Nitride semiconductors GaN-InN-AlN are materials used for fabricating electroluminescence diodes (LEDs) emitting in UV, blue (exciting luminophore to give white light) and green spectral range, as well as blue and green laser diodes (LDs). These devices are used not only in lighting, but also for constructing "Blu-ray" recorders and players, in RGB (red-green-blue) projectors of a superb colour resolution (in future they will be used for 3D projectors without goggles), as well as in medical, military, environmental-protection and quantum (mass sensors, atomic clocks, cryptography devices) technologies.

The subject of this Proposal is examination of properties of layers and ultrathin quantum wells of InGaN, which are the "hearts" of LEDs and laser diodes, as there the radiative recombination of electrons and holes takes place and light is generated. InGaN is very difficult to be grown because of two reasons: i) for a high indium content it is necessary to use low growth temperature, ii) there is a large difference in interatomic distances of Ga-N and In-N. Both factors induce inhomogeneous spatial distribution of indium in InGaN, as well as a high density of point- and extended-defects. Indium fluctuations and defects have strong influence on optical parameters of InGaN, and thus, on light emission parameters in LEDs and LDs.

InGaN is difficult to be grown because it is necessary to use low growth temperatures (at higher temperatures InGaN gets decomposed) and there is a large lattice mismatch between In-N and Ga-N. Both factors induce a non-uniform spatial distribution of indium and InGaN as well as a high concentration of point- and extended-defects. Fluctuations of indium and defects have a significant impact on optical properties of InGaN, and thus, on devices: LEDs and laser diodes.

In those devices, above the InGaN quantum wells, p-type GaN is grown. This should be done at high temperature what makes indium diffusion, leading to homogenization at certain conditions and to decomposition if the temperature is too high.

Physical and chemical phenomena occuring during the growth of nitride epitaxial structures leading to creation and anihiliation of defects, to homogenization and decomposition of InGaN, are being examined in tens of laboratories worldwide, and in Poland, in the Institute of High pressure Physics (IWC PAN) and its spin-off TopGaN.

In this Proposal, we are going to intensify our research by the collaboration with the Karlsruhe Institute of Technology (KIT) and by using an European unique (third, after Japan and the USA) device for MOVPE (Metalorganic Chemical Vapour Phase Epitaxy) growth with in-situ X-ray diffractometric examinations using the synchrotron radiation. In our traditional experiments, we grow the samples, cool it down, and examine them using various analytical methods. It is very laborious, costly and, in fact, we have no information what is happening during the growth. In the in-situ device, we examin the samples in real time as a function of temperature, pressure, reactants and carrier gas flows.

The in-situ MOVPE system was constructed by the Institute of High Pressure Physics and TopGaN by the order of KIT. The system is designed to do growth off-line and on the 7-circle diffractometer installed on the X-ray beam of the ANKA synchrotron in Karlsruhe.

A big advantage of the Project proposed, besides using the in-situ MOVPE device, is a collaboration with three distinguished diffractionists: Vaclav Holy, Tilo Baumbach and Sondes Bauer. Thanked to them, we will be able to extend the methodology of the X-ray diffraction, mostly possible only using an intense synchrotron X-ray beam. For example, we will be able to examine not only a crystallographic net inside the samples, but also the configuration of atoms on the surface.

The project is mostly curiosity driven research, but should have also an impact on technology of laser diode manufactured in Poland.