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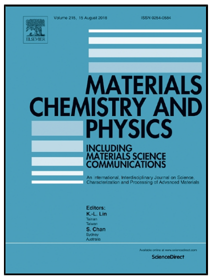

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Influence of warm-rolling and annealing temperature on the microstructure and mechanical properties of ductile non-equal molar $Co_{40}Cr_{25}Fe_{10}Ni_{25}$ high entropy alloys

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Abstract

The influence of warm-rolling and annealing temperature on the microstructure and mechanical properties of ductile non-equal molar $Co_{40}Cr_{25}Fe_{10}Ni_{25}$ high entropy alloys (HEAs) were investigated. The results indicate partial recrystallization occurs after annealing at 600 °C, heterogeneous grain structures are obtained after annealing at 700 °C, and complete recrystallization and grain growth occur at 900°C. The different combination of ultimate tensile strength (830-1400 MPa) and ductility (10-70%) of $Co_{40}Cr_{25}Fe_{10}Ni_{25}$ HEAs were obtained, which is related to the microstructure after the rolling and annealing process. The heterogeneous grain structure leads to form the elongate voids during tensile deformation, owing to the local stress concentration in the especial structure.

Keywords:

High entropy alloys; Microstructure; Mechanical properties; Thermomechanical treatment; Face-centered cubic structure

1. Introduction

High entropy alloys, or multiple principal element alloys, have drawn great attention owing to the numerous opportunities in the huge unexplored compositional space for designing novel materials with exceptional properties [1-6]. Recent studies indicate stronger alloys are not necessarily those with the most elements [7, 8], and the diffusion in HEAs do not always retard with an increasing numbers of elements [9]. It is important to explore the non-equal molar HEAs [10-12], or solid solution island proposed by He [13], based on the nature of the constituent elements. The strength and ductility of non-equal molar $Co_xCr_{25}Fe_{50-x}Ni_{25}$ HEAs are improved with the increase of Co content from 25 at% to 35 at% [14]. Co element has better solution strengthening effect, and could reduce the stacking fault energy of alloys, which is beneficial to the TWIP effects [14]. Thus, it is positive to obtain better combination of strength and ductility as the Co content increases. So $Co_{40}Cr_{25}Fe_{10}Ni_{25}$ alloy is selected in this work.

Hot rolling or cold-rolling and annealing processes are generally performed to refine the grains to achieve better mechanical properties for 3d transition metal HEAs [7, 8, 15, 16]. Annealing at 900°C for different time is always performed to obtain full recrystallization grains and to control the grain size, which is beneficial to strength-ductility due to the twinning induced plasticity (TWIP) effect [8], transformation induced plasticity (TRIP) effect [10, 11] and grain boundary strengthening [11]. In relation to engineering application, the ductility of these alloys is often surplus while the strength is generally insufficient. Huang [17, 18] has developed an alloy design strategy by dislocation engineering, which means high dislocation density is the reason for the improved strength through dislocation forest hardening, while ductility is achieved by the glide of dislocation

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