Behavior during severe plastic deformation of the Al$_6$(CoFeMnNi) high entropy alloy: experiments and crystal plasticity simulations

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The evolution of microstructure, texture, and mechanical properties of an induction melted non-equiaatomic 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 $\approx$ 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 $\approx$ 1.073 GPa, and hardness of 407 $\pm$ 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 $B/B\{112\}\langle110\rangle$ 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 $\{111\}\langle112\rangle$ 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.