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Liquid and vapor separation in liquid jet impingement cooler for low surface tension fluids

Advanced wick cooling preventing dry-out, enabling stable high-power electronics and data center cooling.

Researchers at Purdue University have designed a novel wick structure for enhancing liquid jet impingement. Liquid jet impingement in a boiling regime has a superior cooling rate due to the utilization of latent heat. However, the simultaneous presence of liquid and vapor in the boiling regime poses challenges such as pressure fluctuations and flow instabilities, which reduces the dry out limits and makes the process less appealing for engineering applications.

This technology developed by Purdue University researchers improves the current liquid jet impingement process by separating liquid and vapor during a two-phase operation, preventing dry-out to very high heat flux scenarios. The porous media wick structures of this technology offer more nucleation sites, allowing for consistent and uniform boiling throughout the evaporator. Moreover, liquid jet impingement complemented with capillary driven evaporation has tremendous potential to dissipate high heat flux while maintaining a near uniform temperature over the target surface.

Technology Validation:

The chip-level model developed by Purdue University served as a foundational precursor to the current model, providing essential insights and methodological cues. Leveraging past studies conducted at the Binghamton Data Center as a point of reference, the researchers delved into comprehending the intricacies of two-phase dynamics within racks. Preliminary findings have unveiled that a reduced flow rate throughout the rack has the potential to yield significantly heightened vapor quality, consequently resulting in reduced pumping power requirements.

Advantages:

Technology ID
2024-WEI-70610

Category
Semiconductors/Thermal Management & Cooling Technologies

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-Allows for jet impingement to operate in a capillary-driven boiling mode

-Avoids sudden dry-out conditions for unsteady thermal loads during real-time electronic operations

-Ensures a steady feeding of the coolant through capillary action to the region where boiling occurs

-Alleviates challenge of smaller wicking lengths at higher heat flux for low-surface tension coolants

Applications:

-High-power electronics

-Data center thermal management practices

-Phase change-based cooling solutions

TRL: 3

Intellectual Property:

Provisional-Gov. Funding, 2024-05-07, United States

Utility-Gov. Funding, 2025-05-05, United States

Keywords: High-efficiency liquid jet cooling,Phase change thermal management,Capillary-driven cooling,Two-phase flow control,Vapor-liquid separation technology,Electronic device cooling,Advanced heat dissipation,Data center cooling solutions,Boiling heat transfer enhancement,Thermal management for high-power electronics,Stable cooling under variable loads,Wick structure cooling technology,Uniform temperature maintenance,High heat flux cooling systems