

Two-Phase Micropillar Evaporators to Enable Cooling of next-Generation GPU Servers

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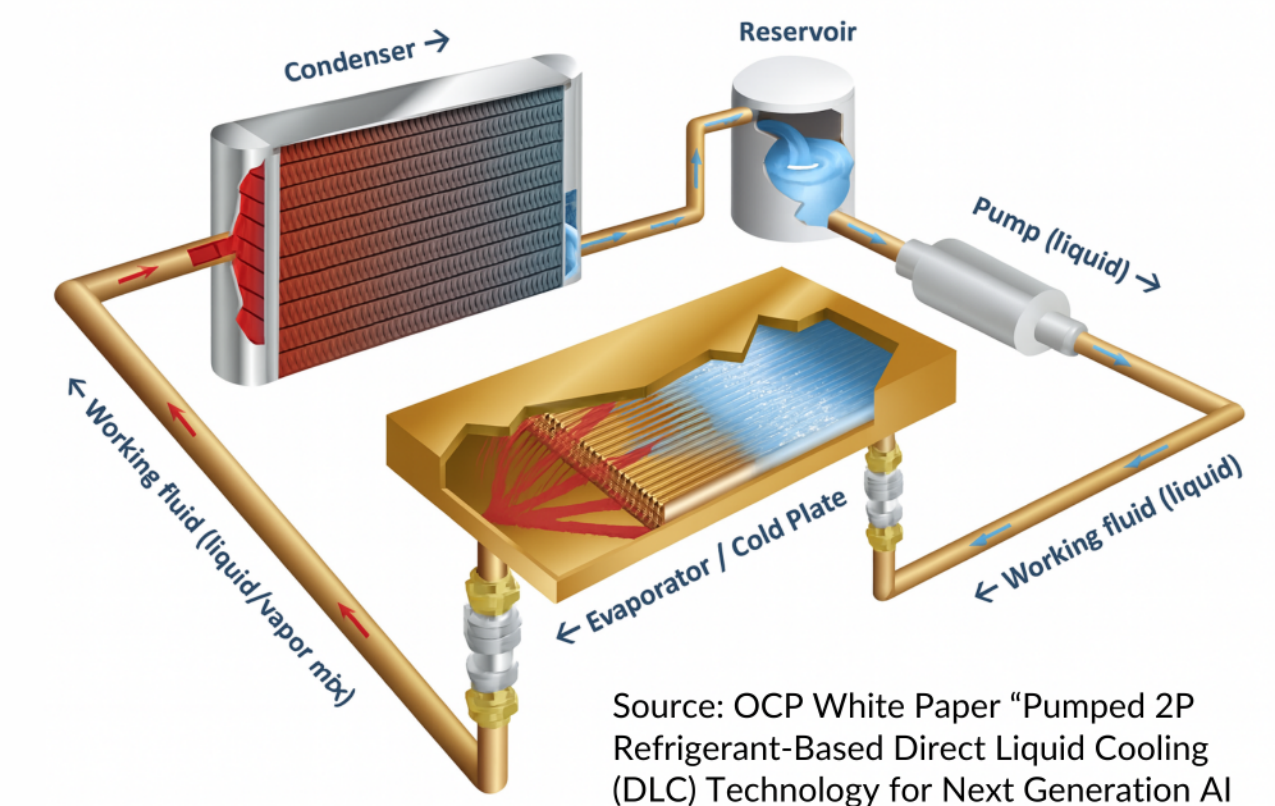
