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Numerical Simulation of Evaporating Two-Phase Flow in a High-Aspect-Ratio Microchannel with Bends

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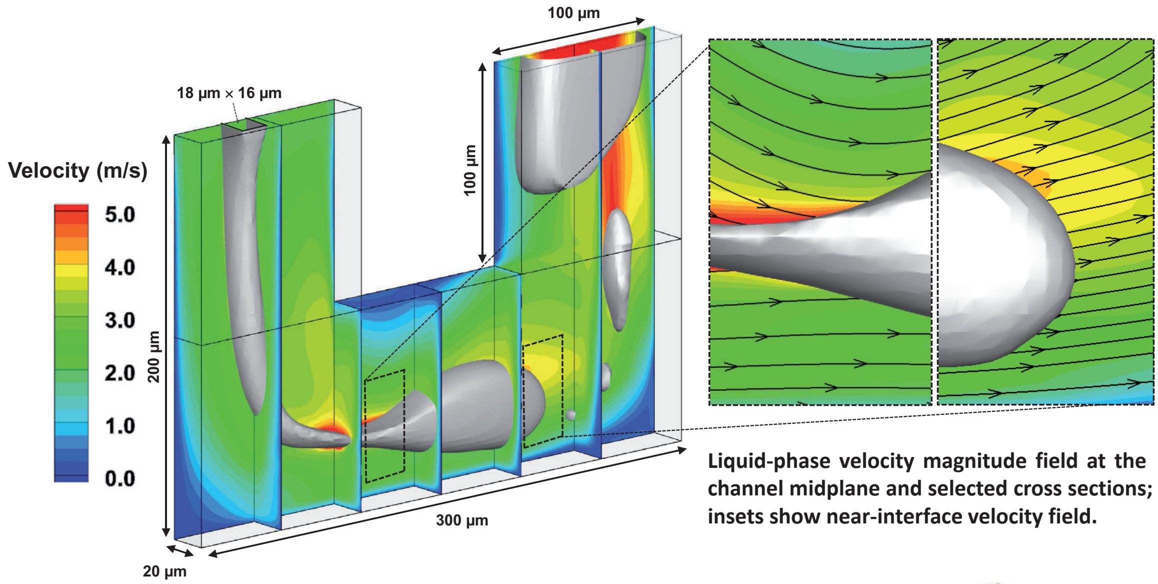
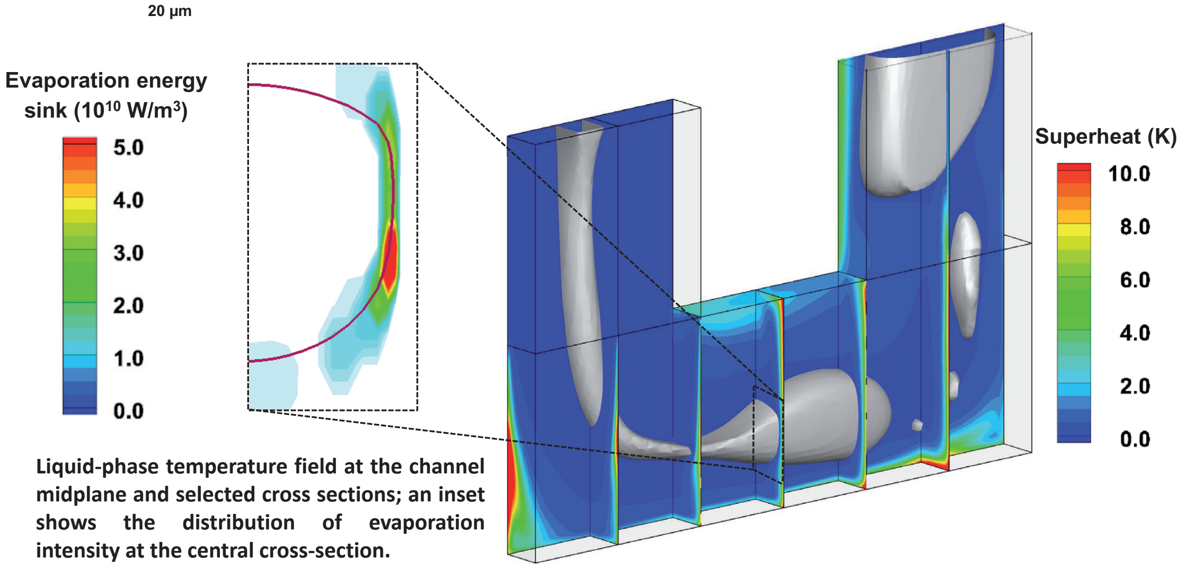


Liquid-phase velocity magnitude field at the channel midplane and selected cross sections; insets show near-interface velocity field.



Liquid-phase temperature field at the channel midplane and selected cross sections; an inset shows the distribution of evaporation intensity at the central cross-section.

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Despite the demand for high-performance, two-phase cooling systems, high-fidelity simulations of flow boiling in complex microchannel geometries remains a challenging numerical problem. We conduct a first-principles-based simulation of an evaporating two-phase flow in a high-aspect-ratio microchannel with bends using a volume of fluid-based numerical model. For the case shown, the lower horizontal section of the microchannel has a constant flux of 20 W/cm^2 applied to the wetted wall area (heat flux at the base of 133 W/cm^2); HFE-7100 vapor and liquid enter the channel at 2 m/s. The three-dimensional channel geometry requires a refined near-wall numerical mesh to resolve thin liquid film flow features. The recently developed saturated-interface-volume phase change model (*Int J Heat Mass Trans* 93:945-956, 2016) is implemented for prediction of mass and energy exchange across the liquid-vapor interface at a low computational cost (~80 hr; 6-core parallelization on Intel Xeon E3-1245V3). The model reveals transport details including the interface shape and fluid velocity and temperature fields. The interfacial temperature remains fixed at saturation with smooth velocity contours near the interface. The highest evaporation flux is located in the thin liquid film region near the heated wall.

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