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Seungwoo Kim

- Ph.D course
- Department of Mechanical Engineering
- Korea Advanced Institute of Science and Technology (KAIST)
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- Research interest: Electronics thermal management, Jet impingement cooling, Immersion cooling, Thermal test vehicle (TTV), ANN based optimization

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Academic Experiences

Korea Advanced Institute of Science and Technology (KAIST) Sep.2022-Present

Ph.D in Mechanical Engineering (Advisor: Prof. Youngsuk Nam)

Korea Advanced Institute of Science and Technology (KAIST) Jun.2021-Aug.2022

Researcher (Advisor: Prof. Youngsuk Nam)

Kyung Hee University (KHU) Mar.2021-Aug.2022

M.S. in Mechanical Engineering (Co-Advisor: Prof. Youngsuk Nam & Prof. Choongyeop Lee)

- Thesis: Development of energy-efficient Jet impingement cooling for semiconductor thermal management utilizing surrogate model based multi-objective optimization

Kyung Hee University (KHU) Mar.2015-Feb.2021

B.S. in Mechanical Engineering (Advisor: Prof. Youngsuk Nam)

- Thesis: Thermal Optimization of Multi Finger GaN HEMT Considering Circuit Integration

Journal Publications

7) **Seungwoo Kim**, Han Ku Nam, Sanghyung Han, Dongwook Yang, Jun Soo Kim, Suhyun Maeng, Chulmin Ahn, Younggeun Lee, Byunggi Kim, Young-Jin Kim, and Youngsuk Nam "Femtosecond Laser Structuring on Direct Bonded Copper (DBC) for Energy-Efficient Thermal Management of Power Electronics" (Under review)

6) 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)

5) 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).

4) Soosik Bang, **Seungwoo Kim**, Seokkan Ki, Junyong Seo, Jaechoon Kim, Bong Jae Lee and Youngsuk Nam "Artificial neural network (ANN)-based multi-objective optimization of the vapor chamber with liquid supply layer for high heat flux applications", *International Communications in Heat and Mass Transfer*, Vol. 159 pp.108302 (2024)

3) **Seungwoo Kim**, Seokkan Ki, Soosik Bang, Sanghyung Han, Junyong Seo, Chulmin Ahn, Suhyeon Maeng, Bong Jae Lee, Youngsuk Nam "Optimizing Energy-Efficient Jet Impingement Cooling Using an Artificial Neural Network (ANN) Surrogate Model for High Heat Flux Semiconductors", *Applied Thermal Engineering*, Vol. 239 pp. 122101 (2023)

2) Jaehwan Shim, Seungtae Oh, **Seungwoo Kim**, Donghyun Seo, Subeen Shin, Haeseung Lee, Younghwan Ko, Youngsuk Nam "Long-lasting ceria-based anti-frosting surfaces", *International Communications in Heat and Mass Transfer*, Vol. 140 pp.106550 (2023)

1) Seokkan Ki, Jooyoung Lee, **Seungwoo Kim**, Jeongmo Sung, Jaehwan Shim, Seungtae Oh, Sumin Cho, Soosik Bang, Donghyun Seo, Joongnyon Kim, Youngsuk Nam "An energy-efficient battery thermal management system incorporating a porous metal-based multiscale flow manifold", *Energy Conversion & Management*, Vol. 269, pp. 116147 (2022)

Patents

2) Su Hyeon Maeng, Kwang Min Choi, Baek Yu Kim, Chul Min Ahn, Dong Hui Cheon, Sun Sung Kwon, Won Seok Lee, Young Suk Nam, Sang Hyung Han, **Seung Woo Kim** , "Power Module Cooler" , Application No.: 19/388,777 (US) , 202511871320.9 (CN), 102025148620.4 (DE), Date of Application: Nov. 13, 2025 (US), Dec. 12, 2025 (CN), Nov. 24, 2025 (DE).

