INVESTIGATING THERMALLY ACTIVATED DEFORMATION MECHANISMS BY HIGH TEMPERATURE NANOINDENTATION – A STUDY ON W-RE ALLOYS

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Since the advent of indentation at elevated temperatures the technique of high-temperature nanoindentation has been further developed, currently enabling testing temperatures above 1000 °C. Due to small sample sizes and a variety of different testing techniques this method provides the opportunity for alloy development at a new level regarding composition variety or efficiency. In this study the thermally activated deformation mechanisms in binary W-Re alloys will be investigated by using a high-end in-situ nanoindenter.

For that purpose, three different materials were tested, namely commercially pure W, W5Re and W10Re, all of them in both, coarse grained and ultra-fine grained condition. Nanoindentation experiments were conducted from ambient temperatures up to 800 °C, thereby overcoming the critical temperature T_C of tungsten at around 450 °C. With temperature increments of 100 °C a large range of the normalized temperature with respect to T_C is covered, allowing general conclusions regarding the appearing deformation mechanisms in bcc metals. Additionally to constant indentation strain rate tests, strain rate jump tests were utilized to determine the mechanical properties and to evaluate the impact of temperature and microstructure on rate-dependent parameters.

A strong influence of the alloying level with Re as well as the grain size on both, the thermal and athermal contribution to the flow stress, is observed. The origin and effects, such as solid solution softening for W5Re at temperatures far below T_C, will be discussed in detail. Furthermore, the dominating deformation mechanisms in dependence of temperature and grain size are determined. In the coarse grained materials a change in deformation processes from kink-pair mechanism to dislocation-dislocation interaction at higher temperatures can be observed, while in ultra-fine grained materials grain boundary/dislocation interactions are responsible for the maintained time-dependent mechanical behavior.