

## Ground Investigation for Microgravity Experiment of Particle Accumulation Structure (PAS) in Thermocapillary Convection

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### 1. Introduction

The floating-zone method is one of the techniques to procedure a high-quality and large single crystal under the microgravity. In this method, a liquid bridge is formed between poly- and single-crystal rods. The central part of liquid bridge is heated while both ends cooled. As the result, thermocapillary convection is induced by surface tension gradient due to the temperature difference in the material processing. Half-zone model, which mimics a half of the floating zone, has been applied extensively for the research. Liquid bridge is sustained between cylindrical hot and cold disks in this model. Upon increasing temperature difference  $\Delta T$  between the end surfaces, the thermocapillary convection shows a transition from an axisymmetric steady to a three dimensional oscillatory flow [1].

The induced flow is usually visualized by using fine particles as tracers. The particles were found to accumulate under certain experimental conditions. This phenomenon was first observed by Schwabe et al. [2] and named particle accumulation structure (PAS). In the traveling oscillatory flow, the particles accumulate along a single closed spiral loop. The loop structure rotates in the azimuthal direction at a constant frequency. This is called spiral loop PAS (SL-PAS). Azimuthal modal structure of oscillatory flow depends upon the aspect ratio  $F (=H/R)$ , where  $H$  is the height of a liquid bridge and  $R$  the radius of disks. The shape of SL-PAS also changes depending upon  $F$  as shown in Fig. 1. An SL-PAS with a smaller mode number  $m$  is observed in a higher  $F$ . The SL-PAS has been investigated mostly for  $m \geq 2$  because of the difficulty in the formation of a long liquid bridge on the ground. The present study aims to examine the SL-PAS with  $m=1$  both experimentally and numerically.

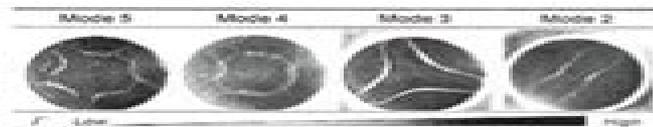


Figure 1  
Top view of SL-PAS with different azimuthal modal structure in terms of the aspect ratio.  $D=5.0$  mm, 2cSt silicone oil.

Our group is going to carry out the microgravity experiment on Japanese experiment module (JEM), which is the first Japanese manned experimental facility on international space station. This research aims to investigate the onset of oscillatory thermocapillary flow and to observe the dynamic particle accumulation structure under the microgravity. The JEM experiment is going to be made by using fluid physics experiment facility (FPEF). FPEF consists of the liquid bridge formation equipment, sample cassettes, temperature control systems and so on. It is possible to form automatically a half-zone liquid bridge with a large diameter of 30 mm and an aspect ratio of  $F=4$ . A sample cassette is composed of 5cSt silicone oil ( $Pr=69$ ) and gold coated fine particles. Now, we are collecting data for the forthcoming microgravity experiment on the ground and are planning experimental conditions.

### 2. Experiment

Experimental apparatus is shown in Fig. 2. The ground experiment for a long liquid bridge was made by using smaller disks whose diameter was 1.5 mm. Temperature difference  $\Delta T$  was imposed by heating top disk and cooling the bottom one. It was increased in small steps, and was kept constant until the shape of SL-PAS attained a fully developed state at each step. In the flow visualization, the top and side views were captured simultaneously by using two high-speed cameras. The top disk was made of sapphire, which enabled us to observe the flow field through the top. Aspect ratio  $F$  was varied from 2 to 3. The test fluid was 2cSt silicone oil ( $Pr=28$ ) and n-decane ( $Pr=15$ ). Silver coated hollow glass spheres of 10  $\mu\text{m}$  were used as tracers.

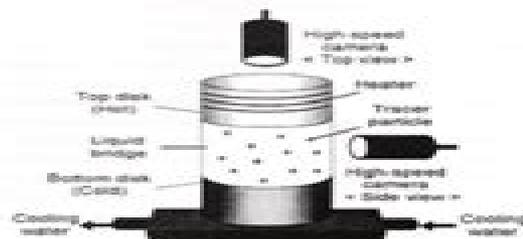


Figure 2 Experimental apparatus.

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