Silicone Grease Solutions For Your Thermal Interface Needs

Dow Corning

Electronics and Advanced Technologies

MEETING THE CHALLENGES

Across Applications and Industries

DOW CORNING

Electronics
Solutions

Contents

- Why Use A Silicone Grease?
- Why Choose Dow Corning?
- Thermal Interface Material (TIM) Application
- Product Overview
- Testing Methodology
- Product Processing
- Frequently Asked Questions

Why Use A Silicone Grease?

Lower contact resistance

- Flowable matrix fills micro gaps and reduces contact resistance better than pads, films and phase change materials. This results in lower thermal resistance

Extremely thin bond lines

- Very thin bond lines, ~ 8 microns, can be achieved, which also lowers thermal resistance

Application versatility

- There are many ways to apply grease making it great for the factory or field-work
- Easy re-workability

Lower cost

- Greases lack the extra manufacturing steps of pads, preforms, etc. giving them lower cost structure

High Reliability

- Silicones withstand heat & stresses better than organic greases

Why Choose Dow Corning?

Leader in silicone formulation & technology

- 60 years ago Dow Corning pioneered the use of silicones and today remains a global leader in silicone technology and manufacturing

Prevent "pump out" during thermal cycles

- Dow Corning's next generation greases with advances silicone fluids reduce "pump-out". Once you apply the grease it stays in place. In most cases, it doesn't run from the substrate during power cycling

Thermal Compound Innovation

- Continual advancements in thermal grease formulation such as DOW CORNING® TC-5026 solvent-free high performance grease launched in 2007 and new DOW CORNING® TC-5600 extreme performance grease.

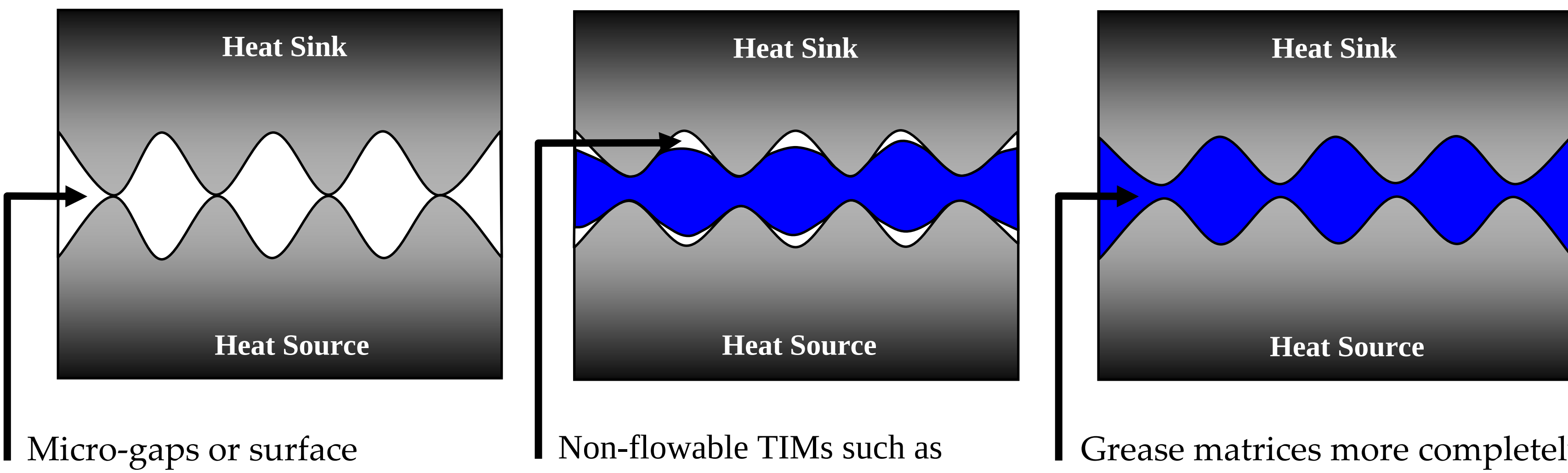
One stop shop & service

- Choose from a broad line of thermally conductive compounds, adhesives, gels and encapsulants complimented by an array of device packaging adhesives and coatings all backed by global applications support

Void Fill Advantage Of Grease

No surface is perfectly smooth. These microscopic blemishes increase contact resistance and reduce heat flow between surfaces.

No Thermal Interface Material (TIM) | Thermal Pad | Dow Corning Silicone Grease



Micro-gaps or surface roughness prevent effective heat transfer potentially leading to device failure.

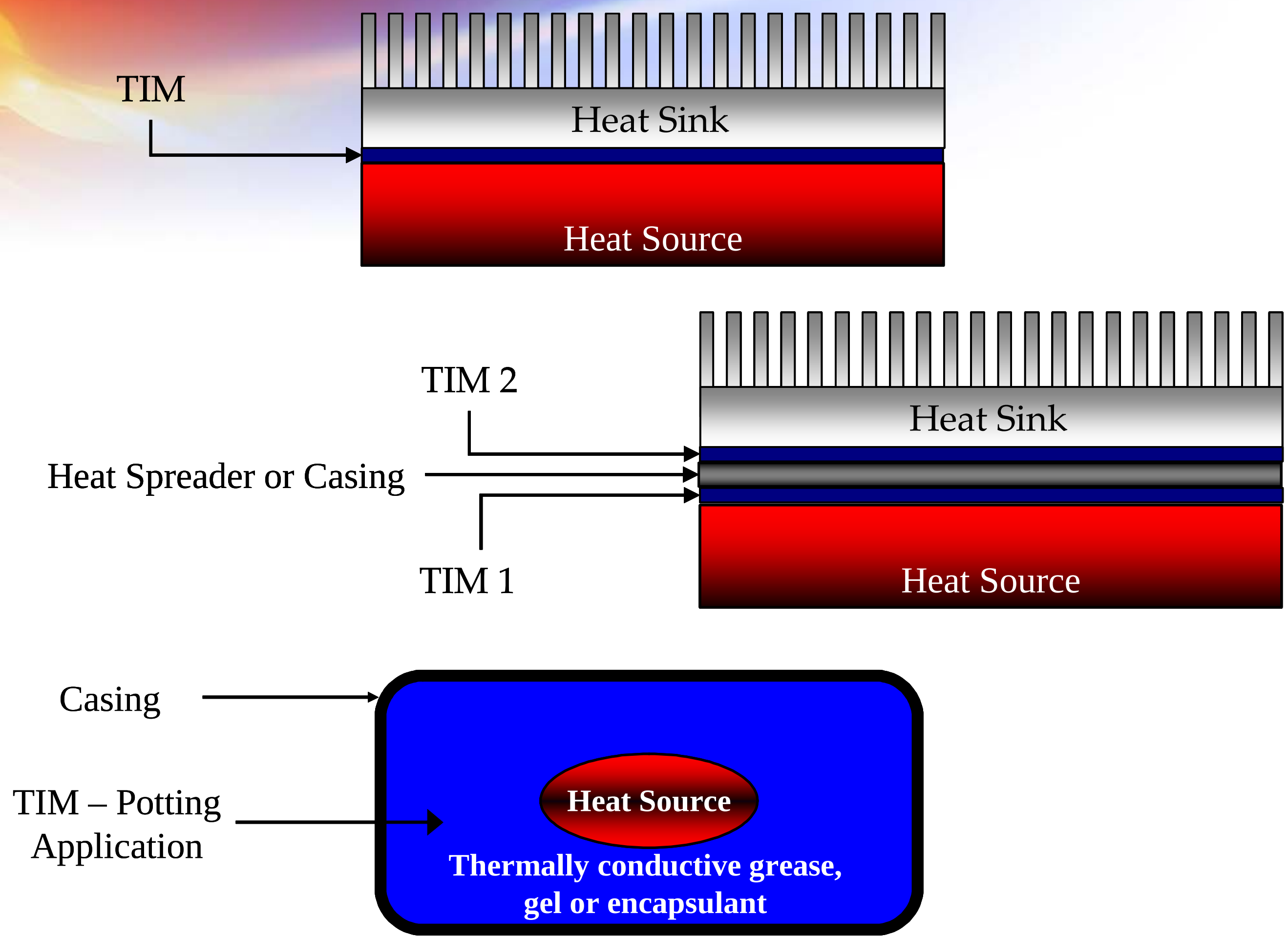
Non-flowable TIMs such as thermal pads may leave voids that inhibit heat transfer

