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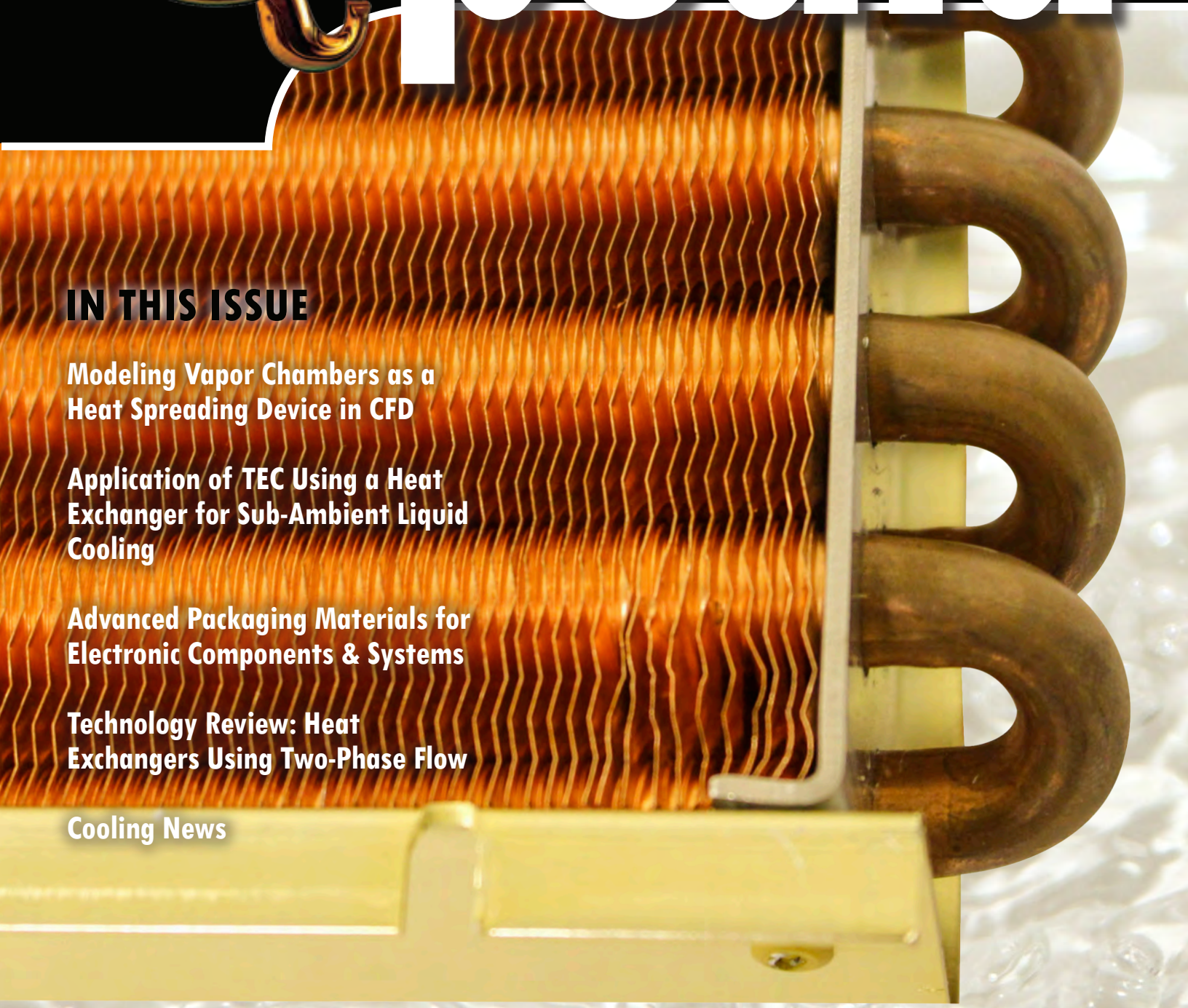

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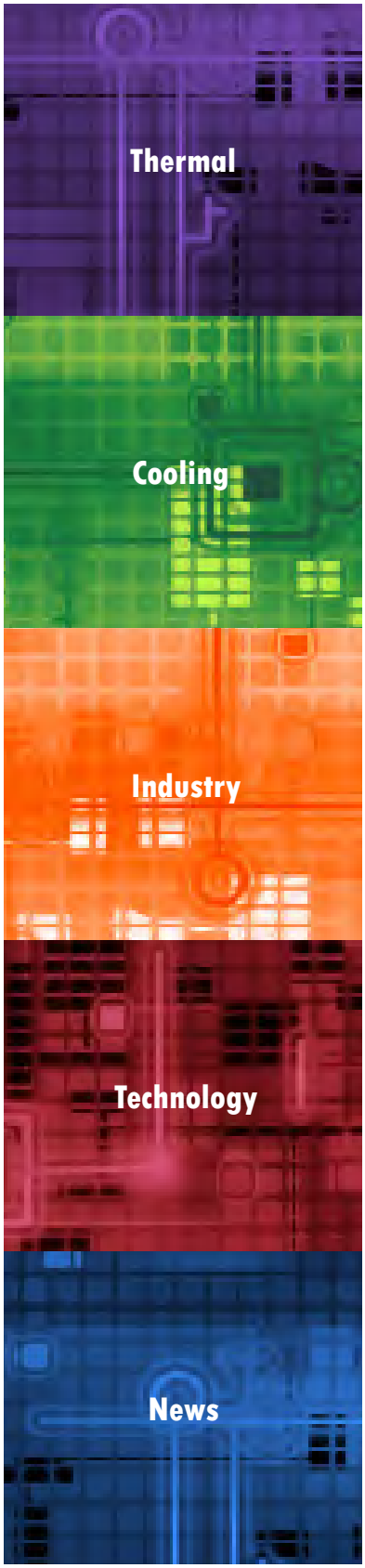
Features

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Modeling Vapor Chambers

as a Heat Spreading Device in CFD

As the power dissipated by the devices increases, and the devices get smaller, the heat densities increase rapidly, and heat dissipation gets more localized. The heat fluxes approach 100 W/cm^2 and local heat fluxes at hot spots are even higher, however the proper junction temperature must be maintained to meet performance and reliability requirements. In some cases this temperature has to be as low as 85^{o}C or even lower. This trend drives the need for the fast heat spreading. One such device is a vapor chamber.

Wei et al. [1] attempted to evaluate the feasibility of integrating vapor chambers into a device package as a heat spreader or lid to enhance the heat spreading and to reduce the conduction resistance. In addition, they attempted to quantify the thermal benefit of vapor chamber heat spreader as compared to a solid metal heat spreader. A vapor chamber, just as a heat pipe, is a heat spreading device with large effective thermal conductivity due to the phase change phenomenon. A typical vapor chamber consists of two thin layers of sintered copper powder with a vacuum space in the middle enclosed by two thin stamped copper parts. There is also a small amount of liquid, typically water, saturated in the wick. Unlike the heat pipe, the vapor chamber consists of only two sections, an evaporator and a condenser, and the condenser covers the entire top surface of the evaporator. Heat enters the evaporator section located on top of the heat source. The liquid saturated in the wick evaporates, and the vapor carries the heat into the vapor space. The vapor flows from the higher pressure region in the evaporator to the condenser section and rejects the heat to the ambient air through condensation and external cooling. The liquid flows back to the evaporator section through the capillary action in the wick structure.

Wei at al [1] built 2 conduction models of the thermal interface between the heat generating chip and the ambient air in the CFD computational tool called Flotherm. One of the models had a vapor chamber as the heat spreader to quantify the thermal performance, the other model had a solid copper lid, to compare the performances. As a model the study used a single chip package with a chip size of 10x10 mm mounted on 42.5x42.5 mm carrier. In the studies with the fixed size of the lid, the size of both the vapor chamber lid and the copper lid was 40.5x40.5x4 mm.

