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Author: Dr. Satoshi Matsumoto
Japan Aerospace Exploration Agency (JAXA), Japan

Prof. Shinichi Yoda
Japan Aerospace Exploration Agency (JAXA), Japan
Prof. Hiroshi Kawamura
Tokyo University of Science, Suwa, Japan
Prof. Koichi Nishino
Yokohama National University, Japan
Prof. Ichiro Ueno
Tokyo University of Science, Japan
Dr. Mitsuru Ohnishi
Japan Aerospace Exploration Agency (JAXA), Japan

MARANGONI EXPERIMENT UTILIZING MICROGRAVITY IN KIBO

Abstract

Marangoni convection is a surface-tension-driven flow which driving force is localized at the only surface. In general, surface tension becomes high with decreasing temperature. When a temperature difference exists along surface, the surface is pulled toward low temperature region. Marangoni convection affects the quality of grown crystal such as semiconductors, optical materials or bio materials. Therefore, it is important to reveal the behavior of Marangoni convection. Marangoni convection occurred in a liquid bridge is observed to make clear the flow transition phenomena resulting from a fluid instability. Silicone oil with a viscosity of 5, 10 or 20 cSt is employed as experimental sample. Liquid bridge is suspended between a pair of solid disks (30 or 50 mm in diameter). The length of liquid bridge is variable up to 62.5 mm. Small amount of fine particles (30 or 180 μm in diameter) is mixed into liquid bridge for flow visualization. One of the disks is heated and another cooled to impose temperature difference on both end of the liquid bridge. The temperature difference is gradually enlarged in order to increase the driving force of Marangoni flow. The flow transits from steady to oscillatory flow at the certain critical temperature difference. With increasing the temperature difference, the convection becomes more complicated toward turbulent via chaotic flows. These transition processes are observed in detail. We employ Fluid Physics Experiment Facility (FPEF) mounted in Ryutai Rack inside KIBO Pressurized Module. Experiment is conducted in combining FPEF and an experiment unique hardware which is exchangeable according to the purpose of investigation and is called "Experiment Cell". Typical results from microgravity experiment using the International Space Station are listed below. (1) Highly precise data concerning the condition of flow transition can be obtained under wide range of parameters because we effectively utilize the big advantages of the ISS, long duration and high quality microgravity environment. (2) Some of previous experimental results were overthrown by precise and detailed observation (eg. propagation direction of thermal wave, flow transition condition). (3) We have succeeded in observing "Particle Accumulation Structure (PAS)" for the first time. This finding may give a hint to the mechanism of planet formation and apply for future micro-nano fluidic devices. JAXA has been promoting four Marangoni experiments involving twenty international scientists from Japan, Europe, America and Canada to fully understand Marangoni convection in microgravity. It will complete in 2016.