Grease matrices more completely fill micro-gaps to ensure heat flow away from vital parts.

Greases enable thinner bond lines, further reducing thermal resistance.

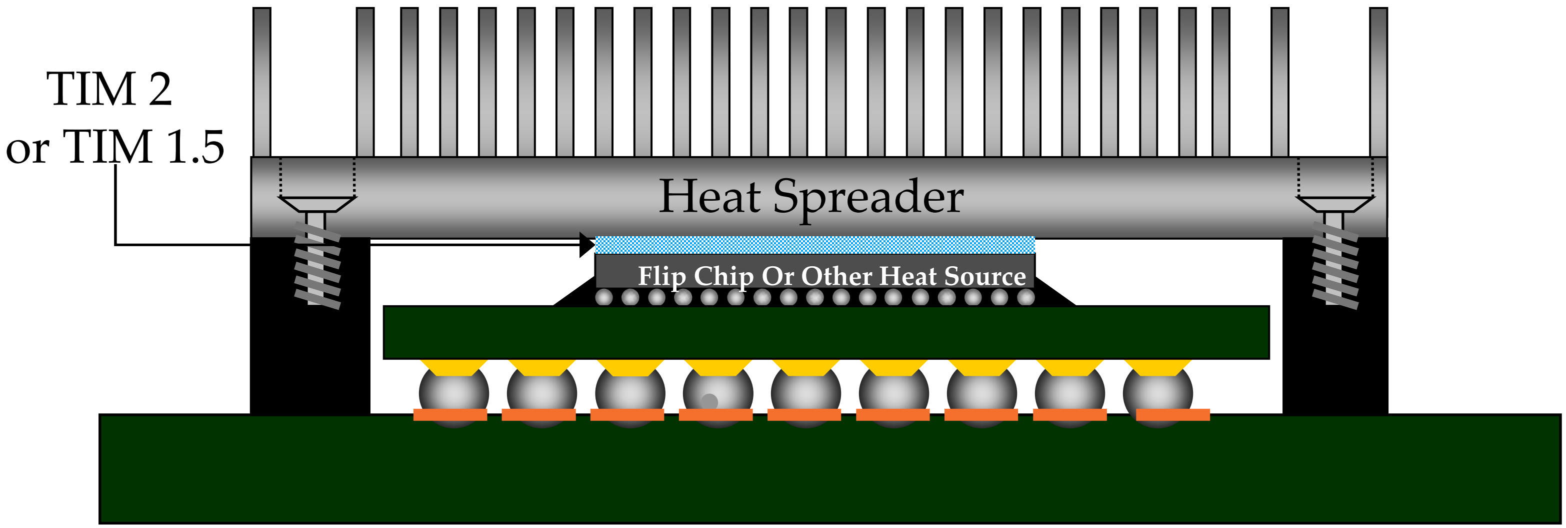
TIM Applications

Use Dow Corning TIMs at any junction between a heat source and cooling source to overcome contact resistance and improve heat dissipation away from vital components



Example Of Possible Thermal Grease Application

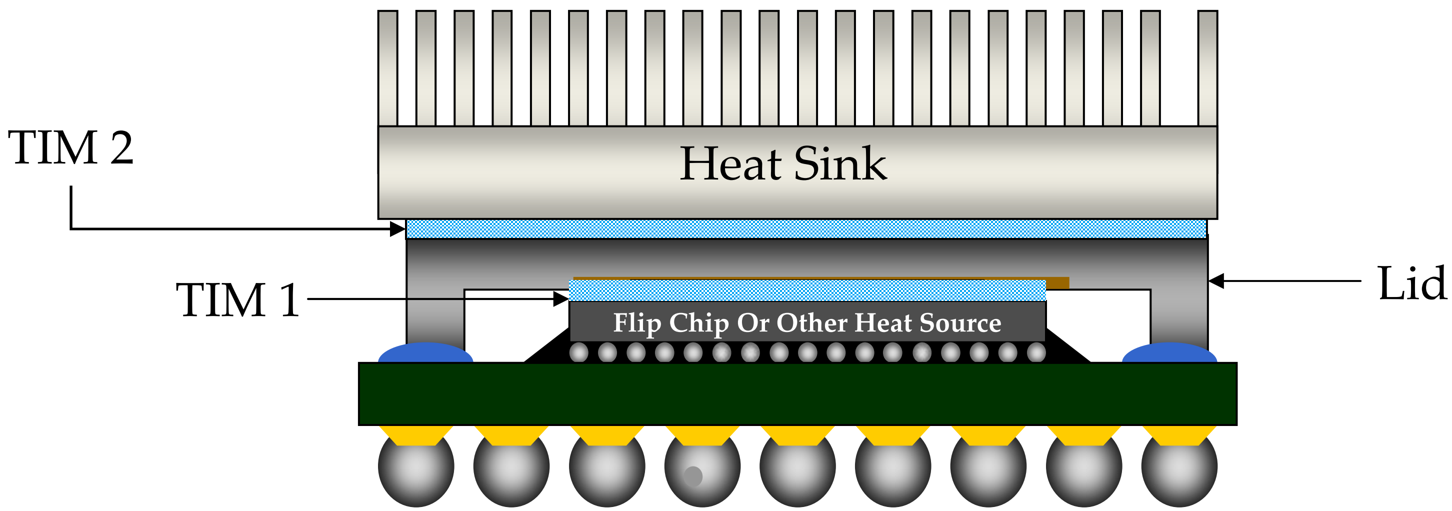
Flip Chip BGA Heat Spreader Attach TIM 1.5 or 2
Heat Source – TIM - Heat Sink Direct