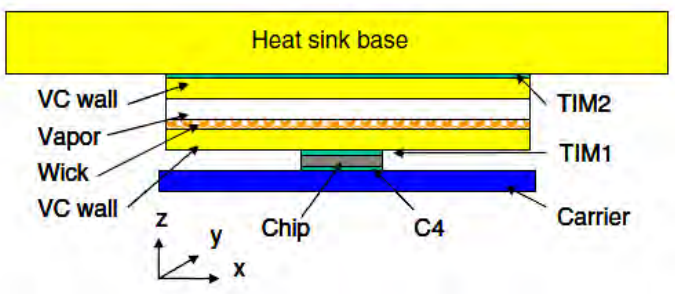

Figure 1. Schematic of the Physical Model [1]

The vapor chamber is represented by multiple solid layers, as shown on Fig. 1, with effective thermal conductivities as follows:

1. For the vapor chamber wall thermal conductivity of copper was assigned at 385 W/m·K

2. For the wick structure consisting of sintered copper powder thermal conductivity was assigned at 30 W/m·K

3. For the water vapor effective thermal conductivity was assigned at 30,000 W/m·K

The results of the simulation showed that the thermal performance for both cases was similar. However, the temperature drop across the lid thickness was higher for the vapor chamber because of the relatively low thermal conductivity of the wick structure. On the other hand, the temperature across the width of the lid was a lot more uniform for the vapor chamber because of the aggressive lateral heat spreading. It was also clear that the resistance of the thermal interface material, located between the chip and the lid, is the dominant resistance.

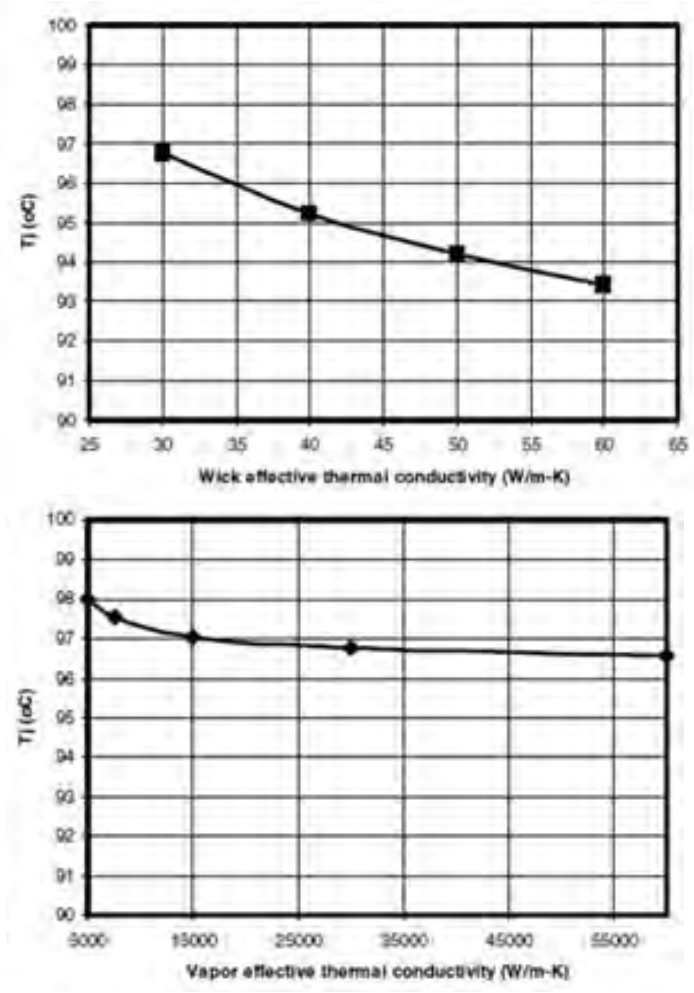

Figure 2. Effects of Wick and Vapor Thermal Conductivity [1]

A parametric study was conducted to explore the effect of various parameters of the interface as follows:

1. A sensitivity study was conducted to determine the effect of thermal conductivities of the wick structure and the vapor space.

In the first part of this study, the vapor effective thermal conductivity was fixed at 30,000 W/m·K while the wick thermal conductivity varied between 30 and 60 W/m·K.

In the second part of this study, the wick thermal conductivity was fixed at 30 W/m·K with the vapor thermal conductivity varying between 5,000 and 60,000 W/m·K.

The results clearly showed that the effective conductivity of the wick structure affects the performance more significantly than the vapor thermal conductivity. Given the fact that the effective thermal conductivities for the wick structure and the vapor space are still not well defined due to the complexity of the geometry and the phase change phenomena, a conservative estimate should always be used for the wick structure thermal conductivity. For the vapor thermal conductivity it is safe to use a typical high number since the overall performance is not sensitive to this value.

2. A sensitivity study was conducted to determine the effect of the convective heat transfer coefficient.

In the main study, the effective heat transfer coefficient was fixed at 1,400 W/m^2·K at the surface

of the heat sink base. However this coefficient can vary significantly for different air flow conditions, and different types of heat sinks. In this study the heat transfer coefficient varied from 400 to 50,000 W/m²·K using a vapor chamber lid and a solid copper lid. The results showed that at a low heat transfer coefficient, the vapor chamber provides a better hat transfer than the solid copper lid. The performance difference decreases with increasing heat transfer coefficient. The solid copper lid actually outperforms the vapor chamber at the extremely high heat transfer coefficient of 50,000 W/m²·K. With the high heat transfer coefficient, the heat flow pattern is close to one dimensional, which overcomes any benefit of vapor chamber lateral spreading. Therefore, the vapor chamber is more effective in air-cooled heat sinks with a limited heat transfer capability.

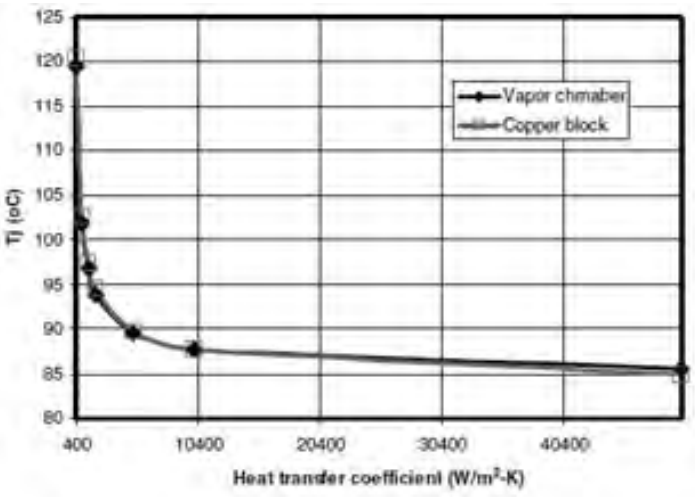

Figure 3. Effects of Effective Convective Heat Transfer Coefficient [1]

3. A sensitivity study was conducted to determine the effect of the lid width.

In this study the lid width varied from 10 mm to 90 mm using a vapor chamber lid and a solid copper lid. The results of the study showed that a solid copper lid outperforms a vapor chamber lid of the same size at a smaller footprint area. Since the major benefit of the vapor chamber is the enhanced

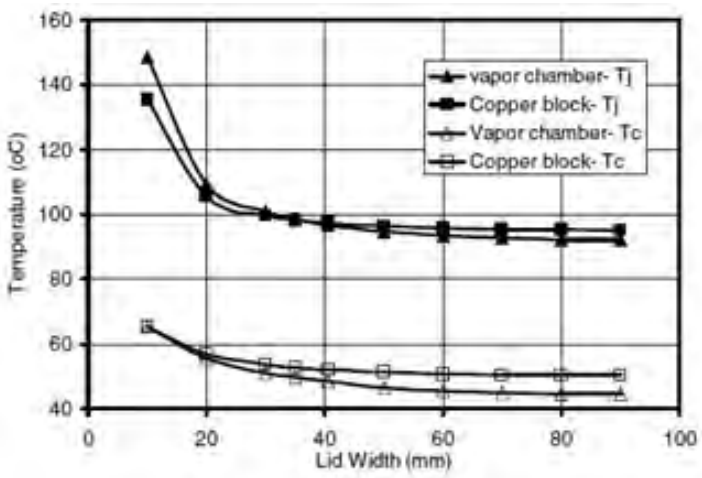

Figure 4. Effects of lid Width on the Thermal Performance of both Vapor Chamber and Copper lid [1]

lateral spreading, the vapor chamber is a lot more effective when a large surface area change and large spreading resistance occurs. From the purely thermal point of view, the vapor chamber is more suitable for direct heat sink attachment where the entire heat sink base is available for heat spreading.

