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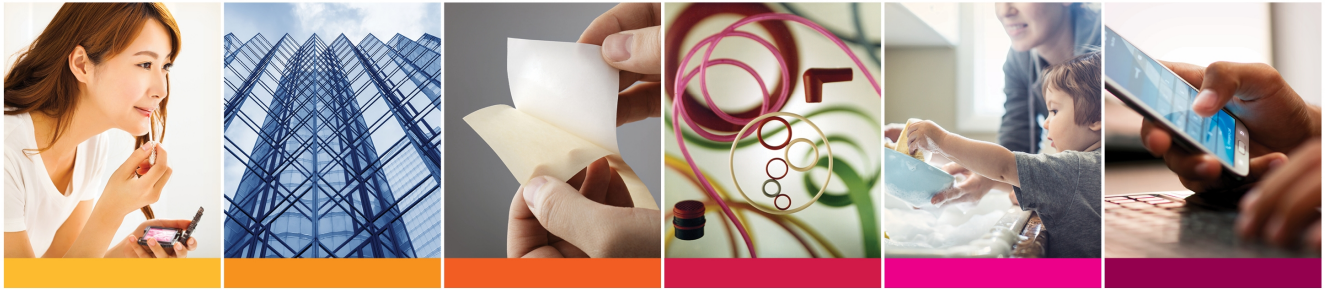

Silicone Thermally Conductive Grease: Improving Thermal Management of Electronic Assemblies

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Agenda

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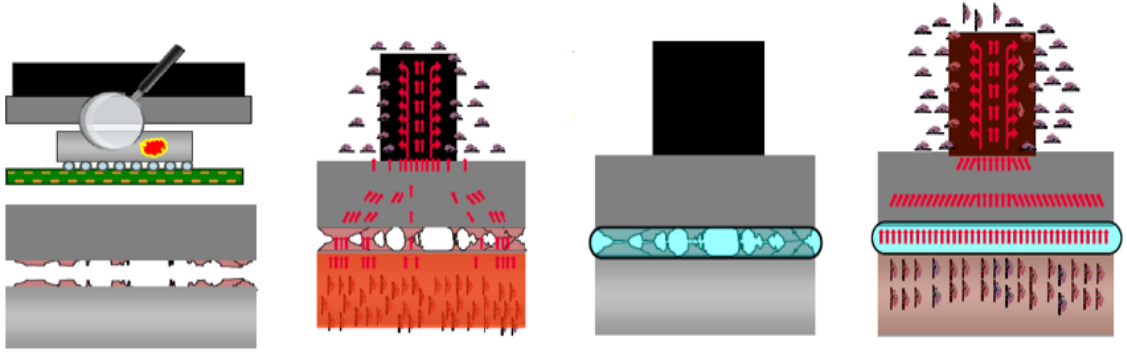
- Pete Vert, AAS TS&D Manager
- Bianxiao Zhong, Research Scientist
- Greg Becker, AAS TS&D Specialist

Introduction

- Market trend: Smaller, more efficient, more powerful, run faster
- ICs and other sophisticated electronic components typically operate efficiently only under a certain range of temperatures
- Operational temperatures must be kept within a suitable range
- Excessive heat can damage performance and can even cause system failure

Thermal Interface Materials

Thermal Interface Materials (TIMs) play a key role in the thermal management of electronic systems by providing a path of low thermal resistance between the heat generating devices and the heat spreader/sink.



Rough surfaces | **Conduction through point contacts** | **Filling air gaps** | **Uniform conduction of heat**

Typical TIM Solutions

- Adhesives
  - **Greases**
- Gels
- Phase Change
- Pads
- Solder Alloys

- Easy to Dispense
- Easy to Re-work
- No Curing
- High Thermal Conductivity
- Typically Low Cost

Thermally Conductive Greases

- Organic
- Inorganic ➡ **Silicone**

} **Oil**

- Iron Oxide and Silicon Dioxide (quartz sand) – lower-end applications
- Aluminum and Zinc Oxide – low to medium applications
- Boron Nitride, Silver and Diamond – high-end applications

