SILICONE OR SILICONE-FREE?

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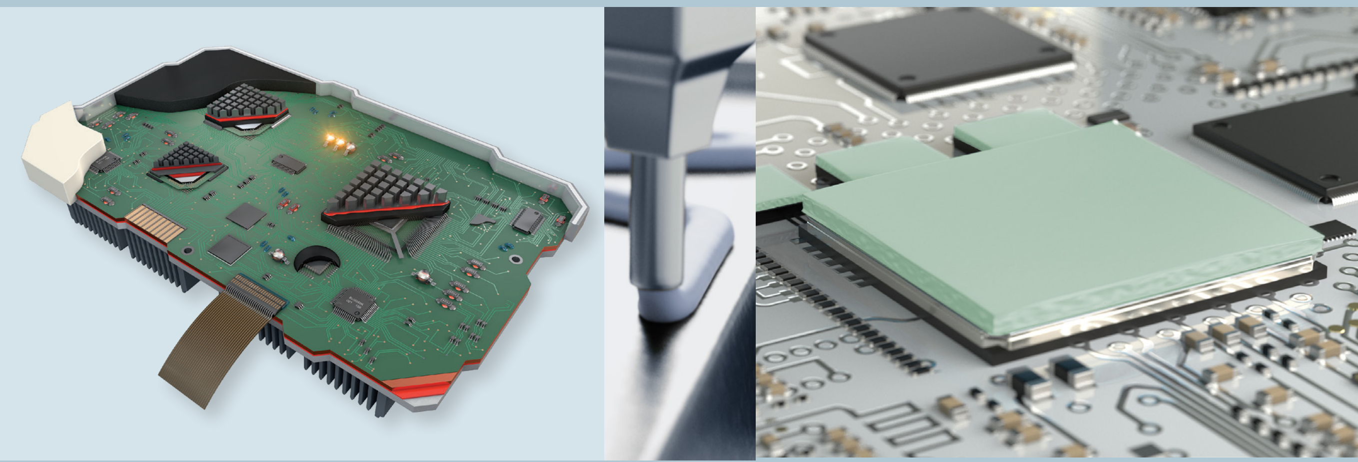

In electronic applications, silicone-based chemistries are used across a wide variety of formulations including encapsulant, sealant, gasketing, potting, and thermal interface materials, to name a few. There's good reason for that. Silicone has many characteristics that make it an ideal chemistry platform for electronics. These include:

- Stability against mechanical shock, electrical shock, and vibration
- Flexibility enabled by high elongation
- High durability
- Resistance to chemicals, oils, and water
- Ability to cope with extreme environmental conditions
- Very high temperature resistance and retention of durability within tempera-tures that can range from -65°C to over 200°C
- Low toxicity, high purity, and good electrical properties

Silicone's unique properties are hard to resist. Sometimes that's necessary.

Electronic devices see tough conditions – from automotive to aerospace to consumer and industrial environments – making silicone's unique attributes ideal.

As these applications become more powerful, functional, and complex, their reliable performance and longevity also largely depend on their ability to dissipate heat.

Because of its thermal stability, silicone is particularly well-suited for thermal interface materials, also known as TIMs. Not only does the chemistry address environmental and functional temperature extremes, it also provides excellent thermal conductivity to move heat away from components to prevent temperature-induced failures. But that's not all. Silicone also has good electrical, insulating, and flame retardancy properties, which are critical for many situations.

For high-power and high-temperature applications where excellent heat dissipation is absolutely essential, silicone-based TIMs provide superior thermal stability, minimal exothermic heat rise during cure, and good coefficient of thermal expansion (CTE).

Given these realities, why wouldn't silicone be the first choice for TIMs for most applications?

Why not silicone when at all possible for TIMs?

Most chemical engineers and TIM formulators would probably recommend silicone use whenever feasible. Its unique capabilities put the chemistry in a class by itself.

There are, however, exceptions and manufacturing environments where silicone use may be considered problematic. The primary concern with silicone is related to silicone outgassing, or the release of silicone volatiles. When this happens, outgassing presents in three different failure modes:

ELECTRICAL

This can occur in applications with moving parts (i.e., hard disk drives, electric motors, gears, etc.).

Silica dust generated from silicone outgassing has the potential to interfere with the movement of small parts and prevent operation.

FOGGING

Outgassing may result in a foggy appearance on optical lenses.

For applications that integrate optics or optical sensors, this can inhibit proper function of the device.

ADHESION

Silicone volatiles that find their way to various surfaces can – because of silicone's excellent chemical resistance – prevent adhesion.

Silicone contamination can impact paints or other coatings, limiting the ability to adhere to part surfaces properly.

These concerns underscore the importance of considering the final application for the end product when selecting a TIM. For example, suppose an automated robot that integrates TIM materials may be destined for an automotive body parts factory. In that case, the robot manufacturer may want to use a low-volatile or silicone-free TIM material.

It is important to note, however, that all polymers – silicone or not will have some amount of outgassing. Minimizing that risk for certain applications is the goal.

Alternative approaches

With many years of formulation expertise, Henkel scientists have successfully developed TIMs that mitigate silicone outgassing or migration issues. Engineering TIMs with low volatiles content can normally resolve any of these concerns, though silicone-free products are also part of the Henkel portfolio for manufacturers that have that requirement.

While there is no 'drop-in' replacement for silicone, robust alternative chemistries have been leveraged for the development of silicone-free GAP PAD materials, liquid gap fillers, and phase change material (PCM) TIMs, as well as circuit board protection materials including potting materials, gasketing materials, and some encapsulants.

Most of Henkel's silicone-free TIMs are polyurethane-based and, while they may provide similar thermal conductivity, other properties can vary significantly from silicone so an application-specific assessment should be conducted.

While it's true that silicone generally has the most desirable characteristics, there are numerous alternatives available that can meet demanding application requirements.

LEARN MORE

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

DID YOU KNOW?

Higher filler loading in TIMs reduces the amount of silicone present and lowers the propensity for migration. High filler loading generally correlates with high thermal conductivity, so two objectives can be achieved.

Liquid silicone migration can be observed as an oil that leaks out of the material. While this is not ideal cosmetically, it generally does not affect the material's performance or cause any contamination.

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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 materials 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.

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