

Insik Lee

- Integrated MS - PhD course
 - Mechanical Engineering
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 - Research interest:
 1. 2.5D/3D semiconductor thermal management
 2. Multi-phase jet-impingement cooling
 3. Boiling dynamics and heat transfer modeling
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Academic Experiences

Korea Advanced Institute of Science and Technology (KAIST) Integrated M.S. - Ph.D.
(2024.02 – Present)

Korea Advanced Institute of Science and Technology (KAIST) B.S. Summa Cum Laude
(2020.02 – 2024.02)

Journal Publications:

2) **Insik Lee**, Hyunho Cho, Seungwoo Kim, Jaechoon Kim, and Youngsuk Nam "High efficiency single and multi-phase direct liquid jet-impingement cooling for heterogeneous packaging" [Energy Conversion & Management, Vol. 348, pp. 120665 \(2026\)](#)

1) Hyunho Cho, **Insik Lee**, Seungwoo Kim, Soosik Bang, Jaechoon Kim, and Youngsuk Nam "Optimization Framework for Energy-Efficient and Uniform Jet Impingement Cooling for Heterogeneous Integration Packaging" [Energy and AI, Vol. 21, pp. 100587 \(2025\)](#).

Conference Presentations:

10) **Insik Lee**, Hyunho Cho, Seungwoo Kim, Jaechoon Kim and Youngsuk Nam, "Thermo-hydraulic performance comparison between single-phase and multi-phase coolants for direct-liquid jet-impingement cooling of 2.5D semiconductor packages", *KSFM Winter Conference*, Korea, Dec. 3-5, 2025

9) **Insik Lee**, Hyunho Cho, Seungwoo Kim, Jaechoon Kim and Youngsuk Nam, "Thermo-hydraulic performance evaluation of direct liquid jet-impingement cooling with single and multi-phase fluids for chiplet packaging", The 23rd International Symposium on Microelectronics and Packaging (ISMP 2025), Korea, Nov. 4-7, 2025

8) **Insik Lee**, Hyunho Cho, Seungwoo Kim, Jaechoon Kim and Youngsuk Nam, "Direct liquid jet-impingement cooling with single-phase and two-phase fluids for heterogeneously integrated

semiconductor packages”, *KSME Spring Conference*, Korea, Apr. 23-26, 2025.

7) **Insik Lee**, Hyunho Cho, Seungwoo Kim, Jaechoon Kim and Youngsuk Nam, "Single and Two-Phase Jet Impingement Cooling for Thermal Management of 2.5D Semiconductor Packages”, *KMEPS 2025*, Incheon, Korea, Apr. 1-3, 2025

6) Hyunho Cho, **Insik Lee**, Seungwoo Kim, Soosik Bang, Jaechoon Kim and Youngsuk Nam, "Active learning-based design optimization of direct liquid cooling modules for heterogeneously integrated semiconductor packages”, *The 3rd Pacific Rim Thermal Engineering Conference (PRTEC 2024)*, Hawaii, USA, Dec. 15-19, 2024

5) Hyunho Cho, **Insik Lee**, Seungwoo Kim, Soosik Bang, Jaechoon Kim and Youngsuk Nam, “Jet nozzle array optimization for enhancing temperature uniformity in direct liquid cooling of semiconductor packages with non-uniform heat fluxes”, *The 22th International Symposium on Microelectronics and Packaging (ISMP 2024)*, Korea, Nov. 5-8, 2024

4) Hyunho Cho, **Insik Lee**, Seungwoo Kim, Soosik Bang, Jaechoon Kim and Youngsuk Nam, “Design optimization of single-phase jet impingement cooling module for efficient thermal management of heterogeneous integration semiconductor package using CNN-based surrogate model”, *KSME Spring Conference*, Jeju, Korea, Apr. 24-26, 2024.

3) Hyunho Cho, **Insik Lee**, Seungwoo Kim, Soosik Bang, Jaechoon Kim and Youngsuk Nam, Optimization of thermal management performance of direct liquid cooling module for chiplet packages using active learning and hierarchical exploration, *KSFM Winter Conference*, Korea, Nov. 29 – Dec. 1, 2023

2) Hyunho Cho, **Insik Lee**, Seungwoo Kim, Soosik Bang, Jaechoon Kim and Youngsuk Nam, “An active learning approach to performance optimization of jet impingement – based cooling module for chiplet semiconductor package”, *KSFM Summer Conference*, Korea, July. 5-7, 2023.

