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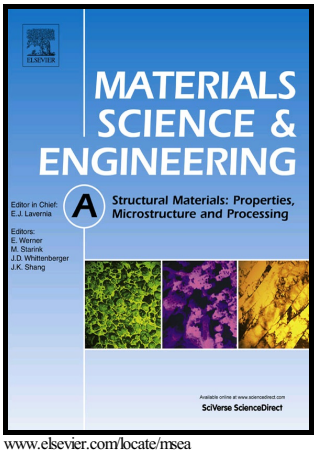

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Effect of annealing on mechanical properties of a nanocrystalline CoCrFeNiMn high-entropy alloy processed by high-pressure torsion

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Abstract

A CoCrFeNiMn high-entropy alloy (HEA) was processed by high-pressure torsion (HPT) under 6.0 GPa pressure up to 10 turns at room temperature. It is shown that there is a gradual evolution in hardness with increasing numbers of turns but full homogeneity is not achieved even after 10 turns. Microhardness measurements reveal that the material reaches a saturation hardness value of ~4.41 GPa and in this condition the microstructure shows exceptional grain refinement with a grain size of ~10 nm. An ultimate strength value of ~1.75 GPa and an elongation to fracture of ~4% were obtained in a sample processed for 5 turns. The nanostructured HEA was subjected to post-deformation annealing (PDA) at 473-1173 K and it is shown that the hardness increases slightly to 773 K due to precipitation and then decreases up to 1173 K due to a combination of recrystallization, grain growth and a dissolution of the precipitates. The formation of brittle precipitates, especially σ-phase, at 873 and 973 K significantly reduces the ductility. Short-term annealing for 10 min at 1073 K prevents grain growth and leads to a combination of high strength and good ductility including an ultimate tensile strength of ~830 MPa and an elongation to failure of ~65%.

Keywords: CoCrFeNiMn; High-entropy alloy; High-pressure torsion; Nanostructured materials; Post deformation annealing; Severe plastic deformation.

1. Introduction