Smart Heat Sink
High performance immersion cooling easily integrable heat sink

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Context

The increasing trend in the computational power, along with the continuous scaling of microprocessors, results in the creation of high heat flux zones on the chip processor that require advanced heat evacuation technology for cooling[1]. The existing commercial heat sinks with embedded heat pipes have reached their limit in heat evacuation capacity[2]. According to the International technology roadmap for semiconductors (ITRS), the servers will require a thermal design power of up to 500 W per socket in 2034 which would be excessively demanding for the traditional air-cooling systems. In a typical data center, the thermal management (cooling) of server electronics consumes approximately a third of the electricity used by the facility. It is important to find new thermal solutions that will lower the costs of operation in data centers and enable the highest-performance computing systems.

This paper highlights the Next Generation of Smart Heat Sink developed by Systemex Energies, East-West Manufacturing and the University of Sherbrooke.

Description

Since 2017, the research consortium has been collaborating to develop a novel two-phase immersion heat sink for microelectronics and microprocessors cooling applications. This new technology integrates the advantages of two-phase cooling in an air-cooled heat sink. Heat from the CPU (or electronics component) boils a fluid inside a chamber that changes liquid to vapor. The vapor flows up to a condenser in a close thermal cycle. The air-cooled condenser liquefies the vapor, and the liquid flows back by gravity. This heat sink is designed for compatibility with existing integrated chip sockets and packages. A new multi-scale electroplated porous coating (MuSEP), was developed to enhance the boiling efficiency of the heat sink and reduce the thermal resistance. This coating can be added to an Integrated Heat Spreader or directly to the backside of an exposed die. A key characteristic of the technology is that the boiling liquid is fully contained within the heat sink, so that all the performance benefits of immersion cooling can be achieved, without the risk and complexity. This heat sink technology improves the cooling of electronic parts compared to conventional techniques by enabling a thermal design power of up to 500 W per 2U socket and 1000 W per 4U socket, and by reducing the thermal resistance (junction-to-air) by more than 20 %.

Applications

This novel heat sink technology is extremely efficient to remove heat produced by microchips. As conventional air-cooling technologies approach a thermal limit in terms of cooling, the two-phase cooling approach is most important in a future where microelectronics components tend to be increasingly compact and have large power density.

Several sectors of interest are targeted for this novel technology:

- **Gaming industry**
- **Computing and Data Center applications**
- **Military & Optical applications**
- **Electrical Vehicle applications**

Technical Advantages

- **Simple solution that replaces standard air-cooled heat sinks:**
    - Form factor can be adapted to fit existing server configurations
    - 4U and 2U standards are available
    - Low pressure heat sink

- **Increased Performance**
    - Lower thermal resistance
    - Lower intensity of the temperature cycling
    - Allow higher tolerances in multi-chip modules
    - Lower CPU junction temperature
    - Reduces greenhouse gases (GHG) emissions
- **Reduced energy consumption**
    - Lower thermal resistance

    - Operates at ambient temperature up to 35ºC
    - A data center that operates at a 15ºC warmer air temperature has over 25% reduction in energy consumption for cooling[3].

- **Proprietary coating achieves state-of-the-art thermal performance**
    - Lowest possible junction temperature at high power with air cooling
    - Future-compatible with power per socket up to 500W with air cooling
    - Reliability tests performed: Extensive testing without any issue
    - Fully compatible with standard packages

Commercial Advantages

The consortium has resulted in the development of a unique type of closed thermal solution through localized immersion cooling.

Additionally, a unique IP has been developed on the MuSEP coating which is a key differentiator in packaging technology. The coating can be applied on the IHS or on the chip die, thereby eliminating thermal layers. This simple solution aims to achieve best thermal performance in multi-chip modules which have shown very high thermal performance enabled at the IHS or chip level. This feature can be used to improve full-immersion cooling.

About Systemex Energies. Systemex is a company working in the field of development of technologies with energy consumption applications and has further developed its own HPC3 technology that provides an electronic equipment cooling solution by immersion cooling technologies through wide collaboration with research partnership that include leading universities, research institutes and industries in related fields as well as government bodies.

About East West Manufacturing. East West is a company engaged in the design, manufacture and distribution of electro-mechanical products**.**

About 3IT Sherbrooke. 3IT Sherbrooke is a center of collaborative innovation, where world-renowned researchers, university and graduate students and research professionals combine their know-how in a common goal: Stimulate technological development by offering an interdisciplinary ecosystem of scientific research, entrepreneurship and innovation.

Intellectual Property

Patent applications filed

Commercial licence available

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Annex

List of scientific publications

Pool Boiling Experiment of Dielectric Liquids and Numerical Study for Cooling a Microprocessor

- 2019 18th IEEE Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems (ITherm)
- https://ieeexplore.ieee.org/document/8757380

Localized Pool Boiling and Condensation Experiments over Functional CPU: Optimizing the Overall Thermal Resistance via Different Heat Transfer Scenarios

- 2020 19th IEEE ITherm
- https://ieeexplore.ieee.org/document/9190371

Two-Phase Closed-Loop Thermosyphon Filled with a Dielectric Liquid for Electronics Cooling Applications

- 2021 20th IEEE ITherm
- https://ieeexplore.ieee.org/document/9503149

Two-Phase Immersion Cooling of Microprocessors with Electroplated Porous Heat Spreaders: Thermal Performance and Reliability

- 2021 20th IEEE ITherm
- https://ieeexplore.ieee.org/document/9503279

Multi-Scale Electroplated Porous Coating for Immersion Cooling of Electronics

- 2022 21st IEEE ITherm
- https://ieeexplore.ieee.org/document/9899660

Boiling and Condensation of a Dielectric Liquid in a Closed Enclosure for Electronics Cooling Applications

- 2022 21st IEEE ITherm
- https://ieeexplore.ieee.org/document/9899604

Study of the Impact of the Airflow and Filling Ratio on the Thermal Performances of a Two-Phase Immersion Cooling Prototype

- 2022 21st IEEE ITherm
- https://ieeexplore.ieee.org/document/9899558

Experimental Investigation of the Effect of Heat Spreading on Boiling of a Dielectric Liquid for Immersion Cooling of Electronics

- Journal of electronic packaging
- https://asmedigitalcollection.asme.org/electronicpackaging/article-abstract/143/4/041103/1115200/ Experimental-Investigation-of-the-Effect-of-Heat?redirectedFrom=fulltext

Numerical and Parametric Investigation of the Effect of Heat Spreading on Boiling of a Dielectric Liquid for Immersion Cooling of Electronics

- Journal of electronic packaging
- https://asmedigitalcollection.asme.org/electronicpackaging/article-abstract/144/4/041011/1130852/Numerical-and-Parametric-Investigation-of-the?redirectedFrom=fulltext

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2. K. Baraya, J. A. Weibel, and S. v Garimella, “Heat pipe dryout and temperature hysteresis in response to transient heat pulses exceeding the capillary limit,” Int J Heat Mass Transf, vol. 148, p. 119135, 2020.
3. *Moss, D. & Bean, J.H. Energy impact of increased server inlet temperature.*

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