PHASE TRANSFORMATIONS AND LOCAL DEFORMATION MECHANISMS – A CASE STUDY ON CU 20 M.% SN

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Bronze, a Cu-Sn alloy, has numerous applications, ranging from electrical components to alloys used in musical instruments. This evidences that this material exhibits a broad spectrum of properties. Particularly beneficial for adjusting the properties are the occurring intermetallic phases and the accompanying phase transformations [1]. Thereby one major task of this work is to investigate the local mechanical properties as a function of temperature.
As the intermetallic phases β, γ, and δ have not been mechanically characterized in literature, high-temperature nanoindentation (HT NI) presents itself as a versatile measurement approach [2]. Not only conventional mechanical properties, such as hardness and modulus can be studied temperature-dependent via HT NI, but also thermally activated mechanical properties such as strain-rate dependence and the associated activation volume can be investigated: This correspondingly allows conclusions on the prevailing rate-controlling deformation mechanisms and the change in these depending on the individual phases.

In this work, the Cu-20 m.% Sn alloy was studied in detail with respect to its thermal properties and correlated to its mechanical properties. First, in-situ investigations were carried out utilizing high-temperature X-ray diffraction and high-temperature scanning electron microscope up to a temperature of 535 °C. Two metastable, previously unreported phases, here called HEX_{β} and HEX_{γ}, were discovered in the temperature range between 160 and 340 °C. Further, these phases, as well as the intermetallic high-temperature phases β, γ, and δ, were characterized by HT NI up to 535 °C. It is found that the high-temperature β and γ phases have similar properties, as both resemble a body-centered cubic structure and thus the so-called double-kink mechanism is rate-controlling during deformation. The crystallographically very complex δ phase shows face-centered cubic-like and therefore temperature-activated deformation behavior. The results indicate that the newly discovered metastable phases exhibit similar properties as the equilibrium δ phase.

Summarized, the Cu-20 m.% Sn alloy, including its intermetallic phases, was characterized regarding their thermal stability and mechanical properties. Two metastable phases were detected and mechanically characterized together with the intermetallic phases β, γ, and δ up to 535 °C.

References

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