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Shear avalanches in plastic deformation of a metallic glass composite

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Abstract

Changes in intermittent shear avalanches during plastic deformation of a $Cu_{50}Zr_{45}Ti_5$ (atomic percent) alloy in response to variant structures including fully glassy phase and/or nanocrystal/glass binary phase are investigated. Second crystalline phases are introduced into the glassy-phase matrix of a $Cu_{50}Zr_{45}Ti_5$ metallic glass to interfere with the shear-avalanche process, which can release the shear-strain concentration, and then tune the critically-dynamic behavior of the shear avalanche. By combining microstructural observations of the nanocrystals with the statistical analysis of the corresponding deformation behavior, we determine the statistic distribution of shear-avalanche sizes during plastic deformation, and established its dependence on the geometric distribution of nanocrystals. The scaling behavior of the distribution of shear-avalanche sizes follows a power-law relation accompanied by an exponentially-decaying scaling function in the pure metallic glass, and the metallic glass containing the small nanocrystals, which can be described by the mean-field theory. The large shear-avalanche events are dominated by structural tuning-parameters, i.e., the resistance of shear banding, and the size and volume fraction of the second crystalline phase in metallic glasses.

Keywords: Metallic glasses composites; Second phase; Dynamics of shear avalanche; Nanotwin