ICSMA19 Metz, France, June 26 - July 1, 2022
International Conference on Strength of Materials

Behavior during severe plastic deformation of the Al_6(CoFeMnNi) high entropy alloy: experiments and crystal plasticity simulations

Surya N. Kumaran[a,b], Sudeep K. Sahoo[c], Christian Haase[d], Luis A. Barrales-Mora[b], and Laszlo S. Toth[a,e,f]

[a]Université de Lorraine, CNRS, Arts et Métiers ParisTech, LEM3, F-57000, Metz, France.

[b]Georgia Institute of Technology - CNRS 2958, George W. Woodruff School of Mechanical Engineering, Metz Technopole, 2 Rue Marconi, 57070, Metz, France.

[c]Université de Bordeaux, I2M UMR CNRS 5295, Arts et Métiers Institute of Technology, F-33400 Talence, France.

[d]Steel Institute, RWTH Aachen University, 52072 Aachen, Germany.

[e]Laboratory of Excellence on Design of Alloy Metals for Low-Mass Structure (Labex-DAMAS), Université de Lorraine, 57070 Metz, France.

[f]University of Miskolc, Institute of Physical Metallurgy, Metal Forming and Nanotechnology, Miskolc, Hungary.

[a]surya.nilamegam-kumaran@univ-lorraine.fr

The evolution of microstructure, texture, and mechanical properties of an induction melted non-equiatomic Al_6(CoFeMnNi) high entropy alloy subjected to severe plastic deformation was investigated experimentally and by simulations. Analyses using electron backscatter diffraction and transmission Kikuchi diffraction images revealed the evolution of the microstructures. The coarse-grained initial structure was deformed down to a grain size of ≈ 50 nm after a shear strain of 11 by employing the high-pressure compressive shearing process, at room temperature. The high deformation led to a significant increase in the strength, up to ≈ 1.073 GPa, and hardness of 407 ± 15 HV. Transmission electron microscopy analysis showed the presence of nano-twins. X-ray diffraction macro-texture analysis revealed a shear texture with the dominance of the $B/\bar{B}\{112\}\langle 110\rangle$ type component whose intensity varied with strain. A two-step Taylor-type polycrystal plasticity simulation approach reproduced the texture by a correlation value of 91%. In the first part of the modeling, grain fragmentation was considered, while in the second part, grain boundary sliding and deformation twinning was considered together with the operation of $\{111\}\langle 112\rangle$ type partial slip. The effect of twinning was also examined in the texture modeling and the simulations confirmed that it had little effect on the texture evolution, in spite of its presence in the microstructure.

Keywords: High Entropy Alloy; Severe Plastic Deformation; Texture; Grain boundary sliding; Polycrystal plasticity, High-Pressure Compressive Shearing.