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# Optical and photoelectrical properties of nanostructured thin ZnO films for UV-sensors

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**Abstract.** The article presents the results investigations of the optical and photoelectric properties thin films zinc oxide obtained by the reactive ion-plasma method. It is shown that the optical and photoelectric properties of thin ZnO films has equivalent characteristics to the properties of single crystal zinc oxide and can be used to create UV-photoresistors.

## 1. Introduction

Thin ZnO films, obtained by the reactive ion-plasma method are referred to direct-gap semiconductors having a large band gap (more than 3.3 eV). This determines a lot of interesting properties of ZnO, which are widely used in solid-state devices of optoelectronics and integrated optics. Also, due to low optical losses in the visible spectral range, high mobility of charge carriers and the possibility of doping, thin ZnO films are widely used as an active material for UV-photodetector [1–3].

In optoelectronics, are used various methods to grow thin zinc oxide films such as: a CVD process, pulsed laser ablation of a ceramic target from extra clean ZnO or electron beam deposition in a pulsed mode [4]. In comparison with them, the method of reactive ion-plasma sputtering of a metal target makes it possible to create ZnO films with the smallest structural changes in the film; in addition, this method allows doping of the film composition during its growth [5]. The purpose of this work was to investigation the optical and photoelectric properties of thin ZnO films obtained by reactive ion-plasma sputtering in argon-oxygen plasma of a Zn metal target.

## 2. Method preparation of thin films samples

The process of ion-plasma sputtering of the metallic target was carried out using a magnetron operating in a constant current mode. Process the synthesis of a zinc oxide film occurred in a gas atmosphere consisting of 30 % oxygen and 70 % argon. The pressure of the gas mixture under the cap of the sputtering installation did not exceed 101 Pa, and the substrate temperature did not exceed 423 K. The metal target was made from zinc grade extra clear. The substrate was making of quartz particularly transparent in the UV-range. Plates of quartz were polished in grade 12 cleanliness classes and were thickness of 2 mm.

The spraying of Al electrodes occurred on the magnetron installation. According to the data of microscopic studies, the thickness of the ZnO film was 1 μm. The thickness of Al film contact was 0.5 μm. X-ray diffraction investigation of synthesized zinc oxide films showed the presence of the hexagonal structure of ZnO films and its preferential orientation in the (001) direction. The dimensions of ZnO crystallites did not exceed 13 nm. The drawing of the investigated ZnO samples with the scheme by Al electrodes is shown in figure 1.

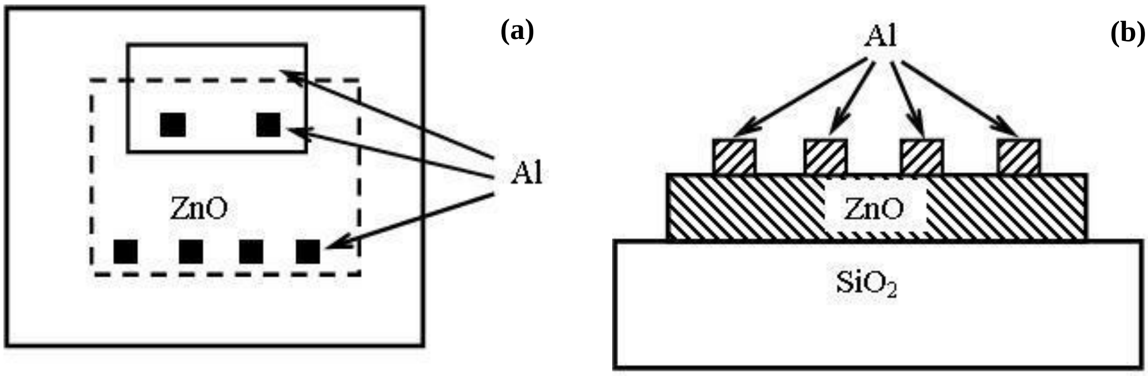


**Figure 1.** Appearance of the samples under study, top view (**a**) and side view (**b**).

## 3. Investigation of optical and photoelectrical properties in ZnO films

Investigation of the photoluminescence spectra of ZnO films was carried out on a Perkin Elmer Lambda 650 spectrometer at spectral range from 200 to 800 nm. The measurements were carried out at a temperature of 300 K. Figure 2 shows the optical properties of a thin film ZnO.

