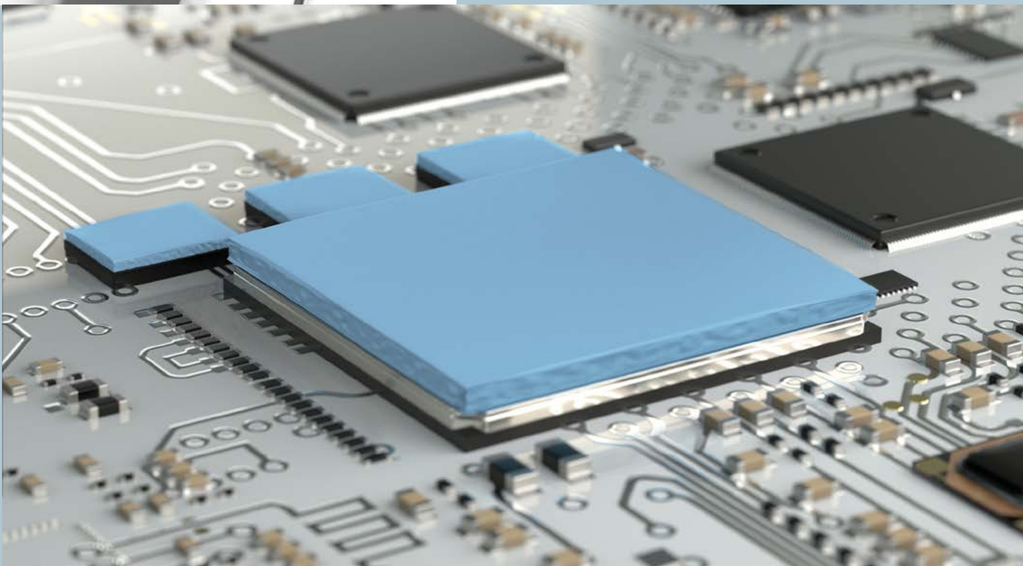
Henkel Adhesive Technologies

THERMAL INTERFACE MATERIALS FOR THICK GAP APPLICATIONS:

LIQUIDS OR PADS?

