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Dynamic recrystallization nanoarchitectonics of FeCrCuMnNi multi-phase high entropy alloy

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ABSTRACT

Dynamic recrystallization behavior of the FeCrCuMnNi high entropy alloy (HEA) was investigated through hot compression test at different temperatures and at constant strain rate. The results revealed that during hot deformation of FeCrCuMnNi HEA, flow stress and work hardening rate rapidly decreased with increasing the deformation temperature. Discontinuous dynamic recrystallization (dDRX) was found to be the main active mechanism during hot deformation, which was the governing mechanism even at higher temperatures. In addition, bulging was an effective mechanism for inducing new recrystallized nuclei. Grain growth was occurred at slow strain rate in comparison to conventional alloys and other HEAs. This behavior was attributed to the continuous nucleation during dDRX, sluggish diffusion, high solution hardening characteristics of HEAs, and the presence of multiple phases in the FeCrCuMnNi HEA. Texture analysis showed that at lower temperatures, deformation texture including < 110 > // CA fiber was formed. By increasing the deformation temperature, the formation of recrystallization texture fibers such as < 100 > // CA and < 211 > // CA rapidly intensified.

1. Introduction

Thermomechanical processing (TMP), a combination of deformation and thermal processes, plays a vital role in developing components for various engineering applications. Achieving the desired shape, control the final microstructure, and modification of the as-cast structure are known as the main objectives of TMPs followed in industrial production lines [1–3]. Nowadays, hot deformation processes such as hot rolling, forging, and extrusion are essential to the industrial fabrication of various metallic materials. Research into the hot deformation behavior of different metallic materials has always been one of the interesting topics in the materials science world, with a significant number of research works annually published in this field [4–6].

High entropy alloys (HEAs), also known as multi-principal element alloys (MPEAs), with equimolar or near-equimolar ratios of at least four major elements, have recently received high attention due to their superior mechanical, physical, and chemical properties [7–10]. A noticeable number of articles have been published on the different properties of these alloys. It has been revealed that high entropy of mixing increases the possibility of forming simple structure solid solutions [11–14]. In addition, severe lattice distortion and sluggish diffusion have been reported as two other specific characteristics of HEAs, which could strongly affect their properties [15,16]. Guo et al. [17] reported that original coarse as-cast grains, severe lattice distortion, and sluggish diffusion were the main reasons behind the slow restoration process and high recrystallization temperature in $Al_{0.5}CoCrFeNi$ HEA.

Due to the variety of HEAs alloying compositions and the possibility of alloy fabrication by various methods such as casting and mechanical alloying, the previously published papers have primarily focused on the characterization of the as-produced alloys [18–20]. However, during the last few years, many studies on the characterization of hot deformation behavior of the HEAs have been presented, and it was revealed that dynamic recrystallization (DRX) occurred typically in HEAs during hot deformation [2,4,6,21–23]. Based on the microstructure evolution, two main mechanisms for the occurrence of DRX in HEAs have been reported: nucleation of new grains followed by grain growth, known as discontinuous dynamic recrystallization (dDRX), and transformation of low angle grain boundaries (LAGBs) into high angle grain boundaries (HAGBs) followed by the formation of a recrystallized microstructure, known as continuous dynamic recrystallization (cDRX) [4,23].

Jiang et al. [24] studied the hot deformation behavior of the $CoCrCu_{1.2}FeNi$ and reported that the DRX mechanism of the alloy was mainly

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