1) 맹수현, 최광민, 김백유, 안철민, 천동희, 권순성, 이원석, 남영석, 한상형, **김승우**, "파워모듈 냉각 장치", 출원번호 (국내): 10-2025-0047645, 출원일: 2025년 04월 11일

Conferences

18) Sang Hyung Han, **Seungwoo Kim**, Chul Min Ahn and Youngsuk Nam, "Energy Efficiency Analysis of a Double-Sided Jet Impingement Cooled EV Inverter Assembly", *KSME Spring Conference*, Jeju, Korea, Apr. 23-26, 2025

17) **Seungwoo Kim**, Sungwook Yoon and Youngsuk Nam, "TTV-Based Two-Phase Immersion Cooling for Thermal Performance Evaluation of 2.5D Semiconductor Packaging", *KMEPS 2025*, Incheon, Korea, Apr. 1-3, 2025

16) 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

15) 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

14) 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

13) **Seungwoo Kim**, Seokkan Ki, Soosik Bang, Sanghyung Han, Junyong Seo, Chulmin Ahn, Suhyeon Maeng, Youngsuk Nam, "Efficient Cooling Solutions for High Heat Flux Electronics: ANN Optimization of Jet Impingement and Micropost Systems", *InterPACK 2024*, San Jose, CA, October, 8-10, 2024

12) **Seungwoo Kim**, Seokkan Ki, Soosik Bang, Sanghyung Han, Junyong Seo, Chulmin Ahn, Suhyeon Maeng, Youngsuk Nam, "Enhancing Thermal Management with Jet Impingement and Microposts: Inducing Vortices and Reducing Boundary Layer Thickness", *ICTAM 2024*, Daegu, Korea, August, 25-30, 2024

11) Soosik Bang, **Seungwoo Kim**, Seokkan Ki, Junyong Seo, Jaechoon Kim, Bong Jae Lee and Youngsuk Nam, "Optimizing the vapor chamber with liquid supply layers for high heat flux applications using an ANN-based multi-objective genetic algorithm", *The 23rd Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems (ITherm)*, Denver, CO, USA, May 28-31, 2024

10) Sanghyung Han, **Seungwoo Kim**, Su Hyeon Maeng and Youngsuk Nam, "Design of jet impingement cooling system for multi-device power module with double-sided cooling", *KSME Spring Conference*, Jeju, Korea, Apr. 24-26, 2024

9) 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

8) 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*, Jeju, Korea, Nov. 29-Dec. 1, 2023

7) **Seungwoo Kim**, Seokkan Ki, Soosik Bang, Sanghyung Han, Junyong Seo, Chulmin Ahn, Suhyeon Maeng, Youngsuk Nam, "Thermal Management in EV Inverters: Optimizing Jet Impingement Cooling with Micropost Integration", *The 21th International Symposium on Microelectronics and Packaging (ISMP 2023)*, Korea, October 25-27, 2023

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

5) 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*, Busan, Korea, Apr 19-22, 2023

4) **Seungwoo Kim**, Seokkan Ki, Soosik Bang, Chulmin Ahn, Choongyeop Lee and Youngsuk Nam, "The Optimization of a Jet Impingement and Micropost Hybrid Cooling System for High Heat Flux Semiconductors", *8th Thermal and Fluids Engineering Conference (TFEC)*, USA, March 26-29, 2023.

3) Soosik Bang, **Seungwoo Kim** and Youngsuk Nam, "Numerical analysis on heat transfer characteristics of ultra-thin vapor chamber with liquid supply layer based on multi-objective optimization", *KSME Fall Conference*, Jeju, Korea, November 9-12, 2022

2) Seokkan Ki, Jooyoung Lee, **Seungwoo Kim**, Joongnyon Kim and Youngsuk Nam, "Battery thermal management system using manifold flow channels combined to porous metal layer", *KSME Spring Conference*, Korea, April 20-22, 2022.

1) **Seungwoo Kim**, Seokkan Ki, Soosik Bang, Chulmin Ahn, Choongyeop Lee and Youngsuk Nam, "Direct cooling system based on multi-objective optimization to improve high heat flux chip cooling efficiency", *KSME Spring Conference*, Korea, April 20-22, 2022.

Project

12) 고발열 1U 서버용 DTC-액침 하이브리드 냉각 기술 성능 검증

LG Electronics, 2025.08 ~ 2026.12.