Understanding Distinguishing Factors and Selection Considerations

Peter Jones

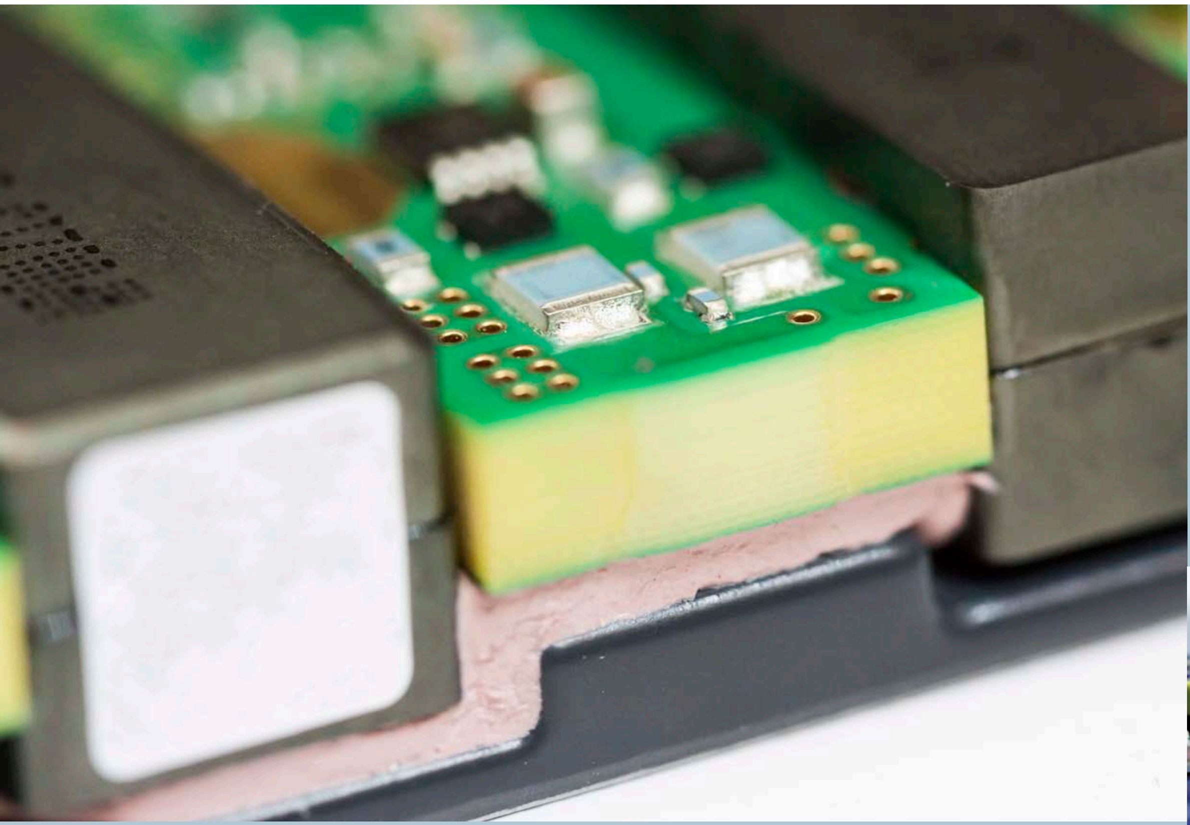


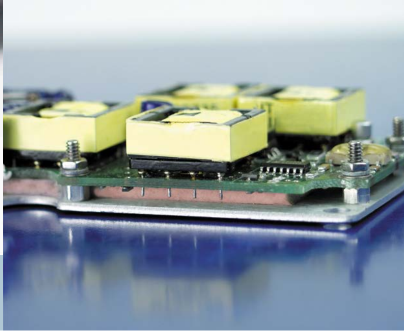
Operational heat generated from electronics can be function-limiting and, in extreme cases, even result in complete device and/or system failure. Maintaining optimal temperature, therefore, is one of the most critical aspects of electronic system design.

There are many ways to manage operational temperatures, and techniques are often combined. These include active air cooling (fans and air conditioners, for example), submersion liquid cooling, cooling pipes, heat sinks, and thermal interface materials (TIMs). Heat sinks are well-known and ubiquitous. And while heat sinks are highly effective, the air gap between the heat-generating component and the heat sink acts as an insulator, reducing thermal transfer efficiency, limiting component cooling, and, ultimately, holding back device performance.

Filling the gap with a thermally conductive material helps more efficiently move heat to the heat sink. But gap geometries are all different. Varying thicknesses, dimensions, and complex architectures – among other considerations – influence TIM selection.

This piece examines applications with thicker gaps and the TIM materials that are most effective for those designs.