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Application of TEC Using a Heat Exchanger

for Sub-Ambient Liquid Cooling

Thermoelectrics are solid-state devices capable of transferring heat across a temperature gradient. As a solid-state technology, there are no moving parts and no working fluids, which translates into simple integration, essentially no maintenance, quiet operation, and acceptable reliability. For applications involving relatively steady state cooling and low humidity with a continuous and uniform supply of DC voltage, thermoelectric module reliability is extremely high. Mean Time between Failures (MTBFs) in excess of 200,000 hours are not uncommon in such cases and it is generally considered to be an industry standard [6]. In addition, the degree of cooling may be readily controlled by means of the current supplied to the thermoelectrics.

Thermoelectric modules offer the potential to augment the cooling of electronic module packages to: 1) reduce chip operating temperatures at a given module heat load, or 2) allow higher module heat loads at a given chip temperature level. Compounds such as Bi_2Te_3 which is currently used in thermoelectric modules, made possible the development of practical thermoelectric devices for attaining temperatures below ambient without the use of vapor-compression refrigeration which carries the risk of cooling failure due to the mechanical nature of the compressor and electronic expansion valve.

Though sub-ambient temperatures can be achieved with the application of TEM's (thermoelectric modules), they come with the limitation of heat flux resulting in lower coefficient of performance. This limitation can be overcome by use of Thermoelectric Chiller as shown in figure 1, which consists of Thermoelectric heat exchanger, water loop routing cooling the electronic modules and rejecting the overall heat load to air.

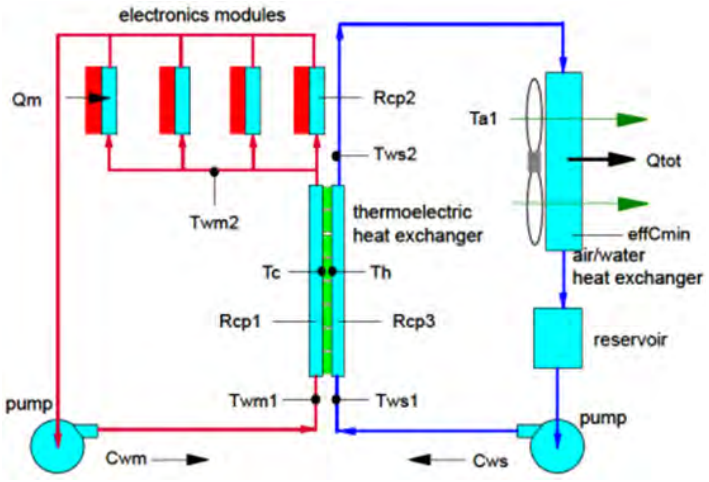

Figure 1. Hybrid Air to Water Cooling Loops with Thermoelectric Heat Exchanger [1]

Liquid Cooling Using a Thermoelectric Heat Exchanger

In this section, three different thermoelectric heat exchanger arrangements (Segregated water loop, Series water loop and Parallel water loop) with respect to pumps and power generating module is explained and a comparative analysis is done to determine the best out of three configurations [1]

The thermoelectric heat exchanger arrangement is as shown in figure 2, where 6 TEMs are sandwiched between two machined copper cold plates. Dow Corning 340 is used as interface material between cold plates and thermoelectric heat exchanger. The springs and bolt assemblies seen on the left side are provided to achieve uniform compressive loading.

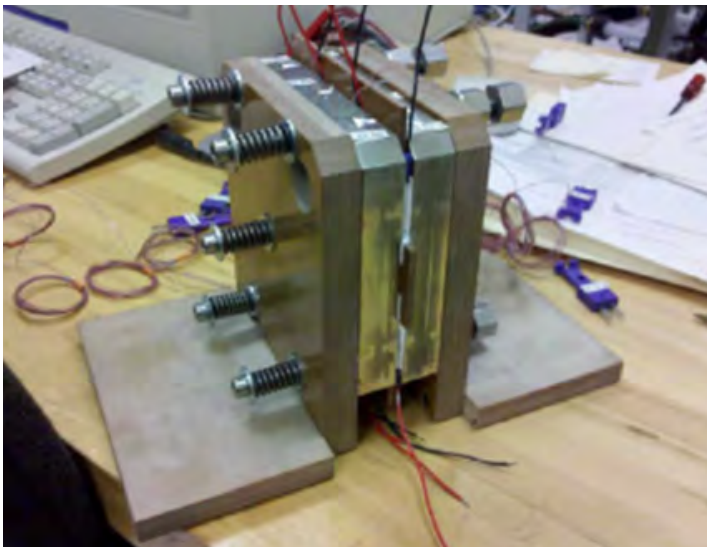

Figure 2. Thermoelectric Heat Exchanger Photograph [1]

Segregated Water Loop(SGWL):

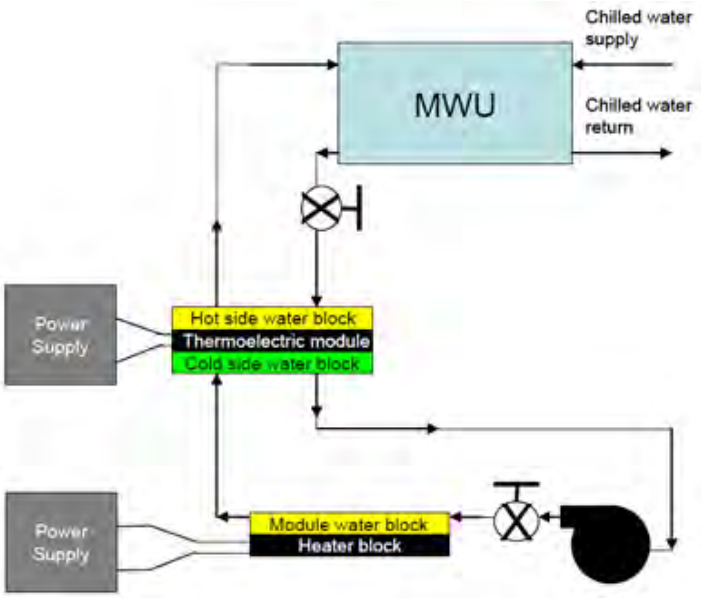

Figure 3. Thermoelectric Heat Exchanger Schematic with Segregated TEM Hot and Cold Side Loops [1]

This arrangement shows two separate water loops; one running on the hot side and other on the cold side of the thermoelectric heat exchanger. The hot side of the thermoelectric module is associated with the ultimate heat sink, i.e. MWU in this case which is a Modular water Unit supplying conditioned water at a specified flow and temperature whereas a separate water loop runs through cold side of the thermoelectric which services electronics module.

