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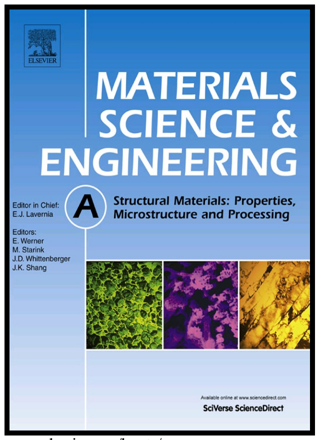

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Influence of Plastic Deformation Heterogeneity on Development of Geometrically Necessary Dislocation Density in Dual Phase Steel

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Abstract

The present investigation examined the evolution of geometrically necessary dislocation (GND) structure following tensile deformation in a commercially produced dual phase steel, DP 590. GND measurements were made using electron back scatter diffraction (EBSD). The average GND density increased with imposed macroscopic strain, however the rate of increased slowed with increasing strain. GND density was found to be influenced by the ferrite grain size and orientation of the ferrite grains. Small ferrite grains generally had a higher GND density. For this steel the highest GND density was measured for {011}[111] orientations. Analysis of these data using the classical Ashby model for GND content shows that GND density is increasing linearly with strain. The discrepancy between measured and predicted GND density is attributed to the plastic deformation of martensite reducing the requirement of compatibility between ferrite and martensite and dynamic recovery of the dislocation structures decreasing the rate of GND storage with strain.

Keywords: Dual phase steel; EBSD; Plastic deformation; Geometrically necessary dislocation density

Introduction

Dual phase (DP) steel is known to have a microstructure that consists of ferrite and martensite. Martensite phases are assumed to be distributed randomly in the soft ferrite matrix [1-3]. This type of microstructure leads to a good combination of strength and ductility and a reasonably high work hardening rate [1-3]. It also results in a gradual transition from elastic to plastic deformation eliminating the obvious yield point in the stress strain curve [1-3]. The major application of this steel is in automobile components, such as car body panels, wheels, bumpers etc. [1-3]. These steels are produced either by inter-critical annealing or by controlled rolling [1-3].

Mobile dislocations in the DP steel are introduced in the ferrite matrix due to the austenite to martensite transformation. This increase in mobile dislocation density, results in the continuous yielding behaviour and the high work hardening rate of DP steel. The movement of these dislocations is responsible for the elimination of yield point elongation and in the observed low yield strength. The interaction of dislocations with each other and with the finely dispersed martensite grains results in a high strain hardening exponent.

Several reports are available on electron backscatter diffraction (EBSD) studies of DP steel [4-9]. The studies have focused on the separation of ferrite and martensite phases using mean band contrast in the EBSD patterns [4, 5]. Kadkhodapour et al. [6] showed that the properties of the ferrite phase change with distance from the martensite grains. The grains of the ferrite phase are harder in the vicinity of the