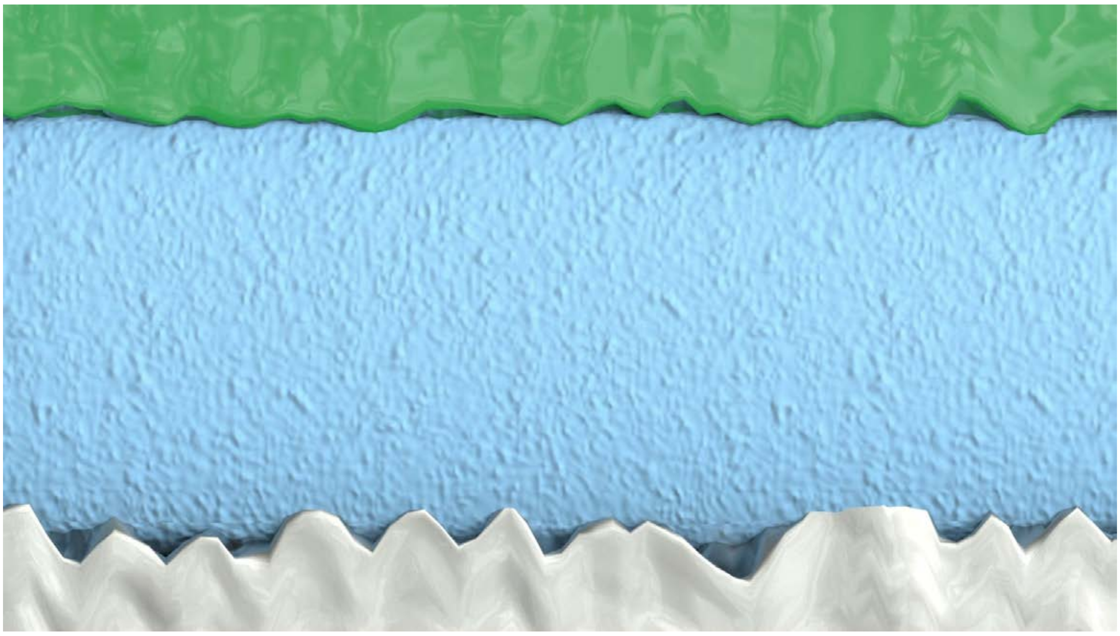


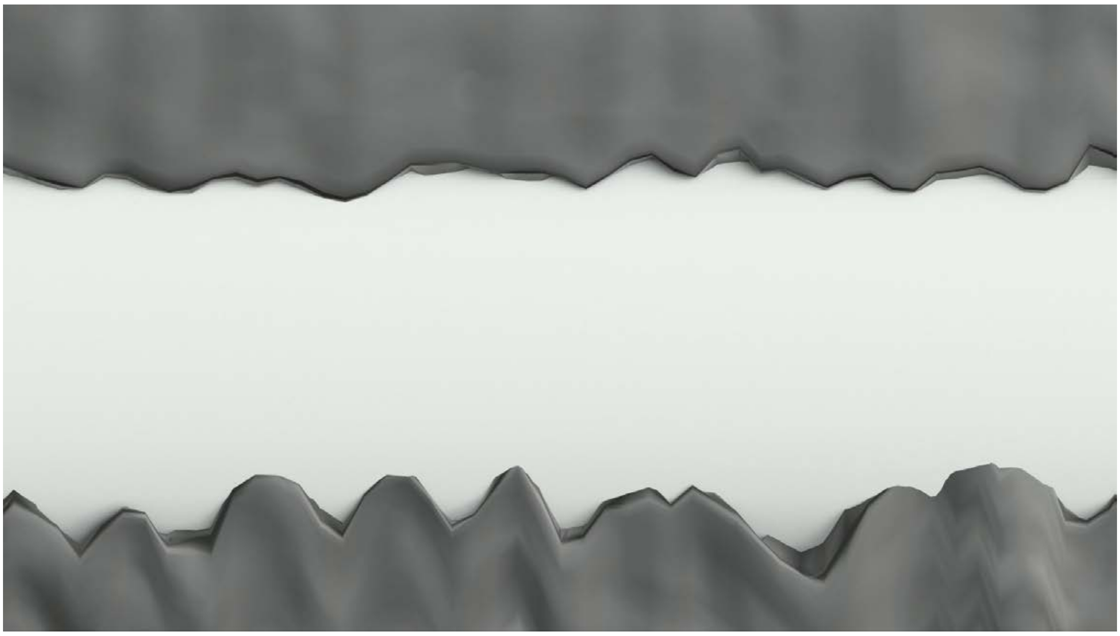


How thick is thick?

Both the heat sink and the component surface, or the structure (coil, windings, battery packs, etc.) and the housing acting as a heat spreader, have visible gaps and microscopic deviations that need to be filled. To optimize heat dissipation, displacing as much air as possible is vital for improving heat transfer between the component and heat sink.

In general, when evaluating 'thicker gaps', the dimensional range is from about 0.5 mm up to approximately 2.5 mm. In addition to gap size, other factors such as part geometry, tolerances between the two opposing TIM surfaces, substrate roughness, processability, and end use help determine the best product for the job. When evaluating which TIM medium is appropriate for thicker gap applications, the two options are thermal pads and liquid (or gel – more on that later) gap fillers.





Thick gap TIMs: Flowable or fixed?

Because liquid materials can flow, they generally offer better surface wetting than a pad, more thoroughly filling microscopic deviations and improving thermal performance. One might assume, then, that a liquid would always be the optimal choice. Not necessarily. Here's why:

Pads are soft, conforming pad-based materials that are pre-cured; the thinnest space they can fill is about 0.5 mm. In comparison to liquid gap fillers, pads have some unique and often necessary features. Pre-cured pads can offer electrical isolation by adding a film in the center of the pad that can meet specific electrical requirements. Because of this feature, pads may be the only option for certain high-voltage designs. Application ease is also a benefit of pads. They are pre-cut into the desired shape and are relatively simple to apply manually (and some can be automated, too). Processes with part volumes in the hundreds (not thousands) make pads a manageable and effective solution. Finally, the shelf-life of pads is longer, on average, than liquid materials. Unlike liquid mediums, there is no concern about material separation because pads are cured.

On the other hand, liquid gap fillers can help streamline inventory management, as the materials can be dispensed in limitless patterns and volumes to fill gaps and architectures of any shape or size. They are not restricted to filling two generally flat surfaces. Supply chain simplification is another advantage. Unlike pads, where each thickness and shape requires a unique part number, a single liquid gap filler can be used for multiple applications and at various locations on a single assembly.

Liquids vs. gels: What's the difference?

Within the liquid TIM category, there are two types, and their differences warrant clarification. Two-part liquid gap fillers are uncured materials most often preferred in high-reliability applications such as automotive and some industrial automation products where vibration and harsh conditions are the norm. Since they are uncured when dispensed, they flow better than pre-cured gels, providing superior surface wetting.

Gel TIMs are technically liquids as well but are in a cured state with a higher viscosity than two-part uncured liquids. These materials deliver excellent thermal conductivity as high as 10 W/mK, low assembly stress, and high gap stability. Gel materials are used when a liquid solution is required but the device is stable and not subjected to movement and vibration. The forces experienced in these applications – like telecom infrastructure systems, for example – are not as extreme as in other environments.

Of course, there are numerous other factors for TIM selection beyond whether to use a liquid or a pad medium. Resin chemistry, cure profiles, serviceability, thermal conductivity, thermal resistance, and many others must all be considered as part of the TIM evaluation. Henkel has several available resources to help determine appropriate TIMs for specific applications.

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The Author

Peter Jones is a Senior Application Engineer for Thermal Interface Materials in Power and Industrial Automation within the company's Adhesive Technology business unit. Peter joined Henkel in early 2022 from Momentive Performance Materials where he also served as an Application Engineer. He has a background working with silicone adhesives and sealants, specifically in the Aerospace Industry. Peter holds a Bachelor's degree in Materials Science and Engineering with a minor in Sustainability Studies from Rensselaer Polytechnic University.

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