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Nanoscale Characterisation of Twins and Dislocation Transmission Using In-Situ TKD-DIC Tensile Testing

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Abstract

Wider industrial adoption of hexagonal close-packed metals (hcp) requires a precise understanding of their deformation anisotropy. This anisotropy stems mainly from the accommodation of c-axis strain by deformation twinning (DT). While the common {10-12} DTs are widely studied, the behavior of {11-21} DTs remains less understood. In particular, their interaction and secondary twinning behaviors are largely unexplored, despite their importance for hardening and failure of hcp metals. This study experimentally characterizes these mechanisms by in-situ Transmission Kikuchi Diffraction (TKD) tensile testing [1] of single-crystal Rhenium. We observe that primary {11-21} DTs readily form secondary twins of the same {11-21} type. They form with a systematic preference for a specific variant. Furthermore, our observations at the interaction sites of different primary DTs challenge established geometric criteria of twin-twin crossings [2]. These criteria predict that the interaction triggers secondary twin variants that correspond to the mutual crossing of the primary twins. Instead, secondary variants are activated that violate this crossing relationship. We rationalize these observations through crystallographic analysis of defect creation (dislocation dissociations) and estimates of the local stress state driving the specific variant formation. These findings establish a mechanistic basis for {11-21} secondary twinning. These insights provide a foundation for improving the predictive capability of crystal plasticity models for high-performance hcp metals.

Keywords:

Micromechanics In-situ TKD Deformation twinning HCP

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