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Strength and deformation of precious high entropy alloys

The present proposal aims at developing a deeper and comprehensive understanding of the deformation and strengthening mechanisms of a single phase, face centred cubic, multi-component homogeneous solid solution. This will be achieved upon a sound description of the structure-property relationships in Au-Cu-Ni-Pd-Pt high entropy alloys. These alloys have been proven to be (i) single phase, and (ii) a homogeneous solid solution can be obtained, which (iii) presumably holds for the entire concentration range.

The Au-Cu-Ni-Pd-Pt system is the only known system that allows to investigate effects of compositional changes, presumably in the whole range, without the necessity to also consider the occurrence of structural changes of secondary phases. The single phase microstructure is the decisive factor for a sound description of the properties, as this allows to solely investigate issues such as solid solution and grain boundary hardening without the necessity to also consider any effect of secondary phases. Consequently, well designed alloy-series with deliberately adjusted compositions will be characterised to visualise the influence of the lattice misfit parameter on the yield strength. This misfit parameter represents the key parameter in the most widely accepted model of solid solution strengthening in multicomponent alloys. With the help of such alloy-series, another assumption of the model, that the shear modulus of an alloy is determined according to Vegard's rule of mixture, will be verified (or falsified). I order to obtain a sound description of the mechanical properties of the alloys, an investigation of the influence of the grain size and the strain rate will also be done. Mechanical twinning is supposed to occur at high strain rates, and it will be shown how twinning is activated with ease at higher strain rates. High strains, as obtained from cold work and severe plastic deformation, as well as the formation of mechanical twins are efficient measures to refine the microstructure. These processing schemes will allow to identify the active deformation mechanism.

The results will be used to separate the material behaviour of the HEAs cleanly from that of single phase conventional alloys and to identify which issues are special for HEAs leading to their peculiar properties.