


Figure 2: Variation of dark resistance against oxidation time for different oxidation temperatures.

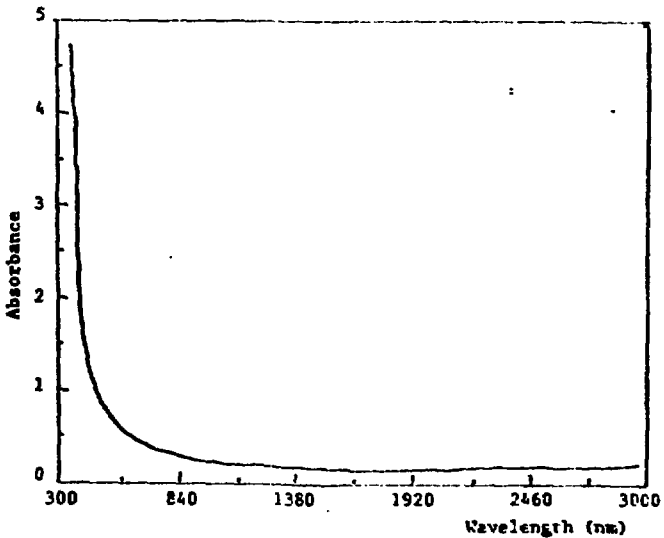


Figure 3: Optical absorption of film after 1 hour oxidation at 500°C.

decreases with decreasing oxidation time and decreasing oxidation temperature. As oxidation time increases, the oxide films becomes more stoichiometric. This reduces the number of carriers since the sample is near fully oxidise. In oxide semiconductor, the carrier concentration is controlled by stoichiometry and doping [8]. In the case of zinc oxide, the variation of resistance with oxidation time indicates that conductivity is controlled by stoichiometry. On exposure to light in the laboratory, the resistances of the films decreases by a factor between 30 and 200. Thus these zinc oxide films are very photoconductive.

Optical absorption of oxide film is shown in Figure 3. The film is transparent and the energy gap is about 3.17 eV. This is very similar to that obtained from published results [1].

Conclusions

We have obtained transparent zinc oxide films using oxidation of zinc metal films at 400°C and at 500°C. The conductivity can be controlled by varying the oxidation time and temperature.

References

1. Afify H.H., Nasser S.A., Demian S.E. J. Mat Science : Materials in Electronics 2 pg 152 (1991)
2. Bahadur L., Hamdani M., Koenig J.F., Chartier P. Solar Energy Materials 14 pg 107 (1986)
3. Manificier J.C. Thin Solid Films 90 pg 297 (1982)
4. Minami T., Nanto H., Takata S. Thin Solid Films 124 pg 43 (1985)
5. Ristov M., Sinadinovski GS., Grozdanev I., Mitreski M. Thin Solid Films 149 pg 65 (1987)
6. Shimizu M., Horii T., Shiosaki T., Kawabata A. Thin Solid Films 96 pg 149 (1982)
7. Takagi T., Yamada I., Matsubara K., Aakaoka H. J. Cryst. Growth 45 pg 318 (1982)
8. Tsuji N., Komiyama H., Tanaka K. Japanese J. Applied Physics 29 pg 835 (1990)
9. Wu P., Gao Y-M., Baglio J., Kershaw R., Dwight K., Wold A. Mat. Res. Bull. 24 pg 905 (1989)