The preparation of the experimental GHF cartridge for the diffusion in high temperature melts as an IAO plan

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1. Introduction

As an activity of the project of JAXA, "Modeling and Precise Experiments of Diffusion Phenomena in Melts under Microgravity ", we are measuring the diffusion coefficient of liquid alloys by the shearcell method on the ground. At present, as the first IAO (International Announcement of the Opportunity) plan, diffusion coefficient of liquid metals is planned to be measured by using the Gradient Heating Furnace (GHF), which is to be equipped in the material science rack of Japanese Experiment Module (JEM) in future.

We are advancing the trial preparation of the shearcell cartridge adapted to the GHF for the microgravity experiment in JEM.

2. Equipment

2.1 GHF-MP

We are planning to use the GHF as the furnace for the measurements of the diffusion coefficient under microgravity in ISS age.

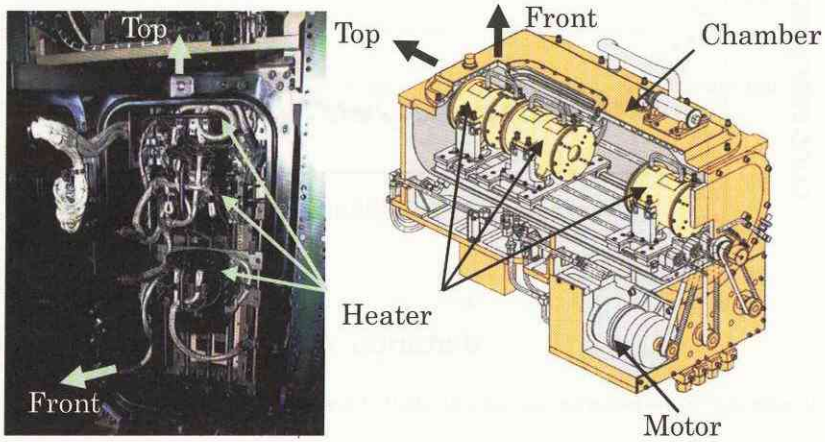

Fig.1 GHF-MP configuration

Fig.1 shows the schematic figure of GHF-MP, which is the experimental system for Material Processing by using the GHF. This system is composed of a 3-zone furnace and was originally planned to be used for the experiment under temperature gradient, such as crystal growth. Therefore, the experiment, which requires an isothermal condition like a diffusion experiment, has been out of targets. However, we investigated the relation between furnace configurations and a temperature distribution using the GHF (prototype model) currently installed in JAXA. As a result, it was concluded that an isothermal domain of ± 1.5°C could be obtained in the range of sample length (60mm) at the temperature up to 1250°C.

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2.2 SCAM

In the JEM, the exchange of the sample cartridge for the experiment is to be performed automatically. Fig.2 shows the photograph and the schematic figure of SCAM, the system for Sample Cartridge Automatic exchange Mechanism, which is composed of magazine, robot arm, and cramp.