11) **파우치형 배터리의 열 균일성을 위한 열교환기-액침 냉각 시스템**

KAIST Undergraduate Research Participation (URP) Program, 2025.06 ~ 2025.12

10) **임베디드 근접 냉각 방식을 적용한 고효율 3D 칩렛 패키징 열관리**

Samsung Electronics, 2025.02 ~ 2027.02.

9) **인버터 냉각 성능 향상을 위한 2-phase 냉각 기법 연구**

HYUNDAI Motor Group, 2024.09 ~ 2026.02.

8) **열관리 고도화 응용을 위한 반도체 박막-공동 3 차원 구조 글로벌 기초연구실**

National Research Foundation of Korea (NRF), 2024.08 ~ 2027.04.

7) **고밀도 데이터센터 Direct-to-Chip 열관리 기술 및 Server-Rack 운영기술 개발**

Korea Energy Technology Evaluation and Planning (KETEP), 2024.07 ~ 2027.06

6) **냉각 실험을 위한 TTV(Thermal Test Vehicle) 제작**

Furiosa AI, 2024.05 ~ 2025.07.

5) **액침냉각용 열전달 유체 성능비교평가**

DL Chemical, 2024.05 ~ 2025.05.

4) **인버터 냉각 성능 향상을 위한 제트 충돌 냉각기 Micropost 최적화**

HYUNDAI Motor Group, 2023.03 ~ 2026.06.

3) **2.5D/3D 고전력 반도체 패키지 일체형 액체 냉각시스템 개발**

Samsung Electronics, 2021.09 ~ 2024.08.

2) **고출력인버터 냉각효율 향상을 위한 직접 냉각시스템 개발**

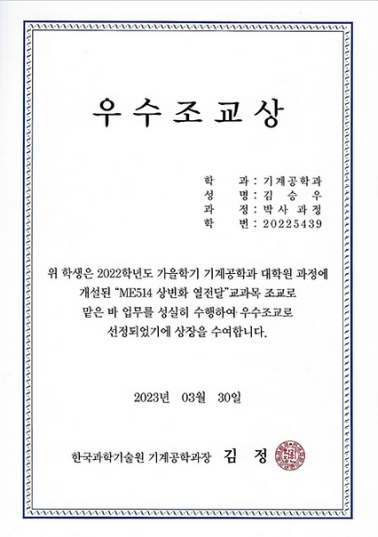
HYUNDAI Motor Group, 2021.03 ~ 2022.08.

1) **메탈폼 이용 액체냉각 최적화 설계**

LG Electronics, 2019.08 ~ 2020.08.

Awards

1) **Outstanding TA award**, *KAIST*, Korea, March 30, 2023.



우 수 조 교 상

학　　과 : 기계공학과
성　　명 : 김 승 우
과　　정 : 박 사 과 정
학　　번 : 20225439

위 학생은 2022학년도 가을학기 기계공학과 대학원 과정에
개설된 "ME514 상변화 열전달"교과목 조교로
맡은 바 업무를 성실히 수행하여 우수조교로
선정되었기에 상장을 수여합니다.

2023년 03월 30일

한국과학기술원 기계공학과장 김 정

2) **Young Scientist Award**, *The 21th International Symposium on Microelectronics and Packaging (ISMP 2023)*, Korea, October 27, 2023.

kmeps

No. 23-39

YOUNG SCIENTIST AWARD

is presented to

Seungwoo Kim[1], Seokkan Ki[1], Soosik Bang[1], Sanghyung Han[1], Junyong Seo[2], Chulmin Ahn[3], Suhyeon Maeng[1], Youngsuk Nam[1,3]

[1]Department of Mechanical Engineering, Korea Advanced Institute of Science and Technology (KAIST), Daejeon 34141, Republic of Korea
[2]Energy Efficiency Research Division, Korea Institute of Energy Research (KIER), Daejeon 34129, Republic of Korea
[3]Research & Development Division, Hyundai Motor Group, Hwaseong, 18280, Republic of Korea

Title: Thermal Management in EV Inverters: Optimizing Jet Impingement Cooling with Micropost Integration