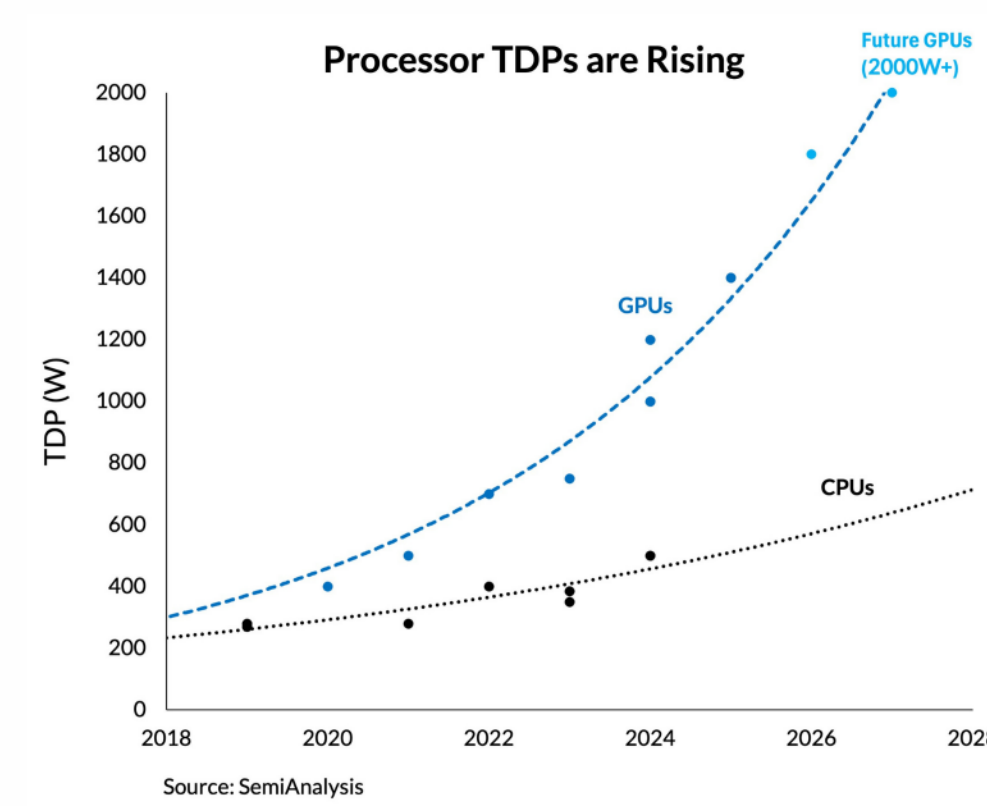
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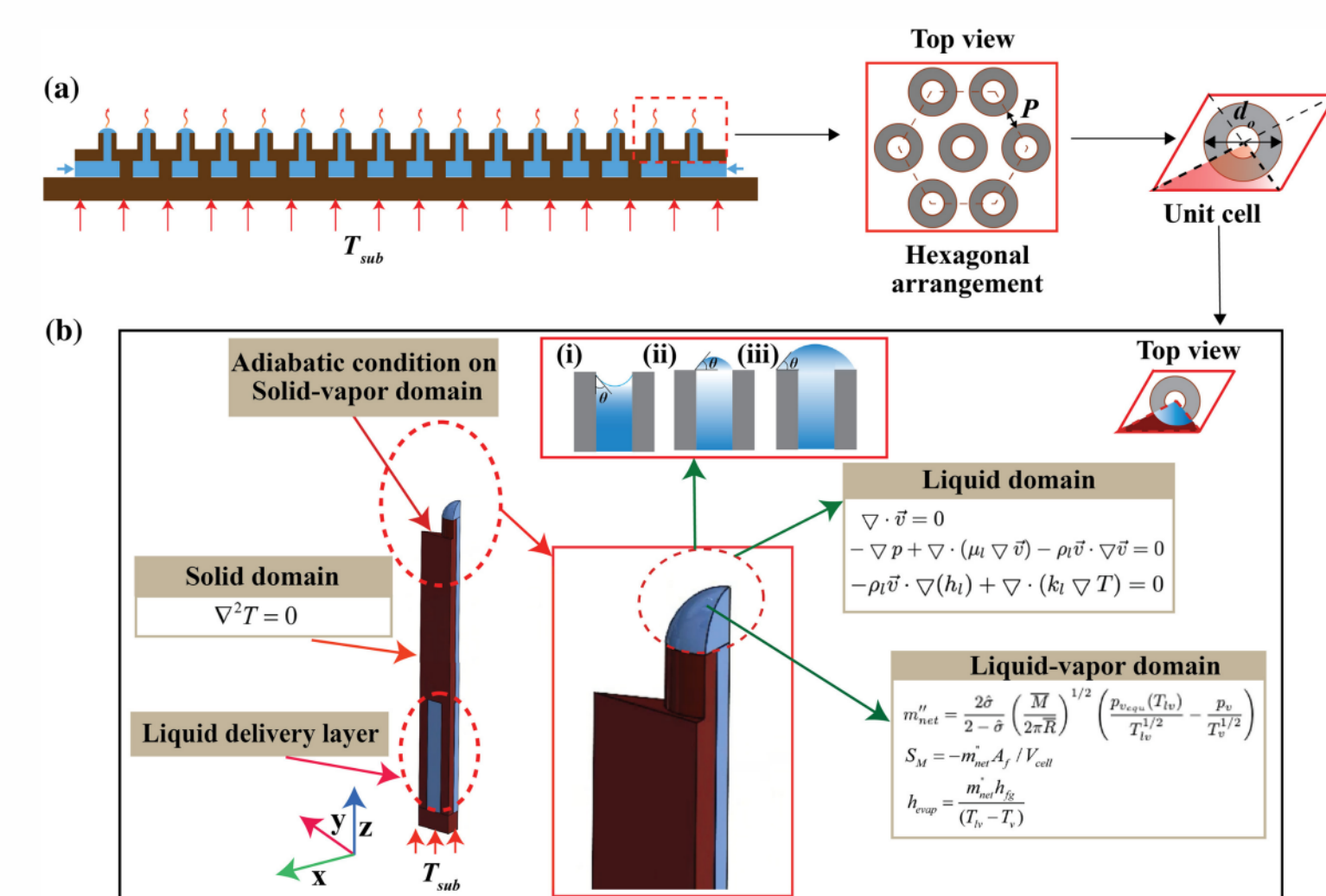
The Market Need

