Aim of the project
The aim of this project is to investigate the synthesis and properties of semiconductor nanowires made of pure and doped indium antimonide. The method of synthesis of these nanostructures is the subject of optimization and synthesis parameters will be correlated with the properties of the obtained materials. Applicants expect that the resulting nanowires will be able to find a practical application as an active elements of modern devices for nanoelectronics.

Reasons for undertaking a research subject and a description of basic research
Multifunctional nanostructured materials attracted the attention of scientists and industry due to the possibility of their use in various fields, e.g. as elements of logic circuits, thermoelectric generators, chemical and biological sensors and nanoelectric devices. The primary limitation associated with the practical application of nanomaterials in relatively high costs of their manufacture. Therefore, the efforts of researchers are focused on the development of new, relatively easy to implement, and above all, inexpensive methods for the preparation of nanomaterials.
There are some methods that allow the preparation of nanostructured materials of various shapes and sizes in a relatively short time. One of them is electrodeposition. It involves causing a chemical reaction between the electrodes by applying an external potential /current. Depending on which electrode the deposition is held, electrochemical processes can be divided into cathodic and anodic process. As a result of electrodeposition, oxide, metal, polymer, transition metal salts and many others nanomaterials can be obtained. Electrodeposition is the method relatively cheap and can be performed at room temperature, thereby reducing the effect of diffusion of the material components. The thickness of the deposited layers can be controlled by watching what charge passed through the cell. The deposition rate can be controlled by varying the current density during the process. In turn, the composition and the number of defects in the material depends on the applied voltage. An important advantage of electrodeposition is that the layers may be formed on the large surfaces of complex shape, and they can also be carried out using porous templates.

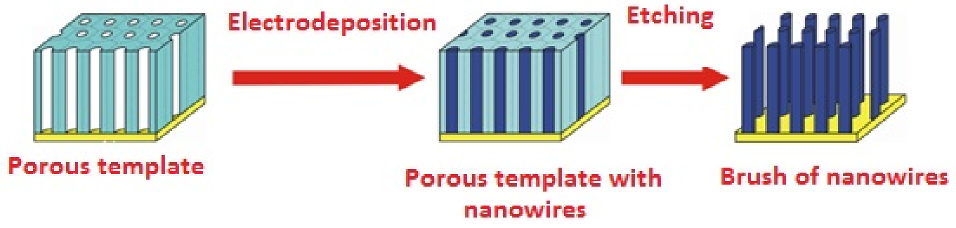

Figure 1. Scheme for the preparation of electrochemical deposited nanowires inside porous templates.

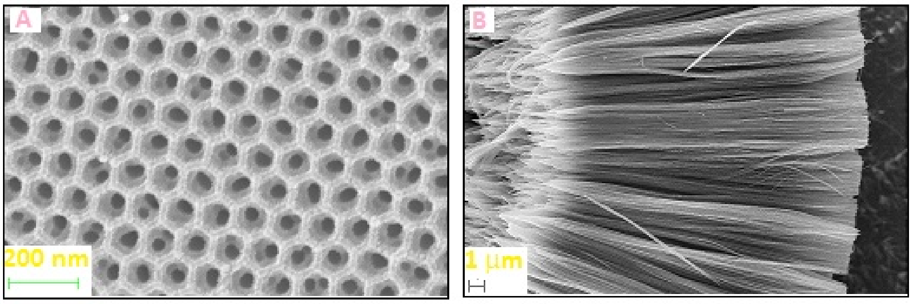

Figure 2. SEM images of the porous template (A) and the nanowire brush made of millions of nanowires (B).

Schematic diagram of the preparation of nanowires via electrodeposition process is shown in Figure 1. The examples of the microstructure of porous templates and nanowires are presented in Figure 2.

InSb is a semiconductor, which due to its good electrical properties is used in gas sensors, electronics or thermoelectric generators. Above it, this material can be effectively modified by the addition of certain atoms, such as: carbon, antimony, manganese, gallium or tellurium, to induce a completely new properties. For example, addition of about 2% of manganese atoms to the indium antimonide causes ferromagentic properties, which previously was not shown by this material. Moreover, according to the research conducted during the last few years, the higher activity of this doped material is at room temperature. So this opens up entirely new possibilities for the use of Mn-InSb in magnetic devices. To further enhance the magnetic response of such materials, it seems advantageous to reduce the dimensionality of the three-dimensional crystals to nanowire brushes composed of billions of one-dimensional nanowires.
Another example of InSb modification is doping it with tellurium atoms. This procedure allows to increase the electrical conductivity of the material, while maintaining thermal conductivity at the same level, or even reduce its value. This seems complicated, however, the newly created structure Te-InSb can be successfully used as a high-performance thermoelectric generator, or devices that can turned electrical energy into heat and heat into electricity. The construction of such devices is extremely important for the recovery of heat (for example emitted by a combustion engine) into electricity. In this way, indirectly, you can reduce the need for fuel, the emission of harmful gases, which are a byproduct of combustion. The last example would be modification of the optical properties of indium antimonide by the addition of gallium atoms into the structure of the material. As in the case of atoms of manganese, here too, even a small addition (about 2%) may cause a drastic change in properties of the resulting material.
All of these structure and properties modifications of indium antimonide are possible to be performed during the electrosynthesis

of this material. It is necessary only to change the composition of the electrolyte. In summary, the electrodeposition as a method of preparing nanowire brushes composed of billions of individual nanowires is also a useful technique for modification the material properties. Nanostructures which are the subject of research of this project are designed to exhibit different properties as a result of simple manipulation, such as addition of a small amount of atoms of other elements. These new properties are particularly interesting from the point of view of possible practical applications in nanoelectronics.