



The effects of mechanical alloying on the physical and thermal properties of CuCrFeTiV alloy

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ABSTRACT

The present work reports the production and key properties of the CuCrFeTiV high entropy alloy synthesized by mechanical alloying and spark plasma sintering. The milled powders and the as-sintered samples were analysed through scanning electron microscopy, coupled with energy dispersive X-ray spectroscopy and particle induced X-ray emission. Magnetic properties together with electrical resistivity, thermal conductivity, specific heat and differential thermal analysis were also evaluated on the consolidated samples. The powders reveal an increasing content in iron as the millings are prolonged up to 20 h. The elemental composition of the sintered alloy, determined through particle induced X-ray emission, confirms the final composition after mechanical alloying with an increase of iron and a decrease in the remaining elements. Furthermore, although the alloy presents an electrical resistivity typical of a high entropy alloy, a ferromagnetic behaviour was found, consistently with a major Fe content as detected in prior observations. Finally, thermal measurements show that this CuCrFeTiV high entropy alloy possesses thermal properties suitable for its potential use as thermal barriers.

1. Introduction

For decades, the demand to supply energy at a global scale has been escalating, requiring new, more powerful ways of energy production. Nuclear reactors can convert the energy released by controlled nuclear fusion into thermal energy for further conversion to mechanical or electrical forms. With the implementation of these machines the opportunity to produce clean energy with nearly unlimited energy reserves arises. In these reactors, the divertor has a plasma facing wall made up of tungsten (W) monoblocks, that will be exposed to high heat and radiation loads. To remove the heat from the monoblocks, these tiles are built to be in contact with CuCrZr cooling tubes where pressurized water will flow. Since the optimum operating temperature ranges of the component materials, W and CuCrZr, do not overlap, it is desirable to use an intermediate layer, a buffer layer capable of functioning as a thermal barrier, guaranteeing an adequate thermal transport between both materials while keeping their temperatures in the proper working intervals.

The concept of high entropy alloys (HEA) introduces a new path of developing advanced materials with the required properties. High entropy alloys are alloys with five or more principal elements, each with a concentration between 5 and 35 atomic percent [1], with substantially higher mixing entropies than in conventional alloys. Because of their unique composition, HEAs potentially offer special properties, such as high-temperature strength [2], outstanding wear resistance and structural stability [3], good corrosion and oxidation resistance [4]. Therefore, HEAs are attractive for use in many fields, including as thermal barriers for nuclear fusion reactors. Apart from the well-rounded compositional and microstructural properties of the HEAs, such as magnetic, electrical conductivity and thermal conductivity and heat capacity enable the assessment of a component lifetime and the evaluation of structural stability. Many studies dedicated to the evaluation of magnetic properties of HEAs, indicate that, when these alloys contain more than 50 at.% of the magnetic elements Fe, Co, and Ni, they are either paramagnetic or ferromagnetic with a saturation magnetization

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