Steady-state crack growth in single crystals under Mode I loading - DTU Orbit (22/08/2019)

Steady-state crack growth in single crystals under Mode I loading

The active plastic zone that surrounds the tip of a sharp crack growing under plane strain Mode I loading conditions at a constant velocity in a single crystal is studied. Both the characteristics of the plastic zone and its effect on the macroscopic toughness is investigated in terms of crack tip shielding due to plasticity (quantified by employing the Suo, Shih, and Vajrak set-up). Three single crystals (FCC, BCC, HCP) are modelled in a steady-state elastic visco-plastic framework, with emphasis on the influence of rate-sensitivity and crystal structures. Distinct velocity discontinuities at the crack tip predicted by Rice [Rice J.R., 1987. Tensile crack tip fields in elastic-ideally plastic crystals. Mech. Mater. 6, pp. 317–335] for quasi-static crack growth are confirmed through the numerical simulations and highly refined details are revealed. Through a detailed study, it is demonstrated that the largest shielding effect develops in HCP crystals, while the lowest shielding exists for FCC crystals. Rate-sensitivity is found to affect the plastic zone size, but the characteristics overall remain similar for each individual crystal structure. An increasing rate-sensitivity at low crack velocities monotonically increases the crack tip shielding, whereas the opposite behaviour is observed at high velocities. This observation leads to the existence of a characteristic velocity at which the crack tip shielding becomes independent of the rate-sensitivity.

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Solid Mechanics
Corresponding author: Juul, K. J.
Contributors: Juul, K. J., Nielsen, K. L., Niordson, C. F.
Pages: 209-222
Publication date: 2017
Peer-reviewed: Yes

Publication information
Journal: Journal of the Mechanics and Physics of Solids
Volume: 101
ISSN (Print): 0022-5096
Ratings:
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.03 SJR 1.988 SNIP 1.83
Web of Science (2017): Impact factor 3.566
Web of Science (2017): Indexed yes
Original language: English
Keywords: Crystal plasticity, Plastic zones, Quasi-static crack growth, Rate-sensitivity, Shielding effect
Electronic versions:
Juul2017b. Embargo ended: 25/01/2019
DOIs:
10.1016/j.jmps.2017.01.012
Source: Scopus
Source-ID: 85012077956
Research output: Contribution to journal › Journal article – Annual report year: 2017 › Research › peer-review