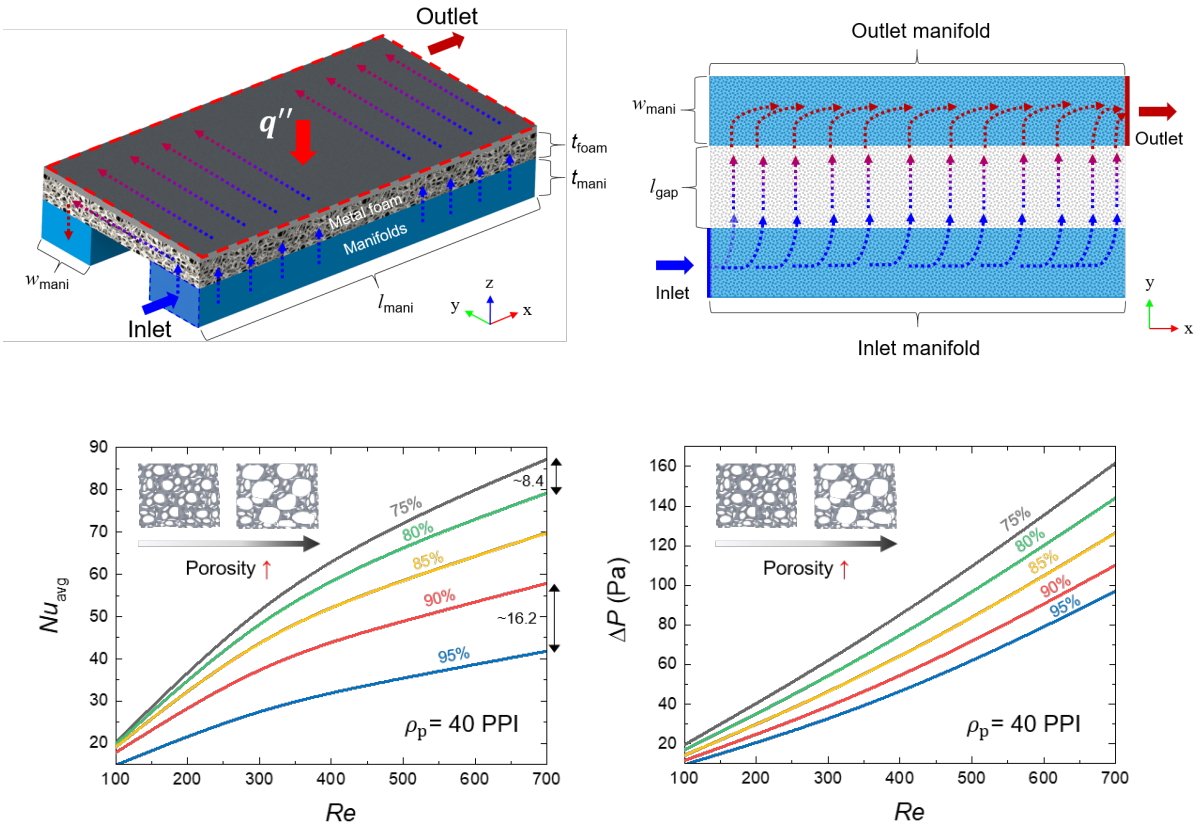
at The 21st International Symposium on Microelectronics and Packaging

