The main objective of this project is to manufacture ultrafine grained copper bars of large dimensions and to provide an insight into their suitability for conductive structural components by evaluating their abilities to plastic forming and electrical conductivity. Copper is widely used in electric and electronic industry, yet low mechanical strength limits possibilities of application. In this project it is proposed to refine the grain size of pure copper by severe plastic deformation thus enhancing its mechanical strength. It is believed that grain boundary strengthening is less detrimental to electrical conductivity than alloying elements. The major problem identified is a lack of methods allowing for production of UFG copper bars of large dimensions and a lack of comprehensive studies of deformation behavior in multiaxial strain, which would give insight into possibilities of forming. The hypothesis of this project is: Producing long bars of UFG copper of high conductivity, good forming abilities and high mechanical strength is possible using Incremental Equal Channel Angular Pressing (I-ECAP) technique followed by upsetting or extension.

Technically pure copper is going to be processed by a novel technique I-ECAP, which allows for incremental processing of long billets with big cross section. In this method, a plastic strain is applied in a series of small deformation increments, which are based on a simple shear, therefore in terms of deformation, the process is equivalent to conventional ECAP. The feeding and deformation steps are separated, which reduces the friction during feeding and enables the processing of very long or even continuous billets. I-ECAP is a relatively new processing route developed at the Faculty of Production Engineering of Warsaw University of Technology. In this project, the copper bars of extraordinarily large dimensions (10mm x 10mm x 200mm) will be manufactured by I-ECAP and subsequently processed by upsetting or extrusion.

Mechanical strength, forming abilities and electrical conductivity directly depend on material’s microstructure, therefore in the project microstructure will be evaluated in terms of grain geometry and grain boundary character. Other examinations will include determination of mechanical response in uniaxial and multiaxial strain mode and assessing deformation mechanisms; evaluation of potential to plastic forming and evaluation of the influence of microstructure on electrical conductivity.

The project concerns the most important issue in UFG materials, namely how to enhance the effectiveness of the fabrication process in terms of enlarging billet size, which is of utmost importance for creating application potential. The project also focuses on proposing a solution for efficient enhancement of copper mechanical strength while maintaining sufficient electrical conductivity. Providing insight into the influence of microstructure on conductivity will allow to properly shape it. What is more, the innovative part of the project will be multi-axis stress analysis and formability, as most of the available studies concerning ultra-fine grained copper processed by SPD focus solely on the mechanical properties in a single-axis stress state. The proposed project will have a major impact on the scientific and technological development of the SPD field, as the I-ECAP method can create ultra-fine microstructure in extremely large billets, which is a significant achievement on a global scale. However, only the exact microstructural characteristics and description of the properties of the acquired material will allow for a conscious choice of the application path.