Flip Chip BGA

Example Of Possible Thermal Grease Application

Flip Chip BGA Application TIM 1, TIM 2
Multi Layer: Heat Source – TIM1 - Intermediate (Lid) - TIM2 - To Heat Sink



Flip Chip BGA

Key Attributes – TIM 1, 1.5, 2

1. Thermal Resistance
2. Bond Line Thickness
3. Cost
4. Processing/Printability
5. Re-workability

Prioritization is Application Driven

Critical TIM Properties

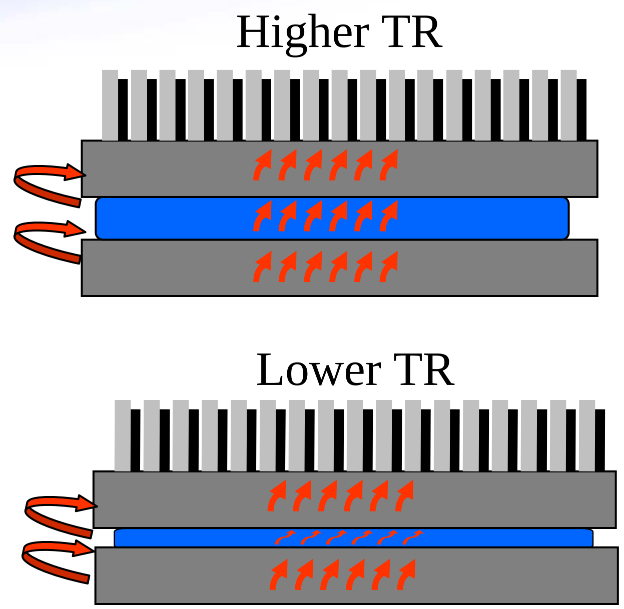
Effective thermal resistance of a device, R_{TIM}.

$$R_{TIM} = \frac{BLT}{k_{TIM}} + R_{c1} + R_{c2}$$

- **BLT** = Bond Line Thickness
- k_{TIM} = Thermal Conductivity
- R_c = Contact Resistance between the TIM and the two surfaces.

Key Goal→ Minimize R_{TIM}

- Increase TIM thermal conductivity (k_{TIM}).
- Reduce Bond Line Thickness (BLT).
- Reduce contact resistances (R_c) .



Bulk conductivity and contact resistance being equal, a thinner bond line will result in lower thermal resistance.

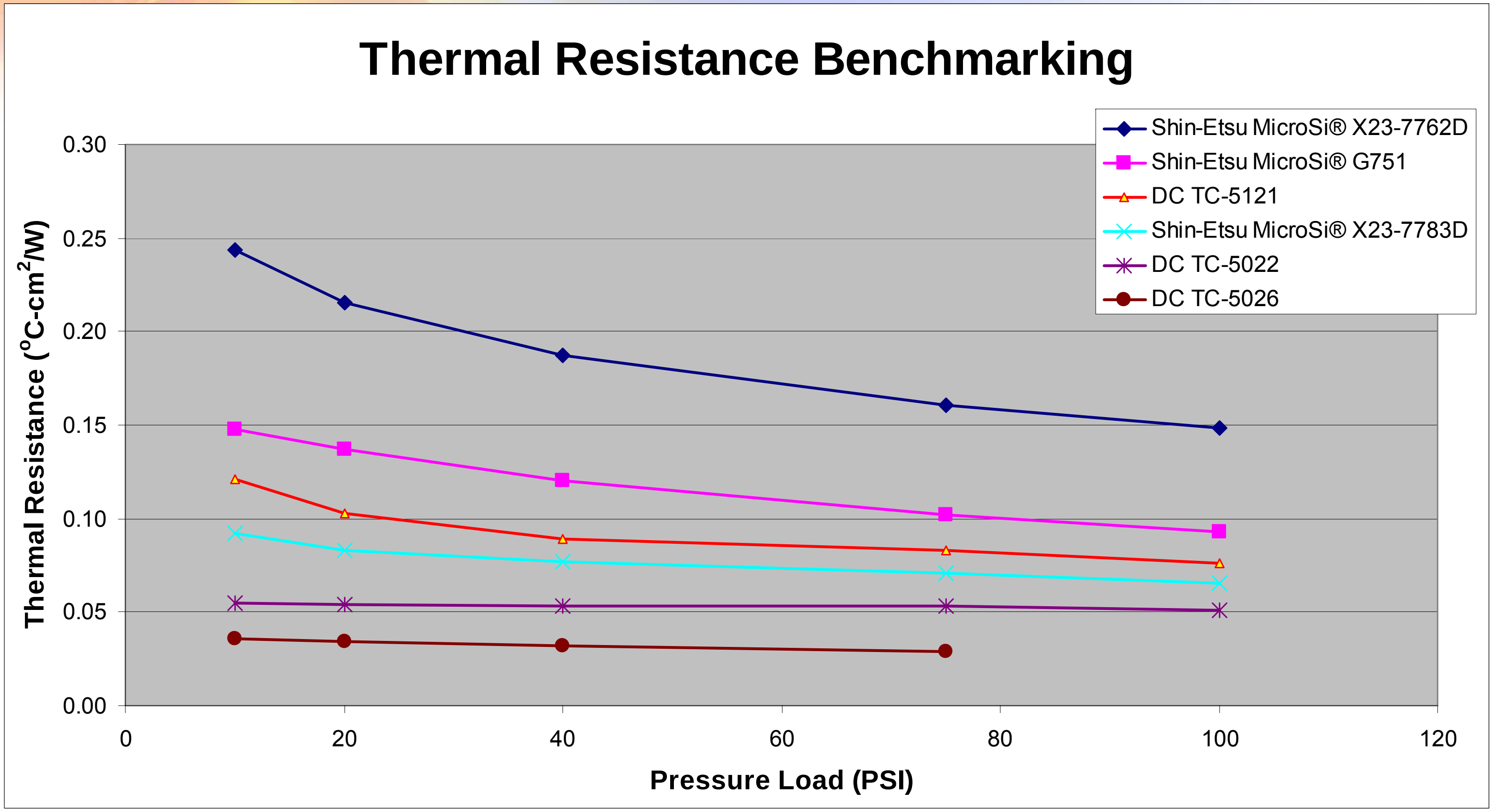
Dow Corning
Thermally Conductive Grease Line Up

Performance

Product	Thermal Conductivity (W/m-K)	Thermal Resistance (C-cm2/W)
DOW CORNING® TC-5026	2.89	0.032
DOW CORNING® TC-5022	4.0	0.061
DOW CORNING® TC-5121	2.5	0.096
DOW CORNING® SE4490CV	1.7	0.32
DOW CORNING® SC 102 Compound	0.8	0.62
DOW CORNING® 340 Heat Sink Compound	0.54	0.162

