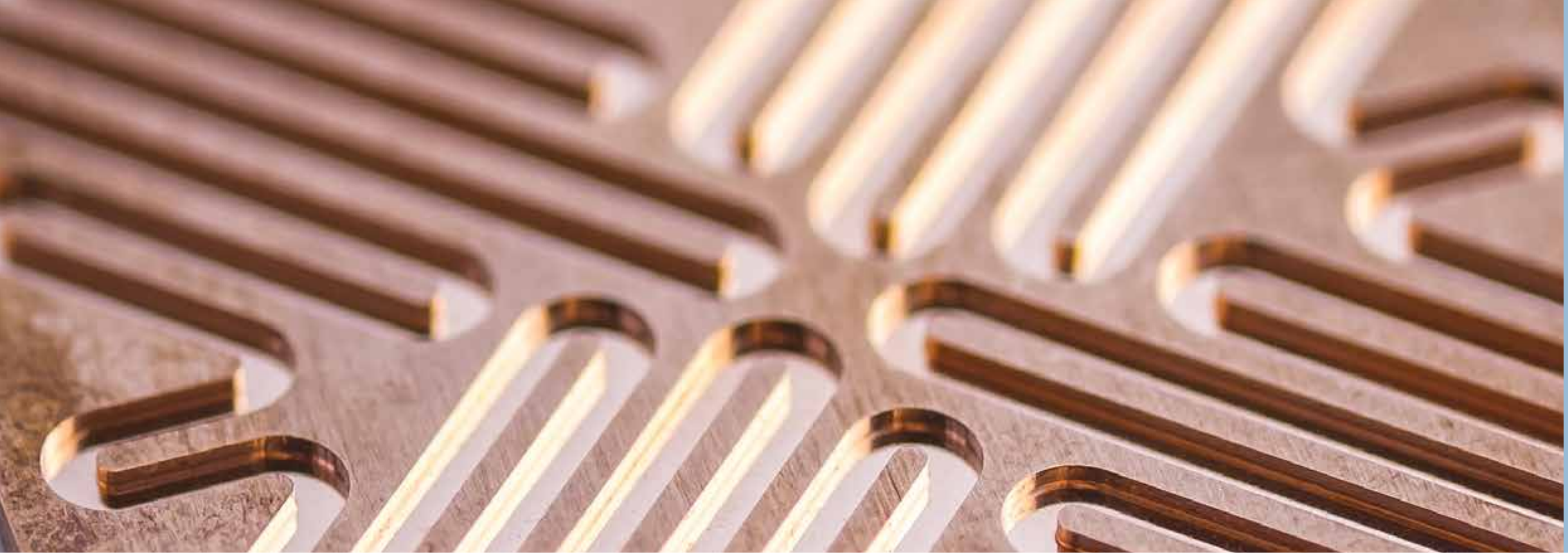


< Specially structured copper plates are suitable for the manufacture of pulsating heat pipes needed to cool hotspots.

GROUP **CALORICS AND THERMOELECTRICS**

Efficient hotspot cooling

When electronic components fail, the cause is usually localized overheating: Over half of all defects in printed circuit boards can be attributed to poor thermal management. Efficient hot-spot cooling is therefore becoming increasingly important, especially in power electronic systems. Fraunhofer IPM is developing an innovative new cooling technology specifically for this application – namely highly efficient heat spreaders based on pulsating heat pipes.

PULSATING HEAT PIPES can dissipate high rates of heat flux extremely efficiently. Just like conventional cooling fins, they belong to the class of passive cooling elements, though their heat transfer capabilities are far superior. Here, heat transfer takes place via a two-phase working medium: The surface tension causes contiguous segments of fluid and vapor to form. The vapor segments expand on the hot side and contract or condense again on the cold side. This means that there are always localized differences in temperature and pressure, which elicit a constant, pulsating motion of the segments. The motion of the segments allows fluid, and thus heat, to be transferred from the hot side to the cold side.

