Ceramic Heatsink Provides Innovative Thermal Management

A new ceramic technology offers an innovative solution for thermally sensitive components and circuits, thanks to its excellent thermal conductivity and stability characteristics and its compact form. CeramCool is the ideal heatsink for high-power semiconductors where it demonstrates its ability to handle high power peaks. **Alfred Thimm, Service Center Design, CeramTec AG, Plochingen, Germany**

Heat-sensitive semiconductor components are often mounted onto substrates. These substrates need to provide electrical insulation while, at the same time, ensuring adequate thermal conductivity. The result is often a kind of 'sandwich' with multiple layers made from different materials, which simultaneously translates into numerous production steps. Each layer is a potential risk and poses an additional obstacle to thermal conductivity. CeramCool transforms the substrate into a heatsink itself. The difference is readily visible in this high-power LED example (see Figures 1 and 2).

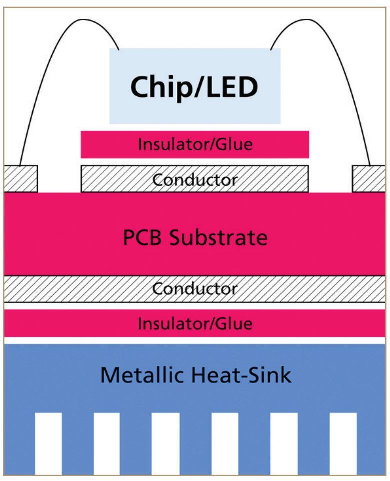

Figure 1: Typical LED system with multiple layers and different thermal coefficients of expansion (TCEs), potential risks are delamination, corrosion, and degradation

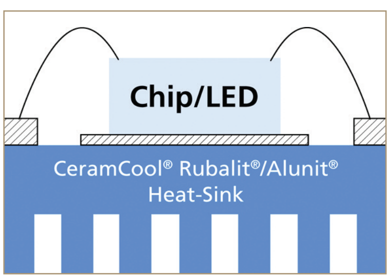

Figure 2: Simpler and smaller LED System with CeramCool and direct metal-to-metal connection

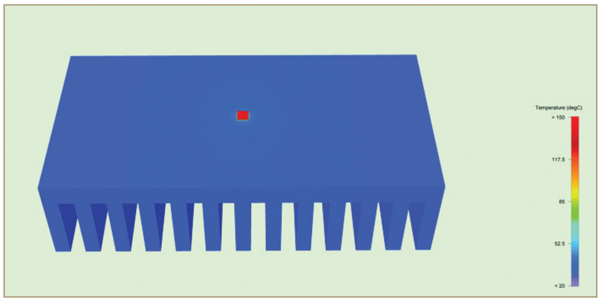

Figure 3: Aluminium cooler remains cool overall, but the chip is getting hotter and has a maximum temperature of 169°C (Source: Fraunhofer Institute)

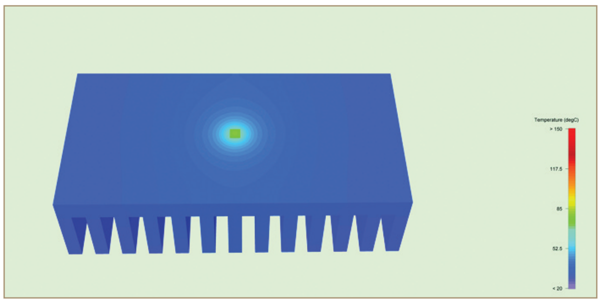

Figure 4: The ceramic heatsink is getting hotter and dissipates the heat coming from the chip, leaving the LED cooler at 82°C (Source: Fraunhofer Institute)

Long life through excellent thermal management

CeramCool is made from ceramic materials such as 450MPa high bending strength material Rubalit 708 (with 96% Al_2O_3), smooth surface Rubalit 710 (with >99% Al_2O_3) or high thermal conductivity material Alunit AlN (180W/mK). These materials have a thermal expansion coefficient (TCE) that is close to semiconductor materials. Especially Alunit® has a TCE of 4.6ppm/K (RT–300°C) that comes very close to Si of 4.7ppm/K. In common the materials possess excellent electrical characteristics (breakdown voltage >20kV/mm at RT, specific resistance >1014Ω*cm) and good electromagnetic compatibility.

At the same time, they are waterproof and corrosion-resistant. CeramCool can be exposed directly to the atmosphere economizing on additional insulation, cooling systems etc. The simplified construction (without glues, insulation layers) combined with a direct and permanent bond between the high-power LED and CeramCool heatsink create good thermal conductivity and electrical isolation for the entire assembly. Secure thermal management increases component life and stabilises for example the LED's colour rendering index.

Cool LED and hot heatsink

The Fraunhofer Institute in Nuremberg, Germany, compared two heatsinks of the same geometry with regard to their surface temperature - a typical aluminium fin cooler with a glue bonded chip versus CeramCool made of Rubalit or Alunit with metalisation pad and directly soldered LED. The contrasting images make the most essential thing clear, even if not at first sight: The aluminium heatsink remains relatively cool, but the chip reaches a maximum temperature of 169°C (Figure 3). The adhesive layer required for the aluminium assembly is blocking heat dissipation. In contrast, the ceramic heatsink becomes hot and dissipates the resulting heat over its surface (Figure 4). The reason is simple, the LED chip is directly and reliably bonded to the electrically insulating