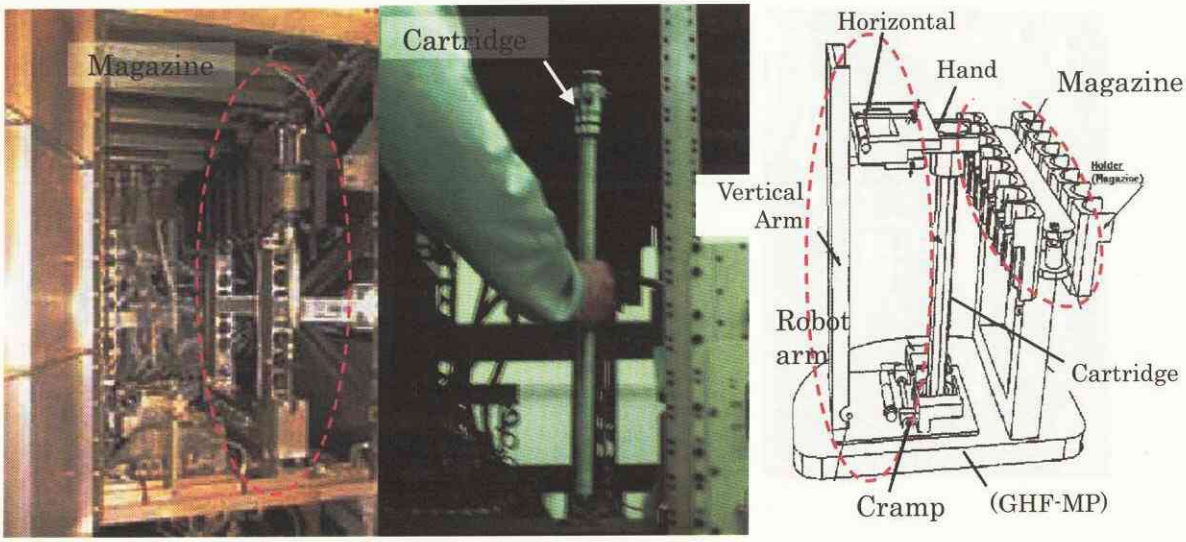

Fig.2 Photograph and schematic figure of SCAM

The magazine can store 15 sample cartridges (at the maximum). The arm is composed of vertical arm, horizontal arm and hand. They automatically exchange cartridges with the variation of experimental condition. Moreover, the cramp fixes the sample cartridge and seal off the GHF-MP.

3. Cartridge conditions for the GHF-MP

3.1 Sample configuration

The configuration of diffusion sample, for example that of the shearcell, is determined depending on the experimental condition of the cartridge configuration. The inside of the GHF-MP must keep vacuous to prevent the oxidation of heating elements. While, in the inside of the sample cartridge, it is necessary to keep at least one atmospheric pressure of inert gas to prevent the evaporation of sample. Therefore, the cartridge is constantly exposed to a pressure of more than one atmosphere. Thus, the minimum wall thickness of cartridge is determined by the condition that it may not be destroyed under such a pressure even at the maximum temperature of the GHF-MP.

3.2 Cartridge configuration

All cartridges used in the GHF-MP is handled by the SCAM. Therefore, the special cartridge for the shearcell should follow the cartridge condition for the SCAM. Moreover, it is necessary that the boss part of the cartridge must keep vacuous, because it is a sealing part of vacuum atmosphere of GHF-MP.

If the sample cartridge is incorporated with a new device, for example, "motor drive system" and/or "atmosphere control", it is necessary for this special cartridge to be accommodated in the SCAM. Therefore, we examined in the SCAM the user area that should not interfere with the magazine and the arm movement of

SCAM. Fig.4 shows the photograph of the inside of the SCAM. The left side is robot arm to carry the sample cartridge and the other side is the magazine to store the sample cartridge. As a result, the left space becomes the area of the experiment sample. As can be seen in these photographs, the available area for users is the center part of the SCAM. The size of the user area is H:200mm×W:60mm×D:300mm.

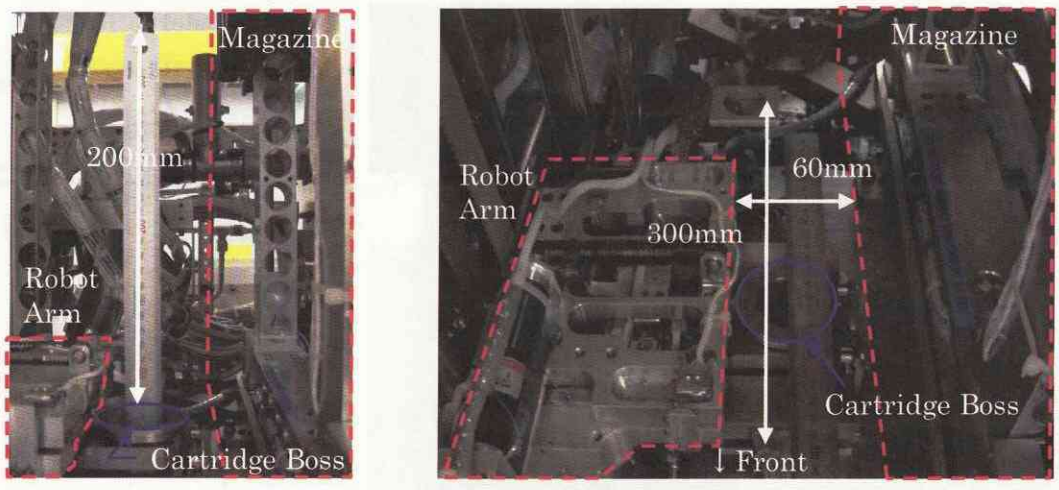

Fig.4 The inside of SCAM

4. Development of shearcell cartridge for GHF-MP

The measurement of diffusion coefficient is performed by the shearcell method. The shear cell method is known as one of most advanced techniques to measure a liquid diffusion coefficient accurately. This method is favorable for such Ge-Si and Ge-Sn systems which have a serious effect of solidification. A diffusion couple is only joined at the planned experimental temperature to avoid diffusion during heating and cooling, and is divided into many pieces to remove the effects of solidification. The shear cell consists of 60 disks with a hole, a rotation shaft, a key bar and a cartridge. To join or to divide a diffusion sample, a stepping motor rotates the rotation