For decades, the processing power of electronic components has grown exponentially as predicted by Moore's law. Thermal power loss has also risen concomitantly with this. As a result of ever more powerful microelectronics with ever greater miniaturization, certain components such as MOSFET transistors can sustain thermal losses of up to 100 watts on surface areas of just one square centimeter. Highly effective cooling concepts are therefore required that will guarantee increasingly impressive thermal performance on ever smaller surface areas.

The ideal heat spreader: Passive and high performing

The passive solutions used to date for heat dissipation – such as copper plates and ceramic substrates – are now increasingly reaching their limits. And whilst active solutions that utilize ventilation or water cooling do achieve the high cooling performance required, they are usually too large, too expensive or too fault prone. What is lacking is a cost-effective, compact and highly efficient technology for dissipating excess heat away from hotspots on printed circuit boards in a targeted manner. An ideal heat spreader should distribute the patches of accumulated heat as evenly as possible across a large area to prevent temperature peaks at critical points.

Thanks to their low levels of heat resistance, heat spreaders with integrated heat pipes represent a promising technological approach. They have recently been employed as a passive solution for dissipating hotspots on printed circuit boards, where they effectively carry heat away to a heat sink on a parallel plane to the printed circuit board. When it comes to industrial-scale use, however, one problem remains unsolved: The hollow structure of standard heat pipes prevents them from being positively integrated into the PC board network. Heat pipes are often deformed, or even destroyed, as a result of the pressure involved in bonding printed circuit board stackups.

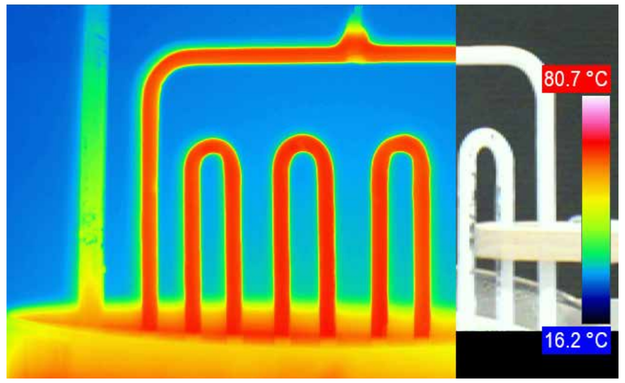
Pulsating heat pipes

Whilst in a standard heat pipe the fluid returns to the heat source by means of either gravity or capillary action, a pulsating heat pipe consists of many thin, meander-line coils which are partially filled with liquid and subsequently evacuated. Such heat spreaders with integrated pulsating heat pipes have a thermal resistance that is up to ten times lower than for conventional, solid-material heat exchangers with the same dimensions – even with power losses of over 400 watts. Together with Fraunhofer IZM, Fraunhofer IPM is working on the problem of sensitivity to high compression forces: A new, planar design with radial heat transfer is designed to allow the pipes to be both bonded and integrated within the printed circuit board at the same time.

As part of its current research, Fraunhofer IPM is working to further optimize the design and production of pulsating heat pipes. For example, systems will in future be manufactured by means of 3D printing. The metrological characterization of heat spreaders also plays an important role here. Fraunhofer IPM is thus developing specialist measuring and inspection techniques for this purpose.

Compact, simple, cost effective

It is not only the outstanding cooling performance of the concept presented here which makes it ideal for industrial-scale use. This heat spreader is also a simple, compact and cost-effective solution for purely passive cooling and it requires neither moving parts nor a power supply. Thanks to their relatively small cavities compared to standard heat pipes, pulsating heat pipes are not sensitive to the high pressures exerted during the bonding of the printed circuit board stackup. At the same time, the entire system is lighter in weight than a customary heat spreader, and at a thickness of just one to three millimeters it is very flat and extremely compact, making it perfect for integration within printed circuit board structures. This enables excellent thermal coupling, particularly for embedded power components.



In a pulsating heat pipe the fluid returns to the heat source via thin, meander-line coils which are partially filled with liquid and subsequently evacuated.

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