Determination of structural and photoelectric characteristics of ZnO polycrystalline thin films and ZnO nanorod arrays obtained by spray pyrolysis

Atanas Tanushevski[1], Maja Lazarova[2], Ivan Boev[3]

[1]Institute of Physics, Faculty of Natural Sciences and Mathematics, University "Sts. Cyril and Methodius", Arhimedova 3, 1000 Skopje, Republic of Macedonia
[2, 3]Faculty of Natural and Technical Sciences, "Goce Delcev" University, Goce Delchev 89, 2000 Stip, Republic of Macedonia

Outline

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- Results and discussion
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Introduction

- Zinc oxide is a semiconductor with a band gap of 3.3 eV.
- The photoconductivity of ZnO leads to an increase in the number of charge carriers, but under certain conditions chemical absorption and desorption of molecules may also occur.
- The semiconductor X-radiation detectors are used in materials characterization devices, monitoring of nuclear reactions, determining the radiation from medical nuclear devices and radiation detectors.
- In this paper, we study the spectral photoconductivity of ZnO thin films and ZnO films of nanorods arrays, as well as the conductivity of films while being irradiated with X-rays.

Materials and methods

- Thin polycrystalline films of ZnO were obtained by spray pyrolysis method of $Zn(CH_3COO)_2$ aqueous solution, on substrates heated at temperature of 450 ^oC, whereas the thin film of ZnO nanorods array was obtained by spray pyrolysis of $ZnCl_2$ aqueous solution on substrates, which were heated to the same temperature.
- To measure the conductivity of the ZnO thin films, they were deposited on glass slides previously covered with a transparent and conductive SnO_2 thin film.
- The photoconductivity spectrum of the films was recorded using the HP 34401A multimeter.
- The absorbed dose of polychromatic X-ray radiation was measured with the AT1117M Radiation Monitor PU.

Results and discussion

- The XRD patterns of ZnO films obtained by spray pyrolysis of $Zn(CH_3COO)_2$ aqueous solution and $ZnCl_2$ aqueous solution, showed a hexagonal wurtzite structure, (figure 1).
- The morphology of films obtained by spray pyrolysis of $Zn(CH_3COO)_2$ aqueous solution shows (figure 2) that the films are polycrystalline, without the presence of holes.
- The films obtained by spray pyrolysis of $ZnCl_2$ aqueous solution demonstrate (figure 3) strong-oriented ZnO nanorods with a maximum diameter of 500 nm and length of 1 μm.
- The optical properties of the ZnO polycrystalline thin film and thin film of ZnO nanorods array were studied by recording the spectrum of transmission (figure 4).

Results and discussion

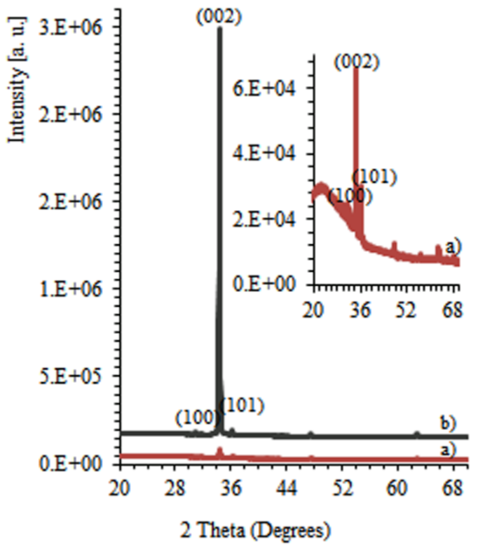

Figure 1. X-ray diffraction pattern of: a). ZnO films obtained by spray pyrolysis of $Zn(CH_3COO)_2$ aqueous solution and b) ZnO films obtained by spray pyrolysis of $ZnCl_2$ aqueous solution.

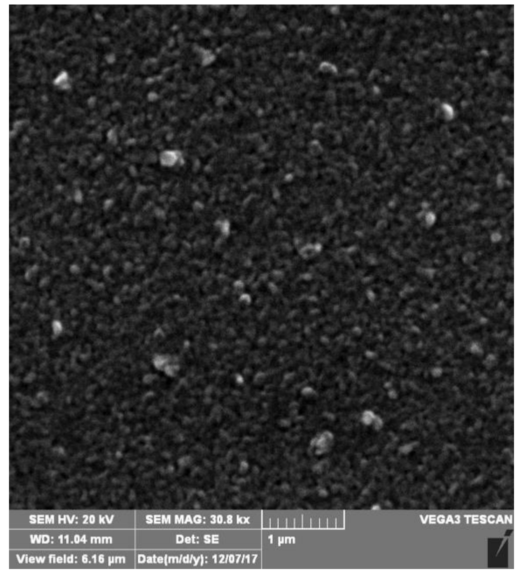

Figure 2. SEM image of the ZnO polycrystalline films.

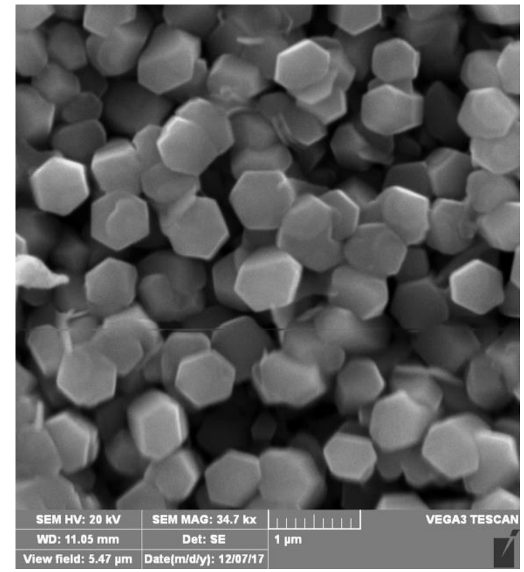

Figure 3. SEM image of the ZnO nanorods array films.

