Electron irradiation effect on crystal structure and electrical properties of aluminum doped ZnO films

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The new trends in the electronic engineering lead to the technological breakthrough in the field of electronics and optoelectronics. The class of semiconductor materials - wide-gap semiconductors - such as GaN, ZnO, SiC and their various heterostructures is the main basis for this technology. They can be used at high temperatures and high voltages. Another important property is their stability in extreme conditions in high radiation environment. Accordingly to literature sources and take into account above mentioned factors we can state that the most promising candidate for these applications is ZnO. The benefits of zinc oxide are low cost and huge reserves of deposits. ZnO is one of the most promising materials suitable for the using in high background radiation, for example, in outer space [1, 2].

We investigate here the influence of irradiation by high-energy electrons on the crystal structure, electrical and optical properties of the ZnO:Al films, containing aluminum within 0.5 to 7 % which were deposited on glass substrates by atomic layer deposition. Two series of samples were irradiated by electrons with high energy 10 MeV and the fluences 10^{15} and $2\cdot10^{15}$ cm^{-2} using the microtron electron accelerator M-30. Electronic devises can obtain these fluences by moving in the Van Allen belt durring 10 and 20 years, correspondingly. The effect of electron irradiation on the properties of Aluminum doped ZnO films is discussed here.

The crystal structure of deposited films was investigated by X-ray diffraction analysis using diffractometer DRON-4 (Cu-Kα, λ = 0.1542 nm). It was established that the method of atomic layer deposition provides a perfect polycrystalline ZnO films with XRD reflexes (100) and (110) indicated preferred orientation of crystallites main *c*-axis in film plane. Temperature dependences of electrical resistance, mobility and carrier concentration were obtained by electrical properties and Hall-coefficient study in the temperature range 77÷300 K. It was established that in all cases after irradiation the mobility increases and electric resistance of the irradiated films, respectively, decreases. It is important that improving the electrical properties is not accompanied by changes in the microstructure, the size and orientation of crystallites and tension. So, defects at grain boundaries are sensitive to radiation annealing. Thus, it reduces the height of the intergrain barriers, which leads to higher values of the mobility. The other important fact is a great enhancement of electrical activity of Al donor impurity after electron irradiation. For example, two times increasing in Al electrical activity was observed for ZnO films with low (0.5 at. %) concentration of Al.

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[2] D. C. Look, *Materials Science and Engineering B* **80** 383 (2001).