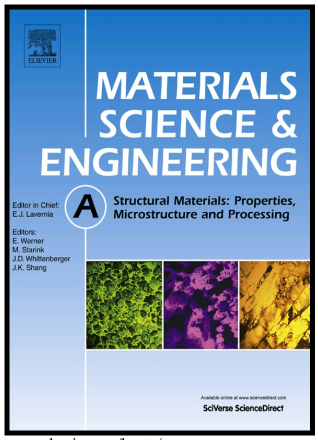

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Flow Stress and Electrical Resistivity in Plastically Deformed Al subjected to Intermittent Annealing

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Abstract

The behaviour of the flow stress and electrical resistivity has been studied in pure Al polycrystals deformed at 4 K with intermittent annealing at temperatures up to 298 K. Electrical resistivity measurements permit discrimination between regimes of plastic flow determined by dislocation–dislocation interactions and dislocation–debris interactions. Continued deformation at 4 K occurs under dynamic quasi–equilibrium controlled by dislocation–dislocation interactions. This regime is represented by a Taylor–type stress – dislocation density relationship, $\tau \approx 0.2\mu b\sqrt{\rho}$. The onset of immediate post–yielding deformation in annealed samples is dominated by dislocation–debris interactions and is characterized by a high rate of dislocation production and a low rate of flow stress increase than determined by dislocation–forest interactions. Upon annealing to 298 K, Al shows two regimes of correlated stress and resistivity recovery, controlled by the amount of energy release during annealing. The relationship between flow stress and density of dislocations for the component of recoverable and unrecoverable defects has been assessed from the experimental measurement data for two different scaling laws. It is found that while Taylor–type equation, $\tau \propto \sqrt{\rho}$, gives good estimates of the flow stress for the density of dislocations determined from resistivity results in continuously deformed samples, it distorts considerably stress – dislocation density dependence in samples subjected to intermittent annealing.

Keywords: Aluminum; plastic deformation; flow stress; electrical resistivity; dislocation density; constitutive relationship

1. Introduction

During plastic deformation of metals and alloys, a large density of point defects is produced in addition to a large density of dislocations. The distinction between