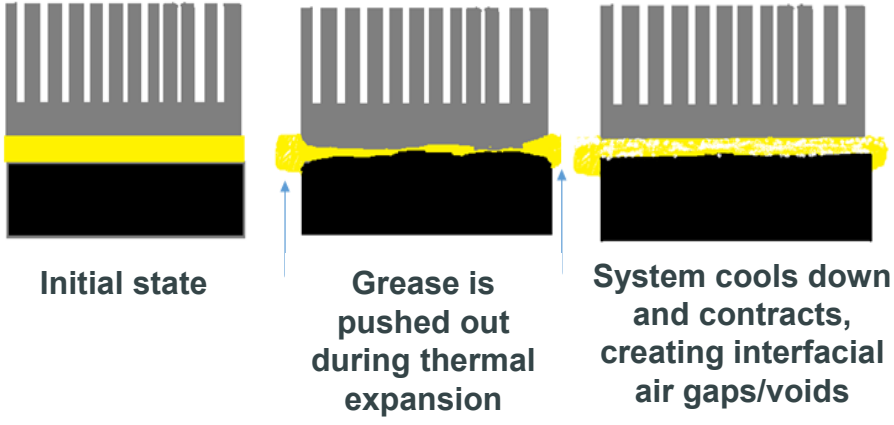
} **Filler**

Silicone

- High temperature stability: -40 to 200ºC
- Low surface energy – wet out many surfaces
- Good dielectric properties – maintains electrical insulation
- Low ionic content and high purity
- Non-corrosive, inert, non-hazardous

Main Problems With Thermally Conductive Grease

- **Dry-out**
  At high temperatures, the drop of viscosity of the silicone oil may promote the separation of the filler from the polymer matrix. The polymer (silicone) tends to flow out of the interface.
- **Pumping Out**
  Applications that cycle on and off cause a relative motion due to changes in temperature and mismatched coefficient of thermal expansion of the substrates. If this movement becomes too great, the grease (which has very little cohesion) will pull apart, allowing air to get in creating voids.



Experimental Work

- Performance of a formulation of silicone thermally conductive grease is studied when exposed to conditions such as: high temperature aging, thermal cycling, damp heat, and power cycling.
- The performance of the greases is recorded as a function of thermal insulation resistance.
- The thermal resistance of the greases was measured using a three-layer “sandwich” sample comprised of a silicon-grease-silicon stack.