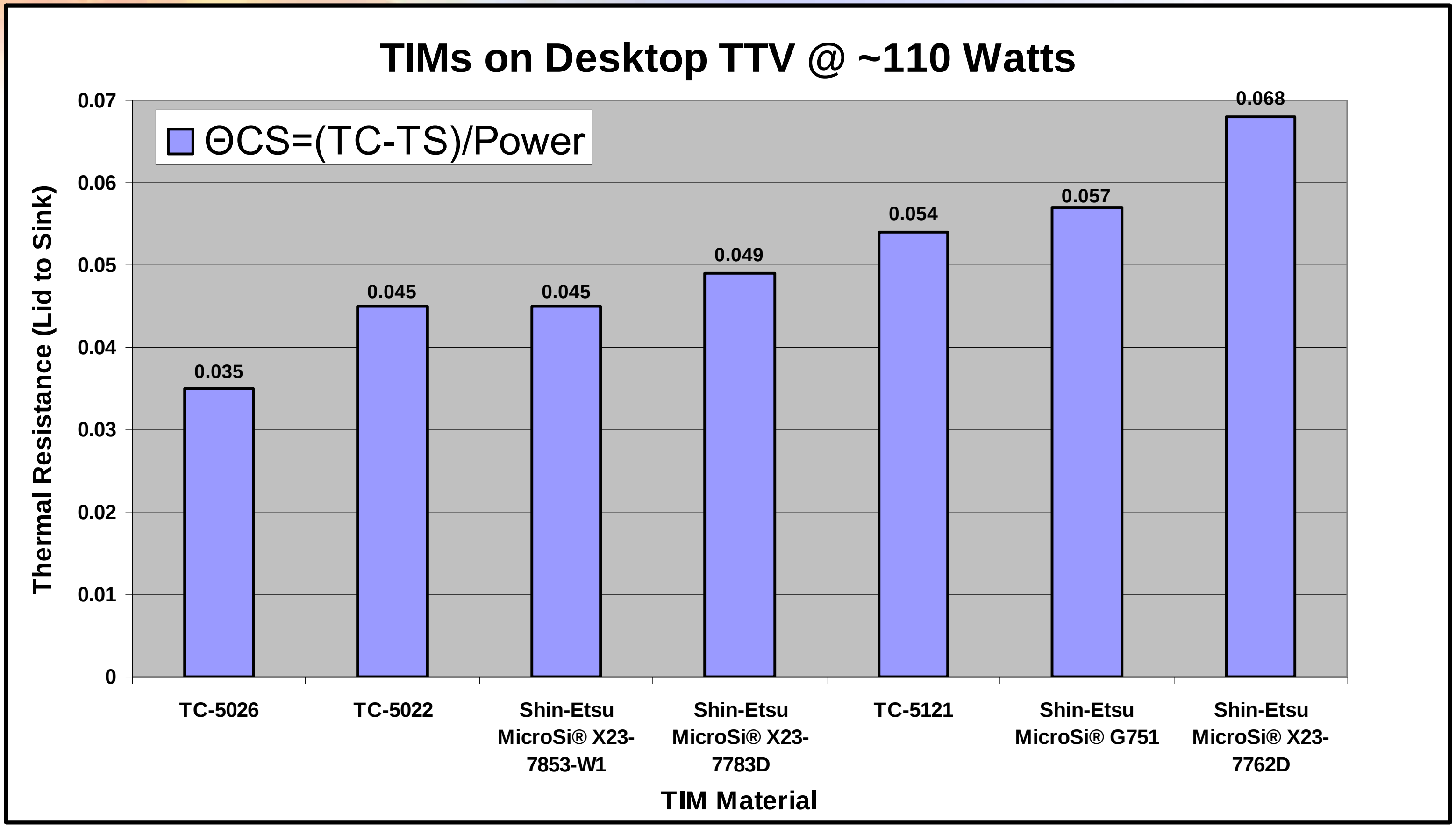
Thermal Resistance Comparison

This graph shows the thermal resistance of various DCC greases benchmarked against competitor greases at various pressure loads. It demonstrates that DCC greases are able to reach minimum bond line and optimal performance even under low pressure Test method is (ASTM # D5470).



Desktop TTV Tester

This graph shows the thermal resistance of various DCC greases on a tester that is intended to replicate a desktop computer. Takes into account lower co-planarity encountered in real systems. The units of measure represented here are different than the guarded hotplate on the previous slide. These units are °C/w instead of °C-cm2/w.



340 Heat Sink Compound

Description	Non-curing, thermally conductive compound
Features	Good performance and economical
Potential Uses	Thermal interface or encapsulant in a wide array of industrial applications.
Application Methods	Screen print, stencil print, dispense .

Form: Non-curing compound	**Color:** White	**Mix Ratio:** One Part
Thermal Conductivity (W/m-K): 0.54	**Thermal Resistance:** 0.162	**Bond Line Thickness (microns):** 100
Viscosity /Flowability, average centipoise : 542,000	**NVC % (120C):** 70.4	**Volatile Content (120C)%:** 29.58
Dielectric Constant at 1 kHz: 5	**Dielectric Dissipation factor at 1 kHz:** 0.02	**Volume Resitivity, ohm-cm:** 2.0×10^{15}
Dielectric Strength (volts/mil): 210	**Specific Gravity:** 2.14	

340 Heat Sink Compound

Part of our product line since 1968, 340 compound is a proven and economical thermally conductive solution for low power applications. This grease can be used in a wide array of industrial applications including power components/power supply for Audio; Video (DVDs, TV Sets, etc.); broadcasting equipment; car-audio, frequency drivers (or frequency inverters) on automation equipment and some minor applications on temperature sensor for auto.

Additional Information

Can be used as a thin interface or encapsulant. For interface, apply grease with a squeegee through a stencil or screen to print a grease pad or spread out bulk material with a spatula.

Dow Corning SC 102

Description	Non-curing, thermally conductive compound
Features	Low cost and good performance. Thin bond lines
Potential Uses	Thermal interface or encapsulation applications
Application Methods	Screen print, stencil print, dispense .

Form: Non-curing compound	**Color:** White	**Mix Ratio:** One Part
Thermal Conductivity (W/m-K): 0.8	**Thermal Resistance:** 0.62	**Bond Line Thickness (microns):** 50
Viscosity /Flowability, average centipoise : <100,000	**NVC % (120C):** 99.68	**Volatile Content (120C)%:** **0**.32
Dielectric Constant at 50 Hz: 4.0	**Dielectric Dissipation factor at 50 Hz:** 0.02	**Volume Resistivity, ohm-cm:** 2×10^{16}
Dielectric Strength (volts/mil): 53	**Specific Gravity:** 2.37	**Shelf Life, Months from DOM:** 24

Dow Corning SC 102

Good performance at low cost. Use for a thermal dissipation in a wide array of industrial applications such as power supplies. Use in similar applications as 340 Heat Sink, but where a higher thermal conductivity is required. SC102 also has the ability to spread to very thin bond lines. Therefore, if the co-planarity of the substrate allows, much lower thermal resistance values than those listed above can be achieved.

Additional Information

Dispense with syringe or apply grease with a squeegee through a stencil or screen to print a grease pad or spread out bulk material with a spatula.

