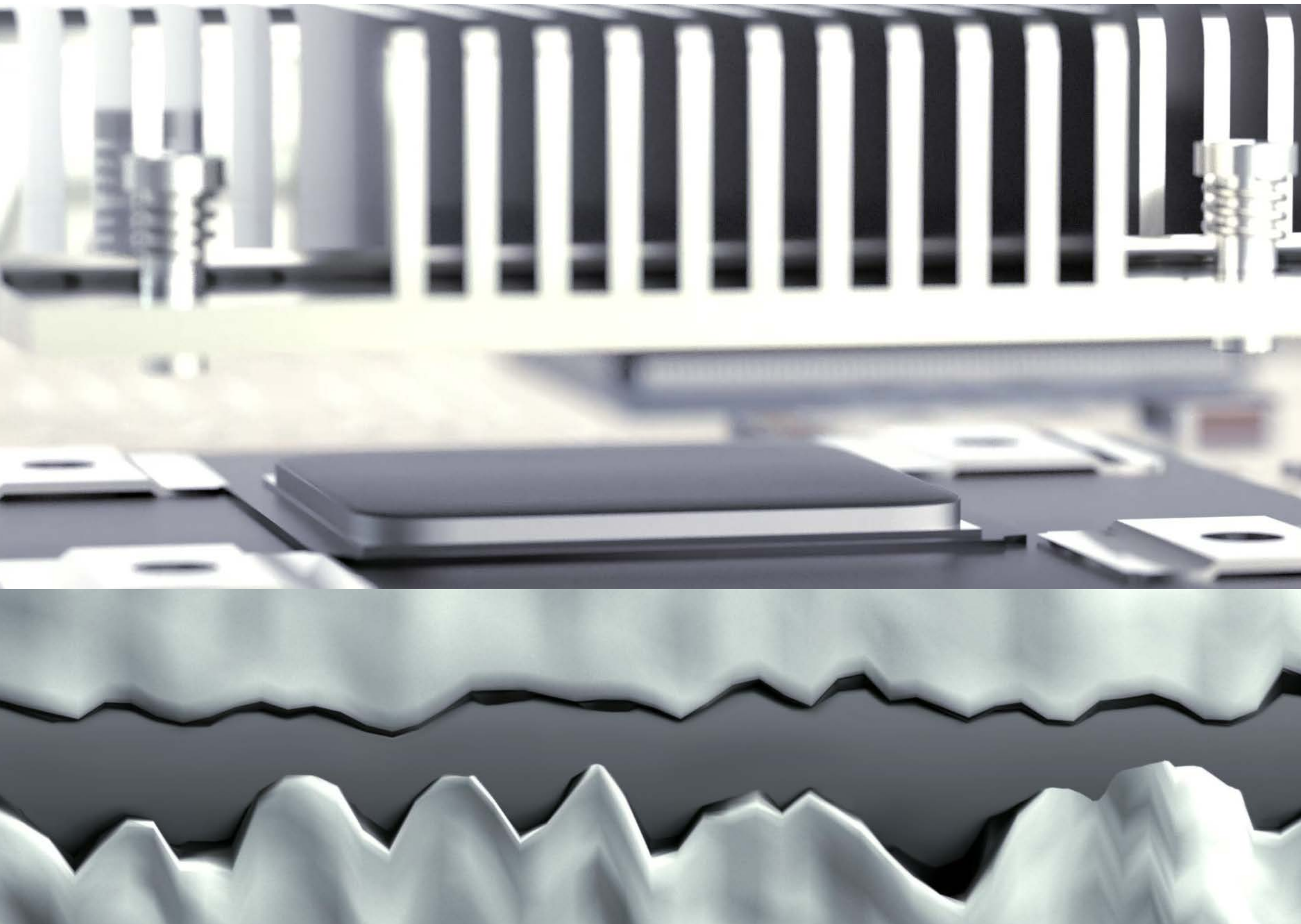