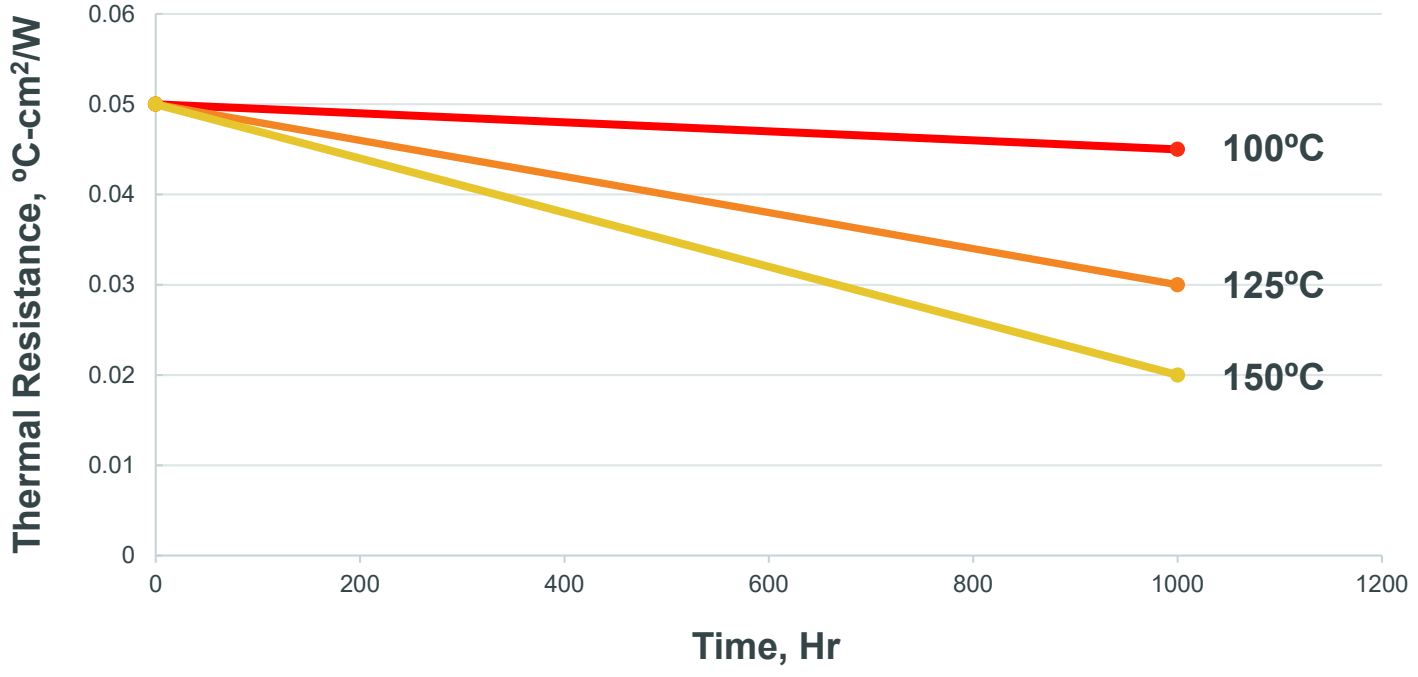
Test Conditions

A sample of the silicone thermally conductive grease was placed between two silicon discs and pressed at 40 PSI to reach the minimum bond line thickness; aged under the specified conditions and tested for thermal resistance following guidelines of ASTM D5470.

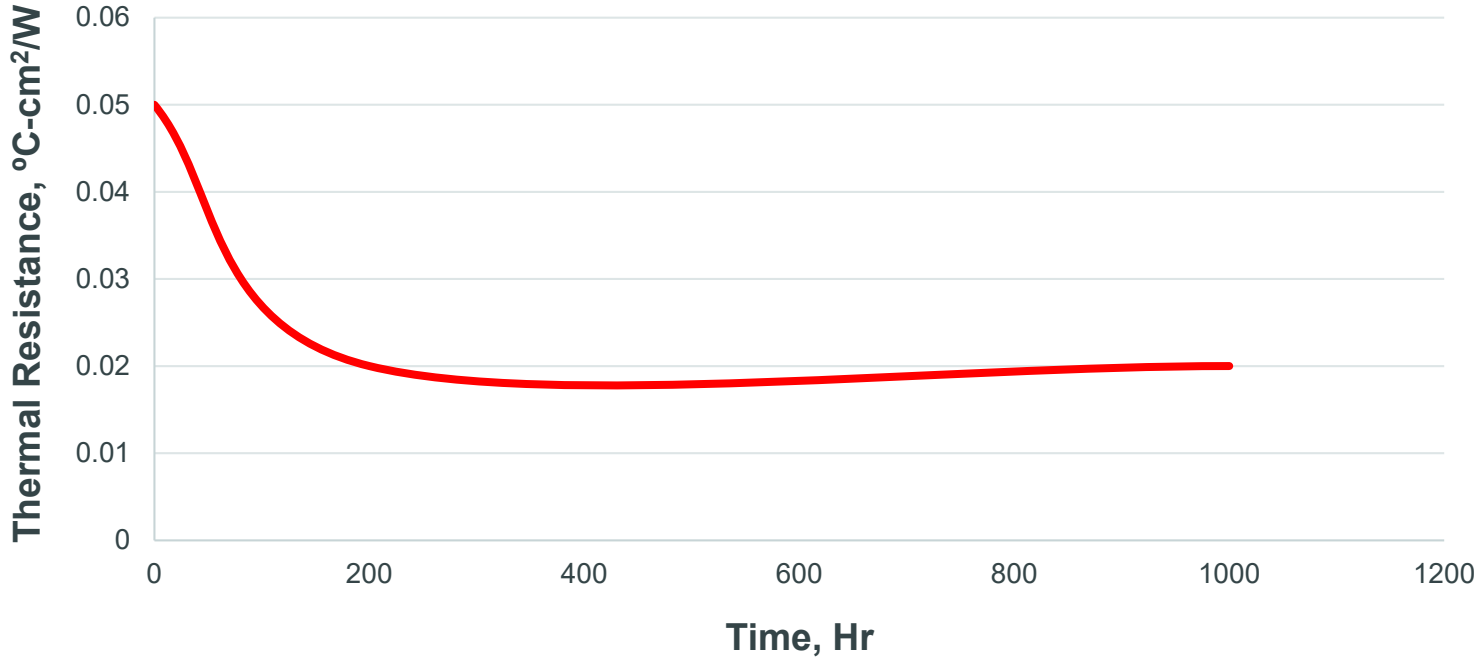
Characterization of Silicone Thermally Conductive Grease

