Abstracts

iNEMI Liquid Cooling Symposium

May 31, 2006, 7 p.m. - 9 p.m.
Executive Center 3
Sheraton San Diego Hotel & Marina
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1. ***Experimental performance of high performance, low cost, water-cooled, copper micro-channel heat sinks***
   Ralph. L. Webb and Hasan Nasir, Omega Piezo Technologies, Inc.

   This paper reports data on two geometry variants of a water-cooled, copper micro-channel, as an attached external sink. The copper micro-channels were formed by commercial copper fabricators and offer potentially low cost commercially viable processes. One method involves embossing copper strip with 0.50 mm fin pitch, 0.25 mm fin thickness, and 0.8 mm fin height. The second method uses a commercial "skiving" process to form the micro-channels. The formed micro-channels are 0.50 mm fin pitch, 0.25 mm fin thickness, and 2.0 mm fin height. The second method may be used to form the micro-channels in copper of any thickness, resulting in a "built-in" heat spreader. The micro-channel heat sinks are 25 mm wide and 20 mm long with 2.5 mm thick heat spreader. Heat is provided by an electric heater, which conducts the heat axially through a 16 mm square block. The 16 mm square block was machined integral with the micro-channel heat sink, which avoids the ambiguity of thermal interface resistance between the heat sink and the heat source. Pressure drop and heat transfer data were taken for a 2-water pass configuration; the measured performance of the heat sink is evaluated and compared to theoretical predictions. The results appear to be very promising low cost technology.

2. ***An integrated cost-effective liquid cooling technology for CPU cooling***
   Ketan R. Shah, Intel Corporation

   A liquid cooling approach with pump and cold plate integrated into a single unit (modular pump) is developed to minimize number of interfaces and to maximize CPU cooling capability. The modular pump parts and integration is done through proven manufacturing techniques to develop a cost-effective solution. The conventional injection molding is used to manufacture modular pump housing, impeller, and encapsulation. The cold plate is manufactured by metal injection molding and insert-mold into the housing, the hydrodynamic bearing rather than ball bearing is used between impeller and housing to reduce overall cost. The liquid is chosen to meet the storage requirements from -40° to 70°C and to provide the needed cooling and flow capability. It would be shown that the modular pump can meet the aggressive thermal and liquid flow performance and acoustic requirements with this cost-effective approach.

   The modular pump can be assembled with heat exchanger, reservoir, and tubing to create a complete solution for a range of computer systems (e.g. ATX and BTX desktop form factors). Heat exchanger is chosen to provide minimum thermal resistance path to air and to be able to fit in desktop systems. The reservoir size and tubing configuration are determined by monitoring fluid mass loss with the pump and different tubing materials to ensure necessary capability for reliable life. Temperature exposure and cycling tests are used to identify

relevant failure mechanisms and metrics. These tests will be performed on a set of assembled units to define the parts reliability. An integrated test, charge, and seal capability areas developed to automate the process of charging the entire assembly and to detect leak and functional capability prior to shipping. This process is intended to provide the parts with consistent thermal and reliability performance.

3. ***Cold Plate Manufacturing—Factors that Drive Up Production Pricing***
Kathryn Whitenack, Lytron, Inc.

This will be a very practical discussion regarding cold plate affordability and manufacturability based on Lytron's 15 years of experience in designing and manufacturing cold plates.

The cold plate is a key component in any liquid cooling system. Most cold plates are customized either internally or externally. Internal customization involves configuring the fluid path to flow beneath the hot zones or components. External customization typically accommodates mounting features or board topography. By considering cold plate cost early, you can reduce its cost with a few design rules.

There are several considerations, which can have a major influence on the production pricing for cold plates. The most obvious is annual demand and performance requirements. Most of the time, the thermal engineer has little control over these factors. Other more subtle factors include flatness requirements, mounting features, and fluid connections. This presentation will review the manufacturing process for cold plates, using vacuum brazed cold plates as the example, highlighting relative cost of each manufacturing step, and identifying areas for cost reduction.

4. ***Passive Two-Phase Liquid Cooling as an Alternative to Aqueous Forced Convection***
Phil E. Tuma, Application Development Specialist, 3M Electronics Markets Materials Division

The industry's adoption of liquid cooling for high power devices in mainstream electronics has focused largely on aqueous fluids pumped through cold plates. This basic concept is taking varied forms as evolving technologies are applied. The more sophisticated of these are still being advanced to the mainstream. For current applications, this has left many "me too" technologies representing slight refinements of centrifugal-pumped, mini-channel technologies already available in the aftermarket. For the most part, the size, cost, heat transfer performance, and pump power requirements of these technologies are similar.

