Effects of stacking fault energy on deformation-induced microstructures in austenitic stainless steel sheet

Skyler Davis[1], Beatrice Lowe[2], Clinton Hawkins[1], Tamas Ungar[3], and Terry Lowe*[2]

[1]Colorado School of Mines – United States
[2]Colorado School of Mines – United States
[3]Eötvös Loránd University – Hungary

Abstract

Austenitic stainless steels are valued for their corrosion resistance, biocompatibility, and high formability that can be imparted through alloy design and processing. In this work, three austenitic stainless steels with computed stacking fault energies (SFE) of 14.1 mJ/m2, 25.6 mJ/m2, and 36.5 mJ/m2, were cold rolled up to 67% reduction to reveal how SFE affects the evolution of deformation-induced microstructures. SFE-dependent trends and interrelationships were quantified using electron backscatter diffraction, x-ray line profile analysis, x-ray texture goniometry, magnetic permeability measurements, and statistical data correlation methods to document dislocation character, slip band spacing, grain size, grain boundary misorientation, phase fractions, and crystallographic texture.

As expected, the dislocation density increased with rolling reduction, however, the relative total length of screw dislocations decreased compared to the total length of edge dislocations in all three alloys. Dislocations were concentrated inside slip bands, which were more widely spaced and more intense in the lower SFE alloys. Band spacing decreased monotonically with increasing strain. The slip bands provided nucleation sites for martensite at their intersections with each other and at grain boundaries. Most of the deformation-induced a'-martensite evolved at grain boundaries, especially at boundary segments having moderately high misorientation angles. Additionally, rolling caused grain fragmentation at all reductions, but the rate of fragmentation and the corresponding increase in total grain boundary length was greater for the lower SFE alloys above effective strains of 0.33.

These results show how lowering the SFE of austenitic stainless steel increases the thermodynamic driving force for martensite transformation and creates more preferential sites for martensite nucleation. Another observation was that a strong rotated Goss texture developed in all three alloys independent of SFE. A rationale is proposed for how the SFE dependencies of grain size, slip characteristics, grain boundary misorientation, martensite transformation, and texture collectively affect formability.

Keywords: Stainless steel, stacking fault energy, deformation, induced microstructures, martensite

*Speaker