Property	Value
Specific Gravity	3.5
Thermal Conductivity	2.9 W/m^{o}K
Bond Line Thickness at 40 PSI	0.007 mm
Thermal Resistance at 40 PSI	0.05^{o}C-cm^{2}/W

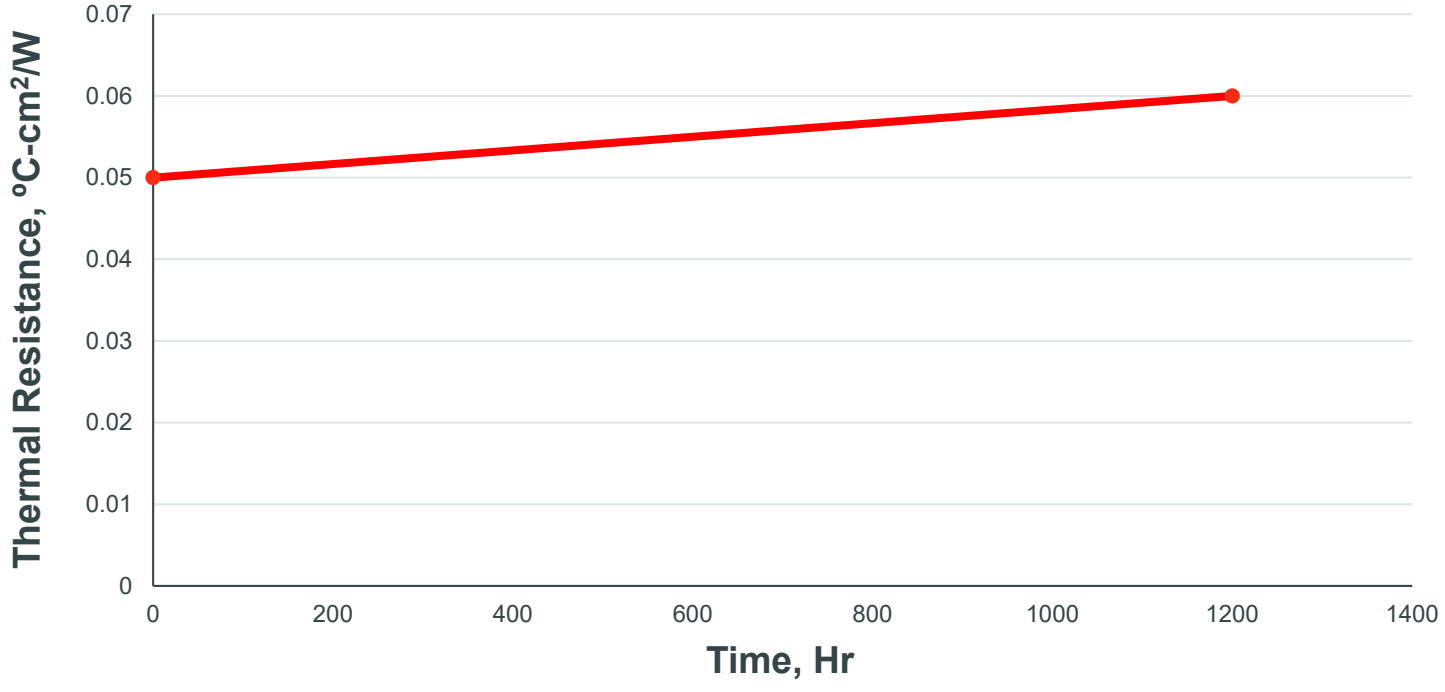
High Temperature Aging



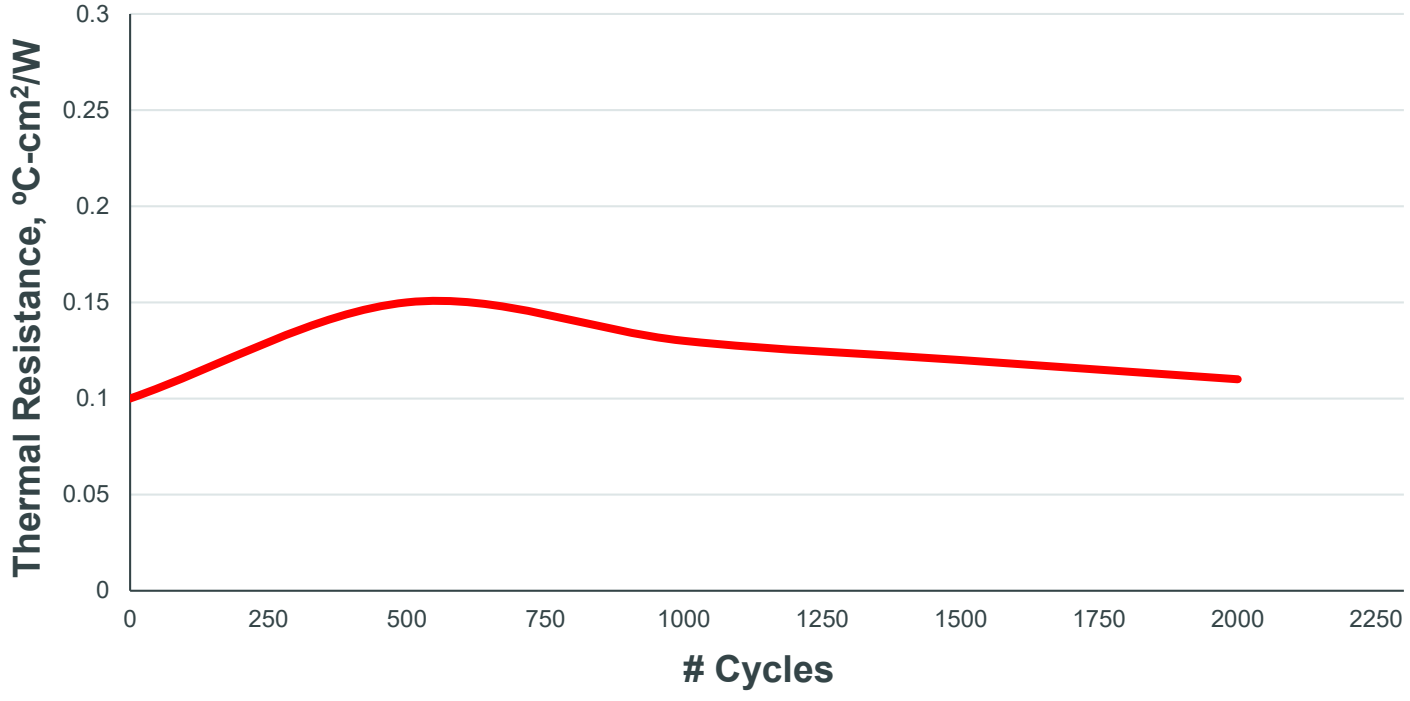
Thermal Cycling (-40 to +150ºC)



Damp Heat HAST (85% RH/85ºC)



Power Cycling TTV



Power was turned on and off periodically. Each “on” time was eight minutes, and each “off” time was 2 minutes. The case temperature reached about 90°C when power was on.

Conclusions

- Thermal Interface Materials (TIMs) play a key role in the thermal management of electronic systems by providing a path of low thermal resistance between the heat generating devices and the heat spreader/sink.
- Typical TIM solutions include adhesives, greases, gels, phase change materials, pads, and solder alloys.
- Thermal greases typically offer better thermal performance and reduced manufacturing cycle times.

Conclusions (cont.)

- Characterizing the reliability of silicone thermally conductive greases is complicated and requires different test methods as compared to other TIM options, such as adhesives, pads or gap fillers.
- Although the three-layered structures used to monitor the thermal performance with reliability testing and those used to monitor visual degradation do not simulate the full range of stress conditions that are seen in a microprocessor package, they provide a means to evaluate thermal greases for dry-out, voiding, and in-plane grease movement during the initial stages of a grease selection process.

Thank You

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