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Microstructure-Functional Behavior-Relationships in High Entropy Shape Memory Alloys

The proposed project aims at developing a detailed understanding of the microstructureproperty-relationships of high entropy shape memory alloys (HESMAs), which represent a fascinating new class of functional materials. HESMAs were introduced by Firstov et al. in three recent publications. These materials represent multi-component functional materials which are able to re-establish their initial geometry after a deformation significantly exceeding elastic strains. This ability is based on a reversible martensitic transformation. HESMAs differ from conventional shape memory alloys (e.g. Ni-Ti) in terms of chemical complexity as they contain five or six alloy components. Little is known about HESMAs but the preliminary results from Firstov et al. have documented fascinating features, which represent key properties for the next generation of shape memory alloys. Most importantly, they show a reversible martensitic transformation at temperatures well above 100 °C, which has motivated the present project to address two scientific objectives in the field of HESMAs: First, to find out how the martensitic transformation occurs in an alloy which does not belong to the conventional binary or ternary alloy systems, but consists of more alloying elements. Fundamental questions like how diffusion occurs in HESMAs, how the yield stress of HESMAs depends on temperature, and how this is related to dislocation plasticity and mechanical twinning also need to be answered. It is not clear how the interplay of alloy elements in a HESMA affects basic atomistic, crystallographic, mesoscopic and macroscopic features of the martensitic transformation. Second, to make a new contribution to the field of high temperature shape memory alloys. Difficulties with other high temperature shape memory alloys like problems with forming (e.g. Ni-Ti-X, X=Hf, Zr) or with melting and fast precipitation of secondary phases (e.g. Ti-Ta) demand new concepts. In the present project the nature of the martensitic transformation, the formation of additional phases (which includes diffusion), and elemental deformation mechanisms, as well as fatigue will be investigated. Furthermore, it is required to investigate how HESMAs with attractive functional properties can be produced. These aspects will be investigated at the Ruhr-Universiät Bochum and the Leibniz Universität Hannover within a joint research project.