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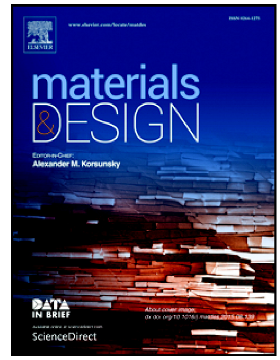

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Superplastic deformation behavior of Zn-22% Al alloy investigated by nanoindentation at elevated temperatures

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Abstract

Due to their high ductility, superplastic metallic alloys are promising candidates for microforming processes. However, it is not yet clear if the macroscopically observed superplastic material behavior also persists at micrometric length scales. For this reason, the superplastic deformation behavior of the eutectoid alloy Zn-22% Al was investigated at the microscale as a function of temperature, strain-rate and grain-size. Nanoindentation strain-rate jump tests at room temperature and elevated temperatures were correlated with the deformed microstructure. A sigmoidal relationship between the hardness and the strain-rate is evidenced, which is typical for superplastic alloys at the macroscale. In the central part of the sigmoidal curve strong indications for superplastic flow at the microscale are found. Microstructural investigations of the residual indents reveal noticeable intercrystalline deformation processes in combination with some intracrystalline dislocation activity regardless of the applied testing conditions. These experimental findings were further coupled with finite element analysis to determine the size of the plastic zone beneath the indents as a function of the penetration depth. Based on this, a critical cubic material volume of 8 grains over the edge length is found to be sufficient for superplastic flow at local length scales.

Keywords: Nanoindentation; Superplasticity; Deformation mechanism; Microforming

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