Over the last two decades nanowires (NW) became the objects of extensive research activity. This was stimulated by the progress in both characterization techniques of nanoscale objects, and the methods to fabricate them. In particular, the research capabilities of transmission and scanning electron microscopy allowed us to look into the nano-world as it was in the case of optical microscopy and micro-world. The nano-objects , such as quantum dots, quantum wires and finally nanowires have been successfully realized since 80-th, 90.th and in the beginning of 21.-st century, respectively. Nowadays nanocrystaline metals, ceramics composites quantum dots and nanowires are also about to use the device-ready stage; but still a lot of fundamental problems concerning their formation methods, and characterization are open for research activity.

The project is devoted to In-operando studies of hybrid nanowires (H-NW) designed as the components of future nano-electro-mechanical systems (NEMS). The objects of interest have diameters in the range from 20 to 200 nm and lengths from 3 to about 10 micrometers. The H-NWs consist of monocrystalline cores from semiconducting material with piezoelectric properties e.g. nitride semiconductor (Ga, In, Al)N, ZnO or wurtzite (Ga, Al,)As, and intermetallic compound shells with magnetostrictive properties such as MnAs, MnGa and FeGa.

Monocrystalline NW core (often with pencil-like shape), is crystallized by molecular beam epitaxy (MBE) using vapor–liquid–solid (VLS) method. The metallic shells will be epitaxialy deposited on the side walls of the monocrystalline cores with the same technique.

H-NWs have a lot of potential applications, e.g., in implantable electronic devices, collecting energy the environment, i.e. from vibration energy, body movement, and junk electromagnetic field.

Due to the nanoscale dimensions, H-NWs show a variety of new properties and functionalities which do not occur in bulk and layered structures of the same materials. Despite extensive research in the field of nanowiers, there are still many open questions about the mechanisms of their formation and specific properties characteristic of these quasi 1D objects.

To investigate these properties, individual H-NWs will be placed on (electron-transparent) membranes of MEMS chips. Individual nanowires will be connected to testing apparatus using the technique of depositing of metal-carbon composites through a focused ion beam in a scanning electron microscope. This will enable precise measurements of electric currents flowing through the nanostructure. Then, the prepared measuring setup, based on a miniature MEMS system will be placed in a double tilt sample holder and introduced into the transmission electron microscope chamber in the area of the magnetic objective lenses.

The nostructure will be "tortured" in the microscope using the voltage applied to the ends of the H-NW core, by the magnetic field generated by the objective lens or heated to induce the tension between the shell and the core as well as the membrane.

Piezo-magnetostrictive nanowires will respond to these stimuli. The core and the shell will deform then the core will generate potential at their ends and the shell will generate magnetic field. All this will be possible to observe and record live at a very high magnification. Moreover change of a magnetic field distribution can be observed vie electron holography.

The deformation of the nanowire crystal lattice will be measured using electron diffraction and quantitative analysis of images of the atomic structure. We will record how the structure changes due to external forces. .

Thanks to such in-operative experiments, we will obtain a huge amount of data that, after analysis, will allow us to understand how such a hybrid nanostructure works and how it can be optimized and used for potential applications.

The project will bring new insights to the phenomena occurring at the interphase boundaries of two different materials of the core and the shell with completely different physical properties. This will be very valuable and useful for other researchers working, e.g. on nano-crystalline composites consisting of nano-grains of various materials.