Segregated Water Loop(SGWL):

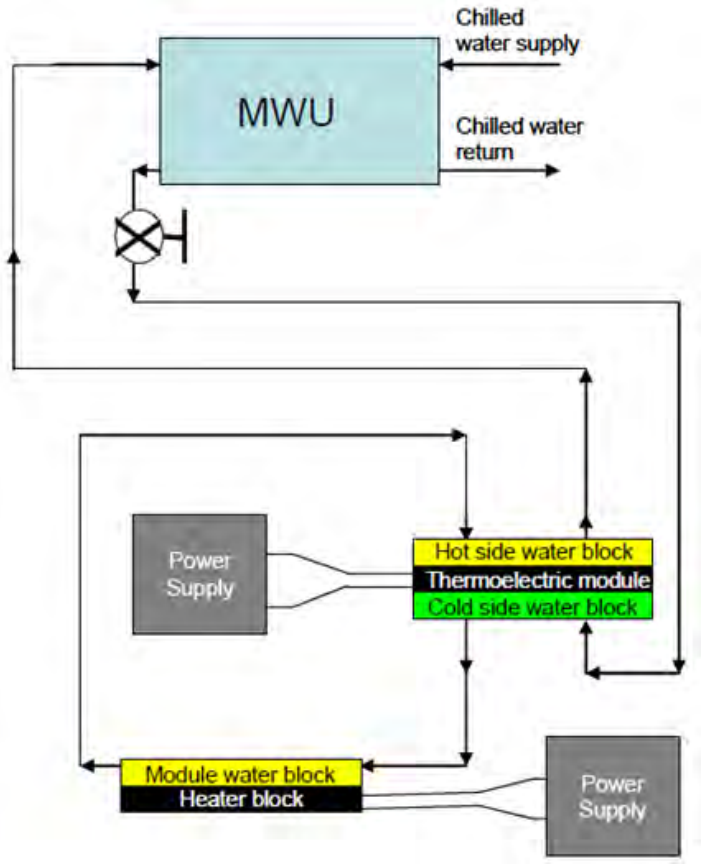

Figure 4. Thermoelectric Heat Exchanger Schematic With the Water Flow in Series for the TEM Hot and Cold Side [1]

The MWU shown supplies water to the cold side of the thermoelectric, to be chilled to a specified temperature value and further passes on to cool the electronic module. Finally, the water circulates through the hot side of the thermoelectric and dissipates the system heat to the final sink.

Parallel Water Loop:

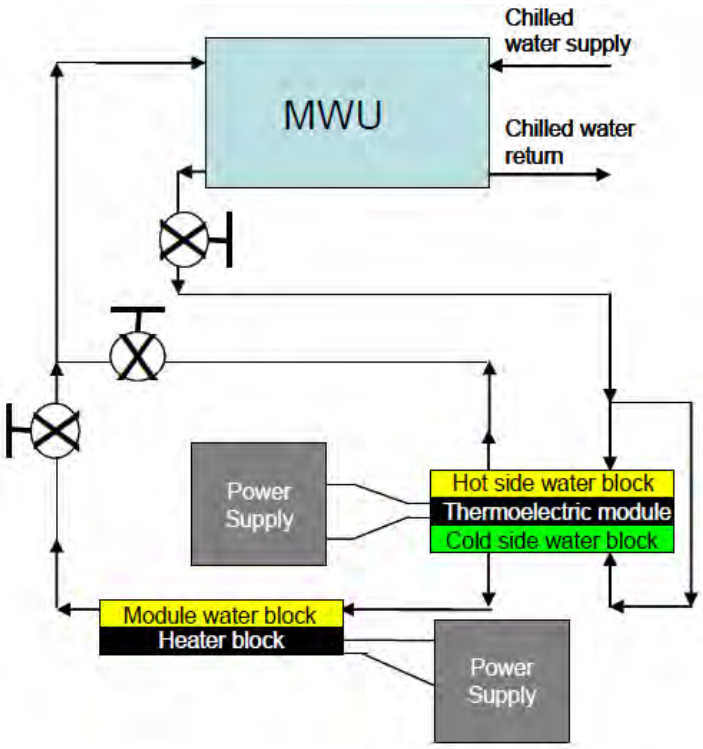

Figure 5. Thermoelectric Heat Exchanger Schematic with the Water Flow in Parallel for the TEM Hot and Cold Side [1]

The MWU shown contains a pump, liquid to liquid heat exchanger, and a reservoir; its function is to serve as the heat sink for the loop and to provide the process flow. The liquid- to-liquid heat exchanger interfaces with the loop and with a controllable flow of chilled water (using an electronic proportional valve)[2].

From MWU, the water stream breaks into two paths, one is diverted to the hot side of TEM and the remainder is chilled by the cold side of the TEM. Heat is transferred from the water to the hot side via the thermoelectric modules, resulting in a lower water temperature entering the Module water block. Similarly, the water flows through the hot side of the thermoelectric heat exchanger, thus pulling out the heat. The hot and cold side streams meet downstream of the load (heater block), and finally the water is returned to the MWU pump and heat exchanger thus dissipating the system load at the ultimate sink.

Comparison Between Segregated, Serial and Parallel TEC Heat Exchanger Arrangement

The application under investigation is a 500W load, with the thermoelectric heat exchanger hot side inlet temperature (T_{whi}) set as nearly as possible to 20.8°C and the water flow through the heat source fixed at 3.79 l/min (1.0 gpm). The temperature of the water supplied to the heater block (module water block), is considered as benchmark to gauge the relative effectiveness of the three arrangements. [1]

As shown in figure (6), for each arrangement, the thermoelectric modules were operated at four power levels. The benchmarking point discussed above is a function of this power supplied to TEM's.

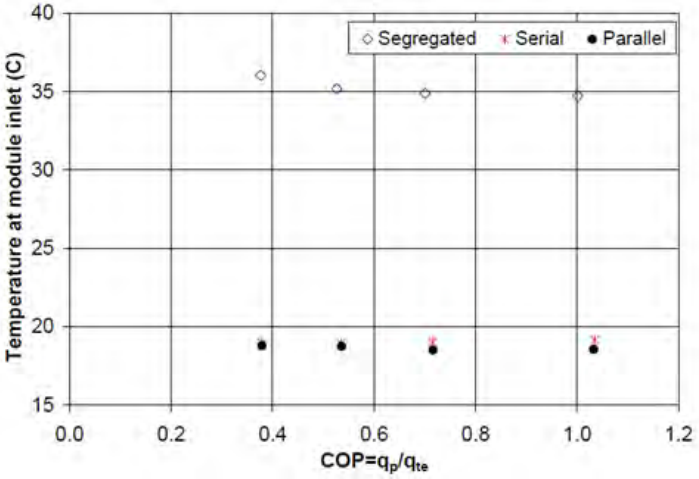

Figure 6. Comparison of Heat Load Inlet Temperature as a Function of Loop Arrangement and Ratio of Heater Power to TEM Power [1]

The results show that, Serial and Parallel configuration provides lower water temperature to the heater block. In addition to this, the parallel and serial loops require only one pump in comparison to two pumps required by segregated loop.

In serial loop, the arrangement causes the Thermoelectric Heat exchanger hot and cold side flows to be equal, and this approach requires higher water flow rate as compared to Segregated and Parallel loop. Additionally, the hot side

thermoelectric heat exchanger water is preheated by heat from the heater block. With these shortcomings, the arrangements of Figure 3 and Figure 4, both results in a lower thermodynamic efficiency at the thermoelectric heat exchanger to achieve a target water temperature to the module. Parallel flow architecture overcomes these shortcomings and is the most sophisticated, which allows separate control and optimization of the water flow on the hot and cold sides of the thermoelectric heat exchanger. In Parallel flow architecture, some adjustments with respect to water flow parameters and heat transfer quantities, helps to maximize thermoelectric heat exchanger cold side temperature reduction (or conversely minimize electrical current to the thermoelectric heat exchanger for a specified temperature reduction). Adjustments such as, providing the lowest cold side flow rate at which the module will be sufficiently cooled can be one way or conversely providing the highest hot side flow rate within the system pump capabilities can be other way. Also, lowering thermal resistances on the thermoelectric hot and cold side cold plates can improve the thermoelectric heat exchanger cold side temperature reduction. These advantages along with better control features, makes the parallel arrangement the most attractive for an electronics cooling application.

More work and data are needed to correlate the performance of the TEC with various parameters such as water block thermal resistance, flow rates and chilled water supply temperature.

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Industry Developments:

Advanced Packaging Materials for Electronic Components & Systems

A number of high performance materials are now available for electronic housings and packages that can provide advantages over traditional choices. Most of these materials are advanced composites that are lighter, more weather resistant, with better thermal properties.

