Recently, zinc oxide (ZnO) attracts worldwide attention due to its interesting optoelectronic properties. Thanks to them, it has a potential of replacing gallium nitride, which is commonly used in blue and white electroluminescent diodes (LED). Unfortunately, not all properties of zinc oxide are well known. Each semiconductor may possess two types of conductivity - the one, in which major participants in current transport are electrons (n-type) and another one, in which mostly holes (being simply lack of electron) participate in conduction process (p-type). Each type can occur naturally or be artificially obtained, by introducing into material so-called "dopants", which are just atoms of some other element. Incorporation of dopants into material changes its structural, optical and electronic properties, therefore wide and detailed knowledge about both types of conductivity in each material is crucial in the process of developing well-working, efficient and stable optoelectronic devices, such as LEDs, lasers or detectors. In case of zinc oxide, achieving p-type conductivity turns out to be problematic, mostly because of the fact, that ZnO is natural n-type semiconductor, which in some way compensates the artificially introduced opposite conductivity. However, due to technology improvement, p-ZnO becomes feasible, but today's knowledge about this material is limited. The aim of this project is to cover the lacking part of knowledge about structural properties of p-ZnO.

Raman spectroscopy could shed some light on properties of both types of zinc oxide. This is very sensitive and precise measurement technique, which allows to study structural properties of materials. It employs inelastic (Raman) scattering of monochromatic light on atoms' vibrations (called phonons) in the material. Knowing crystal structure of investigated material, results of measurements can be theoretically predicted. Therefore, every deviation from theoretical calculations, indicates the differences occurring in the structural properties of material. Examples of information, which can be provided by this method are composition of the investigated material, its crystalline quality and contamination, impurity concentration or crystal orientation.

Research in this project will include few methods of Raman spectra measurements, which provide information about different properties of investigated materials. Examples are studies with use of different laser lines (514 nm and 325 nm), with polarization detection, varying laser beam power and in wide temperature range. The analysis will concern a variety of structures, containing ZnO/ZnMgO layers doped for p-type with group-V elements and prepared in specific way in order to investigate the influence of their particular features on their structural properties. Prepared samples will be of different dopant atoms (As, Sb, N; double, triple doping), annealing temperature (300-900°C), time (3-10 min) and atmosphere (O_2, Ar, N_2), dopant concentration, substrate (GaN, Al_2O_3) and Mg content. Raman spectroscopy will be associated by other methods and spectroscopies, e.g. X-ray diffraction or X-ray photoelectron spectroscopy which will help in results analysis and interpretation.

Detailed study on p-type doping in ZnO will bring us closer to development of p-n homojunction based on zinc oxide. Homojunction is a connection of two types (p and n) of the same semiconductor material and is a basis of most optoelectronic devices. Nowadays, junctions of n-ZnO and some other p-type semiconductor material are used, but this solution causes problems, which do not occur for homojunctions. Even if used materials have very similar properties, usually they are not exactly the same, which very frequently results in decreasing device's efficiency. Other thing is that structures of those materials are never the same, and this leads to appearance of strain between materials, which results in high probability of occurring extended defects on the interface between materials. Using homojunctions is much more convenient, therefore developing both types of zinc oxide will eliminate all those problems.

This high interest in developing stable end effective both types of conductivity in zinc oxide comes from the fact, that this material has a great chance to become a more economic substitution of gallium nitride, which is used for blue and white LEDs manufacturing. Besides all the similarities between these materials, ZnO has many advantages over GaN. It has lower requirements for fabrication process, such as 2 times lower growth temperature (500°C vs. 1000°C) or simpler fabrication technology. It can be manufactured with large area and good quality by number of inexpensive methods, which do not require high vacuum, high pressure or do not have to be extremely clean, while gallium nitride requires clean methods, high vacuum, high pressure and high temperature. All these reasons increase price of GaN-based devices, inter alia blue LEDs, which are the basis for white LED lamps, commonly used in our houses. Using ZnO instead of GaN in optoelectronic devices will make it much more economic, simultaneously avoiding the decrease in device efficiency. In case of blue and white LEDs, lower price will make it more available for society, which may result in reducing total energy consumption.