DESCRIPTION FOR THE GENERAL PUBLIC

The classical semiconductor technology is based on the active hetero nanostructures grown as layers on the flat silicon wafer (substrate), which is often inactive part of the semiconductor device. It turns out that it is possible to fabricate layered hetero nanostructures in a different way, as thin shells of elongated quasi-one-dimensional semiconducting nanocrystal, such as silicon or gallium arsenide. Such a cylinder is called a nanowire and its core produced by a method used for deposition of thin crystalline layers, e.g. molecular beam epitaxy (MBE) can have the length of several micrometers and the diameter of several nanometers, as well as well defined side walls on which the radial layers can be grown as in the case of the flat nanostructures. Due to the such an architecture, core-shell nanowires have the active surface to volume ratio higher then their flat equivalents. Regarding this fact, core-shell nanowires are well suited to the application in the efficient solar cells, the sensitive sensors or the effective light emitters as parts of active elements. On the other hand, there is still a search for new materials which will enable processing of the information not by the conventional electron flow (electronics), but using spins of electrons (spintronics) – significantly less energy consuming process. Finding such materials combining electric and magnetic properties at room temperature will allow building very fast and energy-saving electronic circuits.

The studies on dilute magnetic semiconductors (DMS) carried out for two recent decades, which most prominent representative is (Ga,Mn)As, have shown, that this material, grown in the form of several, flat layers reaches the Curie temperature (*Tc*) up to 190K (the temperature, below which the material has ferromagnetic properties). Since no suitable dilute ferromagnetic semiconductor (DFS) material with *Tc* reaching room temperature has been found yet, one of the primary ideas to increase Tc of spintronics devices is the combination of semiconducting materials with magnetic intermetallic compounds with considerably higher *Tc*. These so-called hybrid metal-semiconductor materials, can be obtained as a result of first-order phase transition, well described in the literature in the process of thermal treatment – particularly, the formation of hexagonal MnAs nanoprecipitations with ferromagnetic properties (Tc > 40ºC) from the cubic (Ga,Mn)As of its' native zinc blend structure. It turned out that with use of the molecular beam epitaxy (MBE) it is possible to grow nanowires with shells consisting of (Ga,Mn)As of unusual hexagonal wurtzite structure. Moreover, the direct formation of shells consisting of ferromagnetic metals such as pure MnAs or MnGa is also possible with the same method. Due to the unbalanced hexagonal wurtzite structure instead of a cubic one [common for (Ga,Mn)As] it is expected that the formation of new phases would occur in a different way, and the combination of three-dimensional geometry with strong anisotropy of wurtzite structure will enable fabricating hybrid nanowires of new, yet unexplored properties. We assume that the activation energy of such process will be lower and the precipitations will be smaller.

Transmission electron microscopy (TEM) enables sample imagining in real time with atomic resolution. Thanks to specialized holders, we plan to carry out *in-situ* TEM experiment in which we are going to precisely regulate the nanowires temperature and at the same time register the processes of the morphology and the structure transformations occurring inside and at the side walls of single nanowires. In particular, we would like to check what kind of changes appear under the influence of temperature using Lorentz microscopy, which provides an option for changing the strength and the directions of the magnetic field in the area of the investigated sample. We presume that we will be able to observe directly and quantify the process of the atoms rearrangement leading to the formation of hybrid shells in nanowires, as well as changes in morphology and the creation of defects. This type of research has never been introduced in such a class of nanoobjects so far. We expect that after phase transition in a very strong external magnetic field, magnetic moment of nanoprecipitations might be arranged and the structure of the ferromagnetic properties would be established contrary to the currently established ones – superparamagnetic. The unique advantage of the project is the fact that we will be able to connect the structure of the selected nanowires with their magnetic properties using electron holography and the differential phase contrast technique for local magnetic moments measurements. We foresee that in the case of arranged magnetic moments, the hybrid metal-semiconductor nanowires will exhibit specific magneto-plasmonic properties (surface and volume plasmons), which can be detected thanks to the electron energy loss spectroscopy (EELS) or analysis of emitted light spectra (cathodoluminescence in TEM).