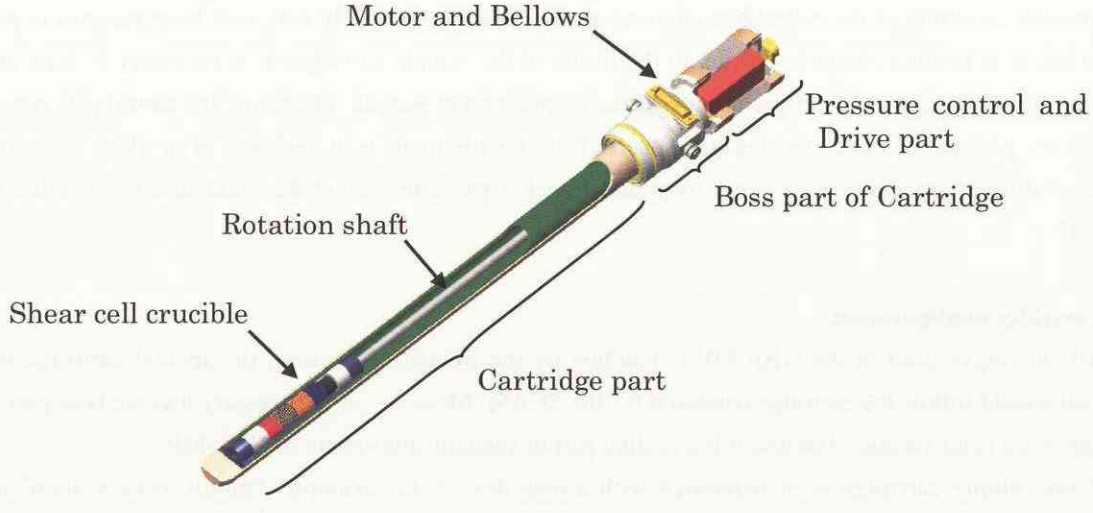

Fig.5 Shear cell cartridge for the GHF-MP

shaft, and the key bar controls the rotating angle of each disk. Therefore, the sample cartridge for the shear cell technique requires the rotation mechanism of the shear cell crucible, because the join and the cut of a liquid sample must be carried out at the experimental temperature. Moreover, the pressure inside the cartridge must be kept to be one atom.

Fig.5 shows the conceptual design of the shearcell cartridge for the GHF-MP. The sample cartridge of shear cell consists of cartridge part, boss part and pressure control part and drive part. The metal bellows was adopted on one end of the sample cartridge to control the atmosphere in the cartridge to be at one atom. Moreover, the drive part is included in the bellows. A small stepping motor, that can rotate the shearcell crucible, is selected (Fig.6).

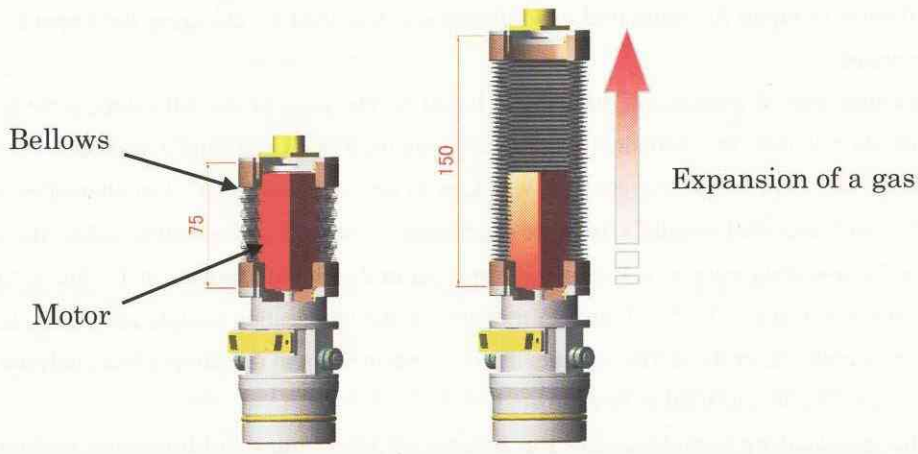

Fig.6 Pressure control and drive part

At present, we are advancing the trial preparation of the sample cartridge for the shear cell. In addition, we will perform the data acquisition on the ground by using the cartridge and GHF-MP described here for the coming ISS age.