Dow Corning SE 4490CV

Description	Non-curing, thermally conductive compound
Features	Controlled volatility grade
Potential Uses	Thermal interface material for a variety of low to mid-range applications
Application Methods	Screen print, stencil print, dispense .

Form: Pre-cured compound	**Color:** White	**Mix Ratio:** One Part
Thermal Conductivity (W/m-K): 1.7	**Thermal Resistance:** .32	**Bond Line Thickness (microns):** 100
Viscosity /Flowability, average centipoise: 500,000	**NVC % (120C):** 99.96	**Volatile Content (120C)%:** 0.04
Dielectric Constant at 50 Hz: 4.8	**Dielectric Dissipation factor at 50 Hz:** 0.001	**Volume Resistivity, ohm-cm:** 2×10^{14}
Dielectric Strength (volts/mil): 102	**Specific Gravity:** 2.62	**Shelf Life, Months from DOM:** 11

Dow Corning SE 4490CV

Controlled volatility and good thermal performance at an economical price point for mid-range applications. This compound uses a a pre-cured matrix to prevent bleeding (separation of liquids from thermally conductive fillers) and to prevent contamination from high volatile silicones. Excellent for applications in proximity to electric motors and relays where migration of high volatility molecules are of concern

Additional Information

Dispense with syringe or apply grease with a squeegee through a stencil or screen to print a grease pad or spread out bulk material with a spatula.

Dow Corning TC-5121

Description	Non-curing, thermally conductive compound
Features	Good thermal performance at an economic price. Thin bond lines.
Potential Uses	Thermal interface material for a variety of mid to high end devices.
Application Methods	Screen print, stencil print, dispense .

Form: Non-curing compound	**Color:** Gray	**Mix Ratio:** One Part
Thermal Conductivity (W/m-K): 2.5	**Thermal Resistance:** 0.096	**Bond Line Thickness (microns):** 25
Viscosity /Flowability, average centipoise : 85,013	**NVC % (120C):** 99.93	**Volatile Content (120C)%:** <0.1
Dielectric Constant at 1 kHz: 19.61	**Dielectric Dissipation factor at 1 kHz:** 0.04	**Volume Resistivity, ohm-cm:** 1.22×10^{12}
Dielectric Strength (volts/mil): 71.67	**Specific Gravity:** 4.06	**Shelf Life, Months from DOM:** 24

Dow Corning TC-5121

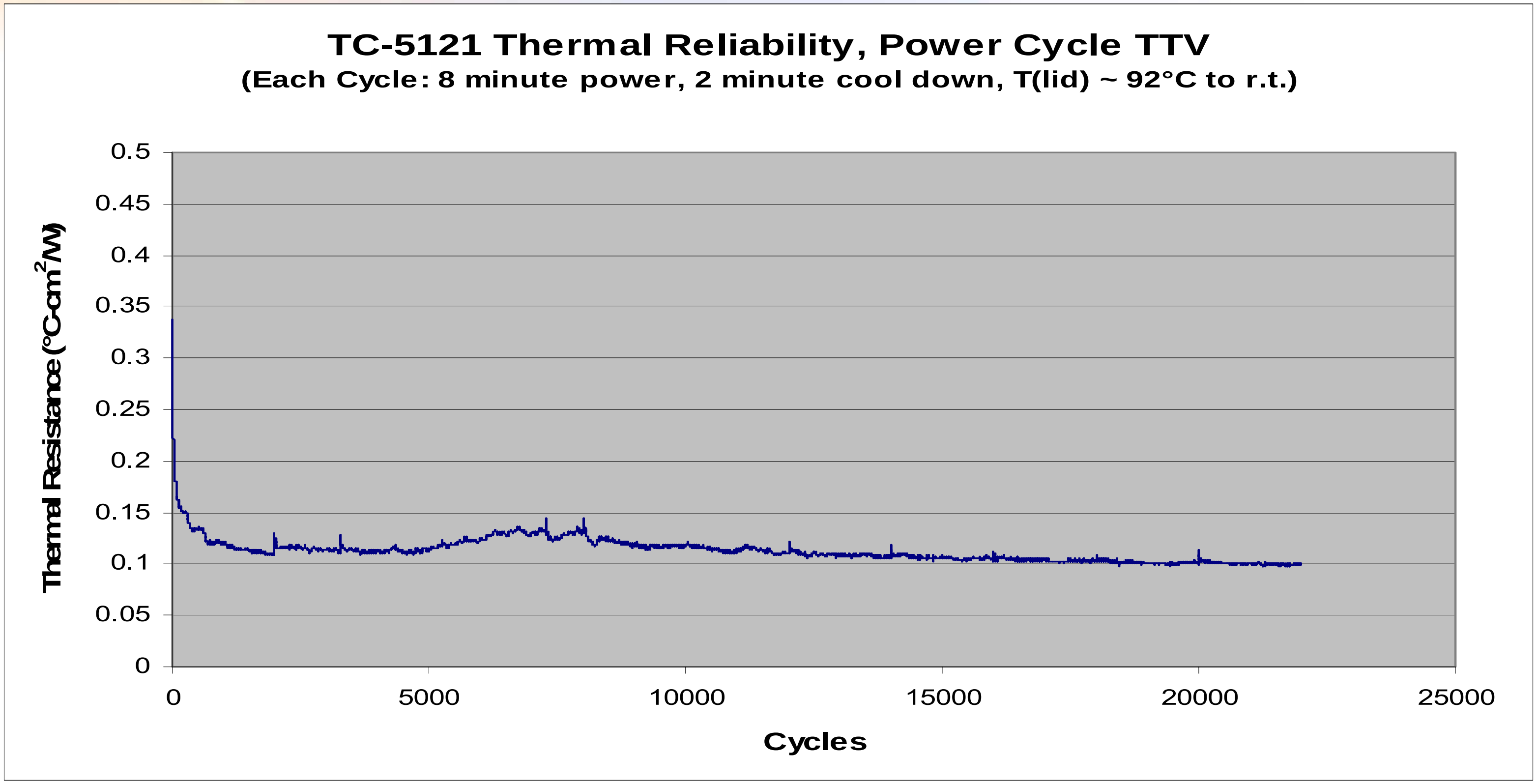
Is an excellent economical thermally conductive solution for mid-range applications. Also uses advanced silicone fluid to help prevent pump out. Because of the small filler particle size in this grease, it has been observed to reach even better thermal performance in applications where high pressure clamping forces a thin bond line. See reliability data on following slide.

Additional Information

Dispense with syringe or apply grease with a squeegee through a stencil or screen to print a grease pad or spread out bulk material with a spatula. Allow the printed grease pad to dry open to the air for 24 hours before assembling and testing. The dry time allows the small amount of carrier fluid in the grease to evaporate and will improve thermal performance.

Power Cycle On TTV Tester

The results reported in this graph show that TC-5121 remains stable through 20,000 power cycles. This test is often used as a method of demonstrating pump-out. TC-5121 has very low end of life thermal resistance, indicating high reliability and stability. This graph is intended to illustrate reliability or change in TR, not baseline TR. Lower TR can be realized than shown in graph.



