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OPTICAL AND ELECTROPHYSICAL PROPERTIES OF ZnO FILMS INTRODUCED WITH Al ATOMS HEAT PROCESSED AT DIFFERENT TEMPERATURES

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Abstract:
Aluminum oxide (AZO) thin films were deposited on glass substrates using the sol-gel dip coating method. The effect of temperature on electrical and optical conductivity properties of Al-doped ZnO thin films was studied. The ratio of the mass of Al atoms to the mass of Zn atoms was chosen to be 3%. ZnO films with Al atoms heat treated at 550°C showed high transmittance up to 84% in the visible and near-infrared radiation fields. When Al atoms are introduced, it is found that the main charge carriers are n types

Keywords: dip-coating, sol, gel, ZnO thin films, metal oxide

1. INTRODUCTION.

Semiconductor ZnO thin films are transparent in the visible range of light, have a bandgap of more than 3 eV, and are widely used in modern electronics as an n-type conducting material [1]. There are possibilities to control the electrophysical properties of ZnO films by introducing different dopant atoms. There are various methods for obtaining metal oxide thin films, such as radio frequency magnetron sputtering[2], sol-gel spin coating[3,4], sol-gel dip coating[5].

Depending on the dopant atoms, ZnO films can be widely used in gas sensors [6], transparent conductive electrodes [7], piezoelectric materials [2], optoelectronics and photonics [8] and other fields of science and technology.

Many scientific studies have been conducted on the production of metal oxide thin films. However, the lack of scientific research on the effect of different temperatures on the optical and electrophysical properties of ZnO thin films can cause various problems in the stable operation of devices based on them that are sensitive to external influences.

In this regard, in this study, the effect of temperature on the empe and electrophysical properties of ZnO thin films with Al atoms, obtained using the sol-gel deposition method, was investigated.

2. EXPERIMENTAL SECTION

Zinc acetate ($Zn(CH_3COO)_2 \cdot 2H_2O$) as a precursor for the preparation of the required mixture sol, isopropyl alcohol as a solvent ($CH_3CH(OH)CH_3$), diethylamine ($C_4H_{11}N$) as a stabilizer, aluminum nitrate as an input $(Al(NO_3))_3 \cdot 9H_2O$) was used and successively zinc acetate, aluminum nitrate was dissolved in isopropyl alcohol, in order to increase the solubility, diethylamine was added dropwise for ~1 min. The solution was stirred using a magnetic stirrer at ~60 °C at a speed of 1500 rad/s until it became transparent. The prepared gel mixture was stored in a special cabinet at room temperature for 430-460 hours.

As a substrate for the growth of films, glass windows cleaned with an ultrasonic bath in distilled water and washed in alcohol were used.

An optimized deposition device was used to grow ZnO:Al films from the prepared gel onto glass substrates. The repetition of processes in growing ZnO coatings with Al atoms in the optimized deposition device was 40. In order to evaporate the solvent from the grown films, they were subjected to heat treatment at different temperatures using a heating oven for 30 minutes.

The optical properties of the grown films were studied using a Perkin Elmer Instruments lambda 35 UV/VIS Spectrometer operating in the 190-1100 nm spectral range.

The type and concentration of charge carriers were determined using the HMS-7000-Hall device.

3. OPTICAL AND ELECTRICAL PROPERTIES

The optical conductivities of the grown ZnO thin films (Al input atoms at a concentration of 3% based on the mass of Zn atoms) were heat treated in the temperature range of 150-650 °C, and the optical and electrophysical properties at these temperatures were studied. In Fig. 1, it was found that the level of high transmittance of the glass substrate starts at 352 nm.

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It can also be seen from Fig. 2 that graphs of optical transmittance of ZnO films with Al atoms introduced and heat treated at different temperatures are presented. It can be seen from the picture that all thin films exhibit high transmittance in the visible and near-infrared radiation regions, which, in turn, allows the investigated samples to be used as transparent windows in optoelectronic devices.

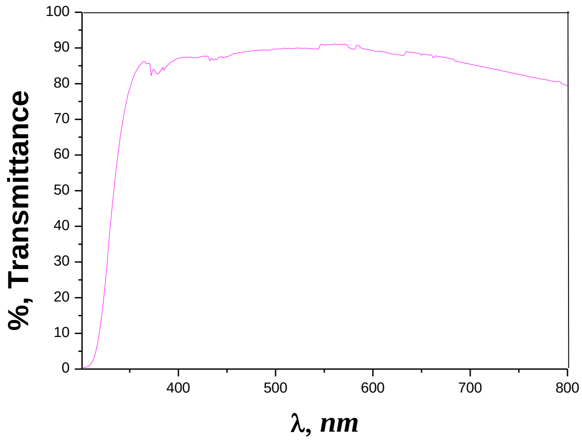

Fig. 1. Optical transmittance spectra of the glass substrate.

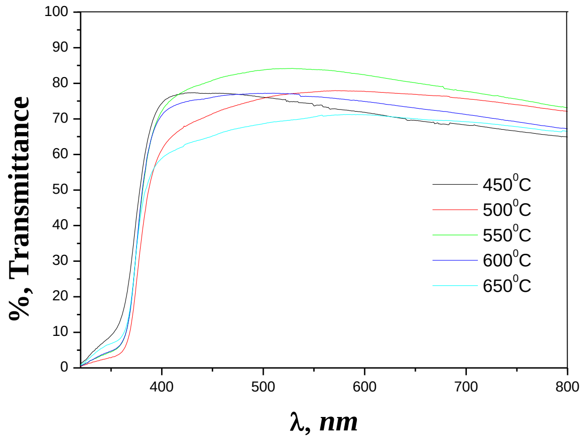

Fig. 2. Optical transmittance spectra of ZnO films doped with Al atoms and thermally treated at different temperatures.

Also, it was found that the charge carriers of ZnO films, where Al atoms were introduced by the Van der Pauw method at room temperature and thermally treated at different temperatures, were n. This indicates that free electrons are formed as a result of ionization (Al^{+3}) and exchange with Zn^{+2} in the crystal lattice of the film formed by introducing Al atoms.

4.CONCLUSION

Based on the conducted experimental studies and the analysis of the results obtained based on them, the following can be concluded:
the optimal conditions for the preparation of the required mixture sol and gel were determined, and based on them, ZnO films with Al atoms inserted (3% Al by mass of Zn) were grown using an optimized deposition device. It was determined that the optimum temperature for grown films was (550 °C) for 30 minutes;
ZnO films with Al atoms heat treated at 550 °C have been found to exhibit high transmittance of up to 84% in the visible and near-infrared radiation fields;
When Al atoms are introduced, it is found that the main charge carriers are n species;

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