Time-Resolved Characterization of Microchannel Flow Boiling During Transient Heating

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Objective

Characterize the dynamic response of a microchannel flow boiling system when subjected to transient heating conditions

Approach

- Apply single or time-periodic heat flux pulses of differing magnitudes and durations to a 500 μm-diameter microchannel
- Use flow visualizations and high-frequency thermal/hydrodynamic measurements to quantify the coupling between transient heating conditions and thermal-fluidic behavior

Impact

Demonstrates the unique challenges presented by next-generation two-phase thermal management systems utilizing embedded cooling, which will need to be overcome to enable commercial adoption

Selected Publications

Kingston, Weibel, and Garimella, *International Journal of Heat and Mass Transfer:* 2020 (154) 119643; 2020 (154) 119686

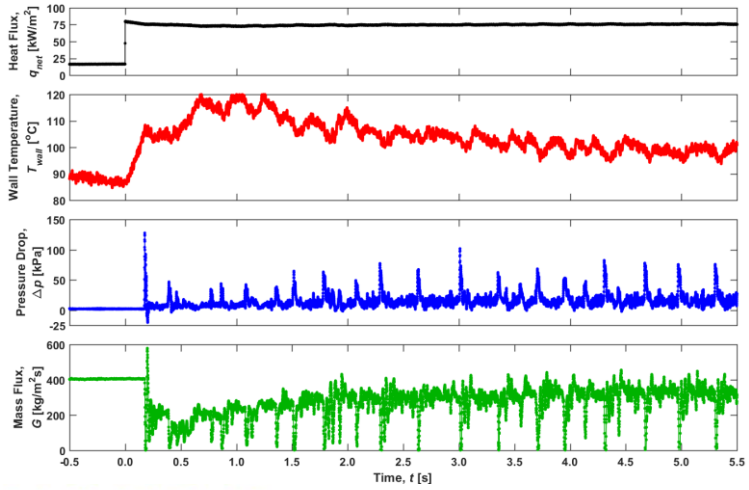
Selected Results

Single Heat Flux Pulse

- At the onset of boiling, the dynamic response resembles that of an underdamped mass-spring-damper system
- During transitions between single-phase and two-phase flow, the wall temperature temporarily over/under-shoots the eventual steady temperature

Time-Periodic Heat Flux Pulses

- A square-wave heating profile with pulse frequencies ranging from f = 0.1-100 Hz is applied
- For heating pulse frequencies $1<f<10$ Hz, thermal and flow fluctuations are heavily coupled to transient heating profile



Left: Dynamic response to a single heat flux pulse. Temperature overshoots 20 °C during transition to time-periodic boiling

Right: Demonstration of the synchronization of heating frequency and thermal-fluidic oscillations at f = 5 Hz