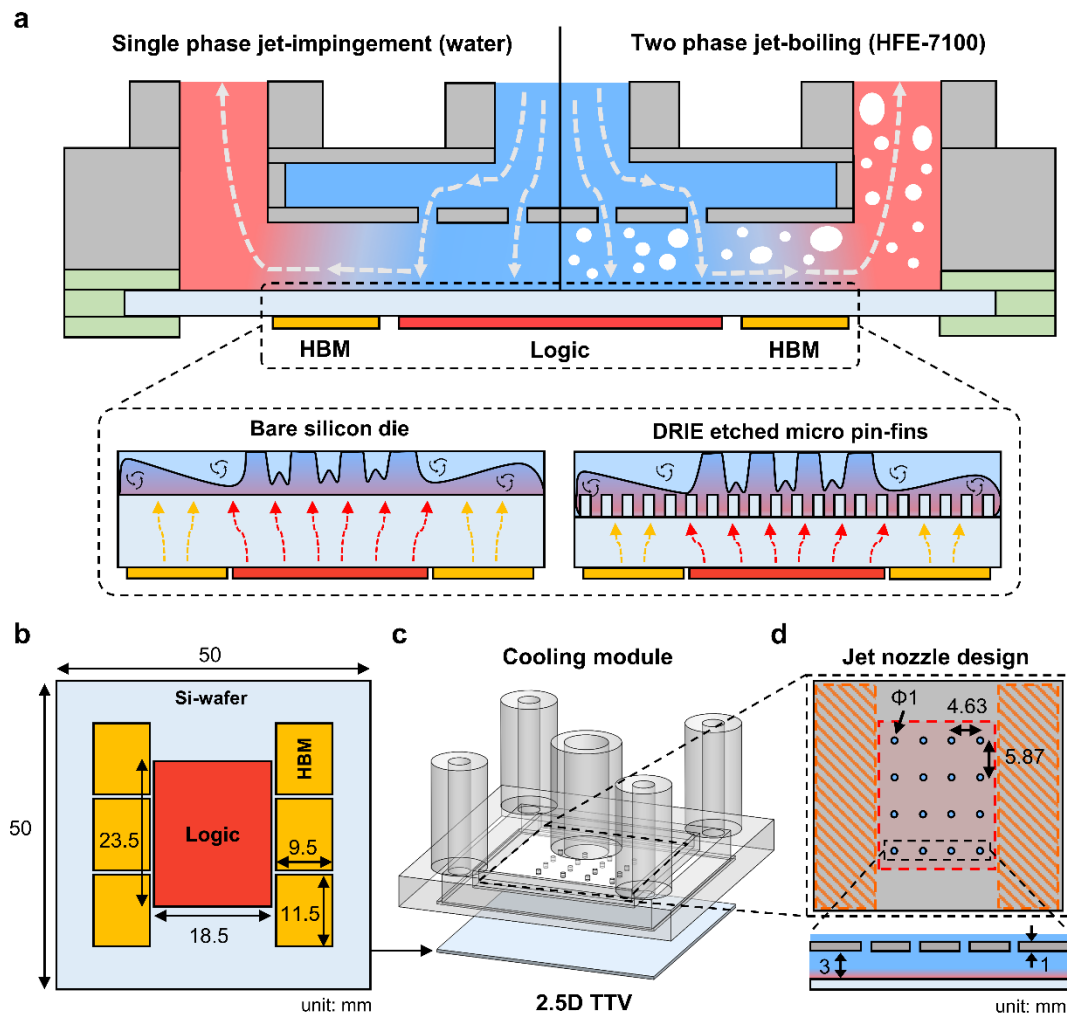
1) Hyunho Cho, **Insik Lee**, Seungwoo Kim, Soosik Bang, Jaechoon Kim and Youngsuk Nam, “Multi-objective design optimization of direct liquid cooling system for multi-chip semiconductor package using active learning”, *KSME Spring Conference*, Korea, Apr. 19-22, 2023.

Award:

Patent:

