Mechanical properties and Microstructure of Gas-atomized CuYZr-WO_3 towards the Overcoming of Trade-off between Strength and Conductivity

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Abstract :

ODS-Cu was recognized as candidate of heat sink materials for divertor in fusion reactor. This research fabricated the CuYZr-WO_3 ODS-Cu alloy by mechanical alloying, showed great mechanical properties and thermal diffusivity simultaneously. The WO_3 addition for ODS-Cu dramatically enhance the production rate as a process control agent (PCA) and decomposed in MA process led to the formation of Y-Zr-O complex oxide and tungsten particles in ODS-Cu.

Keywords: Heat sink material, ODS-Cu, thermal diffusivity, oxide particles

1. Introduction

Copper alloys are good candidate for heat sink materials in fusion reactors due to their excellent thermal conductivity. Nonetheless, further improvements on mechanical properties and irradiation resistance were expected. Cu-Y_2O_3 type ODS-Cu made by mechanical alloying showed excellent mechanical properties and irradiation resistance[1]. Furthermore, Zr addition into the ODS-Cu can improved the mechanical properties by the formation of complex oxide such as $Y_2Zr_2O_7$[2] and YSZ[3]. However, the coarsening of powders in MA process due to the high ductility of Cu is a critical issue towards their mass-production. In this research, WO_3 was chosen as a PCA in the MA process of ODS-Cu powder as well as an excess oxygen supplement in order to improve the coarsening of powder and overcome the trade-off between mechanical properties and thermal conductivity in Cu alloys.

2. Experimental

In this research, gas atomized Cu-Y-Zr powder and WO_3 powder were mechanically alloyed by water-cooling ball milling machine at a rotation speed of 500 rpm in Argon atmosphere. The MAed powder was filtered by the mesh of 500μm and sintered at 880 ℃ with a load of 50 MPa.

3.Results

The WO_3 addition significantly refined the size of MAed powder, achieving an average size of 270 μm, and increase the production rate of MAed up to almost 100%. As for X-ray diffraction results, the WO_3 peaks disappear in the MAed powder and existed as pure tungsten peak and Y-Zr oxide peak in the as-sintered sample. The as-sintered CuYZr-WO_3 sample achieved the Vickers hardness of 286 HV0.1 and thermal diffusivity of 70.2 mm^2s^{-1} at room temperature. TEM observations revealed that the nanosized Y-Zr complex oxide and pure tungsten particles dispersed inside the grain and pinning on the grain boundary.

4.Conclusion

WO_3 addition into ODS-Cu can effectively refined the MAed powder and improved their production rate. WO_3 decomposed during MA process was precipitated as pure tungsten particle and gave excess oxygen in as-sintered sample, leading to the formation of Y-Zr complex oxide and contributing to the mechanical properties of ODS-Cu.

References

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