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Abstract

We present a new methodology for experimental validation of single crystal plasticity constitutive relationships based upon spatially resolved measurements of the direction of the Net Burgers Density Vector, which we refer to as the β-field. The β-variable contains information about the active slip systems as well as the ratios of the Geometrically Necessary Dislocation (GND) densities on the active slip systems. We demonstrate the methodology by comparing single crystal plasticity finite element simulations of plane strain wedge indentations into face-centered cubic nickel to detailed experimental measurements of the the β-field. We employ the classical Peirce-Asaro-Needleman (PAN) hardening model in this study due to the straightforward physical interpretation of its constitutive parameters that include latent hardening ratio, initial hardening modulus and the saturation stress. The saturation stress and the initial hardening modulus have relatively large influence on the β-variable compared to the latent hardening ratio. A change in the initial hardening modulus leads to a shift in the boundaries of plastic slip sectors with the plastically deforming region. As the saturation strength varies, both the magnitude of the β-variable and the boundaries of the plastic slip sectors change. We thus demonstrate that the β-variable is sensitive to changes in the constitutive parameters making the variable suitable for validation purposes. We identify a set of constitutive parameters that are consistent with the β-field obtained from the experiment.

Keywords: B.Single Crystal Plasticity; C.Finite Element Simulations; C.β-fields; A.Lattice Rotation; A.Slip Systems.