Materials Science and Technology Division

"Fracture in Single and Bicrystals of Zinc: Experiments and Computational Modeling"

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10:00 a.m.
4500S, Room A-177

Abstract:

Crystallographic misorientation of preferred fracture planes across grain boundaries plays a significant role in transgranular fracture, and a correlation between fracture resistance and misorientation has been observed in technologically relevant alloys such as Ti-Al, Al-Li and Fe-Si; but, microstructural complexity, a lack of control over misorientation, and a lack of understanding of mechanisms of crack transmission across grain boundaries have hindered a clear understanding of the phenomenon. In the present study, we have conducted *in situ* crack propagation experiments in zinc bicrystals of controlled twist misorientation (of the basal plane) while varying this misorientation in a systematic fashion. In an intrinsically brittle material (K_{Ic} < 1 MPa√m) where crack growth would have proceeded unimpeded otherwise, a twist misorientation alone results in significant crack propagation resistance, thereby establishing an unambiguous causal relationship between the two. Experimental observations have brought to light a complex interplay between several dissipative mechanisms during crack-grain boundary interaction such as strain localization, multiple cracking across the grain boundary, twinning in the crack-wake etc., all of which can be attributed to the crystallographic and geometric constraints at the grain boundary. 3D finite element analysis using ABAQUS and crystal plasticity is used to capture the anisotropy in plastic deformation during crack-grain boundary interaction and qualitatively explain the misorientation dependence of fracture resistance. In addition, basal crack propagation in zinc single crystals was revisited using *in situ* fracture experiments. Some fundamentally new insights into the micromechanisms associated with the process will be presented and discussed. Finite element analysis in conjunction with crystal plasticity is used to evaluate crack-tip fields and explain the fracture mechanism, fracture surface topography, shear ligament toughening, as well as orientation dependent fracture properties.

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