doi:10.1017/S1431927621011648
Microsc. Microanal. 27 (Suppl 1), 2021

Microstructure and Adjustment in Tensile Strength of $Al_{0.8}$CoCrFeNi Fibers

Nestor Florido-Suarez[1], Pedro Socorro-Perdomo[1], Ionelia Voiculescu[2] and Julia Mirza-Rosca[1]

[1]University of Las Palmas de Gran Canaria, United States, [2]Politehnica University of Bucharest, United States

Introduction

The notion of high entropy alloys is a significant new change in alloys design, as they emphasize compositions that are close to the center of a multicomponent phase diagram, in contrast to conventional alloys that are controlled by one basic element. The high entropy alloys can potentially stack solid-solution phases with respect to intermetallic compounds and can give rise to interesting properties such as superior hardness, notable toughness, superior fracture toughness and corrosion resistance [1][2] As potentially remarkable engineering alloys, the AlCoCrFeNi HEA system has stimulated considerable research activities because it possesses a series of attractive physical, chemical and mechanical qualities [3].

The objective of this research is the assessment of the microstructure progression and tuning of the mechanical properties of Al0.8CoCrFeNi fibers produced by cutting followed by annealing at 1100 °C. By thermomechanical treatment and microstructure monitoring, equilibrated tensile properties were obtained at room temperature. In comparison to the bulk as-cast alloy, the heat-treated fibers exhibit an elongation significantly major [4]. The disadvantage in improving the ductility of the fibers was a decrease in yield strength and fracture toughness.

Experimental

The Al0.8CoCrFeNi ingot was prepared from high purity elements by vacuum-arc melting. The molten ingot was cutted into very thin samples (0.5 mm in height) and prepared by grinding (2500 grit SiC abrasive paper) and then polishing them until they were optically flat (0.3µm alumina paste). High-entropy alloy fibers with diameters of 0.4 mm and 1.5 cm in length were then cut from these samples. Afterwards, the HEA fibers were annealed at 1100 °C for 15 min. Tensile tests were performed on a Bose Electro Force 3100 universal testing machine (Bose Corporation, Minnesota, USA) using a strain rate of 10-3s-1 at room conditions (approx. 22°C).

Results and discussion

It was observed that the fibers had an equiaxed grain structure after heat treatment. The ultimate tensile strength (σf), elongation at fracture (εf)) and yield strength (σy) of the fibers were determined. The tensile strength (σf) of the heat-treated fibers at room temperature is comparable to that of the as-cast Al0.8CoCrFeNi alloy.

Fracture images of alloys are routinely examined to identify possible deformation patterns and failure factors. Fig. 1 displays a fractograph of the core area of a typical tensile sample for the fiber with 0.4 mm diameter. The fracture surface morphology exhibits a typical ductile failure.

For Al0.8CrFeCoNi the EDAX nanoscale analysis revealed the dendritic region rich in Fe and Cr but depleted in Ni and Al and the interdendritic region rich in Al and Ni but depleted in Cr and Fe. Only cobalt shows no significant difference in the two areas with a somewhat higher concentration in the interdendritic zone.

It is well known that Co, Ni and Cr are extremely corrosion resistant elements and form a strong passive film on the surface. Co2+, Co3+, Ni2+ and Cr3+ species which are generated in the polarization process form a uniform and compact passive film that successfully inhibits the contact of the Cl- with the metallic surface, thus reducing the corrosion rate and improving the corrosion resistance of the alloy [5].

Conclusions

A systematical survey of the microstructure progression and its effect on the mechanical performance of Al0.3CoCrFeNi HEA fibers before and after annealing at 1100°C was carried out. The following conclusions were reached:

Tensile samples annealed at 1100 °C exhibit significant ductility, i.e., >15%, and higher tensile strength values. These outcomes indicate that the mechanical performance of HEA fibers can be customized to particular class of properties with an adequate selection of the high-entropy alloy and annealing temperature.

The improved ductility of high-entropy alloy fibers may be caused by the reduction of casting defects, the "curing" of small casting imperfections and the reduction of residual stress by annealing treatment and subsequent cutting process. These characteristics clearly demonstrate that the high-entropy alloys fibers can be recommended for low-dimensional products as wires, that require good strength, excellent thermal stability and high ductility.

