Nondestructive characterization of dislocation substructures of planar and wavy slip materials subjected to cyclic plastic deformation

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The object of this study is to evaluate and discriminate nondestructively the dislocation substructures of planar and wavy slip materials subjected to the cyclic plastic deformation. The localization of plastic strain is a typical feature subjected to fatigue damaged materials, which accompanied by changes in the dislocation substructures during cyclic deformation. The cyclic damage starts at the sites of its strain localization, persistent slip band (PSB) and the fatigue crack nucleation is a direct consequence of the temporarily irreversible slip activity localized within PSB. The cyclic fatigue test of the pure copper and brass with much different stacking fault energies was conducted. The correlations among dislocation behavior, ultrasonic wave velocity, and nonlinear ultrasound (NLU) were studied. The dislocation cell substructure was well developed in pure Cu due to its high stacking fault energy, while planar-array dislocation structure was developed in low stacking fault energy materials, brass (Cu-35Zn) alloy without any change of configuration. In both materials, the ultrasonic longitudinal wave velocity decreased, while the NLU parameter increased with fatigue cycles. It does not make any noticeable changes after the evolution of dislocation cell substructure in pure Cu. But, for the brass (Cu-35Zn), the ultrasonic velocity decrease and the NLU parameter increase monotonously with increasing fatigue cycles up to failure. Consequently, it may be concluded that the wavy slip materials are more sensitive to the ultrasonic wave velocity and NLU parameter than the planar slip materials.