THERMOCAPILLARY-DRIVEN FLOWS IN PURE WATER DROPS ON A LOCAL HOT-SPOT

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Phase change and flows in liquid drops are omnipresent in nature and fundamental in industrial processes such as inkjet printing, coating, biomedical analysis as well as thermal management. Considering the progression of densely-integrated microelectronic chips, drop-based cooling is a potential technique for efficient heat removal due to phase change heat transfer. Conventionally, many experimental/numerical studies have investigated water or organic drops on uniformly-heated substrates, while high heat fluxes in local areas i.e. hot-spots are often observed in aforementioned problems. In the present paper, combining infrared thermography with particle imaging, we present thermal and flow visualisation of pure water drops evaporating on a hot-spot. The hot-spot was produced by locally heating the substrate directly below the centre/edge of the drop using a laser. When heating the centre of the drop, a ring-like hot region appeared along the periphery, eventually breaking into two counter-rotating vortices which travelled azimuthally. As heating went on, the vortices began to merge and split in an oscillatory manner. On the other hand, edge heating resulted in more directional vortices with a distinct oscillatory pattern: rather, the vortices swung around the main heat conduction path (from the heating spot to the other side). The origin of these patterns was identified by calculating and comparing the dimensionless Marangoni and Rayleigh numbers, which showed the dominance of the Marangoni effect. This fact was further supported by a second set of experiments where the same flow patterns were observed when the system was inverted i.e. a pendant drop heated from above. Besides heating locations, the effect of heating power on the strength of Marangoni instabilities was also discussed.

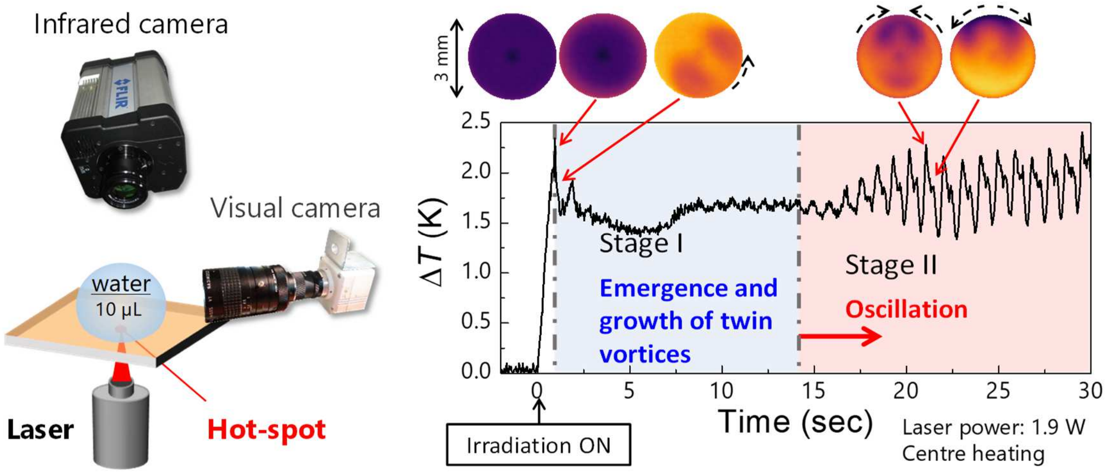

FIG. Schematic of experimental setup (left) and representative result for the mid-power centre-heating case (right). The chart presents the temporal evolution of the maximum temperature difference obtained from the IR images.