Description for the general public

The general objective of the project is to explore the possibility of producing ultrafine grained (UFG) plates with uniform microstructure and capabilities to low anisotropy, deep drawing and superplastic deformation at high strain rates. Ultrafine grained (UFG) materials have attracted significant attention over last years due to their superior mechanical properties, in particular very high strength, which makes them attractive for structural applications. The most popular and efficient way for their production are the so called severe plastic deformation (SPD) methods, in which unusually high strains are applied to a material in order to reduce the grain size. In the present project, SPD processed UFG materials are to be considered as a semi-final products, which will be a subject of further processing via deep drawing or superplastic forming. The most suitable form of a material for such a processing are plates or thin sheets. Although a tremendous progress has been made in SPD processing, the vast majority of them can efficiently deform billets in the form of bars, rods or small disks. In addition, the most important plastic deformation techniques are directional in nature and produce materials with a strong texture and microstructural anisotropy, which transfers into mechanical properties, which depend on the testing direction. Such an anisotropy is undesirable for further processing operations. The problem identified is a lack of reliable and simple technique to produce UFG plates with isotropic UFG structure necessary for deep drawing or superplastic behavior. The hypothesis set in this context is: UFG plates with capabilities to low anisotropy, deep drawing and superplastic deformation at high strain rates can be obtained by Incremental Equal Channel Angular Pressing (I-ECAP).

In this method, a plastic strain is applied in a series of small deformation increments, which are based on a simple shear (in terms of deformation, the process is thus 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. The fabricated plates will be characterized in terms of their microstructures. The microstructural parameters of interest include: average grain size, grain size distribution, grain elongation, distribution of grain boundary misorientation angles, fraction of high angle grain boundaries, distribution of grain orientations (texture). In the next step, the anisotropy of the mechanical properties will be evaluated through microhardness measurements (across the plate's thickness) and in tensile tests (samples for tensile tests will be cut at different angles with respect to the deformation direction of the last pass). The ability to deep drawing will be evaluated by deep drawing test. The superplastic capabilities will be determined in a series of tensile tests conducted at elevated temperature and at various strain rates to demonstrate possible high strain rate superplasticity. Finally, the mechanisms of superplastic deformation will be studied via in-situ and ex-posed investigations. Deep drawing and superplastic deformation is an important field of scientific research because of significant challenges in plastic flow and fracture as well as due to underling basis for commercial superplastic forming, in which complex shapes and curved parts can be produced.