Texture evolution during hydrodynamic microparticle penetration: a case of Cu-Cu impact

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Abstract

Understanding microstructural texture evolution during hydrodynamic penetration (HDP) is of interest to the field of ballistic impact science, especially for the design of damage-tolerant materials. One major challenge though is that HDP, such as those observed during asteroid strikes in planetary applications, shaped charges, and microparticle impact in cold spray applications, are accompanied by extremely large strains and strain rates; this makes texture evolution challenging to study due to low-quality pattern indexing. In this work, a laser-induced particle impact tester is used to launch single copper microparticles at impact velocities above 1 km/s where HDP and material erosion would set on. To examine texture evolution during such microparticle impact in HDP condition, EBSD Dictionary Indexing (EBSD-DI) and orientation refinement by BOBYQA (bound optimization by quadratic approximation) algorithm were employed to evade poor indexing by standard Hough-based indexing. Using this approach, points near the highly strained particle-substrate interface that could not be indexed by standard Hough-based indexing are successfully indexed, and the stray misindexings are eliminated. Furthermore, discrete orientation indexing due to the choice of cubochoric grid is addressed by additional orientation refinement of the dictionary-indexed data. Coupled with scanning transmission electron microscopy, the evaluation of texture aided by EBSD-DI and orientation refinement allows us to catalog heterogeneous microstructures that result during HDP, which includes strengthening of stable end-orientations- and ——ID at the expense of ——ID, deformation twinning, and multiple dislocation-mediated grain recrystallization mechanisms-geometric dynamic recrystallization (gDRX), discontinuous DRX (dDRX), and meta DRX (mDRX).

Keywords: High velocity impact, Hydrodynamic particle penetration, Dynamic recrystallization, Metadynamic recrystallization, Electron backscatter diffraction, Dictionary indexing, Orientation refinement

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