Passive two-phase technologies have been demonstratedi that can achieve similar and often better sink-to-fluid thermal performance than these more common aqueous technologies. For example, new boiler technologies that make use of dielectric, segregated hydrofluoroether fluids enable boilers that can cool a 20mm microprocessor with a sink-to-fluid thermal resistance, Rsf, less than 0.03 C/W at over 300W. If such a boiler is coupled to a 200 cc condenser with a 5 Watt, 92mm fan the resultant indirect thermosyphon achieves a sink-to-ambient resistance less than 0.15 C/W. With a larger condenser or more fan power, sub-0.09 C/W operation is easily demonstrated. Construction of such thermosyphons is a straightforward and inexpensive extension of conventional heat pipe and refrigeration technologies.

5. ***Artech Integrated Liquid Cooled Heatsink***
Gregg Kloeppel, Artech Inc.

Artech Inc. has developed a new spin for liquid cooling. With this innovative design method, many of the existing problems associated with liquid cooling have now been resolved. This

newest approach to liquid cooling combines the pump, heat exchanger, cold plate, hoses, connectors, and fan in one integrated system.
A single muffin fan type motor operates both the fluid pump and fan impeller for fluidic conduction and forced air convection. The pump inlet is the cold plate where heat transfer begins. The body of the pump has fluidic cooling channels, which exchange the heat from the cold plate, like a radiator, to the fins of the heatsink. In some versions of this integrated heatsink the cooling fins are also fluidic channels. The heatsink fins also provide the base support for the fan that is providing both the forced air movement and the driving mechanism for the fluidic pump.

This cooling system can be a very versatile system because the pump provides high flow rate 0.6 to 1.0 gpm and head pressure that allows many configurations for a cooling system. Some of these configurations might include several of these integrated cooling systems with multiple fans and pumps housed in a single extrusion for increased heat density cooling. Another configuration would allow two independent cooling systems to be fluidicly connected with external hoses providing a system for passing the cooling fluid from a cooling system housed inside an enclosure to a second system mounted external to the enclosure. Yet another system would place a cold plate inside an enclosure with the integrated cooling system mounted externally.

This system provides tremendous advantages over typical liquid cooling systems. Reliability increases because of reduced component count. Cost is reduced because the combined fan and pump for liquid circulation and forced air convection eliminates the requirement for a separate pump. Leakage problems are reduced because the connections and hoses of a typical liquid cooling system are eliminated. Finally, the performance of this system can exceed typical liquid cooled systems because its high integration provides a more effective method of pulling heat away faster and its versatility of configurations provide various methods to build a system for increased heat density removal.

6. ***Cost Effective Design and Manufacture of Liquid Cooling Systems***
Michael Lee, Thermaltake Technology Co., Ltd.

After several years of incubating, liquid cooling is finally gaining acceptance by mainstream PC manufacturers and system integrators due to the maturing of liquid cooling manufacturing methods and the continuing demand for advanced cooling designs. A liquid cooling solution has the advantages of (1) improved heat removal from the source (reduction in overall thermal resistance), (2) elimination of the constraints of traditional heat pipes, (3) ability to transport heat longer distances, and (4) allows capture of multiple heat sources and removal of all heat from system in one location. On the contrary, it has restrictions such as: (1) the need to manage pump location and tubing in system, (2) evaporation rates of fluids, (3) freezing and boiling points of fluids, and (4) overall reliability and prevention from leaking.

A good liquid cooling solution requires an exceptional designer and a manufacturer that has the ability to point out critical issues and incorporate new manufacturing solutions to overcome limitations.
Thermaltake Technology is well known for its thermal solutions in both industrial and retail markets. In recent years, it has produced commercial liquid cooling solutions based on its capability of designing and manufacturing individual components such as heat exchanger, source exchanger, and DC pump, coupled with its ability to incorporate these components into a reliable system. Utilizing proven industrial methods for joining metals and producing pump systems, we have improved these components and this overall system while maintaining low cost volume production capabilities in each stage. Our presentation will discuss the changes made in traditional source exchanger design and radiator designs as well as methods used for testing and validation of these components prior to and after final system

assembly. Further, we will touch on the needs for low permeability tubing and custom formulated fluids to reduce the effects of freezing and evaporation in the customers' applications.

Thermaltake is able to provide single module or connective solutions for heat removal of CPU, GPU, RAM, North / South Bridge, VRM and HDD. Years of customized design experience plus conscientious and careful testing procedures have allowed Thermaltake to commercialize the solutions and meet the demands of today's systems.