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鉄銅合金の溶融凝固と液相分離現象

Melting and solidification of iron-copper alloys and liquid phase separation phenomena

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1. Introduction

Fe-Cu alloys are peritectic systems, which they have a near-horizontal liquidus line in a wide intermediate composition range. When this alloy is quenched, macroscopic separation occurs, suggesting the existence of a metastable solubility gap just below the liquid phase line.[1)] When iron-copper alloys are melted and solidified using a container, problems arise such as insufficient undercooling due to impurities and heat release from the container. In such cases, the use of a containerless process such as the gas-jet levitation method can cause sufficient undercooling and formation of a macroscopic structure. In this study, melting and solidification of iron-copper alloys were performed using the gas-jet levitation method, which is one of a conventional containerless process. The structure formed during the process was observed to understand the phenomenon of liquid phase separation during undercooling.

2. Experimental method

An iron-copper alloy was prepared by weighing samples of 99.5% pure iron and 99.9% pure copper. The volume of the sample was approximately 4 mm^3. Boron nitride, which has a low coefficient of thermal expansion and is easy to process, was used for the specimen base. A pyrometer and a semiconductor laser were installed, and the experiment was conducted with argon gas in a glove box to prevent oxidation, whose oxygen concentration was less than 30 ppm. The sample was suspended in argon gas, and temperature data were obtained during melting and solidification with a semiconductor laser. The cross-sectional structure of the iron-copper alloy was observed using an optical microscope. Figure 1 shows a schematic diagram of the experimental apparatus.

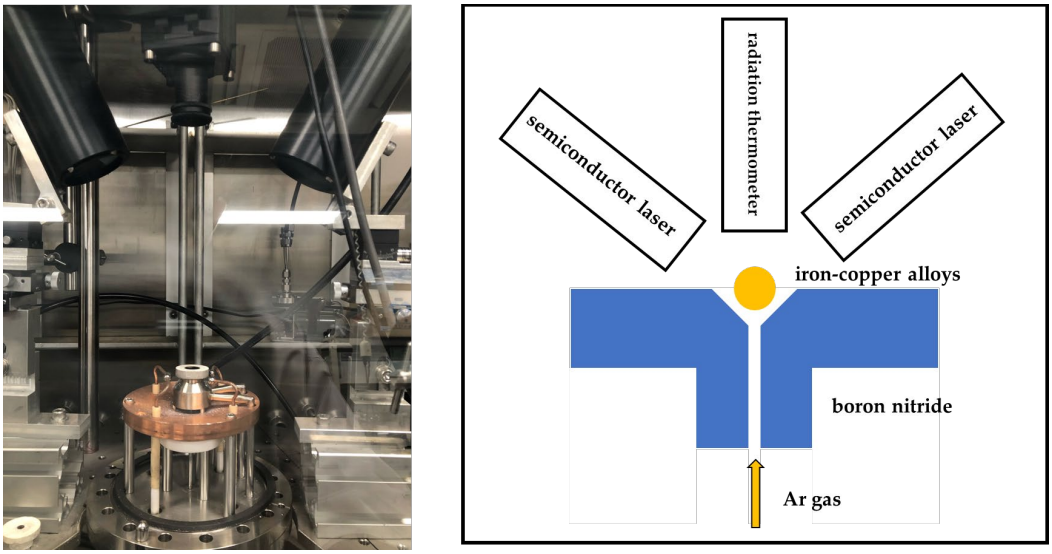

Figure 1 Schematic diagram of the experimental apparatus

3. Experimental results and discussion

Figure 2 shows a cross-sectional structure of the fabricated iron-copper alloy, polished and observed under an optical microscope.

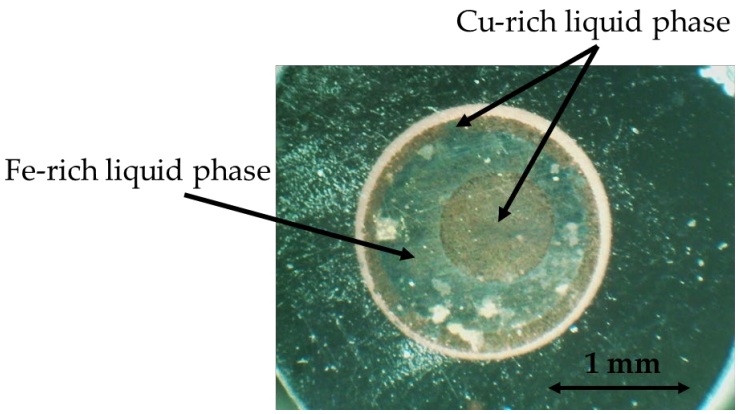

Figure 2 Cross-sectional structure of Fe-50at%Cu

Figure 2 shows that there is a Cu-rich liquid phase within the Fe-rich liquid phase, indicating that a triple macroscopic separation occurs. The factor that causes the triple separation may be related to the maximum temperature during melting and the speed of temperature increase during melting.

References

1) T. KOBAYASHI and K. NAGAYAMA: Journal of the Japan Institute of Metals, **81** (2017), 251page