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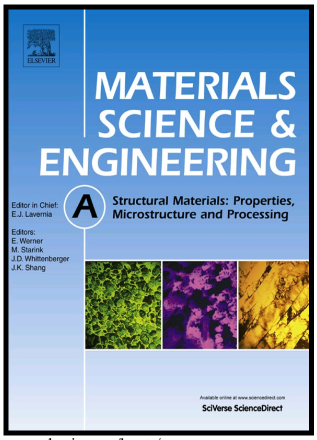

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Microstructures with extraordinary dynamic work hardening and strain rate sensitivity in $Al_{0.3}$CoCrFeNi high entropy alloy

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Abstract:

$Al_{0.3}$CoCrFeNi is an *FCC*-based high entropy alloy (HEA) that can display a wide spectrum of mechanical properties. Cold work and precipitation are good strengthening mechanisms in this HEA, and their effect on dynamic work hardening and strain rate sensitivity (SRS) was investigated. Dynamic deformation testing using split-Hopkinson pressure bar (SHPB) at 2×10^3 s^{-1} and quasistatic tensile deformation at 10^{-3} s^{-1} were conducted on thermomechanically processed conditions. The HEA behaved like a conventional *FCC* alloy with higher flow tresses and work hardening in the dynamic regime. All the conditions showed substantial dynamic work hardening due to the low stacking fault energy (SFE) of the HEA. Precipitates enhanced twinning, as observed from post-SHPB deformed microstructures, and resulted in an extraordinary work hardening rate > 2200 MPa. Cold work introduced large-scale deformation twins and these suppressed further twin nucleation during testing, and a lower work hardening of 1000 MPa was observed. SRS was highly microstructure-sensitive and varied from an exceptional m = 0.063 in the cast condition, where the biggest flow stress contributor is solute strengthening of short-range nature and can be thermally activated. Introduction of long-range athermal incoherent precipitates reduced SRS slightly. Cold work, which introduces much higher density of athermal defects, dislocations and large-scale deformation twins, drastically reduced SRS to m= 0.006. Upon annealing the rolled material, partial recovery of cold work and precipitation occurred together and coupled to result in a moderate SRS, m= 0.02.

Keywords: Dynamic mechanical behavior, work hardening, strain rate sensitivity, *FCC*-based high entropy alloy, $Al_{0.3}$CoCrFeNi.

Introduction:

High-entropy alloys (HEAs) are a new paradigm of metallic alloy development of stabilizing simple microstructures with multiple principal elements in equimolar proportions. Significant multi-element effects as compared with conventional alloys were proposed in HEAs; e.g., high entropy, sluggish diffusion, lattice distortion, and cocktail effects and have been studied extensively [1-4]. These remarkable mechanical strength, resistance to corrosion, and creep properties of alloy systems have fascinated many researchers in last decade. Investigations of chemical and structural stability of these alloys and the unique structure-property relationship are alone intriguing. The mechanical properties, in particular, are of crucial importance in engineering. Al_xCoCrFeNi is prominent among the several alloy systems identified on the basis of simple crystal structure design strategy; it changes from *FCC* to *BCC* structure with increasing aluminum content, and displays a wide range of mechanical behavior [5-8]. $Al_{0.3}$CoCrFeNi (x=0.3) is an *FCC*-based alloy with low Al content, which is single phase in the cast condition, but precipitates intermetallic phases upon high-temperature annealing. Previous studies have confirmed that Hall-Petch and precipitation strengthening mechanisms can be used to significantly enhance mechanical properties [9]. The stacking fault energy (SFE) of similar *FCC*-based HEAs, CrFeCoNi and CrMnFeCoNi, is reported to lie between 20 - 30 mJ/m^2 [10]. With addition of Al in CrFeCoNi, the SFE is expected to decrease further [11], and hence, $Al_{0.3}$CrFeCoNi is estimated to have a very low SFE. So,