Tuning of nanomaterials by high pressure annealing

One of the foundations of our modern world are highly functional materials. The possibility of controlling materials properties is important in their development and applications. A large part of the material production consists of the base manufacturing (alloying, mixing, …), modifying the initial microstructure (casting, forging, …) and a final adjustment step (quenching, annealing, …). In the case of metals usually heat treatment is needed. The factors adjusted for influencing properties of the final product are annealing time, temperature and heating/cooling speed.

Recently, a new group of materials – **nanostructured materials** (of structural elements below 100 nm) have emerged. They are materials of unpreceded strength and many other extraordinary properties e.g. magnetic, electrics, thermoelectric etc. However, they exhibit limited plasticity as well as thermal stability. In this project nanomaterials (copper, silver, nickel, and copper alloys) will be produced by severe plastic deformation, more precisely by high pressure torsion. High pressure torsion is the method of choice for fundamental research since it is the most efficient method for grain refinement. Subsequently, deformed samples will be annealed in an unconventional manner and conventionally for comparison. **The high hydrostatic pressure annealing has been proposed as a new innovative option for annealing.** This process assures one more controllable parameter during annealing, consequently, increases the possibilities to optimize the properties of nanomaterials. Previous research performed on a nanostructured austenitic stainless steel has successfully showed that this method makes it possible to slow down diffusion processes.

As a result, the annihilation of defects and the rate of grain growth are retarded and the nanostructure of much greater thermal stability than after conventional annealing can be preserved after such annealing. Moreover, the controllable annihilation of defects and grain growth may enable obtaining nanostructures of the desired strength-plasticity balance and in case of nickel magnetic properties. The application of high hydrostatic pressure annealing as an innovative method to improve the properties nanostructured materials is an original approach since using the same device for deformation and annealing enables fast and efficient processing, which will also be important for the application. In addition, it makes possible the verification of pressure impact between deformation and annealing. Moreover, in-situ synchrotron investigations will create new knowledge about described phenomena impossible to achieve by standard research techniques. **This opens new possibilities for tuning nanomaterials to create materials that will improve the world we live in.**