Some advanced materials provide thermal conductivities more than four times those of copper. The benefits from this include improved thermal design, and the ability to eliminate heat pipes, fans, and liquid loop cooling systems, including their space requirements and noise. Weight savings can reach 90% and size reductions up to 65%. Using advanced composites can also reduce power consumption, thermal stress and warping. CTEs for such materials can be more precisely matched, allowing direct bonding attach. Systems using these composites have increased reliability and improved performance. For OEMs, these materials increase manufacturing yields and may lead to part and system cost reductions. [1]

Advanced Material Classes

Advanced composite materials with thermal properties suitable for electronic packaging include monolithic carbonaceous materials and carbon matrix composites, metal matrix composites (MMCs), ceramic matrix composites (CMCs), and polymer matrix composites (PMCs).

All of these composites consist of two or more physically and/or chemically distinct components that together provide characteristics superior to the individual materials. Typically, a reinforcing component is distributed in a continuous or matrix component. When the matrix is a metal, the composite is termed a metal matrix composite, or MMC. In MMCs, the reinforcement usually takes the form of particles, whiskers, short fibers or continuous fibers. [2]

Composites are nothing new in electronic packaging. For example, E-glass fiber-reinforced polymer PCBs are PMCs; and copper/tungsten and copper/molybdenum are MMCs, rather than alloys. There are also many ceramic-particle and metal-particle-reinforced polymers used for thermal interface materials (TIMs), underfills, encapsulants, and electrically conductive adhesives. All are PMCs. [1]

Monolithic Carbonaceous Materials and Carbon Matrix Composites

Advanced carbon materials used for electronic packaging and electronics thermal management are typically monolithic carbonaceous materials. These include graphite and diamond, along with carbon matrix composites. They may be combined with metals or other materials to yield complex materials that are easier to process into manufactured components. Graphitic materials are lower density than metallic materials such as copper and aluminum, but provide equal or higher thermal conductivities. Carbonaceous materials can be processed to form low-density thermal insulators to protect electronics from heat sources.

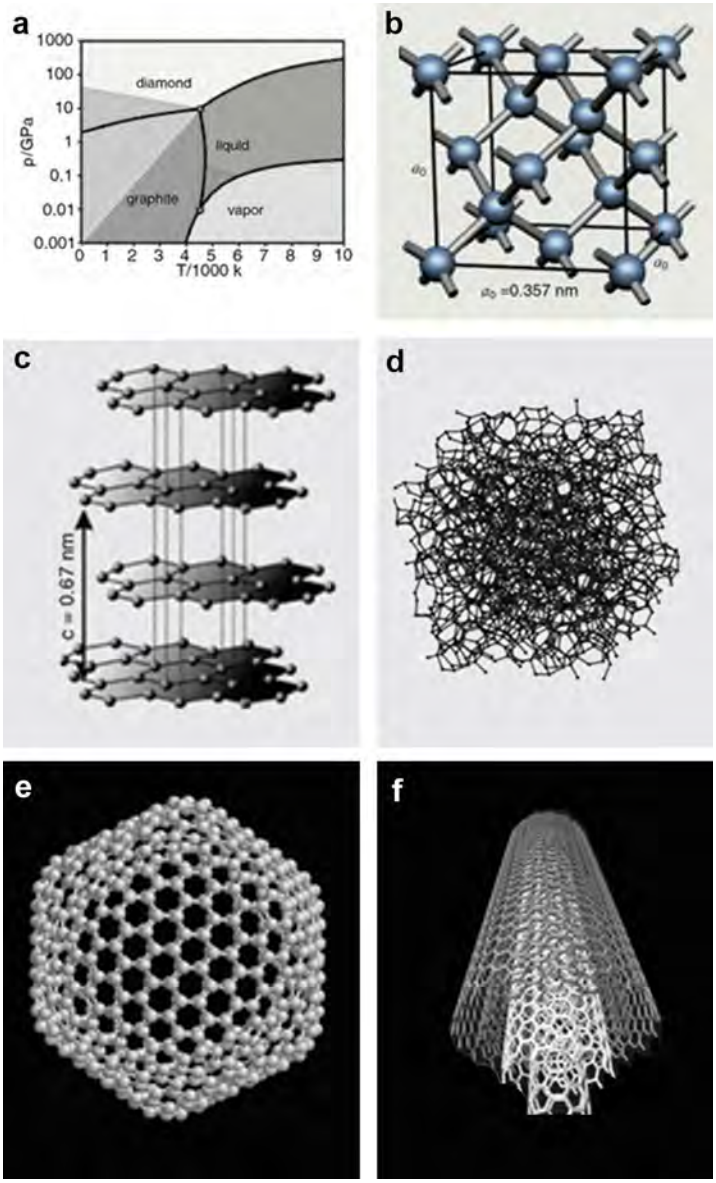

Figure 1. (a) Phase Diagram of Carbon, and Carbon Allotropes: (b) Diamond, (c) Graphite, (d) Fullerene, and (e) Carbon Nanotube [3]

Metal Matrix Composites

Metal matrix composites, or MMCs, are made by dispersing a reinforcing material into a metal matrix such as aluminum, magnesium or titanium. Reinforcing materials include SiC (silicon carbide) and carbon and diamond. Among other characteristics of the reinforcement generally distinguish MMCs: short fiber- or whisker-reinforced MMCs, and continuous fiber- or layered MMCs. Continuous fibers typically provide the highest degree of load transfer from matrix to reinforcement, owing to their high aspect ratio. Particle and short fiber reinforced metals have a lower aspect ratio, and thus exhibit lower strengths than their continuous fiber counterparts. MMCs can be tailored to have optimal thermal and physical properties for packaging systems including substrates, carriers and housings. Continuous boron fiber-reinforced aluminum composites have been used as heat sinks in chip carrier multilayer boards. [3]

Several MMCs with high thermal conductivity and adjustable coefficients of thermal expansion are used in electronic packaging for thermal management. An issue with MMCs is their fabrication into usable parts. For example, while C/metal composites are easily machine-fabricated, diamond/metal composite has non-wetting characteristics and presents undesirable interfacial reactions in the fabrication process.

Qu et al [5] looked at key factors hampering the manufacture of MMCs, and ways to improve their thermo-physical performance. They developed methods to overcome MMC difficulties in terms of

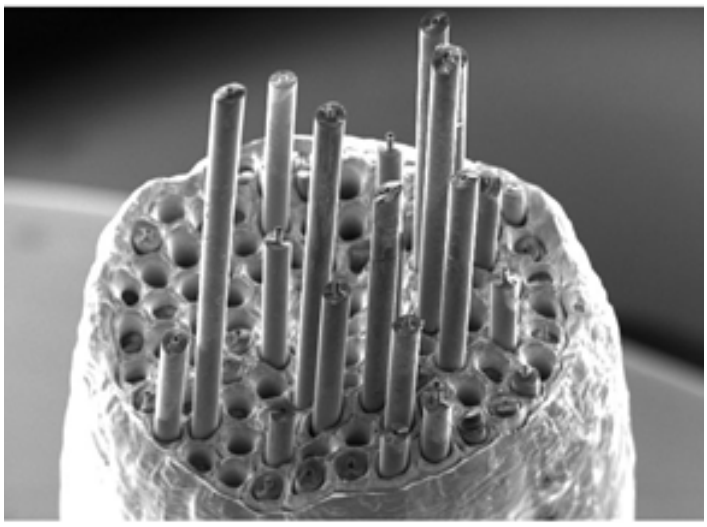

Figure 2. Silicon Carbide Fiber-Reinforced Copper Metal Matrix Composite [4]

thermo-physical properties, processing methods and electronic packaging processing. The authors found that a combination of pressure-less infiltration and powder injection molding could produce near optimal shape composites. Improving wettability and optimizing interfacial structure were prerequisites for successful fabrication and further enhancement of thermal properties. [5]

Ceramic Matrix Composites

Ceramic matrix composites provide high thermal conductivity and low CTE. Other desirable characteristics of ceramic matrix composites (CMCs) include high-temperature stability, high thermal shock resistance, high hardness, high corrosion resistance, light weight, nonmagnetic and nonconductive properties, and versatility in providing unique engineering solutions. CMCs consist of ceramic fibers embedded in a ceramic matrix, forming a ceramic fiber reinforced ceramic (CFRC) material. Common fibers used in CMCs include SiC and alumina. More recent CMC materials include reaction-bonded SiC composites, aluminum-toughened SiC composites, and ceramic-based nanocomposites. [6]

