A EXPERIMENT WAY TO STUDY THE GRAVITY EFFECT ON SOLIDIFICATION AND MICROSTRUCTURE OF ALLOYS

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A way to study the gravity effect on solidification and microstructure of alloys, which is simply by changing the solidification direction with respect to the gravity vector, is introduced. The solidification of $Zr_{65}Cu_{17.5}Ni_{10}Al_{7.5}$ alloy shown that solidification direction with respect to the gravity vector during unidirectional solidification can largely influence the microstructure of the alloy.

Introduction

Solidification processes of alloys are unavoidably affected by gravity on the earth. More attention has been paid on the microgravity effect on alloy the solidification recently. Microgravity environment restrains the buoyancy convection and sediment, and the solidification processes are dominated by pure diffusion. Before the space experiments, ground-based preparation and short term microgravity experiments are necessary. In this paper, a new way to study the gravity effect on solidification and microstructure of alloys is introduced. Solidification of glass-forming $Zr_{65}Cu_{17.5}Ni_{10}Al_{7.5}$ alloy was realized in different directions with respect to the gravity vector. The objective is to investigate the influence of buoyancy convection caused by gravity on solidification. It is showed that solidification direction with respect to the gravity vector during unidirectional solidification can largely influence the microstructure of the alloy.

The method and the device

On the earth mass transport in liquid is carried out mainly by two mechanisms, convection and diffusion. Convection is more effective than diffusion. The effect of buoyancy convection caused by gravity, which was often neglected in previous studies of solidification [1], makes the analyses of solidification unclear. Diffusion and convection normally entangled during solidification. The studies on the contribution of convection caused by gravity to mass transport in liquid and solidification microstructure is very important in microgravity materials science [2]. Unidirectional solidification is an effective way to reveal the buoyancing-influence on solidification. The gravity vector is always in the same direction, pointing to the centre of the earth. To change the effect of buoyancy convection caused by gravity on the solidification, we can change the direction of solidification with respect to the gravity vector during unidirectional solidification. So the mass transport in the liquid can be changed and the solidification of the alloy can be affected. The device is a unidirectional solidification furnace which can be rotated around a fixed axle. So the solidification direction with respect to the gravity vector can be changed easily. As shown in fig. 1, **α** can be changed from 0° to 180°. There are two extreme positions When **α** is 0° or 180°, the effect of buoyancy convection caused by gravity on solidification is maximal or minimal, depending on the circumstances near the interface of solid and liquid in the liquid. By this method the effect of gravity on alloys solidification can be studied. This is helpful to space experiments in making experimental plans and selecting samples.

There is a temperature gradient in the furnace. Unidirectional solidification of alloys can be completed by moving the samples in the furnace from the high temperature zone to the low temperature zone. To avoid unfavorable