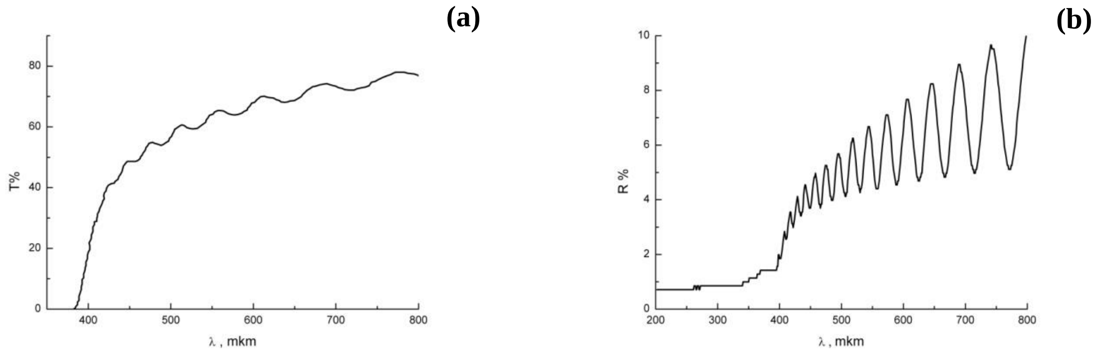


**Figure 2.** Transmission spectrum of ZnO film (**a**), reflection spectrum of ZnO film (**b**).

Using the experimental data of the spectral transmission and reflection dependences, the absorption coefficient were constructed using the technique described in [6] (figure 3).

To determine the width of the forbidden band of a polycrystalline ZnO film, the absorption spectrum was rearranged in the coordinates (αhν) 2-hν (figure 3). The value of the optical band gap $E_g$ was obtained by linear interpolation on the energy axis and amounted to 3.29 eV. The obtained value of $E_g$ differs insignificantly from the width of the forbidden band of single-crystal ZnO, which is 3.33 eV [1]. Measurements of photoconductivity currents were carried out on an automated installation consisting of a UV-source on a xenon lamp and a monochromator MDR-41. The photoconductivity current was recorded with a Keithley 6485 picoampermeter. The voltage applied to the photoresistors structure was 10 V. Figure 4 shows the spectral dependence of the photoconductivity current. It is seen that the maximum of the photoconductivity current corresponds to a wavelength of 375 nm. The increase in photosensitivity in the investigated films by a factor of 3 in the 370–380 nm spectral band, in comparison with the value of the photosensitivity in the region of the long-wave UV-spectrum, makes it possible to create photoresistors and UV-photodiodes based on these thin films.

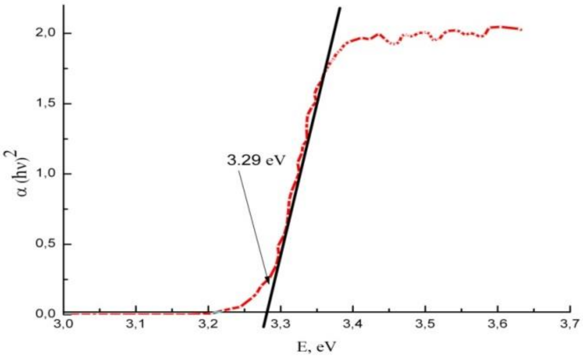


**Figure 3.** Absorption coefficient in film ZnO.

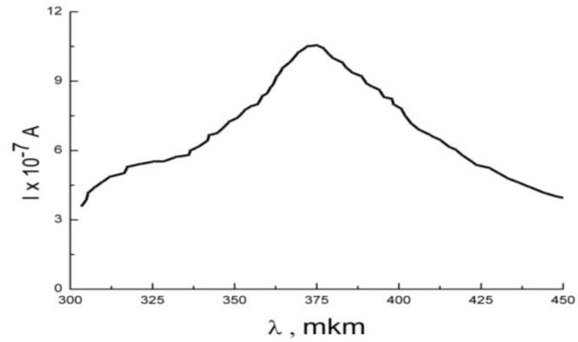


**Figure 4.** The spectral dependence of the photoconductivity current in a ZnO film.

## 4. Conclusions

Synthesis of thin films by a reactive ion-plasma method on pre-heated quartz substrates allows obtaining nanostructured ZnO films with the presence of a hexagonal phase of zinc oxide. The band gap for the synthesized ZnO film is 3.29 eV. This is small different from the value of the band gap for a single crystal or epitacsial film ZnO. Thus, zinc oxide films synthesized by the reactive ion-plasma method have low losses in the visible spectral range and have strong absorption in the UV-part of the spectrum range.

An investigation of the spectral dependences of the photoelectric current showed that the maximum of the spectral sensitivity is near 375 nm. This makes it possible to create photoresistors working in the UV spectral range on synthesized films.

## Acknowledgment

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