Elżbieta Guziewicz

Przewodnictwo elektryczne i kompleksy defektowe w tlenku cynku powstające w wyniku intencjonalnego i nieintencjonalnego domieszkowania

---

The search for new electronic materials is the driving force behind many studies in the field of solid state physics. Zinc oxide (ZnO) is one of the most promising and versatile semiconductors owing to its peculiar physical properties as transparency, strong luminescence in the visible range, piezoelectricity and high thermal conductivity. It is also a biocompatible material, abundantly present in nature and it can be obtained by relatively simple and inexpensive growth methods. Because of that ZnO is recently extensively investigated for new electronic applications as transparent electrode for solar cells, for 3D memories, sensors and others. However, a full potential of this compound semiconductor and its applications in optoelectronics are impeded by a very difficult conductivity control, especially at low conductivity limits. Electrical conductivity of zinc oxide differs by several orders of magnitude depending of a method and parameters of the growth. The origin of this conductivity difference is far from being well understood. Investigations preformed in the last few years reveal that these differences cannot be fully explained by contaminations or native defects itself. Recently published papers indicate that the puzzle of electrical conductivity of ZnO might be explained by a creation of defect-impurity clusters that are responsible for a huge conductivity difference. According to such a picture, only extended investigations on impurities and native defects simultaneously are able to solve the problem of electrical conductivity of zinc oxide.

The objective of the present Project is **to investigate the origin of a huge conductivity difference of zinc oxide taking into account a creation of defect-impurity complexes**. Because of that different growth conditions will be tested in order to tune concentration of such native defects as oxygen vacancies, zinc vacancies and zinc interstitials as well as hydrogen impurity introduced during the growth process. The investigations will be performed on ZnO films grown by Atomic Layer Deposition, which is a novel deposition method that has recently been introduced to semiconductor industry. Dedicated series of ZnO films will be deposited at different growth conditions (variables: temperature, pressure in the reaction chamber, pulsing and purging times) and annealed at various conditions (variables: temperature, time and atmosphere) in order to influence a type and concentrations of native defects and impurities. A part of samples will be intentionally doped with nitrogen and/or aluminum in order to investigate complexes of dopants with impurities and defects.

The complexity of the problem undertaken by the Project requires applying of a wide range of experimental techniques ranging from temperature dependent luminescence (TDPL) and conductivity studies (Hall measurements), through X-ray diffraction (XRD), Secondary Ion Mass Spectroscopy (SIMS) and Raman spectroscopy to modern synchrotron radiation techniques like X-ray Photoemission microscopy (micro-ESCA). The experimental techniques mentioned above will be directed at determination of carbon and hydrogen contaminations (SIMS), type of native defects (TDPL, Hall) as well as native defects-impurity complexes (Raman, positron annihilation spectroscopy).

The achievements of the Project will contribute to extend the present knowledge on an origin of conductivity difference of zinc oxide. In a further perspective, the obtained results will be also important for future applications of this extensively investigated semiconducting oxide with a wide range of potential applications.