Pumped Two-Phase Cooling for the Next-Gen Chips with Heat Flux over 4 W/mm2

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Summary

The rapid growth of AI and HPC applications is driving GPU power consumption and chip heat flux to unprecedented levels. Future GPUs are expected to exceed an average heat flux of 1 W/mm², with hotspot heat flux surpassing 3 W/mm², creating significant thermal management challenges. Pumped two-phase cooling has emerged as a promising solution due to its ability to leverage latent heat transfer and provide higher cooling capacity than conventional liquid cooling.

This study presents the architecture of a pumped two-phase cooling distribution unit (CDU) and coolant loop and evaluates the performance of a two-phase cold plate. Thermal test results are compared with those of the same cold plate operating with PG25 coolant to assess the potential benefits of two-phase cooling. The tested two-phase cold plate demonstrates a heat dissipation capability exceeding 3500 W, indicating its suitability for next-generation high-power GPUs.

The results show that both refrigerant-based two-phase cooling and PG25 cooling are capable of meeting the projected thermal requirements of future GPU platforms. However, the maximum cooling performance of both approaches is constrained by fluid thermophysical properties and flow conditions. While thermal management will become increasingly challenging over the next several GPU generations, current cooling technologies remain capable of addressing these demands through continuous optimization.

An additional advantage of the proposed architecture is its compatibility with existing liquid-cooling infrastructures, allowing two-phase coolant distribution across multiple racks with minimal system modification. Future research will focus on exploring alternative cold plate materials and thermal conductivity optimization to further improve cooling performance and support the continued increase in computing power density.

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