The aim of the project is to knowledge required for production of the ultra-thin wires (diameter about 10 μm) from copper with increased mechanical characteristics. The results of the last research in the area of the micromechanics allows summarize that decrease in the wire diameter, made from the single crystal, to a several μm causes substantial increase in the mechanical properties without loss of the plasticity. The observed increase in material strength is in the range from 10-30% to a several hundred percent depending on the diameter of the wire and material type. This phenomenon is explaining by the geometrical limitation in dislocation motion free path by decreasing in the wire diameter. However, the known methods of obtaining a such thin wires consist of the cutting the wire from single crystals by ion beam or are based on the nanotechnology. These methods do not allow for production of a wire long enough for numerous practical applications and thus it cannot be taken advantages of the described phenomenon of the wire material hardening in technology.

The research hypothesis is based on presumption, that phenomenon of increase in the wire strength will be observed also for the wires made from polycrystalline material if the diameter of the wire will be comparable with the diameter of the material grain and the crystal lattice orientation will be highly oriented (i.e. indicated a strong crystallographic texture). In the preliminary studies authors of the proposal proved that drawing process of the Mg alloy (the hexagonal crystallographic structure) from the initial wire diameter 1 mm to final diameter 50 μm causes ca. 47 % increase in the wire strength (i.e., from 230 MPa to 340 MPa) and that this strengthening in not due to the material strain hardening. In the classical drawing process of copper it is possible to obtain a wire with the final diameter of 20 μm. This limitation is connected with the need of using the diamond dies and results from the minimal available die diameter. This limitation can be overcome by applying the Dieless Drawing process (DD). DD process consists of the controlled tensile of the local heated wire, what allows for production of the ultra-thin wire without using any dies.

Concluding, the main goal of the project is to develop basic science for the technology based on Modified Dieless Drawing (MDD) process of the ultra-thin wire production and the wire material will have an increased strength resulting from geometrical limitation of the free paths length of the dislocations motion.

The main problem in the DD process is insufficient value of the elongation limit because of two reasons. The first one are the fluctuations in the wire diameter along the obtained wire. The second reason is exceeding the technological plasticity and breaking of the wire. The solution of these problems proposed is based on the knowledge about rheological properties of the material and control of the microstructure defects during the process. It is known, that shape of the stress-strain curve depend on the deformation conditions. If the intensity of the local strain is high enough, the mechanism of compensation of the strain localization activates, what leads to strong strain hardening of the material in the place of the increased strain. The appropriate selection of the process parameters allows for control the material properties in a such way to take the advantages of this mechanism and in result, it can be possible to achieve lower diameter of the wire and higher values of the elongation in the MDD process. Moreover it is possible to define the critical state of the material by the analysis of condition of the microfractures formation in the material. The restoration of the plasticity by heat treatment is impossible after reaching the material critical state in the deformation process.

The model of the critical strain can be based on the in situ test or on tensile test performed in Gleeble simulator in vacuum for the temperature range of 20-800^{0}C. The model of critical strain will help to define the process conditions in a such way to not allow for appearing in the deformed material the defects critical for its plasticity and to make possible the plasticity restoration of the material. The experimental research will be supported by FEM modeling of the MDD process and analysis of the impact of yield stress model on behavior of the artificial fluctuations in initial wire diameter.

The input wire with diameter of 20μm for the MDD is planned to be obtain first by drawing process developed by proposal team. Then, optimal parameters of the MDD process will be find and applied for production of the ultra-thin wire with diameter about 10μm. Than mechanical properties of the obtained wire and advanced metallographic analysis will be performed. Modeling of the yield stress of the wires with different diameters by using the molecular dynamic will be also done.

Results of the project will have an impact on the progress in the field of plastic forming of materials, materials engineering, micromechanics and electronics. There will be opportunities to apply the fundamental phenomenon of improving the strength characteristics of copper in technology and microelectronics.