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Comparing the predictions of a non-Schmid crystal plasticity model with phenomenological hardening and dislocation density hardening rules for superconducting cavities used in particle accelerators

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ABSTRACT

High purity niobium is used to make superconducting radio frequency cavities. One potential fabrication method involves deep drawing cup-like shapes form slices of an ingot containing only a few grains. Thus, material models for large strain deformation of multicrystals are needed to predict conditions that lead to forming instabilities and to predict future responses to heat treatments to remove as many dislocations as possible. Deformation behavior of BCC materials does not follow the Schmid law. Therefore, the classical crystal plasticity cannot be used to predict their behavior. In BCC materials, core of screw dislocations expand on three different <110> planes, and influences from the stresses on each of these planes. This is known as non-Schmid behavior. In this study, a non-Schmid crystal plasticity model with a phenomenological hardening rule is developed and calibrated for single crystal niobium (Nb). The model accurately predicts the stress–strain response of Nb; however, the estimated crystal orientation evolution is not as accurate. A dislocation density hardening model is implemented to increase the accuracy of texture predictions. The results of these two hardening models are compared.