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Abstract:

In this paper, we introduce an original experimental protocol that couples microstructural analyses before and after deformation to in-situ grain scale strain measurements in OFHC copper samples during dynamic loading. This analysis is conducted on a modified shear compression specimen (SCS) that exhibits localization within a flat gage section and hence lends itself to ultra-high-speed imaging of the localization evolution. We were thus able to study the influence of the microstructure on strain localization as well as the process of localization in OFHC copper submitted to high-strain rate loading at different rates. We found that in the case of these modified perforated SCS samples, the early stages of localization were geometry driven while grain size and strain-rate dependency only emerged later. For the two smallest grain sizes examined here, a stronger strain-rate dependency was observed. This led to a narrower and more elongated localization of the highest strains at the local scale and to a concurrent harder macroscopic response at higher strain rate. For the largest grain size examined here, the macroscopic response was nearly identical at both strain rates but largely softer than for the smaller grain sizes. This translated into a wider localization pattern in the local strain fields compensating for lower values of maximum local strain. Texture evolution was strongly grain-size-dependent as smaller grain-size samples showed very mild lattice rotation accompanied with dynamic recrystallization into smaller grains, while the large grain-size samples showed a marked texture formation accompanied with both grain growth and stress relaxation phenomena. The introduced experimental protocol can thus give access to data providing new insight into microstructural aspects of localization under dynamic loading; such data is additionally relevant for validating multiscale or crystal plasticity models for dynamic applications.

Keywords: A. dynamics; B. polycrystalline material; C. electron microscopy; C. Kolsky bar; ultra-high-speed imaging