

Stress and strain-induced phase transformations in High-Entropy Alloys

High entropy alloys (HEAs) are a new class of materials breaking away from the conventional alloying strategy. Originally, they were designed as complex alloys containing at least five elements with equiatomic or nearly equiatomic composition. On the basis of large experience with conventional alloys a number of intermetallic phases was expected to appear in the newly formed systems. Surprisingly, the crystal structures obtained were rather simple. The reason for that is the very high mixing entropy of multi-element alloys favouring the formation of a random solid solution rather than intermetallic phases. However, although many studies have been conducted to produce and examine equiatomic HEAs most of them show a very poor plastic response in tensile test. In fact the only one exception from this general trend is reported by Otto et al. where the CoCrFeMnNi HEA shows a good ductility. It has not yet been determined whether it is because of processing issues or whether due to undefined or undictated intermetallic phases which may be distributed within the material.

On the other side thermally or mechanically induced phase transformations seem to be one of the best strategies to improve mechanical properties of metals and alloys. On one hand, it allows to introduce one additional deformation mode (beside slip and twinning) which improves the alloy formability, on the other it makes the microstructure more complex increasing the strength of the material.

Therefore, the main goal of the present research program is to produce a dual-phase microstructure using stress and strain-induced phase transformations in HEA-based materials. The design of high performance and high strength materials will be based on the strategy that stabilizes metastable structures (low-temperature phases). Depending on the system unique mechanical properties at low and high temperatures are expected.

Generally, the HEAs are very stable. Even high hydrostatic pressure does not transform the ground state to martensitic phase. However, applying high pressure combined with extremely high shear deformation allows to reduce the pressure for initiation of phase transformation even up to an order of magnitude. In such a way a dual-phase material containing high and low-temperature phases can be obtained. One of the examples is the prototype Cantor alloys that subjected to high-pressure torsion transforms from *fcc* to *hcp* phase yielding a complex microstructure. Such a microstructure can be even more complex if thermally treated or modified by chemical composition.

For all the foregoing reasons the main goal of the project is (i) to find the mechanism responsible for forward and backward phase transformation in *fcc* and *bcc* HEAs, (ii) to mechanically stabilize the low-temperature martensitic phase, (iii) to chemically stabilize the low-temperature martensitic phase by element variation (iv) to model texture and defects density after HPT and subsequent heat treatment, and finally (v) to produce a dual-phase material with lamellar structure.