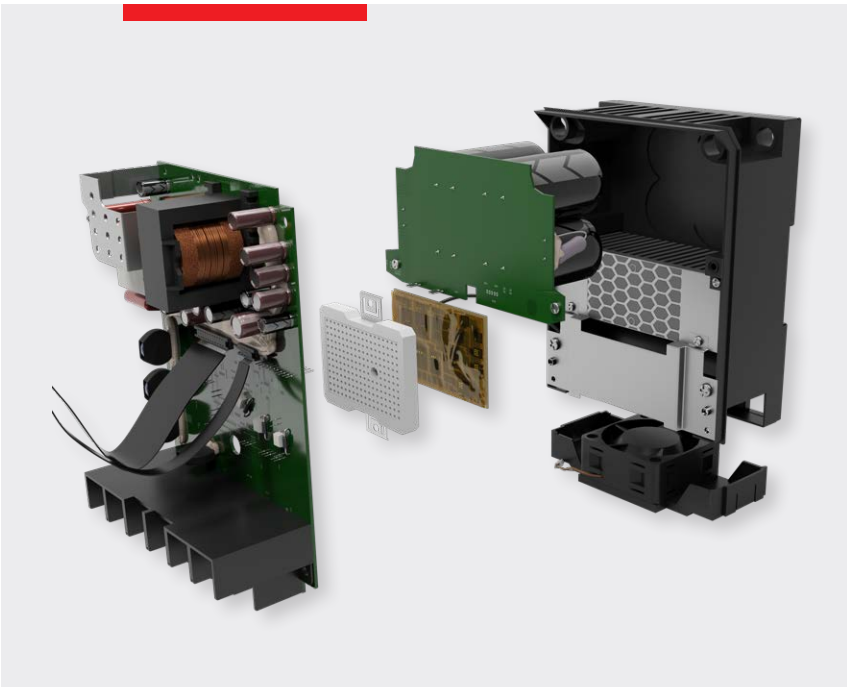
December 2021

POWER MODULES RUN THE WORLD: HOW MUCH BETTER COULD THEY BE DOING IT?

"They power your appliances, electric vehicles, medical devices, robotics, factories and air conditioning units. Power modules are central to the function of systems we use every day. Ensuring they run efficiently and reliably is more important than ever, but that is getting harder to achieve."

Mahmoud Awwad, Henkel

Power module structures generally consist of several power semiconductor devices and are used within power conversion systems such as motor drives, inverters, and a variety of power supplies (UPS, AC-DC, DC-DC, etc.). Like most things electronic, power module designs are seeing radical change, integrating more function and leveraging higher power density silicon-carbide (SiC) and gallium-nitride (GaN) power semiconductors.

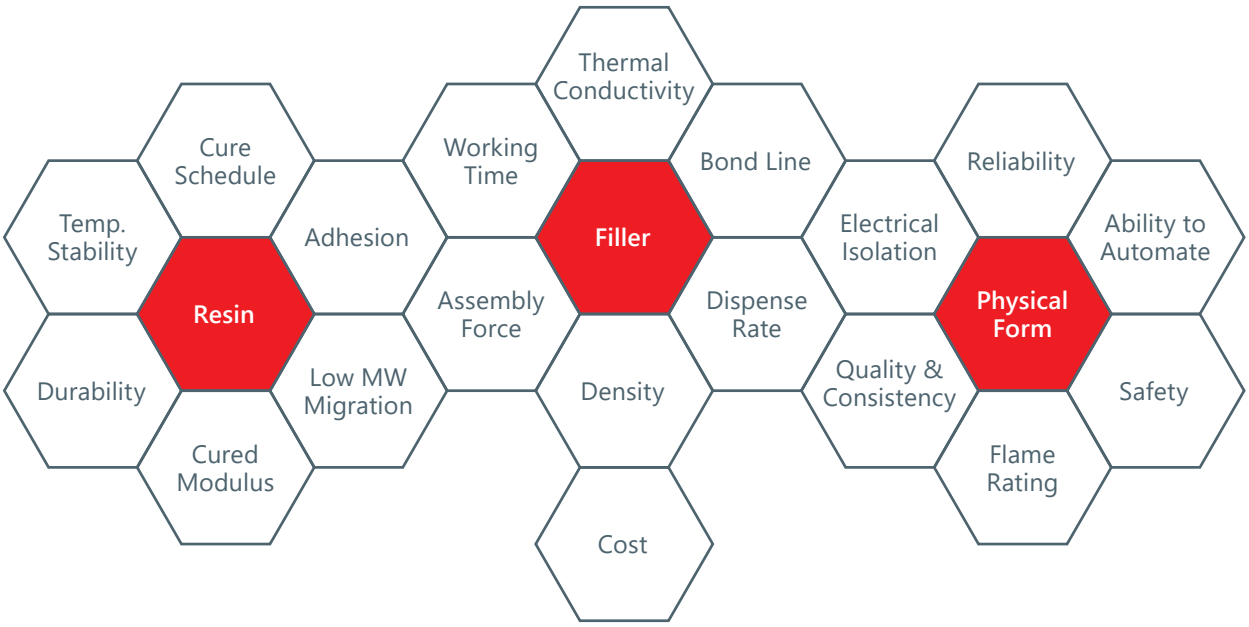


The resulting thermal impact of these developments in power module architecture is putting a more intense focus on effective thermal management solutions to achieve performance and reliability metrics.

