ACEX2019

13th International Conference on Advanced Computational Engineering and Experimenting
ATHENS (Greece) from 1-5 July, 2019

Testing the reliability of methods to determine the critical resolved shear stresses in hexagonal materials with virtual experiments

Aritra Chakraborty, Chen Zhang, Thomas R. Bieler, Philip Eisenlohr

Chemical Engineering and Materials Science,
Michigan State University, East Lansing, MI, USA

Crystallographic slip in hexagonal metals involves a number of geometrically distinct slip families characterized by their slip direction and slip plane (basal, prismatic, and pyramidal).
Owing to the low symmetry of hexagonal lattices, each of these slip families only have few symmetrically equivalent slip systems (family members).
Furthermore, different slip families become active at different resolved shear stress, i.e. have differing critical resolved shear stress (CRSS).
The entailing plastic anisotropy of hexagonal materials renders the numerical prediction of their plastic behavior challenging and depends critically on the knowledge of CRSS values.
The present contribution tests and compares the reliability of three proposed methods for quantification of CRSS values of the different hexagonal slip families.

Those methods (a to c) rely on:
(a) the statistics of surface slip traces in a (slightly) deformed polycrystal;
(b) an iterative adjustment of CRSS values until a simulated single crystal indentation matches the corresponding experiment in terms of load–displacement response and residual surface topography of the indent;
(c) in-situ high-energy X-ray diffraction to identify the lattice orientation and lattice strain evolution of grains that are argued to plastically deform under conditions of single slip.
All three methods are applied to virtual experiments performed on synthetic microstructures to assess how reliably the known CRSS values of the constitutive material description can be identified.