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

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LATTICE BOLTZMANN SIMULATION OF AN ISOTHERMAL AND NON-ISOTHERMAL LIQUID BRIDGE SUBJECTED TO SMALL VIBRATIONS

Abstract

In material processing, a floating-zone (FZ) process is used to produce high quality single-crystals of semi-conductor materials. Marangoni convection occurs in such processes, and their characteristics under both earth gravity and microgravity need to be well understood. Recently, Marangoni convection experiments using a liquid bridge of silicone oil have been performed under microgravity aboard the International Space Station (ISS) [1]. Due to g-jitter, liquid bridges formed between two disks have shown small vibrations [2]. This work addresses vibration effects on a liquid bridge with and without Marangoni convection occurring inside. The effects of small lateral sinusoidal vibrations on a liquid bridge in both isothermal and non-isothermal conditions are investigated numerically using a multiphase Lattice Boltzmann equation (LBE) method. The liquid bridge is modeled using the thermophysical properties of 5 cSt silicone oil. It is subjected to lateral sinusoidal vibrations with different frequencies, amplitudes and acceleration levels. The numerical simulations for isothermal case are carried out under two gravitational acceleration levels: microgravity (g=0 m/s2) and earth gravity (g=9.81 m/s2). The resonance frequency of the liquid bridge is predicted for different aspect ratios by finding the peak amplitude of liquid bridge vibration for different vibration frequencies, and the response of the liquid bridge surface to small vibrations is also investigated. The resonance frequencies for both gravity conditions obtained from LBE method are in good agreement with analytical and experimental results. The effects of relevant physical parameters on liquid bridge vibrational characteristics in isothermal case are discussed in detail. For the non-isothermal case, the effect of lateral vibration on Marangoni convection caused by a temperature gradient imposed between the disks is also investigated.

References

[1] Kawamura, H., Nishino, K., Matsumoto, S. and Ueno, I., "Space Experiment of Marangoni Convection on International Space Station," Paper IHTC14-23346 in Proc. of the 14th International Heat Transfer Conference, Washington D.C., August 7-13, 2010.

[2] Wickramasinghe, D., Kawaji, M. and Das, K., 2010. Investigation of Marangoni Convection in International Space Station. Paper IAC-10.A2.6.7 in Proc. of 61st International Astronautical Congress, Prague, Sept. 27 – October 1, 2010.