ICSMA19 Metz, France, June 26 - July 1, 2022
International Conference on Strength of Materials

On twinning and shear banding in copper single crystals of {110}<112>, {112}<111> and {123}<634> initial orientations deformed at high strain rates

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Abstract

The microstructure and texture evolution in high purity copper single crystals of brass{110}<112>, C{112}<111> and S{123}<634> initial orientations were investigated to evaluate the influence of high strain rate on the intensity of twinning and shear banding. The samples were deformed up to 60% in a channel-die at strain rate of 4×10^5 s^{-1}. Explosive energy was used to propel the punch in the channel-die. The microstructure was characterized over a wide scale of observations by optical microscopy as well as scanning (SEM) and transmission electron microscopy, whereas SEM equipped with electron backscattered diffraction facility and X-ray diffraction were used to evaluate the texture changes in micro- and macro- scales, respectively. The results were analyzed with respect to the behavior of single crystalline samples deformed in plane state at conventional strain rates.

High strain rates deformation of C{112}<111> and S{123}<634> oriented single crystals lead to massive deformation twinning. In spite of identification of three families of compact clusters twins of two generations, the microstructure and texture of both single crystals is dominated by the twinning on the co-planar slip plane. This dominant structure of twin-matrix layers favors the formation of plastic flow instabilities in the form of shear bands (SB). The common twin-matrix layers rotation, within the narrow area, combined with deformation twinning in re-oriented matrix is responsible for final SB texture formation. This mechanism contributes to the formation of orientations from the neighborhood of the {110}<100> orientation. The {110}<112> orientation, stable during plane state of strain deformation at ‘conventional’ strain rates, lost own structural and textural stability and both, twins and shear bands are present in the microstructure of deformed specimen.

Acknowledgments

This research was supported by Polish National Centre of Science (NCN) within the project no.: UMO-2018/31/B/ST8/00942 (Opus).