Growth and properties of the ZnS and ZnSO layers

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Zinc sulfide (ZnS) is a promising wide band-gap semiconductor (with $E_g \sim 3.4\text{-}3.8$ eV) for designing the different optoelectronic devices such as transparent windows for solar cells and transparent electrodes to the low-resistance layers. In addition, this material can be used for substitution of the high-toxic CdS buffer layer in the heterojunction solar cells. On the other hand, large exciton binding energies of the ZnS and ZnO can provide effective exciton emission for optoelectronic devices based on them at the temperatures larger than 300 K. In this regard, a change of the content of the anions or cations in ZnS by introducing the isoelectronic impurities is important in terms of a band-gap engineering [1-3].

Here we present the results of the studies of the influence of the annealing in air on the optical and electrical properties of ZnS thin films deposited onto c-Al_2O_3 and Si substrates at 300 °C by the radiofrequency (rf) magnetron sputtering. A sputtering frequency was 13.56 MHz. A disc consisting of the ZnS powder was used as a target (purity 99.99%). The pressure of the gas mixture in the working chamber was maintained at 10^{-3} Torr. The target-substrate distance was about 40 mm. High-purity argon plays a role of the working gas. A crystal structure was investigated by means of the X-ray diffraction (XRD) technique using DRON-4. Optical transmission spectra were measured at the room temperature using the conventional equipment MDR-23. The resistivity of the films was studied by four-point probe method.

All obtained films had a high optical transparency (70 – 80%) in the visible and ultraviolet region and a sharp edge in a fundamental absorption region. It was found that the characteristic absorption edge shifts to longer wavelengths with increasing film thickness, indicating a decrease in E_g. Heat treatment of the ZnS thin films in air (at specified temperatures and time intervals) leads to a formation both ZnSO layers with different sulfur/ oxygen content, and pure ZnO layers, as evidenced by XRD results and optical transmission spectra. A control of technological conditions gave a possibility to change the film resistivity in a wide range of values.

The results obtained make it possible to control specifically the optical and electrical properties of ZnS films grown using rf magnetron sputtering and optimal technological parameters (including the thickness, temperature, annealing time and so on).

[1]. H. Ke, S. Duo, T. Liu, Q. Sun , C. Ruan, X. Fei, J. Tan, S. Zhan, *Mater. Sci. Semicond. Process.* **18,** 28 (2014).
[2]. K. Nagamani, P. Prathap, Y. Lingappa, R. W. Miles, K.T. R. Reddy, *Physics Procedia* **25,** 137 (2012).
[3]. J. Lee, S. Lee, S. Cho, S. Kim, I. Y. Park, Y. D. Choi, *Mater. Chem. Phys.* **77,** 254 (2002).