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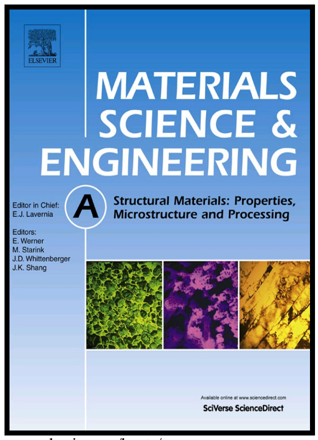

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PII: S0921-5093(16)30228-3
DOI: http://dx.doi.org/10.1016/j.msea.2016.03.022
Reference: MSA33417

To appear in: *Materials Science & Engineering A*

Received date: 10 December 2015
Revised date: 2 March 2016
Accepted date: 3 March 2016

Cite this article as: Fan Liu, Hao Yuan, Jian Yin and Jing Tao Wang, Influence of stacking fault energy and temperature on microstructures and mechanica properties of fcc pure metals processed by equal-channel angular pressing *Materials Science & Engineering A* http://dx.doi.org/10.1016/j.msea.2016.03.022

Influence of stacking fault energy and temperature on microstructures and mechanical properties of fcc pure metals processed by equal-channel angular pressing

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Abstract

Three fcc pure metals–Cu, Ni, and Al, with the same purity level (~99.99 wt%) and different stacking fault energies (SFEs, about 45 mJ/m^2, 125 mJ/m^2, and 166 mJ/m^2, respectively) are processed by equal-channel angular pressing (ECAP) at different temperatures (room temperature, 0.32T_m, and 0.4T_m). A dislocation density-based model is improved by introducing a material-dependent parameter, and the improved model is utilized to predict the evolution of dislocation density, grain size, and strength of materials processed by ECAP processing. The predicted dislocation density, grain size, and strength are compared with the experimental results, with satisfactory agreement. The influence of the SFE on the steady-state grain size d_s is discussed, based on the experimental and modeling results. It is demonstrated that at the same homologous temperatures, the dependence of the d_s on the SFE exists, and that a reduction in the SFE leads to a decrease in the d_s, in case there is no recrystallization in the samples. In addition, increasing deformation temperature leads to a decrease in the dislocation densities and an increase in the steady-state grain size d_s. The predicted values of the d_s match well with the experimental results at lower homologous temperatures.

Keywords. Equal-channel angular pressing; stacking fault energy; deformation temperature; dislocations; steady-state grain size

1. Introduction

Severe plastic deformation (SPD) is an efficient method for producing bulk nanostructured metallic materials with attractive combinations of properties [1, 2]. Under SPD, with an increase in deformation strain, the grain size of an initially coarse-grained material saturates to hundred nanometers or a few tens of nanometers at large strains (i.e., at the steady state). However, despite intensive research [3-6] carried out in the last decades, the origin of saturation of the grain size and the difference observed in the steady-state grain size d_s in different metals is still not quantitatively well understood.