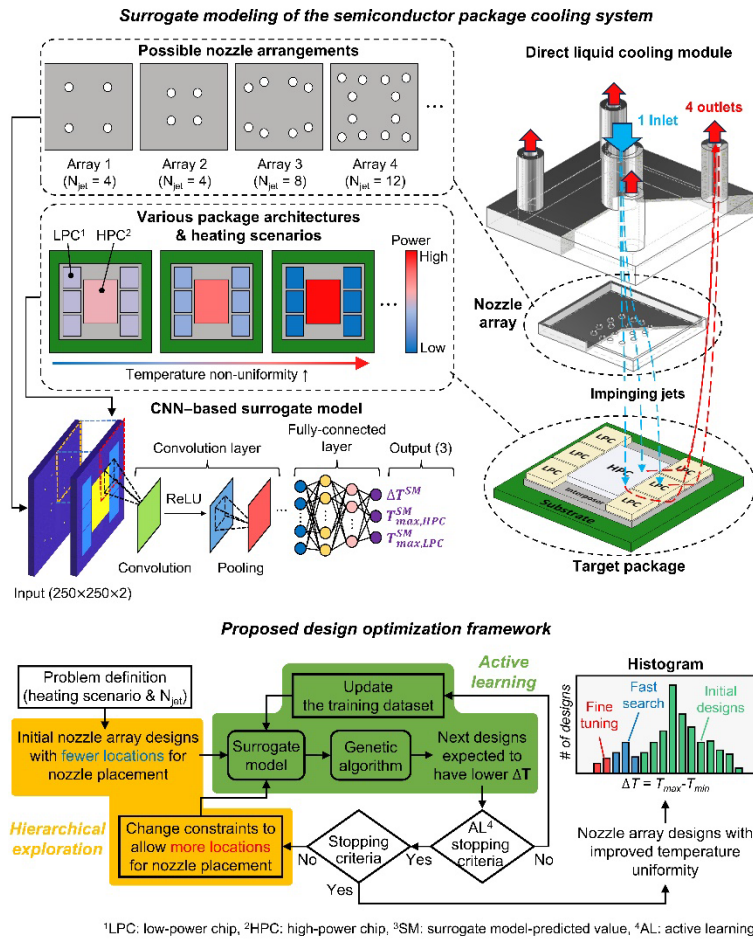
Research Topics:

1) 2.5D Semiconductor Package Direct-Liquid Jet-Impingement Cooling



In this study, an in-depth experimental analysis on the thermo-hydraulic performance of a direct-liquid jet-impingement cooling module with single and multi-phase coolants was conducted using a thermal test vehicle replicating the non-uniform heat fluxes of a typical 2.5D chiplet package. We first compare water and HFE-7100 as coolants in an identical direct-liquid jet-impingement cooling configuration on a silicon-based heterogeneous package TTV, which was fabricated to imitate the realistic thermal characteristics of an actual chip. A hybrid cooling strategy was implemented for the cooling module, where high heat flux logic chips were targeted by a multi-jet array, while low heat flux HBM chips were cooled through horizontal crossflow to reduce hydraulic resistance. IR thermometry was used to decouple and analyze the cooling performance on the logic and HBM chips for both single and multi-phase regimes, where the localized visualization provided direct insight into the physical mechanisms governing CHF in multi-jet array boiling. In addition, DRIE etched micro pin-fins on the silicon TTV further enabled evaluation of how surface modifications influence convective and phase-change heat transfer performance, as well as energy efficiency. Furthermore, an exergy-based performance factor was introduced to evaluate the effects of coolant inlet temperature and surface structuring on the energy efficiency. These findings establish a quantitative framework for evaluating the thermo-hydraulic performance of direct-liquid jet-impingement cooling, offering valuable insights for developing tailored thermal management solutions for high-power chiplet packages in real-world applications.

2) Thermal Optimization with Neural Network based Machine Learning Techniques



In this study, we introduce a jet impingement cooling-based direct liquid cooling system for energy-efficient uniform cooling of heterogeneous integration (HI) applications with non-uniform heat fluxes. We optimized the irregular jet nozzle arrangement to maximize both the temperature uniformity and energy efficiency of the cooling module. A finite element method (FEM)-based numerical analysis model was developed to calculate the maximum temperature difference between chips and the maximum temperature of each chip. A CNN-based surrogate model trained on FEM data works in conjunction with a non-dominated sorting genetic algorithm (NSGA-II) to iteratively select candidate additional data points required for active learning. To ensure the diversity of additional data, we propose a semi-multi objective optimization algorithm (SMO) using a dummy objective variable and a Hungarian algorithm-based design similarity calculation method. By controlling the possible positions for jet nozzle placement, we divided the design space into three subspaces of different sizes, enhancing optimization speed by quickly approaching the near-optimum region in smaller design subspaces before moving to larger ones for fine-tuning. This sequential optimization process of changing design subspaces was termed hierarchical exploration which, combined with active learning, demonstrated significantly higher optimization speed compared to random sampling-based processes. Through our proposed optimization framework, superior designs were identified for four different cases with varying numbers of nozzles, showing substantial improvements in temperature uniformity and coefficient of performance (COP) compared to reference designs with uniform jet-to-jet spacings. These results, along with the numerical model, were partially validated experimentally. Lastly, we explored the potential for further improving optimization efficiency by applying the CNN model to untrained scenarios. The proposed framework can be applied to the rapidly evolving diverse heating scenarios of HI packages, enabling the identification of superior designs more quickly than traditional methods, and contributing to improved cooling energy efficiency in data centers and reliability of high-performing processors.