EMCOOL Inc.
3050 Business Park Dr Ste A1
Norcross, GA, 30071
info@em-cool.com

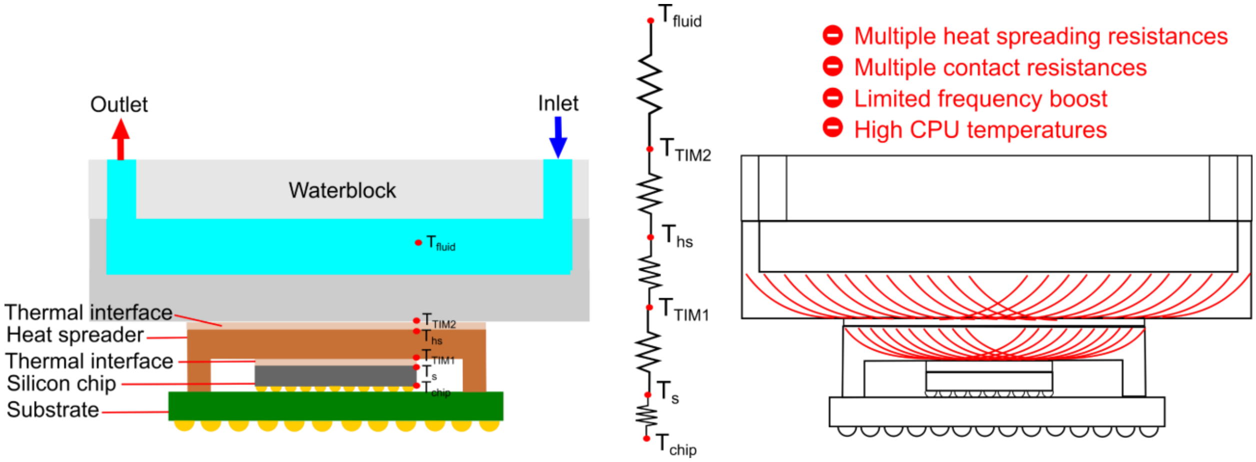
MICROFLUIDIC COOLING SYSTEMS FOR HIGH-PERFORMANCE GAMING/COMPUTING

Overheating is the main reason for degradation/failure in computing systems. Whether it is for gaming, science/engineering modeling, or graphics rendering, the microelectronics in the silicon chip of Central/Graphics Processing Units (CPUs/GPUs) require a certain voltage/current to operate at a specified frequency to perform the necessary operations. Simply put, the higher the operating frequency (or clock speed) of the processor, the faster the calculation proceeds. However, increasing operating frequency comes at the expense of higher input power to the cores, and therefore the challenge of removing higher rates of heat from the silicon chip. If the generated heat cannot be effectively removed, the core temperatures will easily surpass the 85 to 100 °C design limits. Long term operation at these temperatures may result in permanent damage, and to avoid this the chip designers incorporate thermal throttling, which results in undesirable performance reduction or shutdown.

PCs based on flagship CPUs/GPUs require advanced liquid cooling solutions. Although significant advances have been made, current state-of-the-art coolers available in the market still hit chip temperature limits at high frequencies. The performance improvements in microprocessor and graphics chips that occurred over the past two decades have slowed recently due to the difficulties with further scaling down the dimensions of the transistors. The current trend is towards heterogeneous integration, which requires close placement of multiple chips, or chiplets, making careful chip level thermal management a crucial part of system design. EMCOOL is uniquely positioned to provide thermal solutions for these emerging applications.