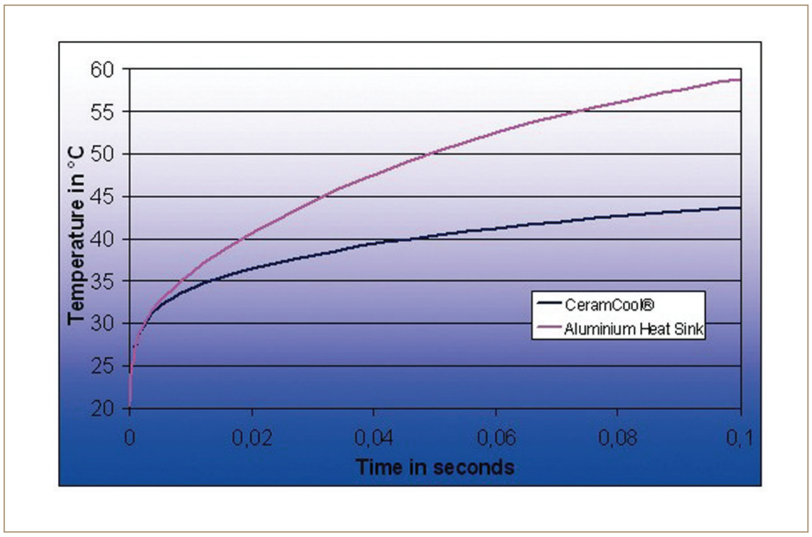

Figure 5: After 0.1s CeramCool reaches a temperature of only 45°C versus approximately 60°C with aluminium (Source: Fraunhofer Institute)

CeramCool using only metals. The result is convincing. The chip's maximum temperature is with 82°C half that of the aluminium assembly. If the heatsink becomes hot it takes the burden off the LED and does exactly what it is made to do, namely cooling of the critical components.

Figure 5 shows the starting phase. What happens to the chip? With CeramCool it gives off its heat to the ceramic heatsink immediately and without barriers. Proof of the system's high dynamics: after 0.1s CeramCool reaches a temperature of only 45°C versus approximately 60°C with aluminium. This results in great load reduction while considerably increasing component life.

Heatsink acts as circuit carrier

CeramCool can be coated directly with proven thick-layer technologies with its high adhesion force (WNi(Au), AgPd, Au, DCB, AMB...) or thin-film processes with its smooth surfaces (allowing precise light angles). A finish for better soldering can be obtained using electroless nickel or gold (immersion or cathodic deposition).

The possibility of metallisation makes the whole surface of the heatsink useable as a circuit carrier which can be firmly packed with LEDs and drivers on customised circuit layouts - while providing reliable electrical insulation (Figure 6). The process can be simplified by bonding the chip directly onto the specially designed CeramCool metallic surface - chip on heatsink!

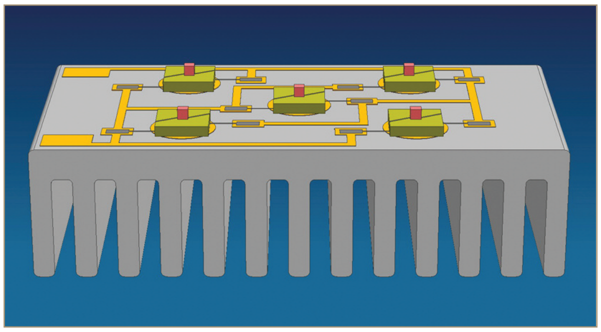

Figure 6: A customer specific layout is applied on the surface and packed with components, qualified processes and RoHS conforming materials can be used

Conclusion

CeramCool has been received the Manufacturing Excellence Award 2007 for the best product innovation, the ceramic heatsink for high-power electronics. One of its important features is its high degree of freedom of design. One the one hand, it can be manufactured according to customer specifications for example with individual forms, with or without metallisation, with sizes between 1 and 200mm and a thickness from 0.05 up to 50mm (Figure 7). On the other hand, product designers obtain a new level of design freedom for their final product. This is because the simplified construction, the ability to use the heatsink as a circuit carrier and efficient thermal management make it possible to achieve miniaturisation.

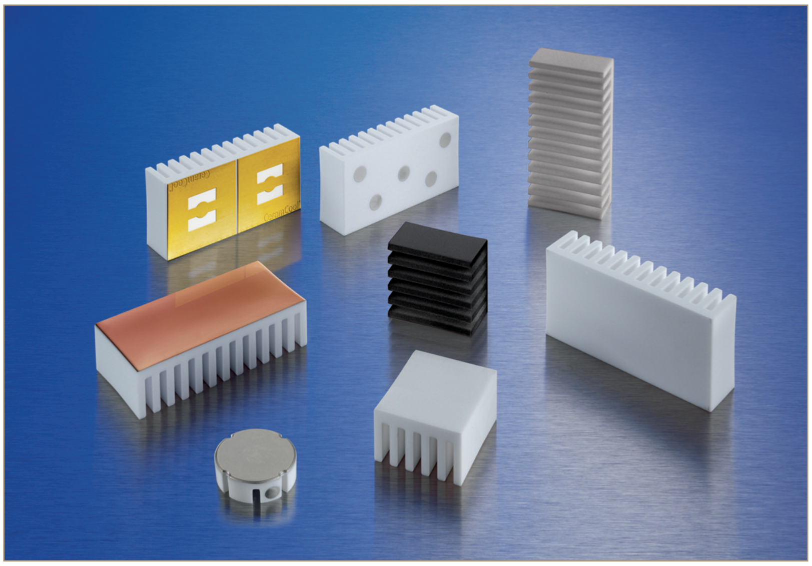

Figure 7: CeramCool in different construction and metallisation forms