Figure 3. A Highly Heat Resistant CMC Combustion Chamber Element from Airbus Defense and Space [7]

Their intrinsic ability to be tailored as composites make CMCs highly attractive in a vast array of high heat applications, most notably internal engine components, exhaust systems and other "hot-zone" structures, where CMCs are envisioned as lightweight replacements for metallic super alloys. [7]

Polymer Matrix Composites

Both thermosetting and thermoplastic polymer matrices present with reasonable thermal conductivity. Different kinds of fillers play important roles in maximizing polymer performance and production efficiency. Cost reduction, density control, optical effects, thermal conductivity, magnetic properties, flame retardancy, and improved hardness and tear resistance have increased the demand for high performance fillers. Several types of reinforcements, especially nanoparticulate fillers, have been used in polymer matrix composites: vapor grown carbon fiber (VGCF), carbon foam, carbon nanotube (CNT), and other thermally conductive particles, such as ceramic, carbon, metal or metal-coated particles, as well as metal or carbon foams. Nanoparticles of carbides and nitrides can be used to reinforce polymer matrix nanocomposites to improve thermal conductivity, mechanical strength, hardness, corrosion resistance, and wear resistance. [8]

Figure 4. Carbon Fiber-Reinforced Polymer Matrix Composites with Pitch-based Fibers Provide Thermal Conductivities Up to 1100 W/m•K. [9]

In a study of polymer composites by Lee, et al, different inorganic fillers including aluminum nitride, wollastonite, silicon carbide whiskers and boron nitride with different shapes and sizes were used alone or in combination to prepare thermally conductive polymer composites. The use of hybrid fillers was found to be effective in increasing thermal conductivity. For a given filler load, the use of larger particles and surface treated fillers resulted in composite materials with enhanced thermal conductivity. The surface treatment of filler also allowed producing the composites with lower CTE. [10]

Conclusion

Materials used for electric and electronic enclosures - steel, aluminum and polymers - date as far back as the nineteenth century. Many applications now require enclosures that are lighter and/or more thermally conductive than can be obtained with these materials. This applies to commercial, military and aerospace applications. We now have several advanced materials that can provide significant thermal and mechanical improvements, and as the result are being used in an increasing number of applications where cost is not challenged, yet performance and application require these.

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Technology Review:

Heat Exchangers Using Two-Phase Flow

Qpedia continues its review of technologies developed for electronics cooling applications. We are presenting selected patents that were awarded to developers around the world to address cooling challenges. After reading the series, you will be more aware of both the historic developments and the latest breakthroughs in both product design and applications. We are specifically focusing on patented technologies to show the breadth of development in thermal management product sectors. Please note that there are many patents within these areas. Limited by article space, we are presenting a small number to offer a representation of the entire field. You are encouraged to do your own patent investigation. Further, if you have been awarded a patent and would like to have it included in these reviews, please send us your patent number or patent application.

In this issue our spotlight is on heat exchangers using two-phase flow. There is much discussion about its deployment in the electronics industry, and these patents show some of the salient features that are the focus of different inventors.

THERMOSYPHON AND METHOD FOR PRODUCING IT

US 2005/0056403 A1, Norlin, et al.

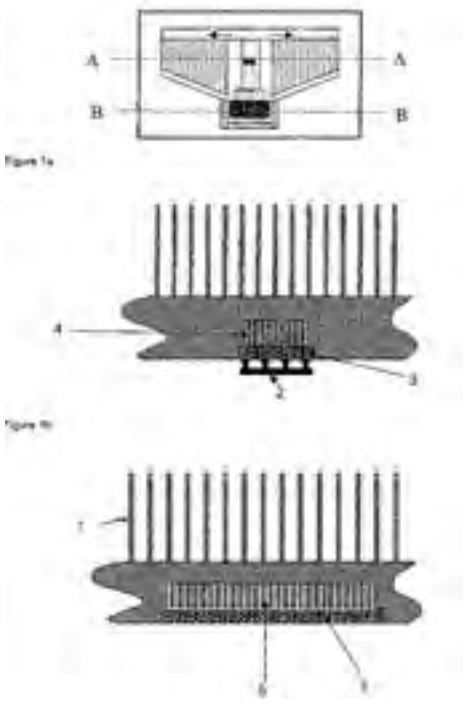
The principle of the integrated thermosyphon according to a first embodiment is shown. A working fluid is heated in the evaporator section whereby the working fluid evaporates and the vapour formed travels in the direction of the arrows, and is condensed back to liquid in the condenser section. Figure 1b is a cross section taken across the line B-B. Here the evaporator fins (4) are integrally produced with the lid (3) by extruding the lid and cutting the extruded profile in desired lengths, whereafter the fins in areas outside the evaporator section are removed by milling. The condenser section is taken across the line A-A. The thermosyphon further comprises extruded heat dissipating fins (1) extending from the base. Other solutions resulting in the same or similar may be obtained by extruding part of the condenser as a part of the lid, or manufacturing the evaporator section as a part of the heat sink base.

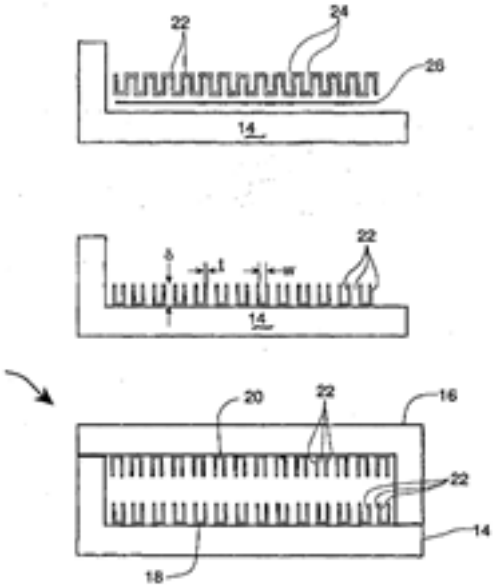
PATENT NUMBER	TITLE	INVENTORS	DATE OF AWARD
US 2005/0056403 A1	THERMOSYPHON AND METHOD FOR PRODUCING IT	Norlin, A., et al.	Mar 17, 2005
US 6,903,929 B2	TWO-PHASE COOLING UTILIZING MICROCHANNEL HEAT EXCHANGERS AND CHANNELED HEAT SINK	Prasher, R., et al.	Jun 7, 2005
US 2009/0229794 A1	HEAT PIPES INCORPORATING MICROCHANNEL HEAT EXCHANGERS	Elbing, Kristofer	Sep 17, 2009

The fins of the evaporator and/or condenser section, at least partially produced by extrusion, form an internal structure with an extended surface area, providing a more efficient heat transfer between the working fluid and the thermosyphon.

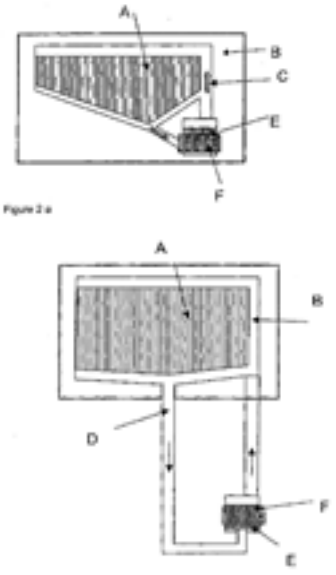
A thermosyphon according to the invention is having a base (B) and a plurality of condenser fins (A) extending vertically from the base. A lid comprising a number of evaporator fins (E) with a separating distance smaller than the distance between the condenser fins extending vertically from the lid is placed over the channel structure (D) so that a thermosyphon of an expanding channel system is formed. A heat dissipating component (F) is attached to the outside of the lid.

By integrating the lid and the evaporator fins into one part, the contact thermal resistance between the lid and the fins is eliminated, which makes the thermosyphon more efficient. The heat dissipating fins are integrated in the thermosyphon, which eliminates the contact thermal resistance between the condenser fins and the outer heat dissipating fins.





