Slip Transfer Analysis and in-situ Characterization of Deformation Twinning in Commercial Purity Titanium

Overview

A tensile specimen of commercial purity titanium with a strong c-texture was deformed to about 3% tensile strain. Consecutively, far-field 2D X-ray diffraction from the synchrotron source at the Advanced Photon Source (Argonne National Lab) was used to identify type I (T1) deformation twinning events. Twin-pair pairs in different regions were identified using criteria for c and a specific orientation and spatial proximity. Slip transfer parameters were used to determine the possibility of a twin-nucleating as a result of slip transfer (S+T) or twin-to-twin (T+T) shear transfer across a grain boundary. The geometrical feasibility of S+T or T+T twinning is assessed using three approaches—first by analyzing the potential for slip transfer, second by examining the relative positions of the grains that could enable slip transfer, and third, by examining resolved shear stress on slip systems in the parent and neighboring grains. Comparisons of the mechanical response for a parent and an adjacent grain are made between experiment and a simulation with a spectral solver-based crystal plasticity model.

Geometry of T1 Extension Twinning in Titanium

Experimental Setup for Far Field 2D XRD

Evaluation of Strain/Shear Stress Tensors and Slip Transfer Parameters

Example Analyses

Example 1: Twin Observation in Layer 6 at 1.05% Strain

Comparison of Stress Evolution in a Parent and Adjacent Grains with Spectral-Based Crystal Plasticity Model

Summary

- Grains reconstructed geometry from center of mass and orientation seeds points
- Inner stress data taken from 200 m to 800 m before the sample was loaded; this was simulated in the crystal plasticity model to an intermediate state
- Stress data from 1% to 2% strain; stress data from 1% to 2% strain; stress data from 1% to 2% strain
- Stress data from 1% to 2% strain; stress data from 1% to 2% strain

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References