Cooling High-Power Electronic Components in Small Packages

Design Challenge

Thermacore, a worldwide leader in electronics cooling solutions has turned to using vapor chambers to manage heat in today's small, high-power electronic devices where effective cooling helps ensure long component life and reliability. In today's electronics cooling market, vapor chambers are used to manage heat flux in diverse applications. The military uses these high-conductivity heat sinks to cool radar TWTs (traveling wave tubes), IGBTs (Insulated-gate bipolar transistors), and other high-flux electronics. The medical industry uses them to warm blood uniformly. Heat sinks in a multitude of mid- to high-range computer servers use vapor chamber technology to manage the heat from high-flux, high-compute-power CPUs that define the speed and performance of the system.

Vapor chambers are essentially flat or planar heat pipes that use the evaporation and condensation of a working fluid to produce a very high-conductivity thermal plane. Bulk conductivities have been measured at over 30 times the conductivity of copper and over 10 times the conductivity of pyrolytic graphite and diamond. Vapor chambers are evacuated vessels with a wick on the evaporator side that have a small amount of working fluid backfilled into the interior. Vapor chambers can be bonded into an existing extrusion or can be used as the base itself, in which case fins can be soldered directly to it.

Solution and Benefit

To demonstrate this spreading phenomenon, a FloTHERM® simulation was created for a typical high-flux electrical component and its cooling sink. For this example, a 6-in. by 6-in. by 1-in. low-profile aluminum heat sink with a standard extruded pitch was used to cool an electrical component that acted as a 0.5-in. by 0.5-in. source at 100 W, or 62 W/cm^2. The high-temperature gradients are evident in the cutaway view. The fins toward the outside edges of the heat sink are quite cool compared to the hot spot directly over the electrical component. The performance of this heat sink with 300 LFM (linear feet per minute) of airflow is 0.46 °C/W, which is

"FloTHERM continues to allow us to design better and more innovative electronics cooling devices for smaller and hotter applications. Using FloTHERM versus a prototype build in this type of application saves approximately $5-10k worth of development costs."

— MATT CONNORS
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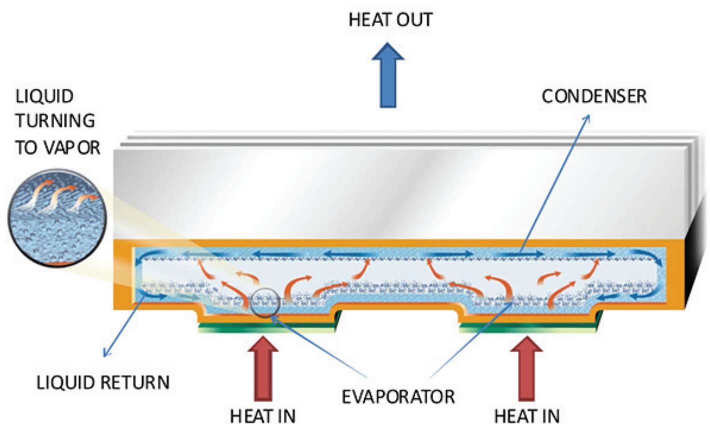

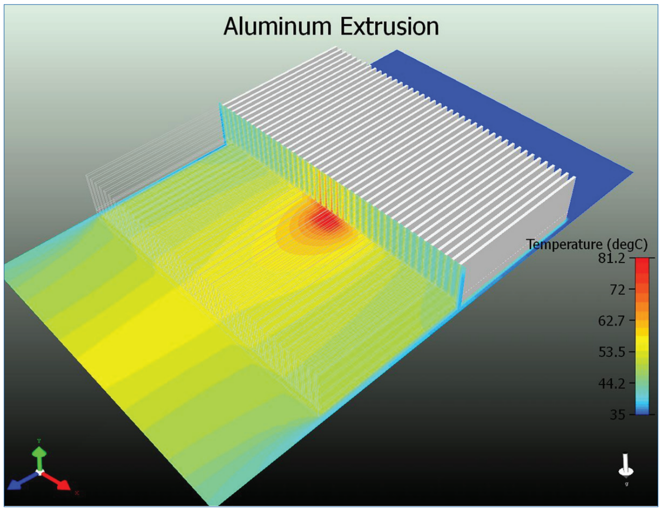

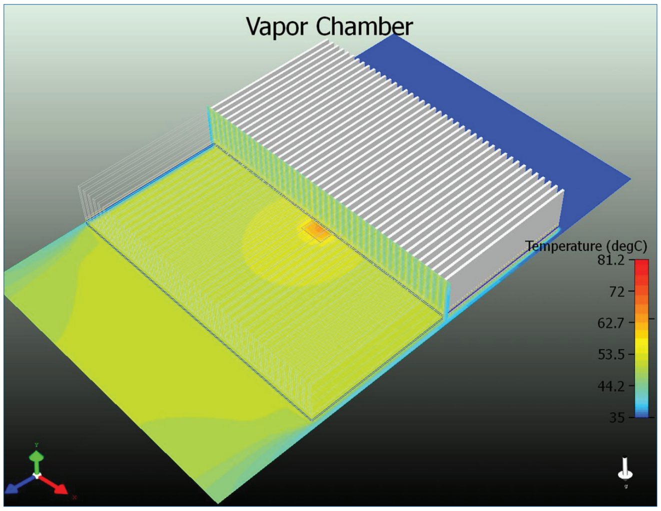

the temperature rise from ambient to the hottest spot on the component divided by the total power dissipated.

The challenge now becomes one of spreading the heat efficiently through the base of the heat sink without changing the existing geometry of the heat sink. It is desirable to stay within the same form factor of the original package to avoid a long, costly redesign of the component enclosure. In order to reduce this high thermal resistance, the heat sink metallic base needed to be replace with a "super" conducting material. In this example, a vapor chamber will be used as the medium to very efficiently spread heat in the base.

To illustrate the thermal performance improvement that a vapor chamber can provide to an all-metallic heat sink, we now examine the same heat sink described above, but with a vapor chamber integrated into the heat sink base. With the different heat sink, the heat is much more evenly spread across the entire heat sink, causing a drop in overall thermal resistance of 37%. The heat sink used in this example, with an embedded vapor chamber, with all of the parameters held constant, shows a resistance of only 0.29 °C/watt

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