Superposition of strengthening mechanisms in hot forged Al$_x$CoCrFeNi high entropy alloys

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Al$_x$CoCrFeNi is one of the most extensively studied high entropy alloy system, as it shows a dynamic change of properties with the variation of Al. In this work, Al$_x$CoCrFeNi ($x=0.3, 0.5, 0.7$) alloys were hot-forged at 1250$^\circ$C. Various characterization techniques such as optical microscopy, x-ray diffraction (XRD), electron backscatter diffraction (EBSD), energy dispersive x-ray spectroscopy (EDS), and hardness tests were carried out to evaluate structure-property relationship. The Al$_{0.3}$ alloy possesses a single-phase face-centered cubic (FCC) structure, whereas Al$_{0.5}$ and Al$_{0.7}$ have dual-phase FCC and body-centered cubic (BCC) structure. An increase in the FCC phase fraction was observed in all the alloy compositions after forging. Forging of alloys increased the hardness of Al$_{0.3}$ and Al$_{0.5}$. In contrast, a reduction in hardness was observed in Al$_{0.7}$ alloy. Microstructure analysis revealed that phase fraction, twins, low angle grain boundaries, and grain refinement are major factors for structure-property relation. Contributions from different strengthening mechanisms were estimated, and a modified rule of mixture is proposed to evaluate the strength of these alloys from the microstructural features.

Keywords: High Entropy alloy; structure-property relation; hot deformation; microstructure; multiphase alloy

Fig.1 EBSD phase mapping of Al$_x$CoCrFeNi in cast and forged conditions.