When we consider large volume crystals, the influence of surfaces on their global properties is usually negligible. However, the smaller the element, the greater the surface-to-volume ratio, the greater the influence of the surface properties on the parameters of the entire system. So, for the objects of reduced dimensionality and nanometer size, surface properties became the priority research subject. Simultaneously, quasi one dimensional structures – nanowires – are considered as the basis of development of semiconductor light sources, such as LED light bulbs routinely purchased for lighting our homes or offices. Nowadays, they contain sets of small semiconductor systems, “sandwiches” composed of layers of nitride semiconductors, like GaN, 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, that we accept it as a ”warm” white light suitable for domestic use. However, there are still important physical phenomena and technological obstacles which limit the efficiency of energy conversion, from electric energy to visible light, in the devices manufactured up to now. Fabrication of perfect, defect-free thin layers of nitride semiconductors 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 – nanowires - grown on the substrate. In such narrow structures, strains due to crystal lattice mismatch with the substrate can easily be accommodated and defect formation avoided. However, the abovementioned surface phenomena (surface electronic states, structural defects, etc.) substantially influence the properties of nanowires, with the range of the impact comparable with with the diameter of the nanowires. The influence can be so strong that the part of the nanowire available for charge transport, charge carrier injection and light generation is markedly reduced. Therefore, the aim of the project is to recognize and comprehend the phenomena that occur at the surfaces of GaN/AlGaN nanowires and may be used to reduce surface-related suppression of carrier transport and luminescence in nanowires, acting as serious factor impairing characteristics of heterostructures or devices built into the nanowires. Until now, the great majority of the reported studies correlated surface modifying procedures directly with the global characteristics of nanowire ensembles or devices based on them. The essence of our project is to study the problem at the level of individual nanowires and their surfaces probed with techniques of nanometer lateral resolution, nanometer surface sensitivity and elemental sensitivity. We propose to focus our research on physical mechanism of surface modification at the atomic, molecular level and discriminate the changes induced on different parts of the multi-component nanowires, heterostructures, nano-devices. The parts of nanowires with different chemical composition or with opposite doping type (p-type or n-type) react in a different way to applied chemical treatments or covering with an oxide shell. So, only detection of the appearing changes with nanometer lateral resolution would make possible to select proper methods leading to improvement of the properties of the whole complex system. We intend:

- to recognize and investigate the surface processes improving surface conditions on GaN, AlGaN, GaN/AlGaN nanowires during passivation by oxide shell growth or chemical treatment,
- to assess their influence on the luminescence and electronic properties of nanowires, their individual parts of different composition and heterostructures built into them,
- to demonstrate that they may be applied to achieve more efficient nano-LEDs in nitride nanowires.

The surface properties would be modified by: a chemical method (like passivation in a KOH solution), coating with oxides (Al_2O_3, TiO_2, ZrO_2, HfO_2, ZnO) by atomic layer deposition, and overgrowth of parts of nanowires with AlGaN shell with higher Al content than in the nanowire core.

The obtained systems would be studied with use of surface sensitive techniques – X-ray photoelectron spectroscopy and polarization dependent X-ray absorption spectroscopy (in a surface sensitive mode). Optical and electronic properties of individual nanowires would be investigated by spectroscopic and mapping techniques based on scanning electron microscopy – cathodoluminescence and electron beam induced current (EBIC).

Having accumulated knowledge of surface modifications induced by the selected technological procedures we will use them to test possible improvement of efficiency of nano-LED made in GaN/AlGaN nanowires.

The primary result of the project implementation will consist in the conclusions concerning fundamental physical properties of surfaces of complex one-dimensional semiconductor systems. Apart from those conclusions, important for basic research, the project should deliver information necessary for optimization of one-dimensional nitride system technology and potential improvement of energy and cost effective sources of light. As a considerable part of human energy consumption is related to artificial lighting, saving any part of it contributes to environmental protection, limiting the green-house effect and supports the sustainable development of the civilization.