MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Science Results from Ground Based Research (4)

Author: Mr. Eric Giddings
University of Toronto, Canada, eric.giddings@mail.utoronto.ca

Prof. Masahiro Kawaji
University of Toronto, Canada, kawaji@ecf.utoronto.ca

EFFECT OF HELIUM CIRCULATION ON THE ONSET OF OSCILLATORY MARANGONI CONVECTION IN A LIQUID BRIDGE

Abstract

Marangoni flow experiments have been conducted using a 5 cSt silicone oil liquid bridge to investigate the effects of various liquid bridge and helium flow parameters on the onset of oscillatory Marangoni convection under normal gravity. A liquid bridge was formed between the two 7.0 mm diameter disks heated or cooled using the temperature-controlled water from constant temperature baths and Peltier elements. The liquid bridge height was 3.5mm, so the aspect ratio (height/diameter) was 0.50. This resulted in a Bond number of 0.075, ensuring that Marangoni convection dominated over natural convection. The liquid bridge was enclosed in a 16.0 mm inner diameter quartz tube, so that helium gas could be injected to flow through a 3.5 mm wide annular gap around the liquid bridge at velocities of 5 30 cm/s. Both upward and downward helium flow direction was tested. The helium gas was also heated so that the injected gas temperature could be set to either 35 or 50 oC. The lower disk temperature was kept at 10 oC or 15 oC, and the upper disk temperature was increased slowly to determine the critical temperature difference, ΔTc, between the upper and lower disks at which oscillatory Marangoni flow could be detected from the liquid temperature measurement using a thermocouple placed inside the liquid bridge. The volume ratio effect was also investigated by varying the minimum liquid bridge diameter to the disk diameter ratio, Q. From the experiments performed, the effects of helium flow, cold disk temperature, and volume ratio on the onset of critical Marangoni convection were determined. A peak value of ΔTc was detected at Q 0.75 which was independent of helium flow. Helium flow in either direction was also shown to increase the critical temperature difference, clearly indicating the stabilization effect. There was an immediate large increase at low helium velocities, with a nearly linear increase in ΔTc as helium velocity increased. The downward helium flow (in the same direction as surface flow) was shown to have a much greater stabilizing effect than the upward flow. The effect of circulated helium temperature remained unclear. At higher helium temperature, the critical temperature difference was lower for lower helium velocities, but increased more dramatically as helium velocity increased, resulting in more stabilization at higher velocities. Finally, it was shown that a higher lower disk temperature resulted in a smaller critical temperature difference.