Annealing behavior of a carbon-doped nanocrystalline CoCrFeMnNi alloy

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Abstract

CoCrFeMnNi type alloy with reduced Cr content and addition of 2 at. % C was processed by high pressure torsion (HPT). Uniform nanocrystalline single fcc phase microstructure was present in as-deformed alloy. This nc alloy with a grain size of 18 nm demonstrated a record breaking strength of 2000 MPa, but was very brittle and fractured just after the onset of plastic flow. However, after annealing at 200∘C for one hour, the yield strength of the alloy further increased to 2300 MPa with simultaneous increase of ductility to 2 %. The microstructure investigations revealed that the mean grain size had not changed, but elemental segregation of Cr, Ni and Mn appeared at the grain boundaries. The increase of annealing temperature to 500∘C leaded to the intensification of GB segregations and precipitation of intermetallic CoFe and NiMn nano-particles, which resulted in a further increase of the yield strength to 2450 MPa, but with a concomitant decrease of ductility to 0.4%. Interestingly, a sequence of precipitation – dissolution of secondary phases reactions was observed starting at 500 ∘C. Significant increase of the precipitates volume fraction and notable grain growth were observed after annealing at 530 ∘C for 1 h. Cr-rich carbides formed at grain boundaries. CoFe phase shows a chemically ordered structure with a few substitutions known as B2 phase, while NiMn phase has a tetragonal structure with chemical disordering. After annealing at 600 ∘C for 1 h, CoFe phase and NiMn phases re-dissolved in the fcc matrix and M7C3 type carbides remained. As a result, the yield strength decreased to 1410 MPa and ductility increased to 7%.

Keywords: High entropy alloys, nanocrystalline, annealing, mechanical properties

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