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The Mechanics of Dynamic Twinning in Single Crystal Magnesium

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Abstract

In-situ ultra high speed optical imaging with 200 ns temporal resolution is used to gain insight into the evolution of twinning in single crystal magnesium under dynamic loading. Under compression along the a-axis, nucleation of twins is observed to occur on two conjugate $\{10\bar{1}2\}$ twin planes. Twin nucleation appears to be stress-driven with the first twins nucleating at resolved stresses of 5-7 MPa. These first twins propagate across the specimen at very high speeds of the order 1 km/s. After the first twins stop growing, twin boundary growth is observed to be very small and relatively slow. The nucleation of additional twins from the boundaries of pre-existing twins is found to be preferred over twin boundary growth at these rates of loading. As a result, twin nucleation is found to have a dominant contribution to twin volume fraction evolution at later times. Lastly, twinning is found to have a dominant contribution to the net plastic strain at these strain rates.

Keywords: Twinning, dynamics, magnesium, in-situ high speed imaging, high strain rate

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1. Introduction and background

Twins are commonly found in metals and some ceramics, and often appear as lenticular bands containing a local reorientation of the crystal lattice. The atomic arrangement inside the twin is a mirror-image of that outside, and hence the name. Understanding twinning involves understanding physical phenomena active over a range of length scales (from atomistic to grain size) as well as a wide range of time scales. While commonly observed in hcp metals, twins also are seen in fcc metals and in bcc metals at low temperatures and/or high rates of loading (e.g. Takeuchi (1966),Johnson and Rhode (1971)). An excellent review of