Local Plasticity of Metals upon Phase Transformations – A Complementary Nanoindentation Study

Verena Maier-Kiener[a],

[a]*Montanuniversität Leoben, Department Materials Science*

[a]*verena.maier-kiener@unileoben.ac.at*

In past years, nanoindentation became a versatile tool for assessing local mechanical properties far beyond hardness and modulus. By adjusting standard nanoindentation methods, it was possible to receive measurement protocols such as nanoindentation strain-rate jump or long term creep tests designed especially to probe thermally activated deformation processes. From both approaches, hardness and strain-rate, and consequently strain-rate sensitivity and activation volume, can be reliably deducted, which provide further information and insights concerning the governing thermally activated deformation mechanism. [1]

A further newly introduced field of application for high temperature nanoindentation as a complimentary method is studying the mechanics of plasticity upon bulk phase transformations. [2] In the presented study, a bell-bronze alloy, namely Cu20Sn, was intensively investigated regarding phase transformations and corresponding local mechanical properties. Within this alloying system various different high-temperature phases were adjusted by different heat treatments accompanied by subsequent quenching. These multi-phase alloys were afterwards investigated in detail by optical, laser scanning as well as electron microscopy, XRD as well as high temperature nanoindentation. Interestingly, two previously unknown meta stable phases were discovered. For those novel phases, fundamental crystal structures were suggested using high-energy XRD investigations. For all adjusted phases, including also these novel hexagonal ones, the local mechanical properties were measured over temperature in order to shed light into their thermally activated deformation behaviour. All together this complementary approach allows a straight forward thermo-mechanical characterization of individual phases in a complex multi-phase material. Furthermore, these analyses also allow the correlated investigation between deformation behaviour and crystal structure of newly discovered unexplored phases.

Keywords: high temperature nanoindentation, phase transformation, rate controlling deformation mechanism.

References:

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