27th October, 2023

Sayoon Kang
General President of ISMP 2023

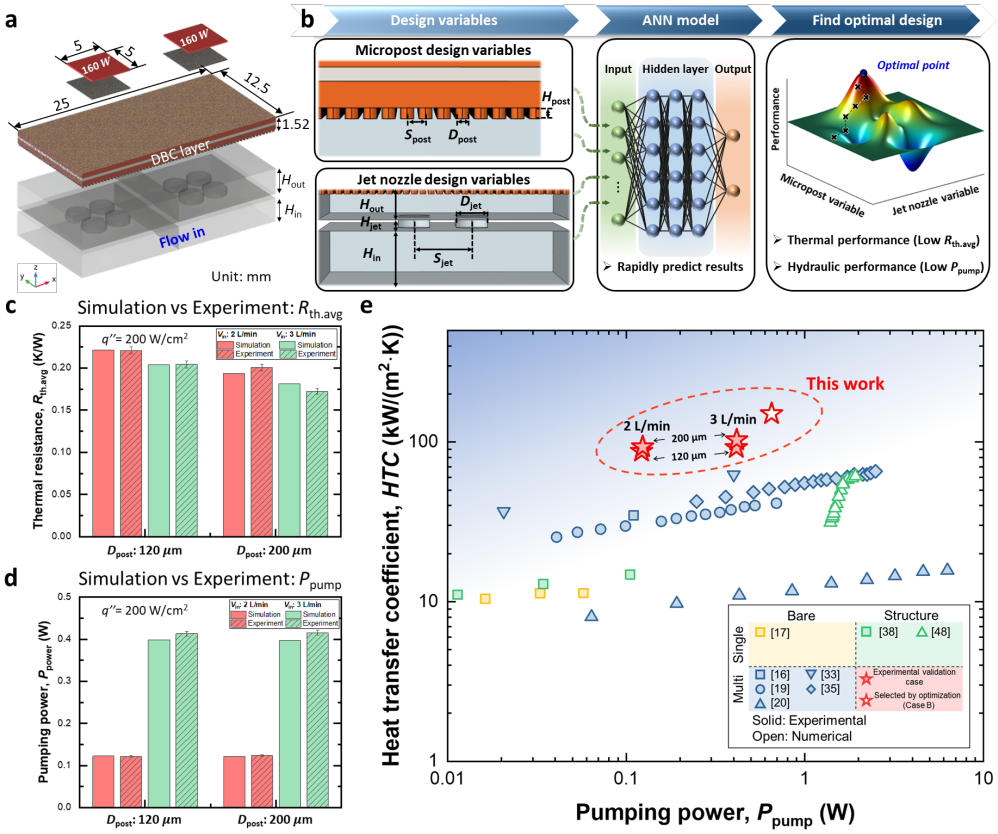
Major Research Topics

1) Development of compact cooling module for battery pack using metal foam: unit geometry



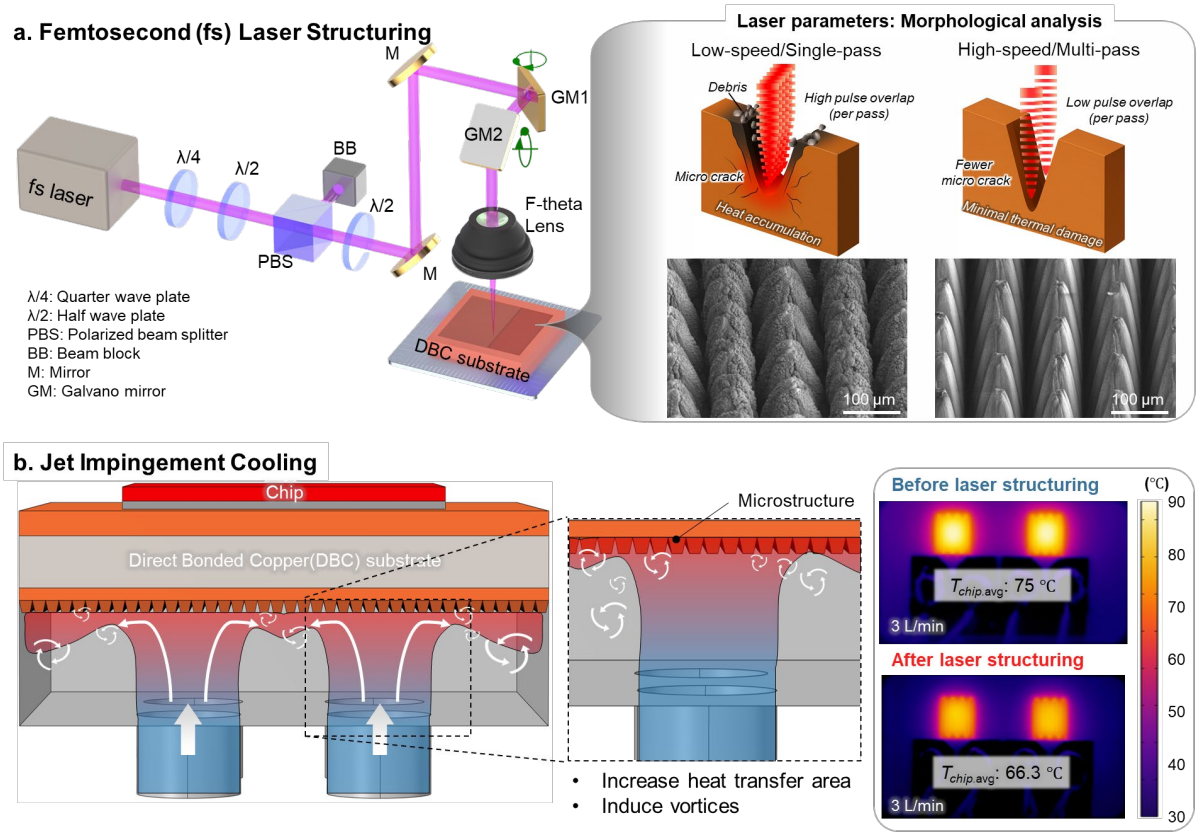
We propose an alternative cooling module which can control the high energy density multiple heat sources by combines the advantages of a manifold structure with a low initial pressure drop to obtain a high mass flow rate through the fluid path, and the advantage of porous materials to achieve efficient heat transfer through the uniform coolant distribution. In this study, we have defined a unit geometry for the manifolds-metal foam (MMF) configuration, where the physical properties of metal foam and geometrical parameters of flow channels were investigated. Also we can find the optimized geometry and metal foam porosity by low computational cost. Based on these results, a full scale battery thermal management system (BTMS) was developed.

