

Subsurface Dislocations Activity under Frictional Sliding: A Discrete Dislocation Analysis

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Discrete Dislocation Plasticity (DDP) analysis is performed on single crystal thin films contacted by a spherical rigid indenter, which can be used to mimic asperity contacts. The research focuses on the subsurface dislocations activity and the induced deformation, stress and strain fields; in particular, the lattice rotation within the crystalline materials underneath the contact is analysed during the sliding process.

Experimental studies have recently observed the microstructure alteration (trace lines) in the subsurface region of various crystalline materials under tribological loads [1]. Numerical investigations including the work presented in literature were performed to understand the intrinsic mechanisms responsible for the subsurface modification under sliding. However, due to the complexity of the tribology contact conditions and non-linear material response, neither experimental nor numerical studies have yet provided a satisfactory explanation of the phenomenon. A more recent experiment that adopts Scanning Transmission Electron Microscopy (STEM) has shown a contrast change in the subsurface of copper films under sliding; here the contrast change is interpreted using our simulations to show a dislocations piling up pattern, which may reveal the mechanism responsible for the microstructural change.

We herein employ the 2D Discrete Dislocation Plasticity calculation framework, which explicitly describes the dislocations activity and thus the consequent material deformation, to understand its link to the microstructural change in the subsurface of single crystal materials under dry sliding condition. The material behaviour is completely governed by the dislocation movement along the predefined slip systems within the crystal. The normal behaviour of the contact between the specimen and single asperity is established by a preceding indentation process, and the tangential interactions are defined using a cohesive relation. Preliminary results generated by a series of simulations reveal that the substructure change observed in the experiment are due to highly localized lattice rotation. This research sheds light on the mechanism of microstructural changes in

metallic thin films by explicitly illustrating the effect that dislocation interactions have on the material response under various indentation and sliding scenarios.

[1] Greiner, C., et al., ACS Appl. Mater. Interfaces, 2016, 8 (24), pp 15809–15819