

The LED light bulbs routinely used for lighting our homes or offices contain sets of small semiconductor systems, "sandwiches" composed of layers of semiconductors with properly selected electric characteristics converting electric energy into blue light which, in turn, is converted in a phosphorescent material into light covering the visible spectrum, so we accept it as a "warm" white light suitable for domestic use. The invention of this energy-efficient, environmentally friendly and long-living light source gave its authors - Akasaki, Amano, and Nakamura, the Nobel Prize in Physics in 2014. But definitely this was not the end of the story. This achievement paved the way for ideas of further development of even more energy and cost effective semiconductor light sources. There are still important physical phenomena and technological obstacles which limit the efficiency of energy conversion, from electric energy to visible light, below the theoretically achievable limit in the devices manufactured up to now. For example, fabrication of perfect thin layers of nitride semiconductor on a cheap substrate which has different parameters of crystal lattice is quite a challenge. One of the seriously considered solutions is to replace in light emitting devices some continuous layers of semiconductors with a "brush" of narrow sticks grown on the substrate. As they usually have diameter of the order of 100 nm or less - they are called "nanowires". In such narrow structures, strains due to crystal lattice mismatch with the substrate can easily be elastically accommodated and defect formation is avoided.

Critical for application in electrically driven devices as LEDs is control of electronic properties of nanowires, in particular their electrical conductivity. This is commonly done by introducing into the crystal foreign atoms called dopants. While processes of dopant incorporation to planar semiconductor layers are quite well established, they are challenging in 3D objects as nanowires. The main problem is a lack of reliable methods of measuring dopant concentrations in such structures. Importantly, the project proposers have access to an unique method that is perfectly suitable for measurements of dopant content in nanowires with very high sensitivity and high spatial resolution. We will benefit from that and study mechanisms of Mg and Si (the most common dopants in nitride semiconductors) incorporation to (Al,Ga,In)N nanowires during their growth by molecular beam epitaxy. Dependence of dopant content on growth parameters will be established to determine how to optimize concentration of the dopant and its distribution along the nanowire. Then we will study how these dopants influence electrical and structural properties of the material. Finally, the elaborated procedures of doping will be used to clarify and control mechanisms of p-n junctions formation in nanowires, which will make them applicable in device structures.

We are convinced that implementation of the project will help to improve properties of III-nitride nanowire based devices. However, the most important is that the research proposed will contribute to deeper understanding of crystal growth processes, physics of semiconductor devices and general knowledge on physics and technology of group III-nitride semiconductors, and will increase our expertise in those areas. Results obtained within the project will be the starting point for further works devoted to design, manufacturing and testing new designs of nanowire-based solar cells, photodetectors and LEDs. We believe that our developments will help to improve considerably properties of such devices, including power, efficiency and extension of their spectral range.