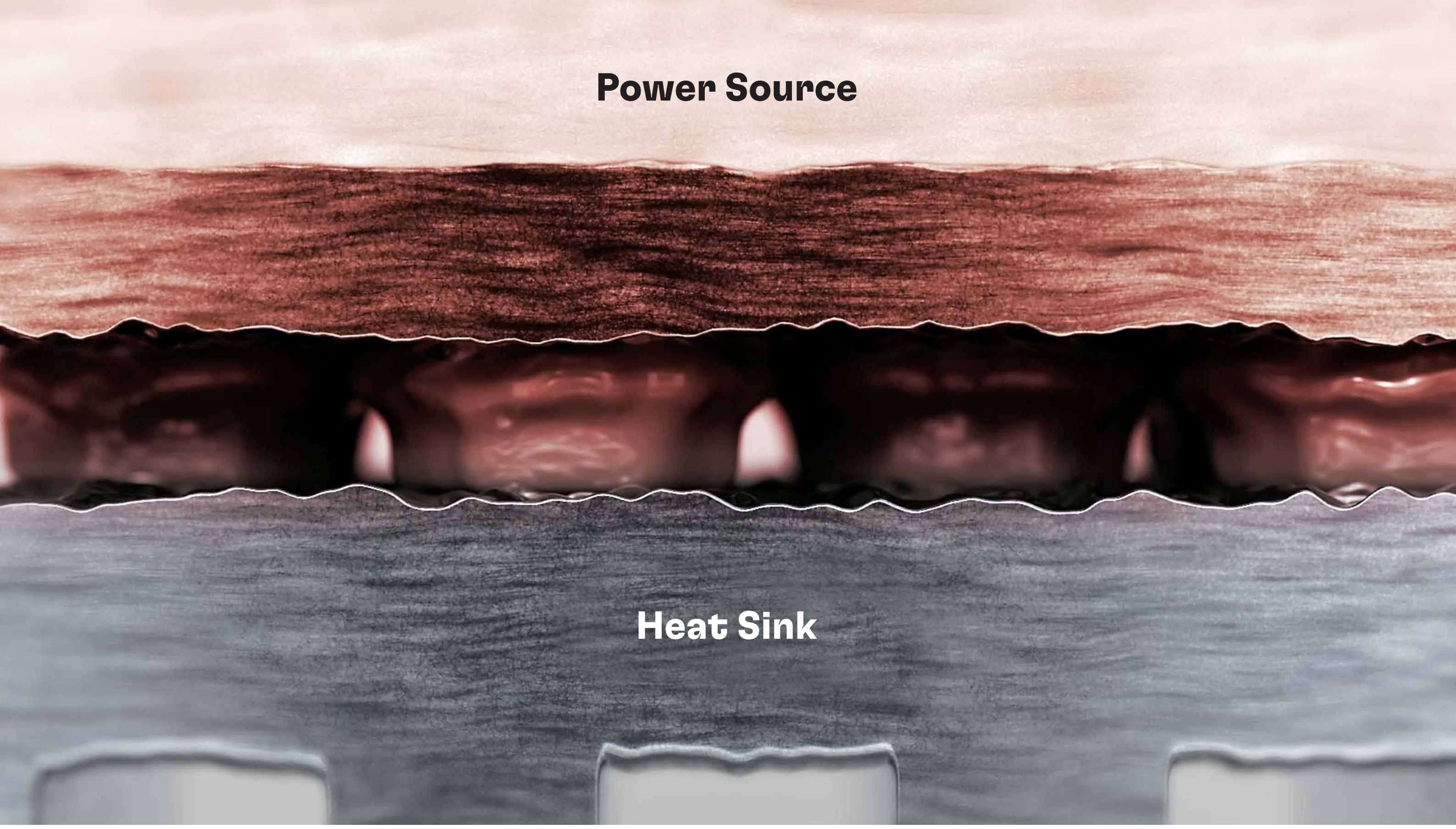
Henkel Adhesive Technologies