Thermal Control:
As Thin as Possible, as Thick as Necessary

As power densities and switching frequencies have increased, so has the urgency to optimize performance through more effective heat dissipation. The better the thermal transfer, the more robust the performance and the longer the lifetime of the module. Deciding which thermal interface material (TIM) to specify is a function not only of the material's bulk thermal conductivity but, perhaps more importantly in some cases, its thermal resistance. For power modules, reducing bond line thickness and improving the wet out of the TIM to the cooling surfaces can be as important as high bulk thermal conductivity in reducing thermal resistance in the application. Streamlining the path between the heat-producing dies and the heat sink is the goal and the thermal stack up and various coefficients of thermal expansion (CTEs) have to be balanced. Of course, that's only part of the equation, as the below graphic illustrates. There are many factors to consider.

Building Blocks for TIM



Historically, thermal grease has been the preferred TIM for the power module to heat sink thermal path. Greases are thin, have very low viscosity, and are effective, especially in the short term; but are also rather messy. Thermal pads and liquid gap fillers are other options, though they have drawbacks in terms of thickness and interface wet out. When balancing bond line thickness, viscosity, microscopic gap filling characteristics and performance over the long term, phase change TIMs may be the most comprehensive approach to today's power module thermal control challenge.

The Match-Up:
Grease versus Phase Change Material

It is well-understood that thermal greases, while highly effective initially, tend to migrate or 'pump out' over time, losing heat-dissipating robustness through filler loss. Our company's internal testing and customer experiences have proven as much, as evidenced by this application case.

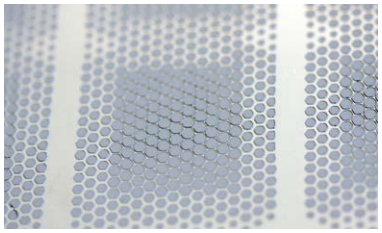
Phase change materials, on the other hand, remain solid at room temperature and only melt at the designated phase change temperature, offering stable protection for devices operating as high as 150 °C. In addition to thermal management, some phase change formulations provide the benefit of electrical insulation. Also, because they return to a solid state when not at the phase change temperature, these materials are typically resistant to pump out, offering better reliability over the device life. Like greases, very thin bond lines (from 10 – 100 µm) are the norm and the materials are automation-friendly.

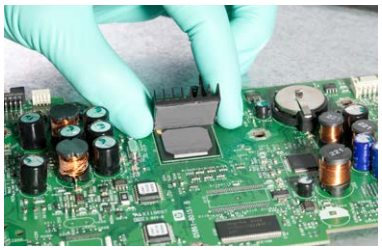
As Henkel's Mahmoud Awwad explains, it's time to transform the traditional:

"Thermal greases are a perfectly fine option for some applications. Given the evolution of power module designs, however, I believe a more durable, flexible solution is the answer. Phase change materials are the way forward."

Product Differentiation:
The Next Level of Value

Phase change formulations come in many different mediums – from films to hybrids to pastes. What they all have in common is the ability to pre-apply them to modules or heat sinks, as they remain dry until pushed to phase change temperature. This flexibility – not to mention their superiority in terms of long-term resistance to material migration – is worth consideration. Power module manufacturers can ship devices thermally prepared with pre-applied TIM phase change material, which adds value to their product, eliminates process steps at the production site, simplifies supply chains for end-product manufacturers and eliminates handling and waste concerns associated with grease-based materials.





Running the World,
Only Better

Enabling more efficient operation of next-generation high-density power module designs is necessary to achieve the performance demands of advanced systems – from EVs to industrial automation to medical technology and everything in between. Many factors influence this result, but high-performance thermal control is one of the most important elements of long-term functional reliability. Phase change TIMs are emerging as the benchmark for the future of power module thermal management.

About the Author:
Mahmood Awwad

Mahmoud Awwad currently serves as Henkel's Business Development Manager for Power and Industrial Automation within the company's Adhesive Technology business unit.

In 2008 Mahmoud joined Acheson in Scheemda (acquired by Henkel in 2008) – in 2011, he joined Henkel Electronics as an Inside Sales Account Manager and has since worked in different account management positions. He has a broad experience in electronic materials solutions for a variety of applications within the electronics market. With a long history of serving customers in multiple markets including Industrial Automation, Power Conversion, Automotive, Medical and Power Electronics, Mahmoud is passionate about identifying needs of the overarching market trends and translating them into solutions that fit customer requirements.

Based in Utrecht area, the Netherlands, Mahmoud holds a Bachelor's degree in Business Administration from the Hanzehogeschool of Groningen.

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