Abstract Title

Ultrasonic Evaluation of Point Defect Dependence of Elastic Stiffness Degradation and Its Correlation with Localized Deformation

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Abstract body

In the authors' previous studies[1]-[8], the dependence of ultrasonic wave velocity on the micro-structural property changes of solid materials under plastic deformations were studied both theoretically and experimentally. For example it is found that longitudinal wave velocity changes between under the simple and pure shear states are quite different, on the other hand transverse wave velocity changes under simple and pure shear states are almost same as similar to the texture development under both shear states. These results clearly suggest that the propagating character of ultrasonic waves is dependent upon its interaction between the propagating mode of ultrasonic waves and micro-structural material changes induced by damage due to plastic deformation. In this paper to identify the dependence of the velocity changes of longitudinal and transverse waves upon what kind of micro-structural material changes, respectively, the longitudinal and transverse wave velocities propagating a pure Aluminum single crystal under pure shear plastic deformation are examined for several combinations of crystal orientations and shear slip directions, and also wave propagating directions; by the comparison of experimental data with theoretical consideration the point defect dependence of the longitudinal wave velocity and the dependence of the transverse wave velocity upon the deformation induced anisotropy are suggested. Then the point defect dependence of the longitudinal wave velocity under the pure shear state is examined based on both of no point defects caused by intersected cross slip among dislocations under single slip stage simulated by FEM analysis for crystal plasticity and experimental evidence of no longitudinal wave velocity changes under the same stage in a pure Aluminum single crystal. The point defect dependence of the longitudinal wave velocity suggests the elastic stiffness degradation due to plastic deformation damage which is closely related to the deformation instability mechanism. Therefore, in this paper FEM numerical simulations regarding to the contour line of amount of point defects estimated by the calculation of the intersected cross slip among dislocations under several proportional loading paths are performed and compared with the experimental results of necking onset strains in an Aluminum specimen measured by laser speckle method. The good agreement between the simulated and experimental results regarding the onset of the deformation instability suggests that the proposed algorithm to calculate the amount of point defects caused by intersected cross slip among dislocations has ability to be unified criterion for both localized and diffused necking

Keywords

Ultrasonic Nondestructive Material Evaluation, Ultrasonic Wave Velocity, Point Defects, Intersected Cross Slip, Deformation Induced Anisotropy, Elastic Stifness Degradation, Localized Deformation, Localized Necking, Diffused Necking, Unified Criterion

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