AS THIN AS POSSIBLE, AS THICK AS NECESSARY

Considerations for Ultra-Thin Bond Line Thermal Interface Materials

Shelby Shevik





To move heat from its source most efficiently, thermal interface materials (TIMs) are an essential element for the proper performance of nearly all electronic devices. Transferring thermal energy from a heat-generating component to a heat sink or heat spreader optimizes functionality by reducing the likelihood of overheating. Over the long term, this will also contribute to an extended working life of the system. TIMs are thermally conductive materials in various forms (pads, liquids, gels, films, etc.) that enhance heat removal by providing a continuous, void-free path for heat transfer.

> **The aim is to fill the gap between the heat source and the heat sink with a material that is as thin as possible to provide the lowest thermal resistance and most efficient path.**

But the material must be thick enough – as thick as necessary – to fill the gap and eliminate any air presence. When evaluating ultra-thin bond line – defined as less than 200 microns – applications, there are generally two categories of TIM materials for consideration: thermal greases and phase change TIMs.

Weighing the Options

Phase change TIMS are available as dryable pastes or films. Once they reach their phase change temperature in application, the materials flow into the interface and fill the gaps. When the heat is reduced below the phase change temperature, these TIMs return to solid form. Conversely, thermal greases remain in a permanent medium viscosity state (think: smooth jelly). The various forms of thin bond line TIMs contribute to some of their advantages and challenges, but other factors also impact their effectiveness. Naturally, product selection is dependent on processing preferences and application performance requirements. Here are some aspects to consider when choosing a thin bond line TIM.

Phase Change TIMs

Advantages

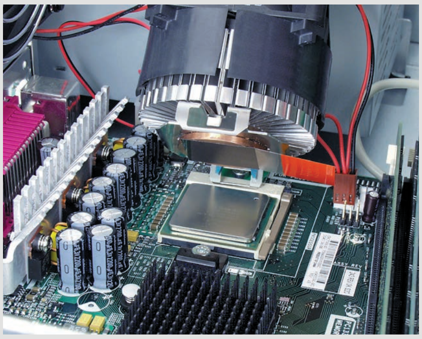
Because the materials remain in a solid state when they are below their phase change temperature, these TIMs are very stable. The phase change pastes can be screen printed or dispensed and then dried, while the film-based materials are designed for easy handling and application. If the phase change film is coated onto each side of a carrier substrate layer, there is the added benefit of a dielectric barrier for electrical isolation. Because of the material stability, phase change TIMs can be pre-applied by the heat sink vendor or by the electronics assembler. Mess reduction is also a benefit, as there is no squeeze out as with grease. From a performance perspective, the stability of the material also limits material migration – or 'pump out' – over time, which helps preserve thermal transfer integrity.