Dow Corning TC-5022

Description	Non-curing, thermally conductive compound
Features	Excellent thermal performance. Thin bond lines, pressure independent. Reduced pump out during thermal cycling.
Potential Uses	Thermal interface material for a variety of mid to high end devices.
Application Methods	Screen print, stencil print, dispense .

Form: Non-curing compound	**Color:** Gray	**Mix Ratio:** One Part
Thermal Conductivity (W/m-K): 4.0	**Thermal Resistance:** 0.061	**Bond Line Thickness (microns):** 20
Viscosity /Flowability, average centipoise : 89,160	**NVC % (120C):** 99.9	**Volatile Content (120C)%:** <0.05
Dielectric Constant at 1 kHz: 18.05	**Dielectric Dissipation factor at 1 kHz:** 0.128	**Volume Resistivity, ohm-cm:** 5.52×10^{10}
Dielectric Strength (volts/mil): 115	**Specific Gravity:** 3.2	**Shelf Life, Months from DOM:** 24

Dow Corning TC-5022

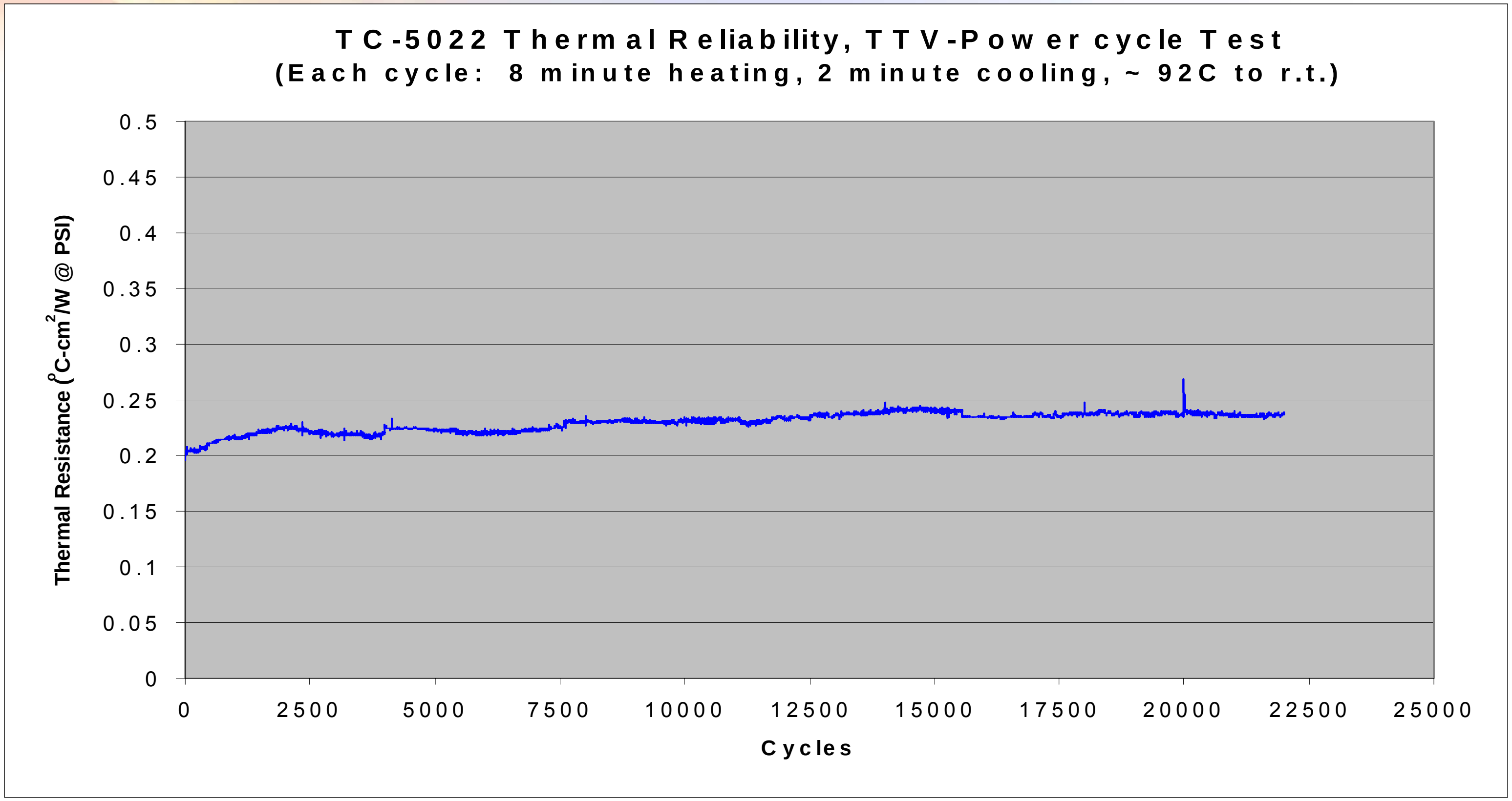
Is an excellent high quality thermally conductive solution for mid-range to advanced applications. Another in our line of next generation silicone greases that uses advanced silicone fluid to reduce pump out. Product spreads out to thin bond lines. For situations where you cannot obtain high surface planarity or where you need to have thicker bond lines use this grease in place of high performance TC-5026.

Additional Information

Dispense with syringe or apply grease with a squeegee through a stencil or screen to print a grease pad or spread out bulk material with a spatula. Allow the printed grease pad to dry open to the air for 24 hours before assembling and testing. The dry time allows the small amount of carrier fluid in the grease to evaporate and will improve thermal performance. ** **Please see following slides for reliability testing on this high performing grease.**