Results and discussion

- From the graphs given in figure 5, the band gap is valued to be 3.21 eV for polycrystalline ZnO films and 3.28 eV for ZnO nanorods array film.
- The photoconductivity of ZnO films was examined in the presence of UV light illumination, due to the chemisorption/desorption of the oxygen on the surface of the ZnO film.
- Figure 6 shows the dependence of the photoconductivity of the polycrystalline ZnO film on the energy of photons, where the maximum photoconductivity matches the photon energy of 3.36 eV, and 3.27 eV for the ZnO nanorods array film.

Results and discussion

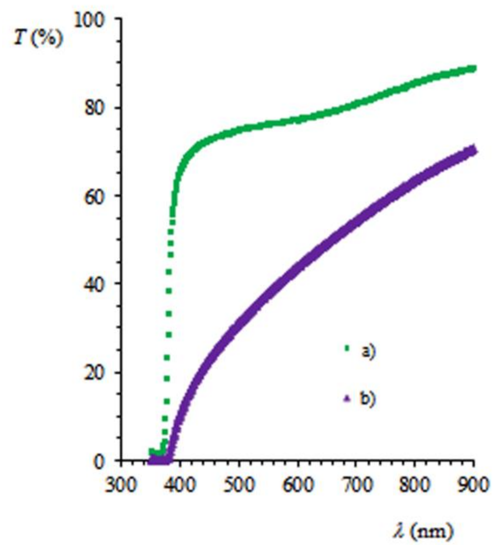

Figure 4. Transmission optical spectra of: a) ZnO polycrystalline films and b) ZnO nanorods array films.

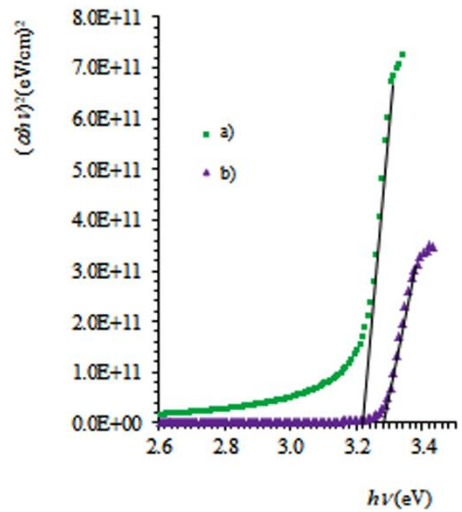

Figure 5. Plot of $(\alpha h\nu)^2$ versus photon energy of: a) ZnO polycrystalline films and b) ZnO nanorods array films.

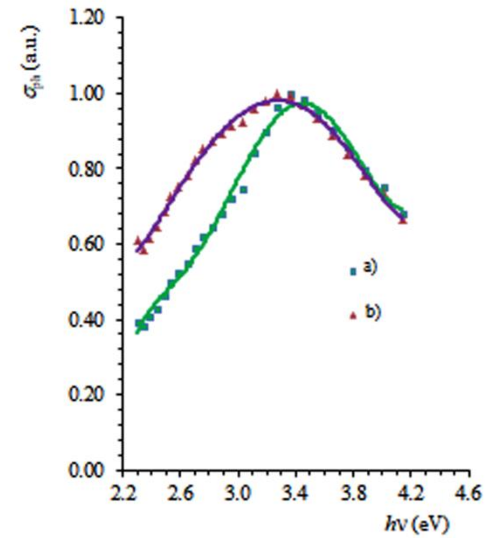

Figure 6. Photoconductivity spectra versus photon energy of: a) ZnO polycrystalline films and b) ZnO nanorods array films.

Results and discussion

- The absorbed dose of 5.9 μR/h was measured for polychromatic X-ray radiation at 30 kV voltage, as well as the absorbed dose of 48 mR/h at 40 kV voltage.
- The R = 444 kΩ resistance of the polycrystalline ZnO film in dark conditions was determined.
- While, the resistance R = 1.096 MΩ under X-ray irradiation was measured at 30 kV anode voltage of the X-ray tube, at anode voltage of 40 kV the resistance had the value of R = 1.160 MΩ.
- The resistance R = 300 kΩ for the ZnO nanorods array film was measured in dark conditions.
- Whereas the R = 279 kΩ and R = 250 kΩ under X-ray irradiation were obtained at 30 kV and 40 kV anode voltage, respectively.

Conclusions

- The ZnO films show hexagonal wurtzite structure with an expressive peak that is due to reflection from the lattice plane (002).
- The optical band gap of 3.21 eV of polycrystalline ZnO films and 3.28 eV of ZnO nanorods array films were determined.
- Further by using the photoconductivity, the bandwidth of the forbidden zone of polycrystalline ZnO films valued 3.36 eV and 3.27 eV for ZnO nanorods array films, were determined.
- The X-ray irradiation of the polycrystalline ZnO film contributes to the reduction of its conductivity, while the conductivity of the ZnO nanorods array film increases.

Thank You for Your Attention

Questions

Prof. Dr. Atanas Tanushevski
University "Sts.Cyril and Methodius",
Institute of Physics, Faculty of Natural Sciences and Mathematics
e-mail: atanas@pmf.ukim.m