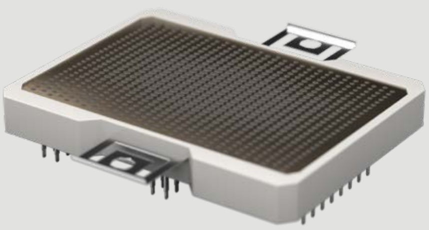
Challenges

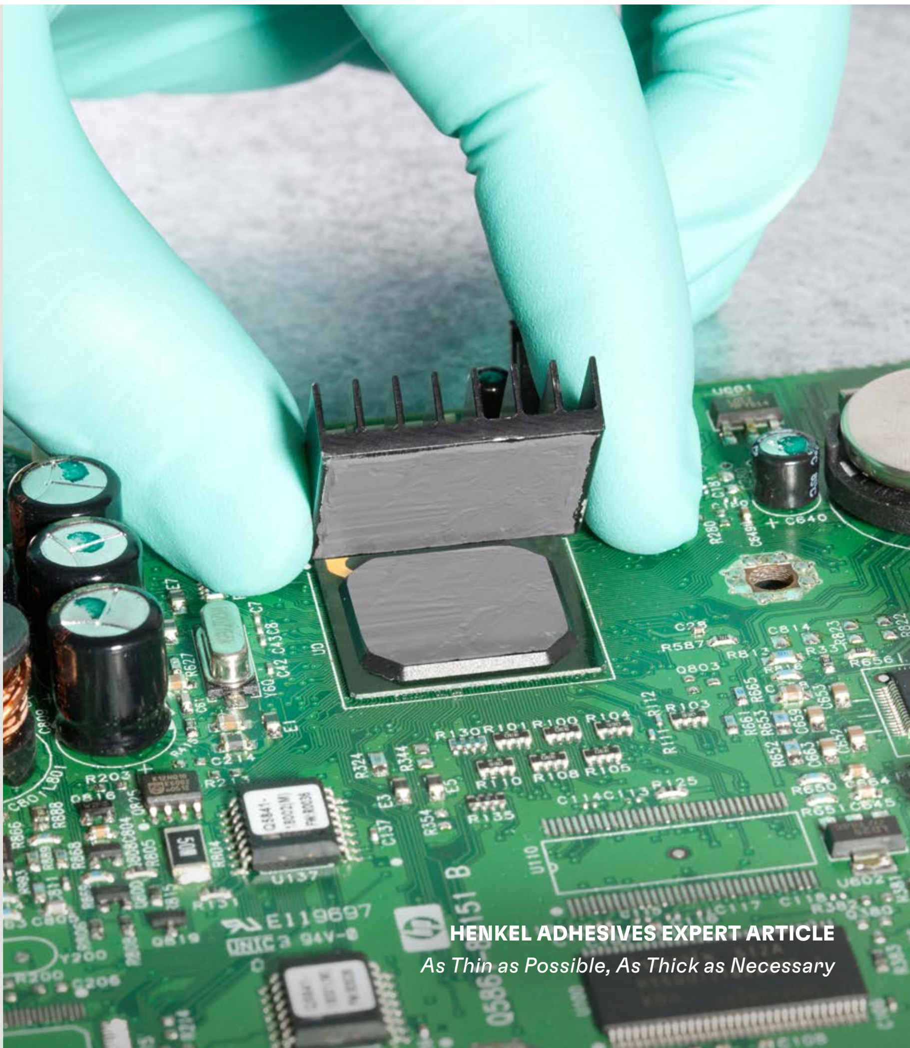
The smallest ultra-thin bond lines are only achievable with thermal greases. High throughput dispensing/printing equipment will require larger upfront investment costs.

Processing

For all formats, phase change TIMs can be manually applied or deposited by an automated system (dispenser, screen/stencil printer, or pick and place equipment).







Thermal Greases

Advantages

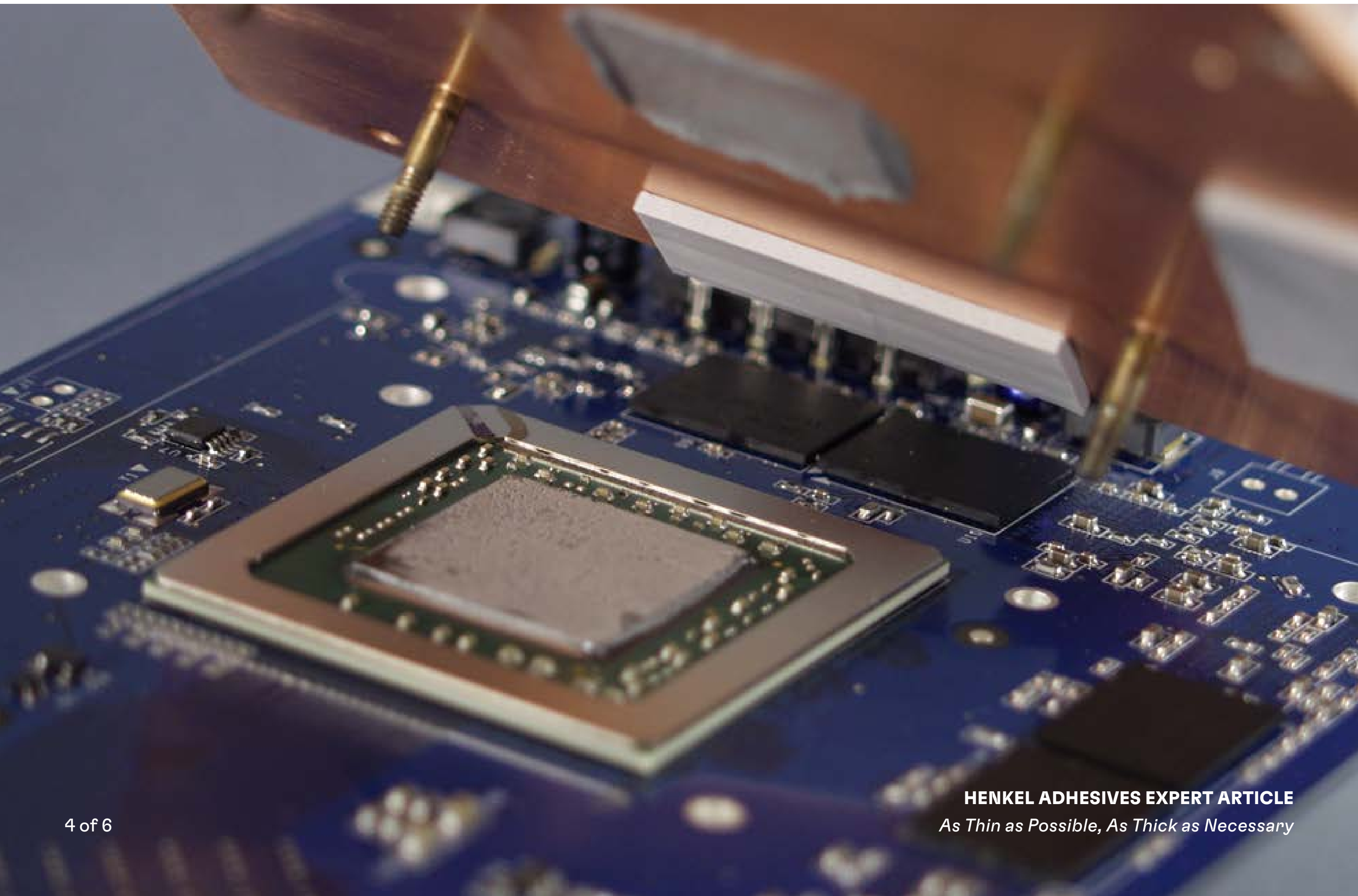
Thermal greases, while often billed as ‘messy’, are simple materials to work with, which is why some assembly specialists prefer them. The materials perform comparatively well and have been a ‘go-to’ thin bond line solution for decades. Primarily, greases are perceived to have good performance for the price point. While performance in high-power density applications is typically not associated with grease materials, some high-end greases can meet relatively demanding requirements.