- Thermal design power of processors and power density of server racks are surging driven by AI workload demands
- Advantages of pumped two-phase (2P) direct-to-chip (DTC) cooling
 - Superior heat transfer: HTC increases with heat flux
 - Isothermality: alleviate silicon warpage
 - Small coolant flow rate: pumping cost reduction and erosion mitigation
 - Dielectric fluid: safety for IT equipment



Direct-to-Chip Evaporator Cooler (DCEC)

- Arrays of silicon-based hollow micropillars integrated with a manifold and liquid delivery layer
 - Enable microscale evaporation of suspended droplets
 - Balance thermal resistance and hydrodynamic performance through controlled porosity and modular evaporator layouts
 - High heat flux dissipation up to 400W/cm²
 - High thermodynamic utilization with an exit vapor quality of 1
- Operates across three liquid expansion regimes depending on pressure, heat flux, and working fluids, due to surface free energy
 - (i) concave meniscus wicking inside the pillar (Stage 1)
 - (ii) droplet pinned at the inner edge (Stage II)
 - (iii) droplet pinned at the outer edge (Stage III)



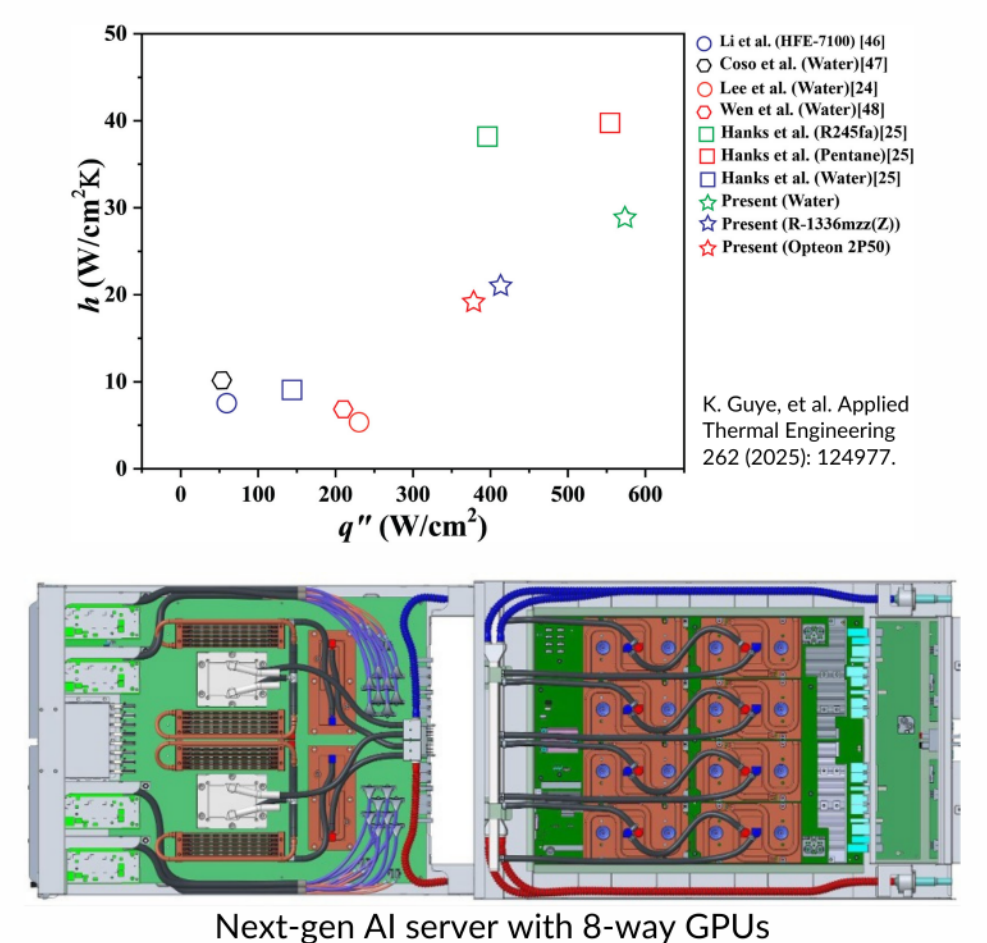
Advanced Two-Phase Coolant Distribution Unit (CDU)

- Closed-loop system with low GWP dielectric fluids
- The largest cooling capacity two-phase in-row CDU: MR250
- Able to cool 250kW of IT power loads in 1-4 racks
- Deployed in UT Arlington Lab contributing to the ARPA-E COOLERCHIPS program



Combined Cooling Performance

- 2P DTC cooling using DCEC and MR250 offers untethered cooling potential
- Maintains GPU case temperature <68°C with 40°C facility water supply at 250 kW load
- Great potential for energy savings in data centers by allowing high facility water supply temperature
- Sufficient thermal headroom for future GPUs with 2~3X of current power and heat flux



Conclusions

- 2P DTC cooling's high performance is required for next-gen GPUs, servers, and racks
- 2P cooling allows high facility water temperature while maintaining low case/junction temperatures, offering great potential for energy savings
- DCEC evaporator + MR250 CDU applied on an advanced AI server can maintain GPU case temperature below 68°C with 40°C facility coolant supply at 250kW cooling load
- 2P cooling offers sufficient thermal headroom to address the cooling demands of the next-generation processors/servers/racks

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