2) Development of energy-efficient Jet impingement cooling for semiconductor thermal management utilizing surrogate model based multi-objective optimization



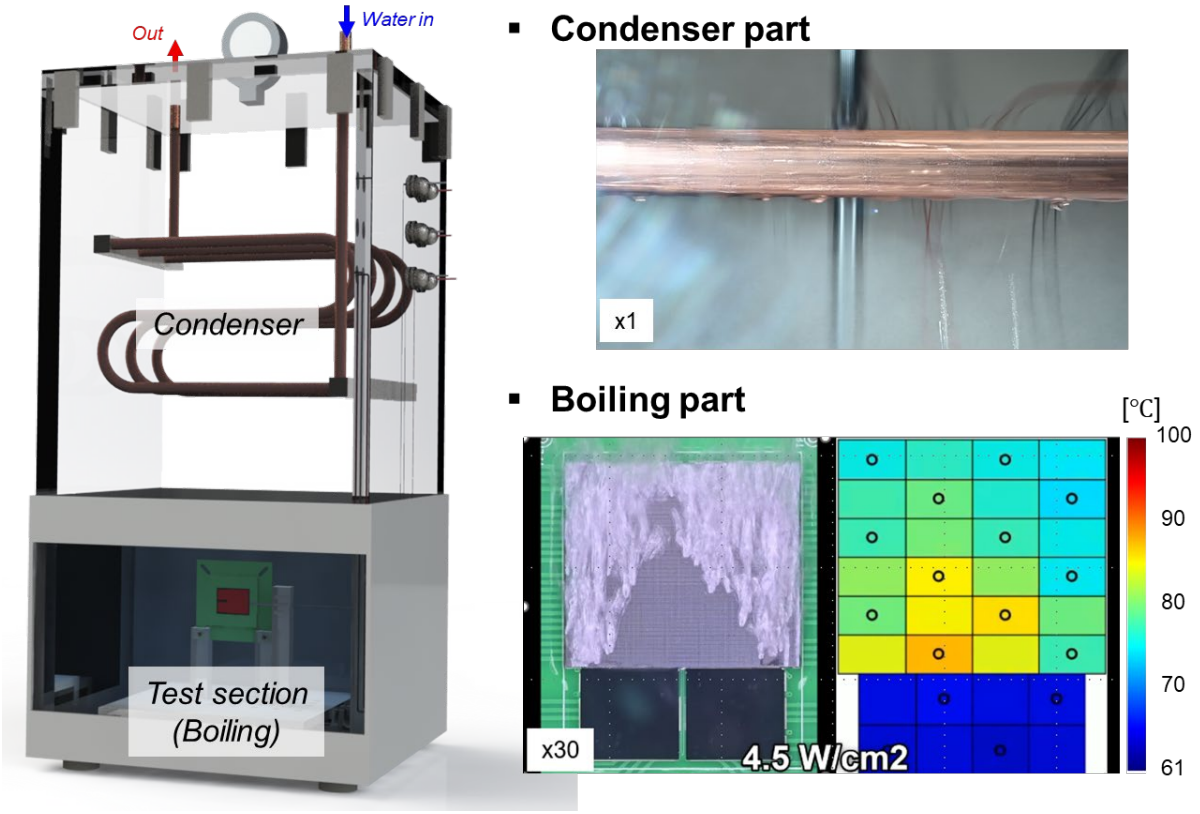
This study presents the optimization of two high-heat flux (865.8 W/cm2) semiconductor thermal management systems targeting an EV inverter. The cooling system employs a jet impingement integrated with microposts. The thermal resistance ($R_{th.avg}$) and pumping power (P_{pump}) were evaluated through computational fluid dynamics (CFD) simulations by varying the jet nozzle parameters, micropost variables, and volume flow rate. To ensure the accuracy of the CFD model, experimental validation was also conducted, demonstrating less than a 5% error. Then a surrogate model predicting $R_{th.avg}$ and P_{pump} was developed using the artificial neural network (ANN) method. The sensitivity analysis subsequently identified the primary influencing factors of the system, and the Pareto optimal fronts were determined via the elitist non-dominated sorting genetic algorithm (NSGA-II). Through optimization, the approach provided multiple optimal designs for a broad spectrum of P_{pump} values, which was feasible within a brief period (less than 200 seconds) due to the rapid estimations by the ANN-based surrogate model. The experimentally validated design achieved a 65% improvement in heat transfer coefficient (~102.96 kW/(m2·K)) at similar pumping power levels (~0.42 W) compared to previously reported jet impingement studies. Moreover, the design chosen through the optimization (Case B) projected a 140% enhancement in heat transfer coefficient (~150.2 kW/(m2·K)) with only a 63% rise in P_{pump} (~0.65 W). By exploring a more diverse range of multi-jet and micropost configurations, we were able to achieve higher performance. This study highlights the potential of combining jet impingement cooling with microposts as a highly attractive strategy for thermal management in high heat flux and multi-hot spot applications.