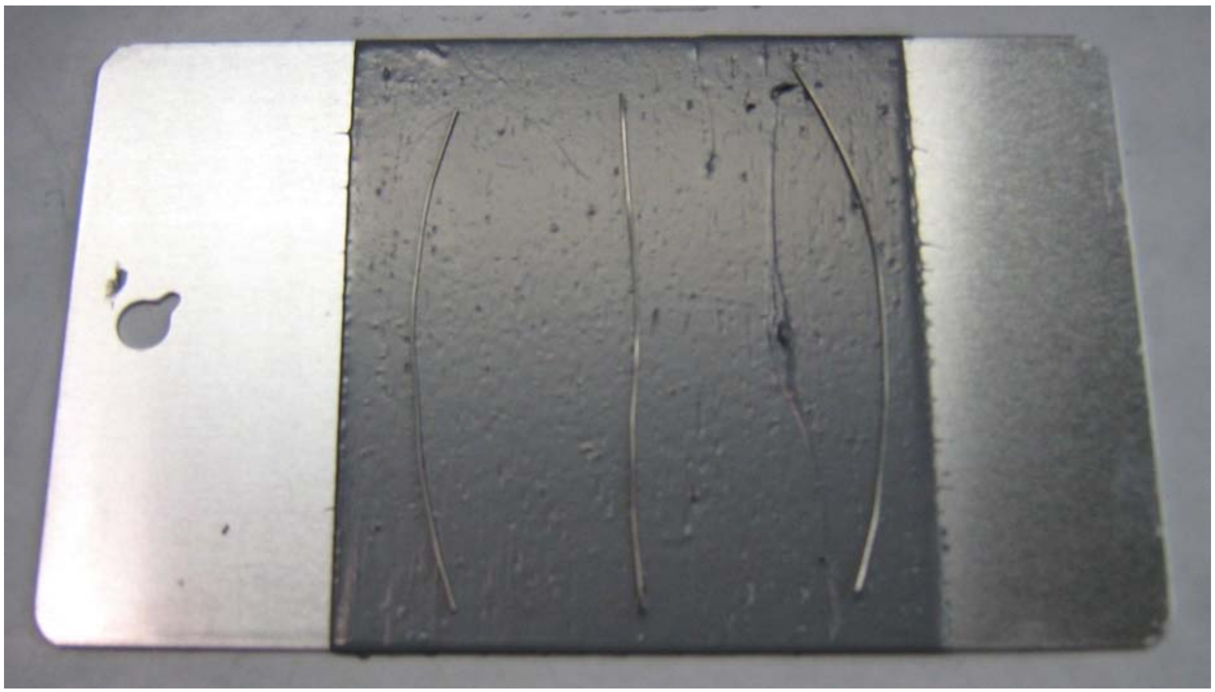
Power Cycle On TTV Tester

The results reported in this graph show that TC-5022 remains stable through 20,000 power cycles. This test is often used as a method of demonstrating pump-out. TC-5022 has very low end of life thermal resistance, indicating high reliability and stability. This graph is intended to illustrate reliability or change in TR, not baseline TR. Much lower TR can be realized than shown in graph.



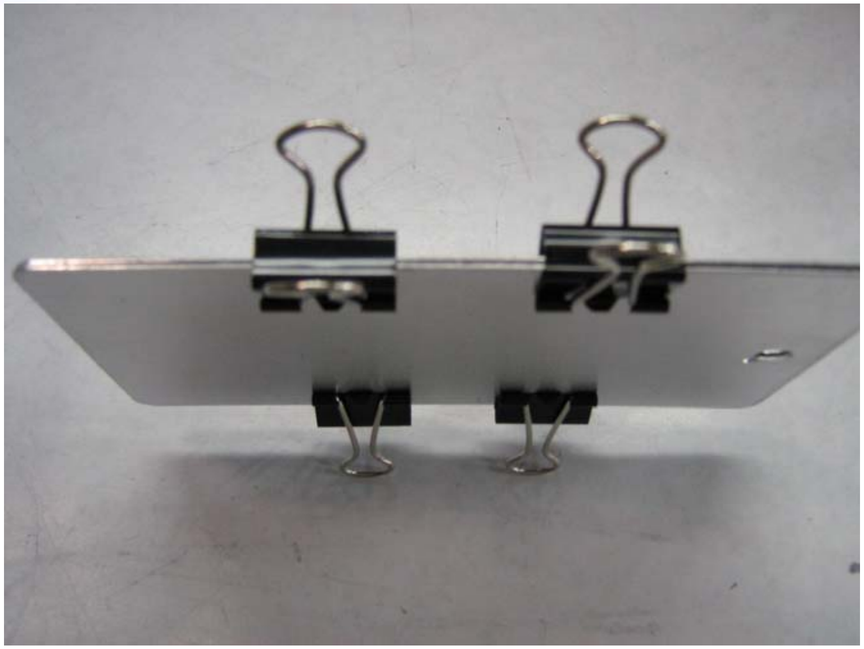
Vertical Slide – Thermal Shock Test

- Dow Corning® TC-5022 thermal grease used.
- Grease layer applied to aluminum test panels.
  - 20 mil wires used to control bond line



