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微小重力下での Fe-Cu 合金球の相分離観察

Phase separation observation of Fe-Cu alloy spheres under microgravity

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1. Introduction

Fe-Cu alloys are one of the peritectic systems and are completely mixed in the liquid state. It is known that a liquid-liquid miscibility gap develops upon cooling to liquid [1)]. If a container is used, solidification occurs from the contact area, resulting in the formation of an Fe-rich phase with a high melting point on the outside and a Cu-rich phase with a low melting point in the center. On the other hand, when a containerless process is used, the Fe-rich phase with high surface tension forms in the center and the Cu-rich phase with low surface tension forms on the outside, resulting in a different solidification phase than when a container is used. We have performed melting and solidification of Fe-Cu alloys using the gas-jet levitation method and clarified the formation of multiple alloy spheres and characteristic temperature profiles. By observing similar levitated solidification under microgravity, we expect to obtain precise data without the effect of gravity. When the electrostatic levitation method is used in space, unlike on the ground, there is no need to maintain a vacuum inside the device, and the experiment can be conducted with the device filled with Ar gas to suppress the loss of electric charge due to sample evaporation and ensure levitation stability. In this study, Fe-Cu alloys were melt-solidified using the electrostatic levitation furnace (ELF) in the International Space Station (ISS) to understand the liquid phase separation phenomenon during undercooling based on temperature variation.

2. Experimental method

A Fe-Cu alloy was prepared from a sample of 99.5% pure iron and 99.9% pure copper. The volume of the sample was approximately 4 mm^3. The preparation was performed in a glove box filled with Ar gas using a semiconductor laser. Boron nitride was used as the specimen base. Five types of samples were prepared: Fe-30at%Cu, Fe-40at%Cu, Fe-50at%Cu, Fe-60at%Cu, and Fe-70at%Cu. The samples were melted and solidified using the Electrostatic Levitation Furnace (ELF) installed in the International Space Station. After the sample was dropped into the center of the ELF and levitated, the sample was heated by laser irradiation. After that,

the laser irradiation was stopped, and the sample was allowed to solidify. The temperature of the sample during this process was measured using a radiation thermometer.

3. Experimental results and discussion

Temperature data for the melt solidification of Fe-60at%Cu alloy spheres are shown in Figure 1.

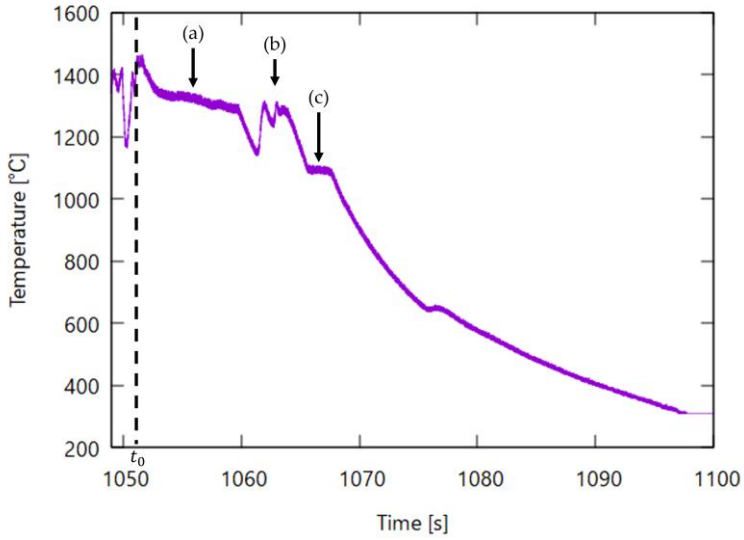

Figure 1. Temperature data of Fe-60at%Cu alloy sphere

(a) Solidification of Fe-rich phase (b) Release of latent heat of Fe-rich phase (c) Solidification of Cu-rich phase

In Figure 1, the laser was turned off at t_0 and cooling was started. The region of small temperature change from 1052 to 1060s in (a) shows solidification of the Fe-rich phase, and the region of small temperature change from 1065 to 1067s in (c) shows solidification of the Cu-rich phase. In (b), multiple recalescences occur, suggesting that small droplets of the Fe-rich phase may be solidifying. Future work will include cross-sectional observation of the samples and comparison with ground-based experiments.

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