In an alternative embodiment, the reference letters referring to the same components as in figure 2a, where the condenser section and the evaporator section are separated and connected by pipes (D) conducting the evaporated working media from the evaporator to the condenser where it is condensed to a liquid and transferred by gravity back to the evaporator. Lids are placed over the evaporator and condenser sections in a similar way as in the first embodiment.



To form a leak proof seal between the lid and the heat sink, joining is preferably done by, but not limited to, friction stir welding. This joining technique is described in EP-A-615480. Typically, a friction welding tool (a probe), inserted into a joint region to be welded, undergoes a cyclic motion to generate a plastizised material and is typically traversed along the joint region. When the material cools a joint of high quality is produced.

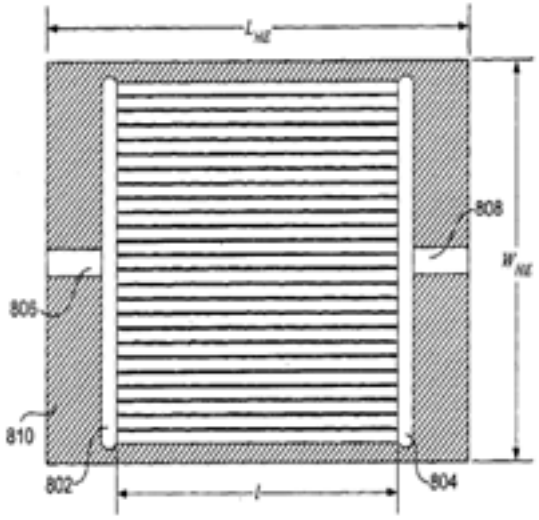
By providing an integrated heat sink/thermosyphon, heat transfer is made more efficient than when junctions are used. The present invention provides a new way of efficiently manufacturing an integrated structure, while keeping the heat transfer of the structure high.

The material selection for the base and lid depends on application requirements for ease of fabrication and service reliability. Aluminum is preferred because of its ease of machinability and lower density compared to other metals, but other materials may also be used.

TWO-PHASE COOLING UTILIZING MICROCHANNEL HEAT EXCHANGERS AND CHANNELED HEAT SINK

US 6,903,929 B2, Prasher, R., et al.

Embodiments of microchannel heat exchanger apparatus, channeled heat sinks and cooling systems employing the same are described herein. In the following description, numerous specific details are set forth to provide a thorough understanding of embodiments of the invention. One skilled in the relevant art will recognize, however, that the invention can be practiced without one or more of the specific details, or with other methods, components, materials, etc. Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention.



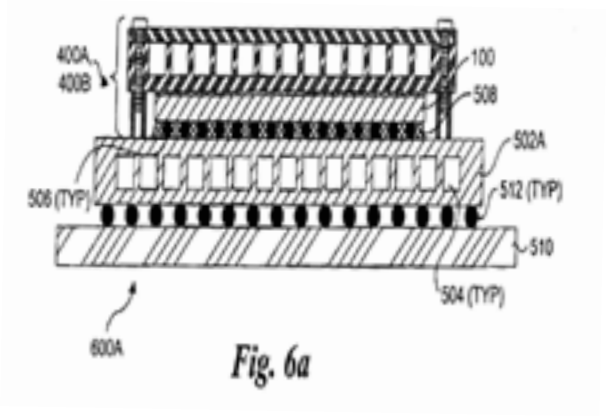
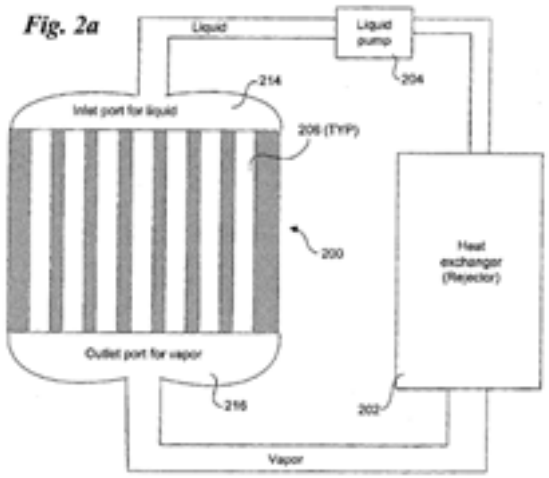


Fig. 6a

Recently, research efforts have been focused on providing thermal solutions for densely-packaged high-power electronics. A leading candidate emerging from this research is the use of two-phase convection in micromachined silicon heat sinks, commonly referred to as microchannels. The system includes a microchannel heat exchanger 200, a heat rejecter 202, and a pump 204. The basic premise is to take advantage of the fact that changing a phase of a fluid from a liquid to a vapor requires a significant amount of energy, known as latent heat, or heat of vaporization. Conversely, a large amount of heat can be removed from the fluid by returning the vapor phase back to liquid. The microchannels, which typically have hydraulic diameters on the order of hundred-micrometers, are very effective for facilitating the phase transfer from liquid to vapor.



In accordance with typical configurations, microchannel heat exchanger 200 will comprise a plurality of microchannels 206 formed in a block of silicon 208, as shown in FIG. 2 b. A cover plate 210 is then placed over the top of the channel walls to formed enclosed channels. Generally the microchannel heat exchanger performs the function of a heat sink or heat spreader/heat sink combination. Accordingly, the microchannel heat exchanger is shown as thermally coupled to a die 100 via a TIM layer 212. In an optional configuration, a processor die with an increased thickness may include channels formed in the processor die silicon itself.

As the die circuitry generates heat, the heat is transferred outward to the microchannel heat exchanger via conduction. The heat increases the temperature of the silicon, thereby heating the temperature of the walls in the microchannels. Liquid is pushed by pump 204 into an inlet port 214, where it enters the inlet ends of microchannels 206. As the liquid passes through the microchannels, further heat transfer takes place between the microchannel walls and the liquid. Under a properly configured heat exchanger, a portion of the fluid exits the microchannels as vapor at outlet port 216. The vapor then enters heat rejecter 202. The heat rejecter comprises a second heat exchanger that performs the reverse phase transformation as microchannel heat exchanger 200—that is, it converts the phase of the vapor entering at an inlet end back to a liquid at the outlet of the heat rejecter. The liquid is then received at an inlet side of pump 204, thus completing the cooling cycle.

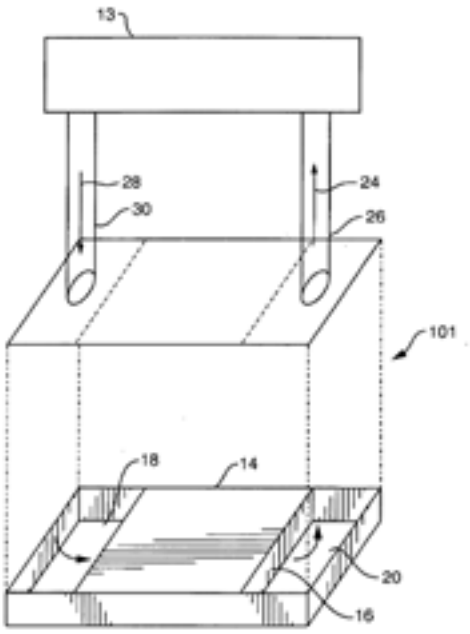
HEAT PIPES INCORPORATING MICROCHANNEL HEAT EXCHANGERS

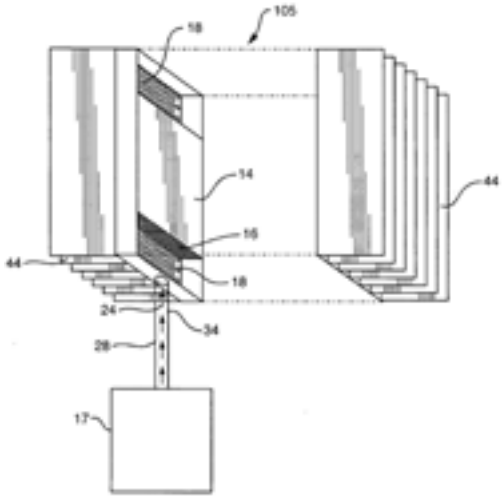
US 2009/0229794 A1, Elbing, Kristofer

A microchannel heat absorber comprising at least one layer defining a plurality of microchannels having a cross-sectional dimension of less than 1000 microns and terminating at a first end thereof in a cool side manifold and at a second end thereof in a warm side manifold, the microchannels adapted to contain a liquid working fluid that absorbs heat and forms a vapor upon flowing therethrough from the first end to the second end,