3) Femtosecond laser structuring for enhanced jet impingement cooling



The increasing power density of electric vehicle (EV) inverters has amplified the importance of thermal management. Jet impingement cooling, among other cooling methods, provides a high heat transfer coefficient at local hot spots. Furthermore, when combined with structures such as micro pin-fins, cooling performance can be further enhanced. In this study, we enhanced jet impingement cooling performance by fabricating high-density microstructures on a direct bonded copper (DBC) substrate using a femtosecond laser. We measured the depth of the microstructures as a function of laser scan speed and number of scanning passes, confirming that a 'high-speed multi-pass' strategy (100 mm/s, 100 passes) was significantly more effective than a 'low-speed single-pass' method. This optimized method generated structures three times deeper (~210 μm) within the same processing time while simultaneously minimizing debris generation. Furthermore, in-situ temperature measurements showing an average process temperature 10°C lower than the low-speed single-pass method confirmed a significantly reduced thermal load during fabrication. Jet impingement experiments demonstrated that the microstructured surface fabricated under optimal conditions reduced thermal resistance by up to 19% compared to a bare surface. This work conclusively shows that femtosecond laser structuring technology is an effective method for enhancing thermal performance.

4) Two-phase immersion cooling



The industry has consistently improved chip performance through semiconductor miniaturization. As semiconductor circuit line widths shrink to a few nanometers, further miniaturization becomes challenging. Moving forward, the solution may not lie in increasing the number of transistors but in exploring '3D chiplet-packaging' technologies. With the emergence of 3D chiplet systems, the thermal issue continues to be one of the most critical challenges. Among various solutions, two-phase immersion cooling emerges as one of the most promising cooling technologies to address this issue. Our primary objective is to predict performance based on packaging design and optimize it. Also, to evaluate both boiling and condensation performances from a holistic system perspective of two-phase immersion cooling, all with the aim of optimizing efficiency and effectiveness.