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Nucleate Boiling in Microchannels

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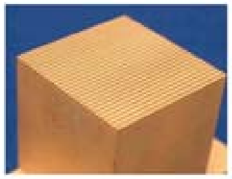
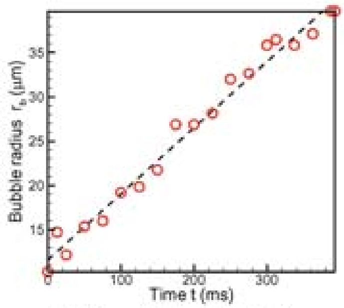
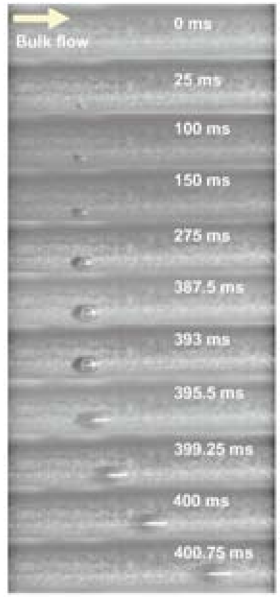


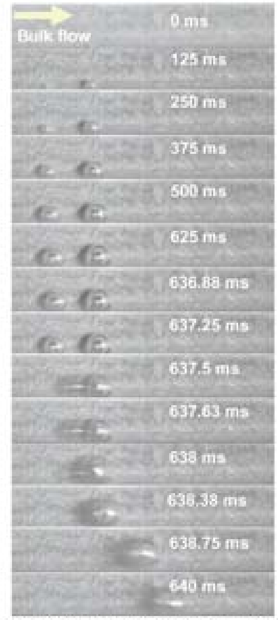
Microchannel heat sink



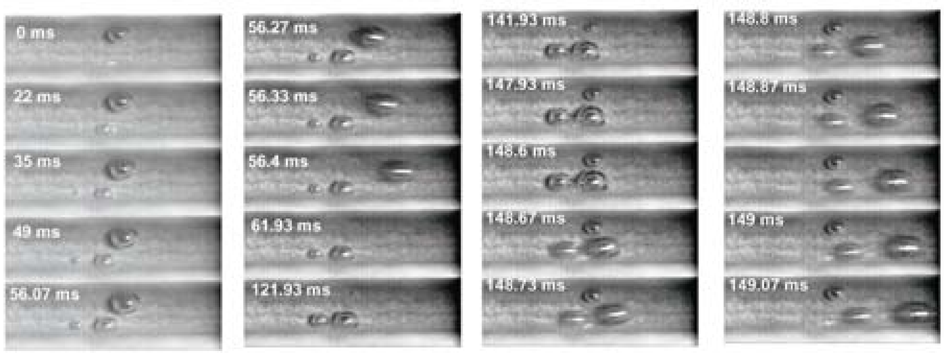
Bubble evolution during boiling



Single bubble nucleates, grows and departs from the bottom wall (4000 fps).



Twin bubbles agglomerate after growth and travel down the channel (8000 fps).



Multiple bubbles grow and depart from the bottom wall without agglomeration (15,000 fps).

Nucleate Boiling in Microchannels

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An understanding of bubble motion and evolution during nucleate boiling is necessary for the analysis of convective heat transfer rates in microchannels. High-speed photography is used in this study to reveal the complex bubble dynamics during nucleate boiling in copper microchannels of hydraulic diameter 384 μm (275 μm wide and 636 μm high) and 25.4 mm length. De-ionized water flows through the microchannels at a velocity of 0.68 m/s (Re = 735) and an inlet temperature of 86.5°C. The exit pressure is maintained at 1.05 bar. A constant heat flux of 16 W/cm^2 is applied at the bottom of the microchannel heat sink. A high-speed digital video camera is used to observe the boiling process at 4,000, 8,000 and 15,000 frames per second.

The images shown looking down into the microchannels reveal the transient processes of nucleation, growth, subsequent departure and interaction of bubbles from nucleation sites on the bottom wall of the channel. The measured bubble radius indicates a linear evolution with time. These results are useful in proposing predictive models for boiling heat transfer in microchannel heat sinks.