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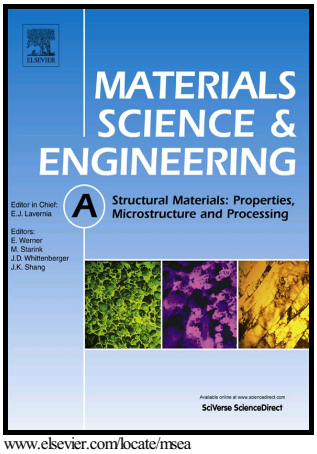

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Properties of a high-strength ultrafine-grained CoCrFeNiMn high-entropy alloy prepared by short-term mechanical alloying and spark plasma sintering

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Abstract

An equiatomic CoCrFeNiMn high-entropy alloy was prepared by induction melting and a progressive combination of mechanical alloying and compaction via spark plasma sintering done at temperatures of 800 °C and 1000 °C. The chosen methods of preparation had a significant impact on the microstructure and mechanical properties of the alloy. In comparison, the as-cast alloy had a much coarser microstructure while simultaneously obtaining inferior mechanical properties compared to those of the 8-h mechanically alloyed and spark plasma sintered alloy compacted at 1000 °C, which achieved a hardness of 424 ± 7 HV, and the alloy compacted at 800 °C showed a lower but still highly comparable hardness of 352 ± 12 HV. Both alloys showed good thermal stability, as expressed by almost negligible hardness changes during 100 h of annealing at temperatures of 400 °C and 600 °C. The investigated alloys also showed their superiority during compressive stress-strain tests at ambient and elevated temperatures of 400 °C and 600 °C. At ambient temperature, the highest compressive yield strength of 1534 MPa was observed for the sample compacted at 800 °C. As the temperature of the compressive test increased, the investigated alloys reduced their compressive yield strengths.

Keywords: high-entropy alloys, mechanical properties, hardness, compressive tests, long-term annealing.

Introduction

High-entropy alloys (HEAs) belong to a relatively new group of materials that have been researched since 2004 [1]. Since then, these materials have attracted increasing scientific interest due to their remarkable properties, including high strength, as well as good plasticity [2], good wear and corrosion resistance [3], magnetic properties [4], and outstanding plastic deformation at cryogenic temperatures [5]. Generally, to be considered a high-entropy alloy, a material must include a mixture of at least five elements with almost equiatomic chemical compositions [6-8]. However, as demonstrated in previous research, these conditions are rather flexible boundaries for the design of high-entropy alloys. In the past few years, ongoing scientific research has reported high-entropy alloys that may be composed of only four elements whose chemical concentrations vary from 5 – 35 at.%. Therefore, such a loose definition can be substituted by a rather more explicit characterization of the phase composition.