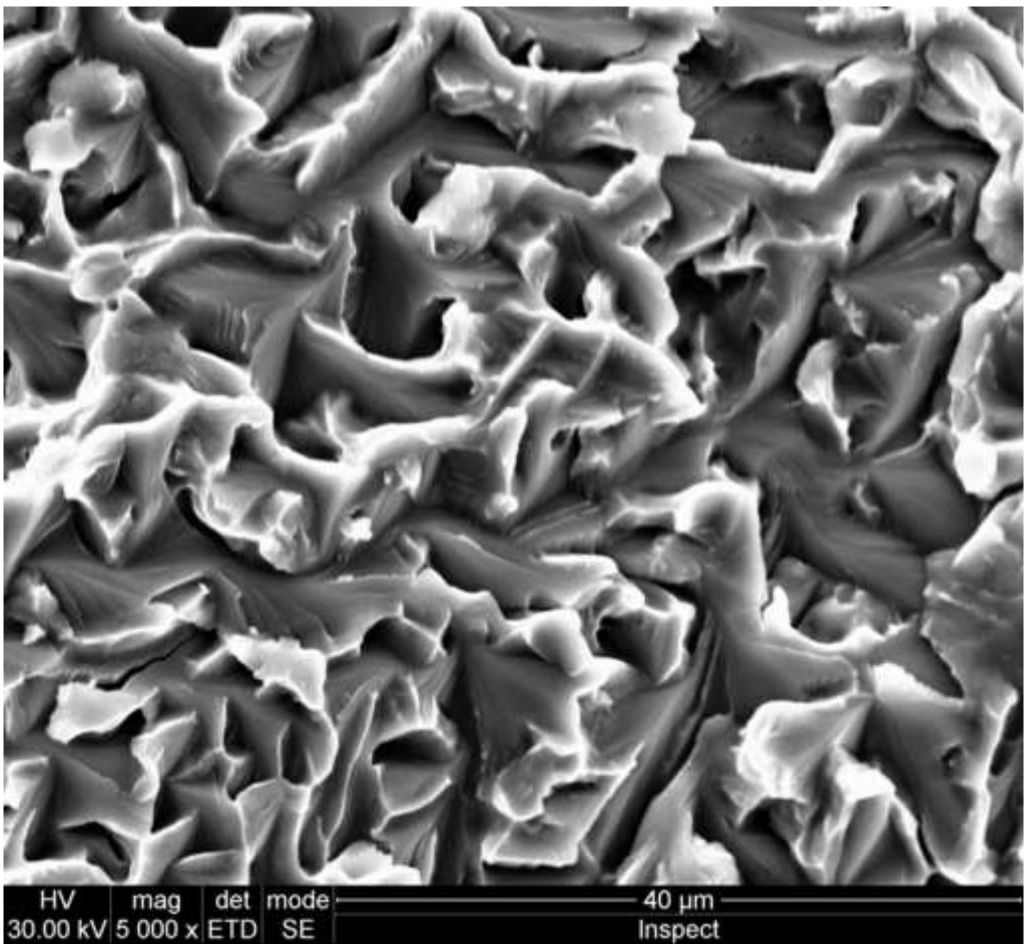

Figure 1. Fig.1 Fractograph of the core area of a tensile sample for the fiber with 0.4 mm diameter.

https://doi.org/10.1017/S1431927621011648

References

[1] Zhang Y. High-Entropy Materials A Brief Introduction. 2019. https://doi.org/10.1007/978-981-13-8526-1.
[2] Pascu A, Rosca JM, Stanciu EM. Laser cladding: From experimental research to industrial applications. Mater. Today Proc., 2019. https://doi.org/10.1016/j.matpr.2019.08.021.
[3] López Ríos M, Socorro Perdomo PP, Voiculescu I, Geanta V, Crăciun V, Boerasu I, et al. Effects of nickel content on the microstructure, microhardness and corrosion behavior of high-entropy AlCoCrFeNix alloys. Sci Rep 2020;10:1–11. https://doi.org/10.1038/s41598-020-78108-5.
[4] Li D, Gao MC, Hawk JA, Zhang Y. Annealing effect for the Al 0.3 CoCrFeNi high-entropy alloy fibers. J Alloys Compd2019;778:23–9. https://doi.org/10.1016/j.jallcom.2018.11.116.
[5] Garcia-Falcon CM, Gil-Lopez T, Verdu-Vazquez A, Mirza-Rosca JC. Electrochemical characterization of some cobalt base alloys in Ringer solution. Mater Chem Phys 2021. https://doi.org/10.1016/j.matchemphys.2020.124164.