Description for the general public

The general idea of presented project is to explore the possibility of producing of new type of ultrafine grained hybrid materials exhibiting high strength and good ductility. Mechanical properties of metallic materials strongly depend on their characteristic microstructural dimensions (eg. the grain size and the density of dislocation). It has been proved that fragmentation of the structure to the micro- and nano scale changes the properties of the material observed in a macro scale. The most popular and efficient way for their production are the so called severe plastic deformation (SPD) methods. In most metallic materials a significant increase of mechanical properties (hardening) is associated with a reduction of plasticity, which from the application point of view is disadvantageous. On the other hand, in some metals like pure aluminium obtaining of true nanocrystalline structure is impossible because of the recovery processes taking place during plastic deformation. Such materials exhibits relatively good plasticity and only a minor increase of mechanical strength (softening), which on the other hand eliminates them from potential industrial applications. The potential solution to this problem lies in the application of SPD processes to produce a new class of hybrid multi-layered materials. Such composites will be characterized by high strength resulting from the presence of elements exhibiting hardening effect and improved plasticity of these exhibiting softening effect. The use of SPD techniques in order to fabricate hybrid materials is a new topic on a field of materials science. It should be noted, that there are only very few reports on the possibility to produce hybrid materials via SPD techniques and they are mostly focused on the microstructure evolution leaving many questions opened. What are the mechanical properties of such composites and what is the impact of the architecture of such materials and processing parameters on these properties? This project is aimed to investigate the issue.

In this project a high pressure torsion (HPT) technique will be used in order to fabricate new class of hybrid materials having unique mechanical properties. The planned studies will be focused on the evaluation of the influence of multilayers architecture (number of layers, their thickness, processed material's combination) and HPT processing parameters (temperature, number of revolutions) on the final microstructure and mechanical properties of fabricated composites. Also the effect of addition of dispersive particles and phase transformations will be evaluated in this project. The quality of fabricated hybrid materials will be verified by microhardness measurements, tensile tests and in a small punch test. Then the samples are subjected to a detailed microstructure analysis with the use of advanced techniques SEM, FIB, TEM STEM, EDX and XRD. Microstructures will be a subject of quantitative and qualitative analysis taking into account evaluation of microstructure and thickness of each layer after the process of HPT, grain size and shape, phase transitions, residual porosity and the quality of the bonding, distribution of dispersive particle in the matrix and changes in chemical composition.

The proposed project is of a great scientific importance and refers to the most current issues in the field of nanomaterials. The project will contribute to the creation of new class of materials having unique microstructure and mechanical properties by joining materials exhibiting different hardening behavior during SPD processing