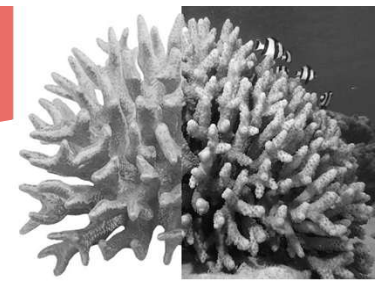




Immersion 5.0

Enabling Two Phase Immersion Cooling to Support High TDP



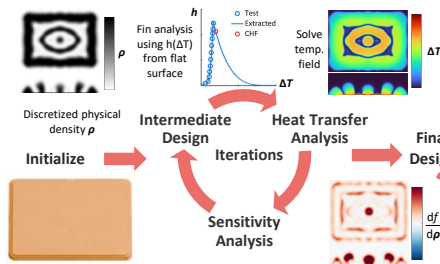
Project Vision

To enable a two-phase immersion cooling thermal solution for future high-power GPU / AI products using topology-optimized heatsinks with embedded spreaders

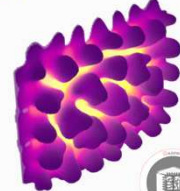
Project Overview

Topology Optimization

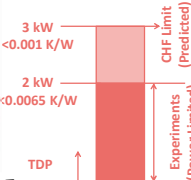
- In pooling boiling boundary conditions



PURDUE UNIVERSITY intel ACT



Solid Cu Heat Sink w/ Boiling Enhancement Coating

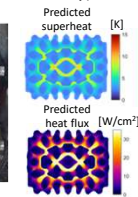


Performance Testing

- Reliability testing complete using Intel TTV
- Solid Cu TO heat sink operates at >2 kW
- Validated model-predicted resistance [K/W]



Immersion Cooling Test Facility (Purdue University)

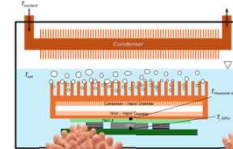


System Integration Results

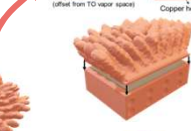
- TO designs meet midterm milestones; clear pathway to final targets for 2 kW & 5 kW TDPs
- 10 kW tank available for characterization of heat spreaders at ACT.
- 160 kW immersion tank under development with Modine for system level testing.



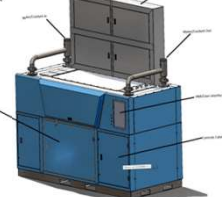
10 kW 2PIC Facility (ACT)



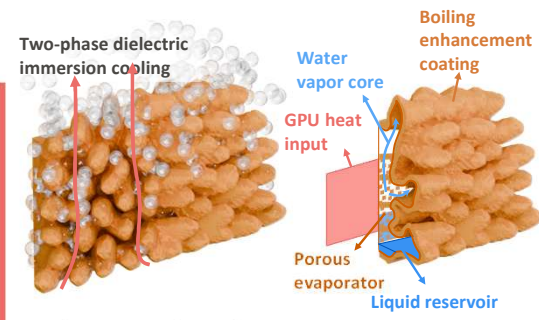
Mfg & Assembly of VC Heat Sinks



160 kW Facility



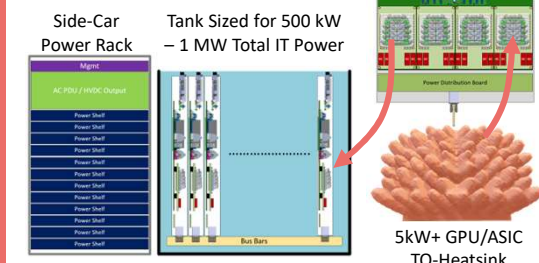
Technology Description



Topology Optimized Two-Phase Immersion Cooling Vapor Chamber

The Megawatt Rack (Tank)

- Breakthrough in heat sink technology enables a scalable thermal architecture future-proof for AI/HPC workloads
- Supports rack-level scaling from 160 kW today → 1 MW by reducing per-device thermal bottlenecks



System Reliability

Interaction	Failure Mode
Die ↔ Vapor Chamber	VC Dryout
Boiling Surface ↔ Fluid	Critical Heat Flux
VC ↔ Condenser	Flooding; NCG Blocking
Fluid ↔ Material Compatibility	Organize Leaching/Plasticizer Release
Condenser ↔ Facility Water	Fouling; Biofilms

Team Members

Intel Corporation

- Andy Fitterer (PI)
- Je-Young Chang
- Kimberley Ridgeway



Purdue University

- Justin A. Weibel
- Yanbo Huang
- Matthew Wood



Advanced Cooling Technologies

- Nathan Van Velson
- Srujan Rokkam
- Hessam Taherian
- SaiKiran Hota

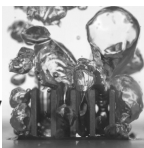


Benefits of Two-Phase Immersion Cooling (2PIC)

- Superior heat transfer efficiency allowing for higher heat flux removal from GPUs/CPUs
- Elimination of active cooling components (pumps, fans chillers)
- Reduction in energy use (PUE) for lower carbon footprint and better sustainability

Key Challenges of 2PIC

- High superheat for boiling incipience → Risk of high T_j without nucleation
- Low CHF (e.g., 15-20 W/cm²) → Limited operation range → Risk of film boiling transition
- Performance prediction accuracy is lower than in single-phase



Technology Targets

FOA metrics	Units
Resistance Target	<0.01 K/W
Cooling Power % of IT Power	<3 %
System Availability	>99.982 %
Chip Power	2 → 5 kW
Power per Rack	160 kW → 1 MW

	Solid Heat Sink @ 2 kW	Vapor Chamber @ 5 kW
Thermal Resistance		
Heat Sink & Spreader	0.0065 K/W	0.005 K/W
Total System	0.015 K/W	0.01 K/W



Cooling Operations Optimized for Leaps in Energy, Reliability, and Carbon Hyperefficiency for Information Processing Systems