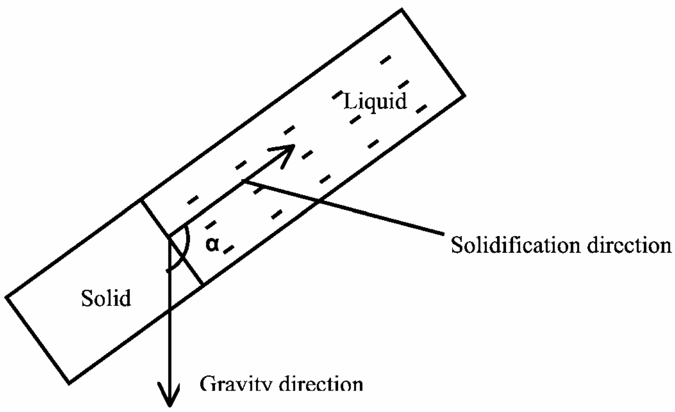


Fig. 1. Schematic of solidification direction α=0~180°

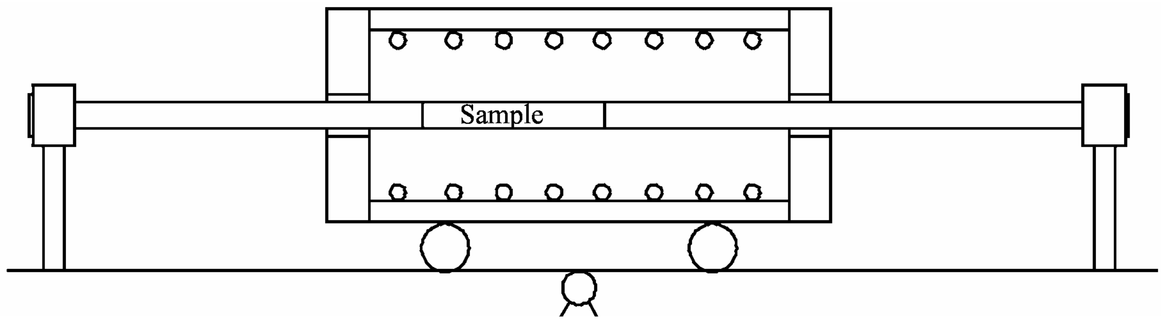
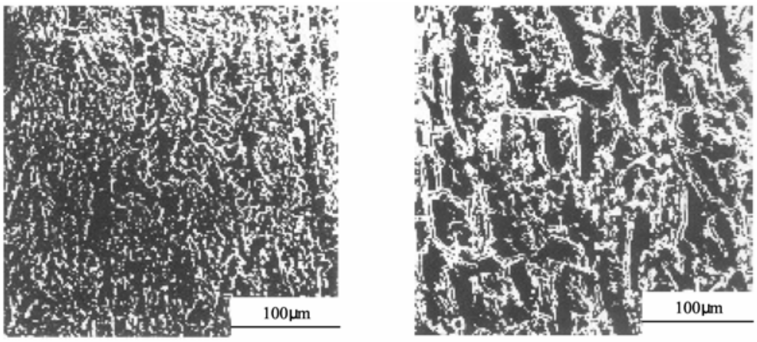


Fig.2. Schematic of the Furnace

influence of vibration caused by the sample moving on the sample during solidification, the samples are kept unmoved but the furnace move can be moved by a motor, as shown in Fig. 2. The moving speed of the furnace can be adjusted from 2 mm/h to 1800 mm/h depending on the experimental requirement. The sample is 10 mm in diameter and 200 mm in length.

The experiment on glass-forming $Zr_{65}Cu_{17.5}Ni_{10}Al_{7.5}$ alloy

The solidification of glass-forming alloys is dominated by mass transport in front of the solid-liquid interface, and the phase morphologies are largely affected by the mass transport [3]. $Zr_{65}Cu_{17.5}Ni_{10}Al_{7.5}$ alloy ingots were prepared by arc melting the pure Zr (99.9%, weight percentage), pure Cu (99.99%, weight percentage), pure Ni (99.96%, weight percentage) and pure Al (99.99%, weight percentage). The containers of the alloy were dry and clean quartz ampoules. Before sealed, the tubes were vacuumized to $1x10^{-3}$Pa. The solidified microstructure of glass-forming $Zr_{65}Cu_{17.5}Ni_{10}Al_{7.5}$ alloy in α= 0° and α=180° at the point 20mm away from initial solidification end are shown in Fig. 3. The microstructures are composed of primary phase and eutectics in both cases. In fact different gravity levels (1g and μg) could not change the solidification largely to change the phases types at low cooling rates [4]. But the morphologies, especially the primary phase morphologies, are quite different. In the 0° sample the primary phase is less and finer than that of the 180° sample. The reason is that the convection caused by gravity is different in two samples. In the 0° sample the bottom end of the sample is hotter than the top, and the mass and heat transport in the liquid was driven more easily by convection. It makes the elements in the liquid more homogeneous. So the microstructure is finer.



a b

Fig. 3. Microstructure of glass-forming $Zr_{65}Cu_{17.5}Ni_{10}Al_{7.5}$ alloy (a) α= 0°, (b) α=180°

Summary

Gravity Influence on solidification can be studied and different microstructure can be obtained simply by changing the solidification direction with respect to the gravity vector during unidirectional solidification.

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