CONVENTIONAL LIQUID COOLING SYSTEMS

Due to the small dimensions of the silicon chip (die) in many commercial CPUs, an Integrated Heat Spreader (IHS) is used to increase the area over which the heat is removed. While this may seem as a good way to remove heat, it creates what is called a "spreading resistance", as it makes the heat path longer. In other words, removing the heat from a small silicon chip comes at the expense of a larger resistance network. An extra spreading resistance is also generated at the base of the waterblock, which further spreads the heat to the fin area. In addition, two "contact resistances" are also part of the resulting network (which include contributions from the interfaces) as well as the Thermal Interface Materials (TIMs) used between the surfaces of the silicon, IHS and waterblock. Finally, the heat resistances due to conduction and convection mechanisms, as well as a resistance associated with the increase in coolant temperature within the waterblock are included to get the equivalent network shown at the center of the schematic below. Each resistance has a finite value, and its sum represents the total heat transfer resistance. When the value of overall heat transfer resistance (units of °C/Watt) is multiplied by the chip power dissipation (Watt), the resulting quantity is the temperature difference between the start and end points of the equivalent network, in this case the average temperature of the silicon CPU and the incoming cooling liquid. As it can be noted, there are multiple resistances and the higher their value, the higher the operating temperature of the silicon chip. The combination of all these factors is why overheating is a big challenge even for the most advanced commercial coolers, which limits the overclock potential and life of the microelectronics.



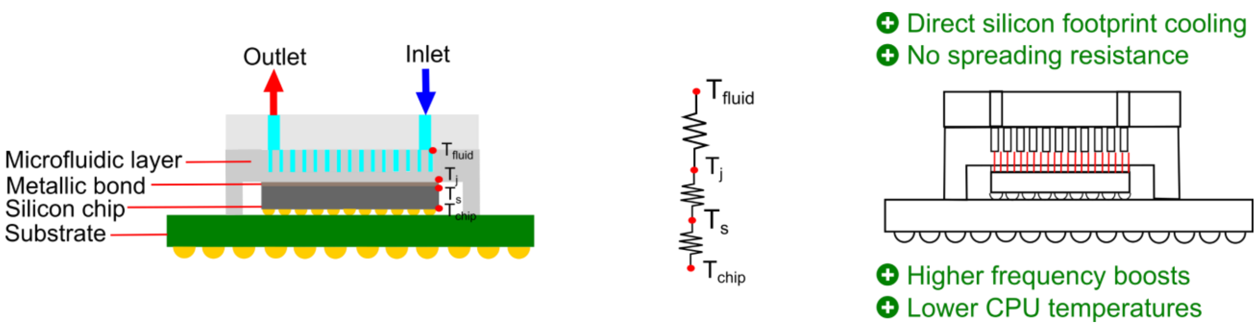
Conventional liquid cooling technology: left) cross-section cut of a CPU package and waterblock assembly, center) thermal resistance network, right) heat spreading path.

EMCOOL EMBEDDED MICROFLUIDIC COOLING TECHNOLOGY™

EMCOOL Inc. has developed the most powerful and efficient cooling solution to date for commercial microprocessors. EMCOOL's embedded microfluidic cooling™ system can unlock the high-frequency potential on flagship CPUs/GPUs while operating well below the thermal limits of its internal circuitry. This means that the computing system can be accelerated to its highest potential, while also protecting the chip from any form of thermal throttling/damage.

EMCOOL uses the exclusive Direct Silicon Footprint Microfluidics (DSFM) technology (U.S. Patent Application No. 16/789,824, and commercially referred as simply microfluidics), which features engineered cooling microstructures that are optimized based on the chip's architecture and footprint; this approach allows unparalleled cooling performance when compared with any other cooling technology in the market.

As seen in the schematic below, with EMCOOL's technology the heat is removed directly at the source through a chip-specific microfluidic cooling layer, which is optimized for each of our supported models to mitigate the heat spreading effects. The ambitious goal of removing the heat in such a small area is accomplished through micro-machined structures of high-aspect ratio, which significantly enhance the fluid mixing and heat transfer. With the combination of these multiple features, the heat spreading resistances are eliminated from the overall network, while also reducing contact and convective resistances. With a significantly lower overall heat transfer resistance than conventional technologies, it is possible to dissipate higher power at lower silicon temperatures, the most important feature of microfluidics.



EMCOOL's embedded microfluidic cooling technology™: left) cross-section cut of a CPU package and EMCOOL assembly, center) thermal resistance network, right) heat spreading path.