Challenges

Thermal greases are not ideal for situations where electrical isolation is required or for extremely high-reliability designs, due to pump out concerns. Handling may also be messy, which can lead to contamination.

Processing

Thermal greases are typically manually applied at the point of electronic assembly. Because they are in a constant viscous state, application at the heat sink supplier is not an option.

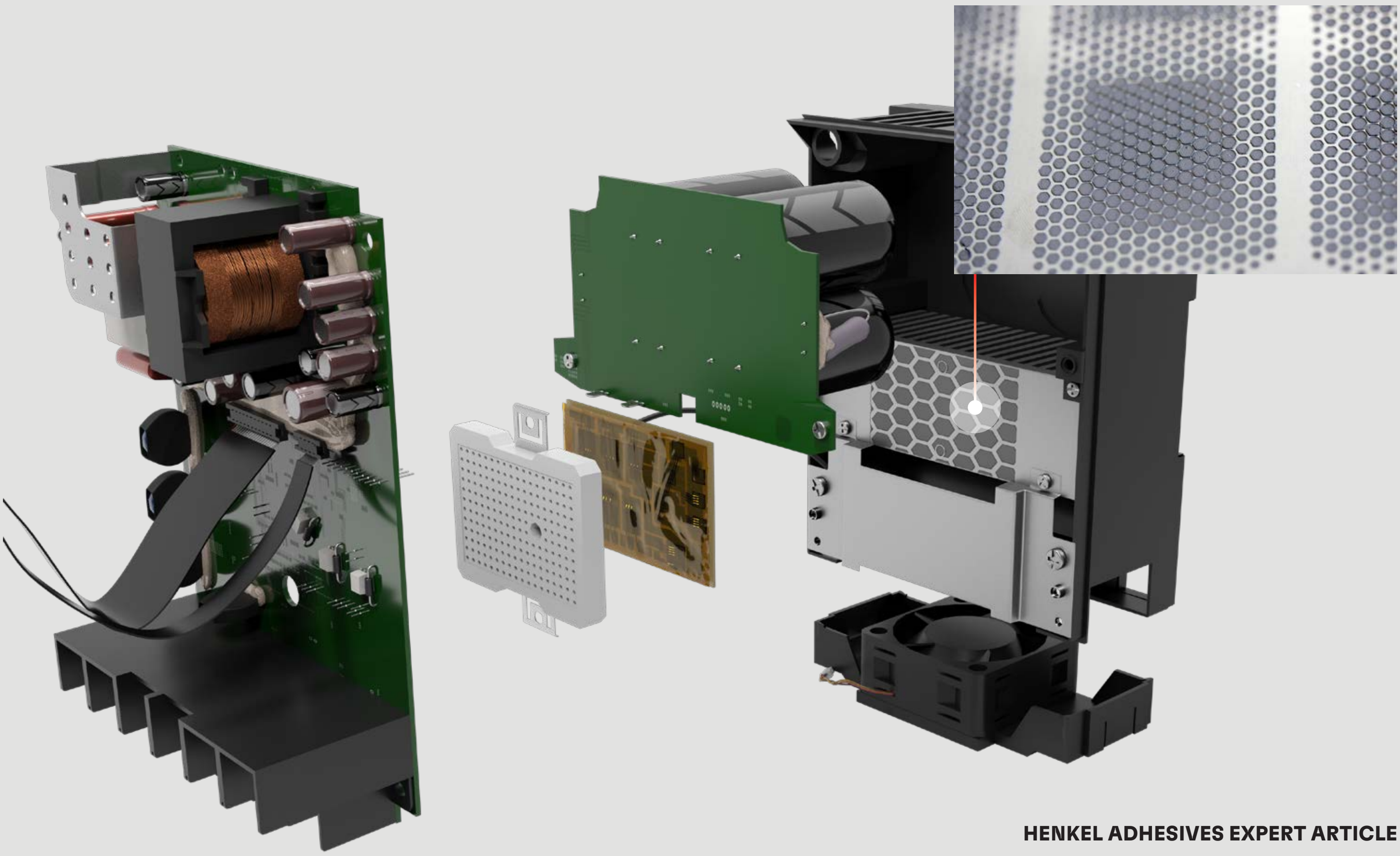


Head-to-Head Comparison

The final application, its life expectancy, and reliability requirements are the primary determinants of thin bond line TIM specification. ***This case study*** highlights how application testing for a new drive system, with system life stability of 25 to 30 years and automated material deposition requirements, led to the selection of a dryable paste phase change TIM. When the phase change TIM was tested against two different thermal greases, its superior reliability was confirmed. Whereas both grease materials failed after 600 to 800 hours of -50 to 150°C thermal shock testing, the phase change performed as expected beyond 1,000 hours. For this application, low thermal impedance was also required. And while thermal greases and phase change TIMs generally have relatively low thermal resistance compared to some thicker TIM solutions, the dryable phase change paste outperformed the grease in this metric as well.

Thin is In

The reality is that more electronic function is being integrated into smaller spaces. And that generates heat. Thinner and larger devices within constrained dimensions require thin bond line TIMs. Because of this, both thermal grease and phase change TIM formulation development is a priority. With larger heat spreaders, the degree of surface flatness is more difficult to control. In addition, pressure becomes a challenge as larger devices require multiple mechanical joining locations, which can lead to die stress and board warpage due to force. This, among other factors, is accelerating use of thin bond line thermal management solutions.



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The Author

Shelby Shevik is one of Henkel's Lead Application Engineers for Thermal Materials in Power and Industrial Automation within the company's Adhesive Technology business unit. Shelby recently joined Henkel in early 2022 but has been a passionate Application Engineer in other industries through the past 5+ years.

She has a broad range of experience in material solutions from Thermal Interface Materials to Fluoropolymers to Hot Melt and Structural Adhesives. With a long history of serving customers in Industrial and Automotive markets, Shelby is passionate about troubleshooting pain points and driving solutions that best fit market requirements. Based in Chanhassen, Minnesota, Shelby holds a Bachelor's degree in Biology with a Chemistry Minor from Bemidji State University.

LEARN MORE

Check out Henkel's portfolio of low-volatility and silicone-free TIMs ***here***.

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