Effect of Directional Solidification on Microstructure Evolution and Mechanical Properties of Eutectic High Entropy Alloy

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Abstract: Directional solidification, as an advanced method for preparing metal materials, can regulate the microstructure and improve the performance of high entropy alloys by controlling the temperature gradient and solidification rate. This study prepared CoCrFeNi3Al1.25 eutectic high entropy alloy (EHEA) at a directional solidification rate of 150 μm/s and investigated the effect of directional solidification rate on microstructure and mechanical properties. Results indicate that directional solidification significantly changes the microstructure, transforming the microstructure from randomly growing microstructure under as cast conditions to eutectic layer structure with a unified growth direction. The tensile strength and elongation of directionally solidified CoCrFeNi3Al1.25 EHEA are 1125.8 MPa and 22.4%, respectively, which are 14.7% and 83.6% higher than the as cast alloy, achieving a synergistic improvement in strength and plasticity.

Keywords: Eutectic high entropy alloy, Directional solidification, Microstructure, Tensile property

1 Introduction

Eutectic high entropy alloy (EHEA) is a new advanced structural and functional material that has attracted widespread attention because of its excellent strength, high corrosion resistance and wear resistance [1-4]. By changing the solidification parameters, directional solidification can prepare microstructures different from traditional castings, and can simultaneously improve strength and plasticity [5-6].

2 Experimental procedure

$CoCrFeNi_3Al_{1.25}$ EHEA are prepared using a directional solidification furnace at a pulling speed of 150 μm/s. The size of the microstructure observation sample is 8 mm × 8 mm × 8 mm. The gauge length of the tensile specimen is 15 mm, the thickness is 1.8 mm, and the width is 2 mm. The microstructure was observed using scanning electron microscopy (SEM). The mechanical properties were tested using a universal testing machine at a tensile speed of 1 mm/min.

3 Result and discussion (Bold, 10 pt., Arial)

Fig. 1 shows the microstructure of as cast and directionally solidified $CoCrFeNi_3Al_{1.25}$ EHEA. Results show that both as-cast and directionally solidified $CoCrFeNi_3Al_{1.25}$ EHEA are composed of FCC phase and BCC phase. The microstructure of the as-cast EHEA shows a disorderly growth direction, and the directionally solidified EHEA shows a significant single growth direction.

Fig.2 shows the stress-strain curves of as cast and directionally solidified $CoCrFeNi_3Al_{1.25}$ EHEA. The results show that the directional solidification significantly improves the strength and plasticity of EHEA. The tensile strength and elongation of the as-cast EHEA are 981.9MPa and 12.2%. The strength of the directionally solidified EHEA is 1125.9 and 22.4%, respectively, which is 14.7% and 83.6% % higher than that of the as-cast EHEA.

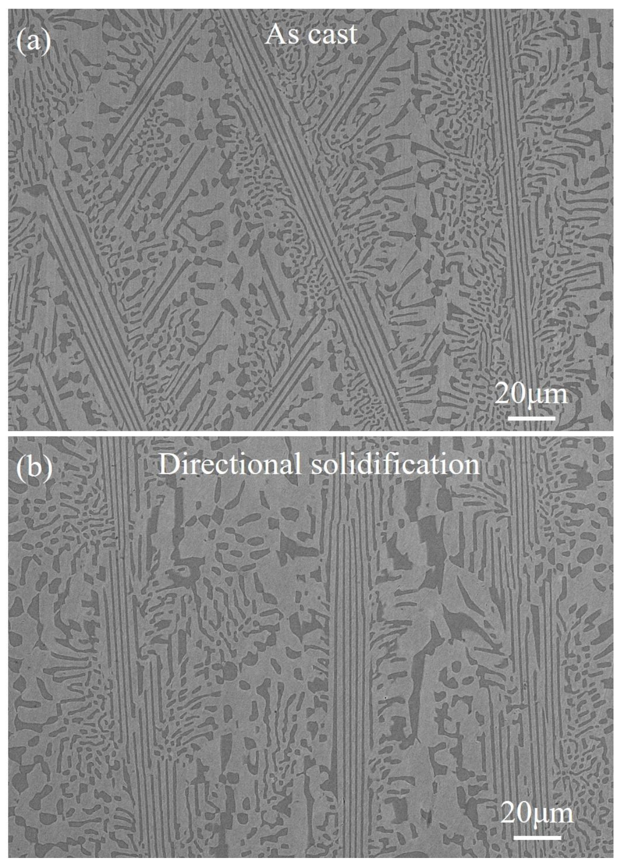

Fig. 1 Microstructure of as-cast and directionally solidified $CoCrFeNi_3Al_{1.25}$ EHEA: (a) As-cast EHEA; (b) Directionally solidified EHEA.

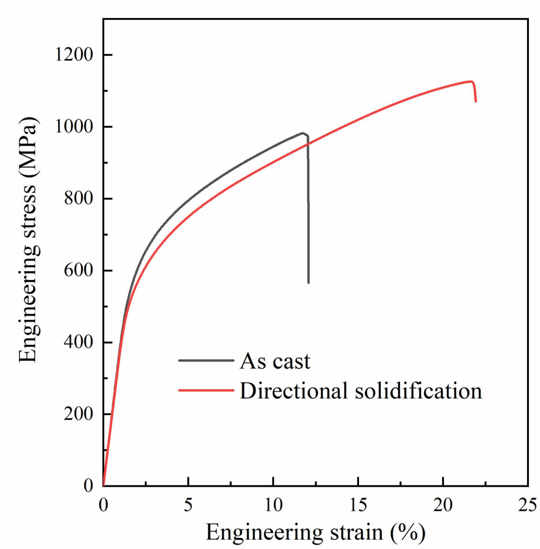

Fig. 2 Tensile stress-strain curves as-cast and directionally solidified CoCrFeNi3Al1.25 EHEA.

4 Conclusion

(1)Directional solidification significantly changed the microstructure of CoCrFeNi3Al1.25 EHEA and generated a layer structure with a single growth direction.

(2)Directional solidification improves the tensile properties. The tensile strength and elongation of CoCrFeNi3Al1.25 EHEA are 1125.8 MPa and 22.4%, respectively, realizing the synergistic increase of strength and plasticity.

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