All possible binary dislocation locks in face-centered cubic materials unearthed via a novel discrete mathematics-based approach

Dhruv Bajaj[1] and Daolun Chen*†[1]

[1]Department of Mechanical, Industrial and Mechatronics Engineering, Toronto Metropolitan University, Toronto, Canada – Canada

Abstract

The concept of dislocations, along with their movement, reaction/intersection and the formation of locks/barriers, is a cornerstone in understanding the mechanical behavior of crystalline materials including strength and strain hardening. Although some dislocation locks in face-centered cubic (FCC) materials, such as the well-known Lomer lock and Cottrell lock, have been identified via high-resolution transmission electron microscopy observations and molecular-dynamic simulations, it remains unknown how many binary dislocation locks are possible when two dislocations come from intersecting slip planes and how immobile these locks are. In this work, a novel discrete mathematics-based approach is proposed to unveil dislocation locks in FCC materials, resulting from all possible reactions of mobile/glissile dislocations (i.e., perfect and Shockley partial dislocations) in two cases: (i) non-coplanar dislocations residing on two {111} slip planes intersecting at both obtuse (109.47◦) and acute (70.53◦) angles, and (ii) coplanar dislocations. In total, eight binary dislocation locks are derived from all possible 50 non-coplanar dislocation reactions together with all coplanar dislocation reactions. Specifically, more dislocation locks (68% of 25 dislocation reactions) are formed when the incoming reactant dislocations are obtusely oriented. Only 24% of 25 dislocation reactions are energetically feasible when the incoming reactant dislocations are acutely oriented. All the dislocation lock planes are found to be uniquely situated in a "fan-shaped" sector convergently. A new definition of the degree of lock immobility is also put forward according to the misorientations between non-close-packed lock planes and close-packed {111} slip planes. Details will be presented at the conference.

*Speaker

†Corresponding author: dchen@torontomu.ca