A heat sink for receiving and condensing the vapor to reform the liquid working fluid and for discharging the liquid working fluid, and

One or more pipes flowably connecting the warm side manifold of the heat absorber to the heat sink and flowably connecting the cool side manifold of





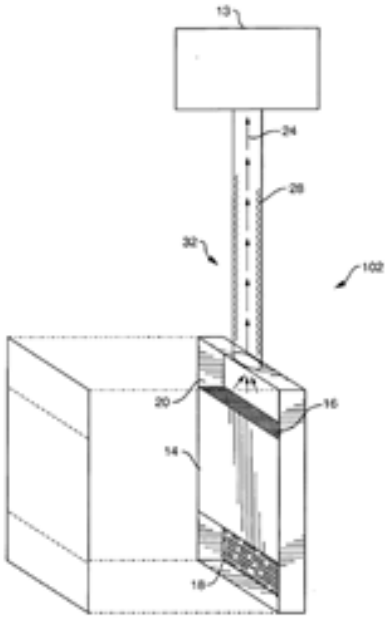
the heat absorber to the heat sink, wherein the one or more pipes are connected so as to permit simultaneous flow of the vapor from the heat absorber to the heat sink and of the liquid working fluid from the heat sink to the heat absorber when heat is applied to the heat absorber.

In another aspect, the invention provides a heat pipe system including a working fluid contained within a heat pipe. The heat pipe includes:

a) a microchannel heat absorber including at least one layer defining a plurality of parallel microchannels having a largest cross-sectional dimension of less than 1000 microns and terminating at a first end thereof in a cool side manifold and at a second end thereof in a warm side manifold, the microchannels adapted to contain the working fluid as a liquid that absorbs heat and forms a vapor upon flowing there through from the first end to the second end,

b) a heat sink for receiving and condensing the vapor to reform the liquid working fluid and for discharging the liquid working fluid, and

c) one or more pipes flowably connecting the warm side manifold of the heat absorber to the heat sink and flowably connecting the cool side manifold of the heat absorber to the heat sink, wherein the one or more pipes are connected so as to permit simultaneous flow of the vapor from the heat absorber to the heat sink and of the liquid working fluid from the heat sink to the heat absorber when heat is applied to the heat absorber.



Cooling News

New Products, Services and Events From Around the Industry

Aluminum/Thermoplastic Replaces Heat Sinks in LED Housings

SABIC's Konduit PX13012 and PX11311U aluminum/thermoplastic compounds deliver improved mechanical properties while keeping manufacturing costs down. Both Konduit compounds have inherent electrical isolation properties and industry-recognized Underwriters Laboratories (UL) ratings (UL94 V0 at 0.8mm for PX13012 and 1mm for PX11311U). Konduit PX13012 compound is a black, cost-optimized solution, which has the highest thermal conductivity of all electrically isolating, flame retardant Konduit compound grades. Konduit PX11311U compound is a white grade which also has good thermal conductivity and improved UV performance, elongation at break, and heat-shock performance across a wide range of temperatures (-40°C to 85°C).

Thermally Efficient Data Center Cabinet

The new V800 cabinet system from Siemon is designed to provide a robust, high performance enclosure that is cost-effective for both high density data center environments as well as floor distributors. Offering increased cabling and equipment density, the V800 achieves thermal efficiency with contoured, high-flow doors, built with 71% perforation to exceed the airflow requirements of major active equipment manufacturers. The cabinet lid includes four integrated brush guards to ensure that cables can enter the cabinet without compromising thermal integrity. Thermal management options available for the V800 include exhaust fans and vertical exhaust ducts. Siemon also offers SnapFit thermal blanking panels to help improve thermal efficiency.

Transfer Sheet Replaces Thermal Pastes

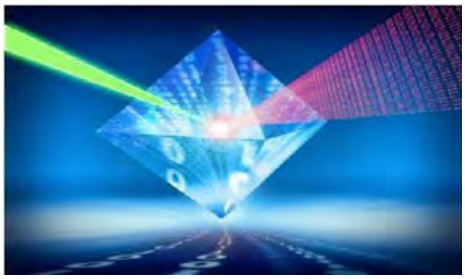
The new TGR200 thermal transfer sheet from ARCOL Resistors is a no-shrink, 100% coverage no-mess alternative to conventional thermal pastes which can be easily trimmed to required sizes with minimal wastage. The sheet is shaped to suit industry-standard resistor packages or in cut lengths, rolls or sheets to best suit the end application and speed the assembly process. TGR200 is oil-free, electrically conductive and ensures a thermally efficient transfer of heat between the mounted product and heat sink. The material has a nominal thickness of 0.2mm with custom thicknesses available. It has a thermal resistance of <0.7°C/W and a thermal conductivity of 3.58 W/m·K.

Control System Determines Thermal Capabilities of IC Devices

Thermal Management Solution, developed by Mechanical Devices and Ironwood Electronics, the device under test (DUT) system enables temperature control of IC devices during thermal characterization using a direct contact technology. Providing accurate and stable temperatures results in precise characterization of the IC. The main components of the thermal management system are the thermal controller, the plunger and the adapter. The thermal controller has an integrated compressor for cooling and a touch screen for parameter inputs. Plungers are designed specifically to accommodate particular IC sizes and are attached to the thermal head. Adapters are custom designed as well to interface thermal heads with plungers to specific IC sockets. The Thermal Management System has an easy to use graphical user interface (GUI). Features include the ability to set a temperature, tune the system, change and save configurations setting, log data and run custom scripts.

New Thermal Grade of CVD Diamond Released

Element Six has introduced DIAFILM TM130, a new thermal grade of diamond grown by chemical vapor deposition (CVD). DIAFILM TM130 has a thermal conductivity in excess of 1300 W/m-K and is available in both metallized and un-metallized wafer forms. Similar to Element Six's material grades in its DIAFILM TM range, TM130 offers full isotropic heat spreading in both planar and through plane directions. Element Six now provides a total of five material grades spanning five levels of performance ranging from 1000 to 2000 W/m-K. CVD diamond is the most thermally conductive material at room temperature. It is uniquely suited for advanced thermal management in applications such as advanced packaging mechanical strength, electrical insulation, low weight and chemical inertness. In this role, CVD diamond enables system size reductions, improved reliability and the opportunity to design higher power systems within an existing module footprint.



New Chillers and Heat Exchangers Series

New portable chiller systems and liquid-to-air heat exchangers for controlling fluid temperatures in looped liquid cooling systems are available from Advanced Thermal Solutions. The new chillers allow precise temperature control of the recirculating coolants used for managing heat in electronic equipment. For fluid baths, the ATS-CHILL iM controls fluid temperature via an immersible evaporator. The chillers provide cooling capacity up to 600W. The new heat exchangers have the industry's highest density of metal fins, which maximizes heat transfer from liquid to air, allowing the liquid to be cooled to lower temperatures than other exchangers can achieve. Available with or without integral fans, the heat exchangers are available in a range of sizes, and heat transfer capacities up to 250W.

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Advanced Thermal Solutions, Inc. (ATS) now offers the complete editorial contents of its widely-read Qpedia Thermal eMagazine in five hardbound volumes. The books provide an expert resource for design engineers,engineering managers, and others who want to learn more about the theories and applications of electronics thermal management. The four volume set contains nearly 250 in-depth articles, researched and written by veteran engineers. They address the most critical areas of electronics cooling, with a wide spectrum of topics and thorough technical explanation.

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