Vertical Slide – Thermal Shock Test

- “Sandwich” created and clamped together

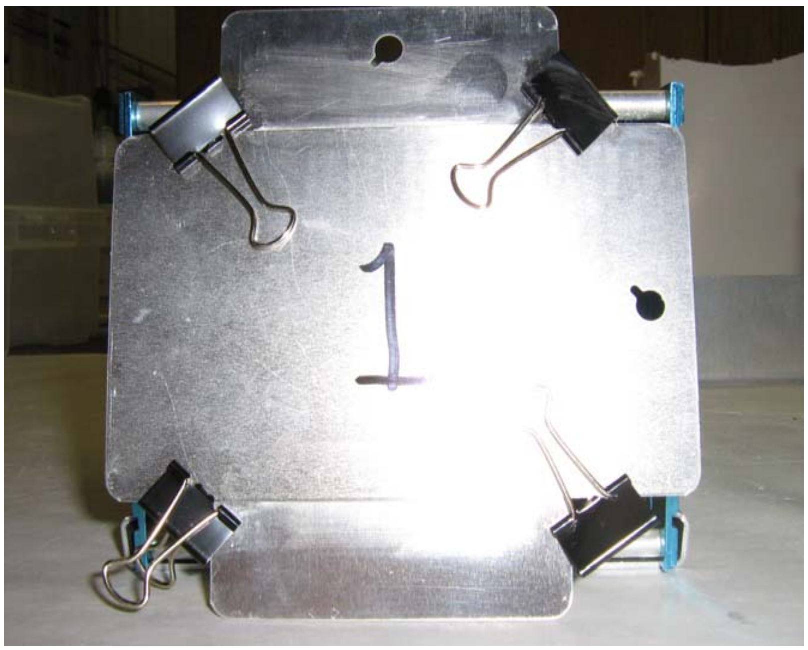


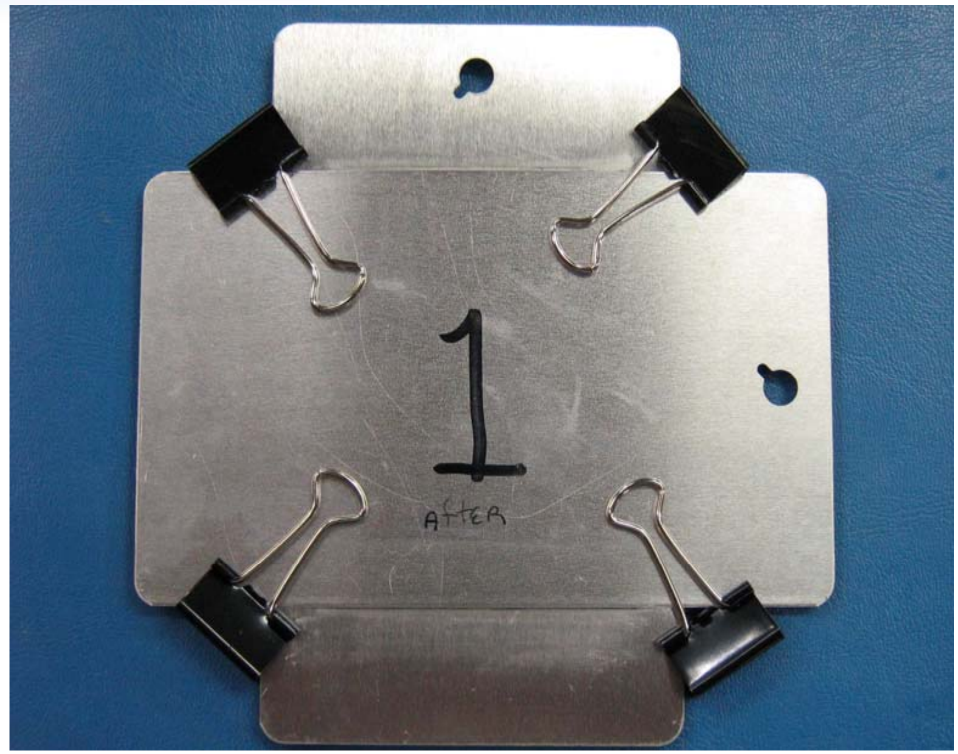
Vertical Slide – Thermal Shock Test

- Assemblies placed vertically in thermal shock chamber
- 400 cycles from 125 °C to 0 °C
  - 15 minutes at each temperature with 2 minute transition

Vertical Slide – Thermal Shock Test

- Before and after pictures taken of 6 sample assemblies.
- Test indicates no vertical slide, running, oozing or flow of material





Dow Corning TC-5026

Description	Non-curing, thermally conductive compound
Features	Premium performance. Ultra thin bond lines, pressure independent. Pump-out resistant. Solvent free for better stability and storage. Engineered for reliability.
Potential Uses	Thermal interface material for a variety of mid to high end devices.
Application Methods	Screen print, stencil print, dispense .

Form: Non-curing compound	**Color:** Gray	**Mix Ratio:** One Part
Thermal Conductivity (W/m-K): 2.89	**Thermal Resistance:** 0.032	**Bond Line Thickness (microns):** 7
Viscosity /Flowability, average centipoise at 1 rpm : 76,194	**NVC % (120C):** 99.92	**Volatile Content (120C)%:** <0.1
Dielectric Constant at 1 kHz: 10.0	**Dielectric Dissipation factor at 1 kHz:** 0.31	**Volume Resistivity, ohm-cm:** 2..0 x 10^{10}
Dielectric Strength (volts/mil): N/A	**Specific Gravity:** 3.5	**Shelf Life, Months from DOM:** 24

Dow Corning TC-5026

One of the best performing and most reliable thermal greases in the market. Validated by independent customer testing. This material contains a high concentration of advanced silicone fluid to reduce pump out during thermal cycling. It also features a small filler particle size that allows extremely thin bond lines for optimal thermal performance. TC-5026's solvent free solution ensures easy application even after storage. TC-5026 was engineered with reliability in mind.

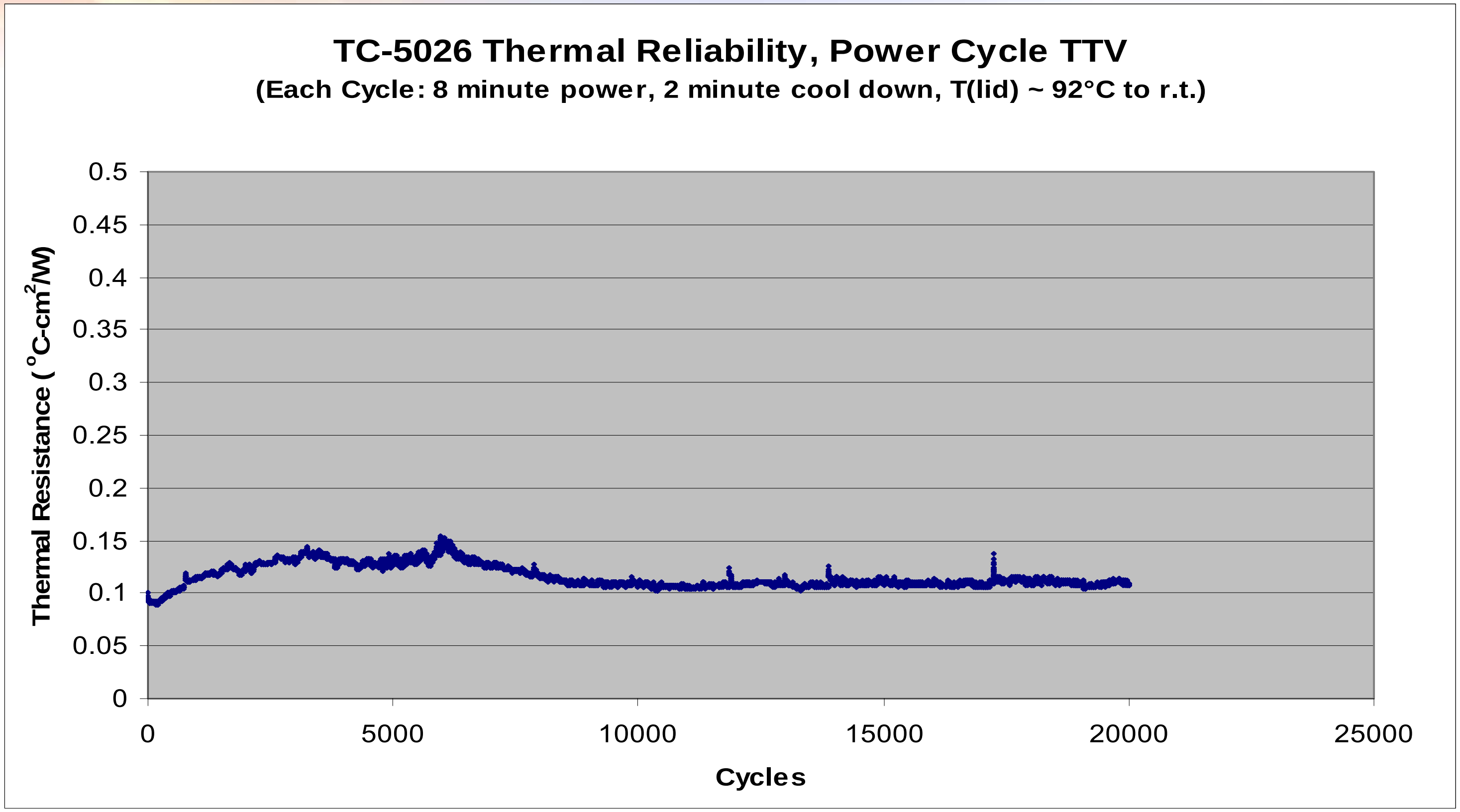
Additional Information

Apply grease with a squeegee through a stencil or screen to print a grease pad or spread out bulk material with a spatula. Solvent free composition does not require drying.

*** Please see additional test data in the following slides for our premier thermally conductive grease – TC-5026. ** For non-planar mating surfaces and thicker bond lines please see TC-5022.**

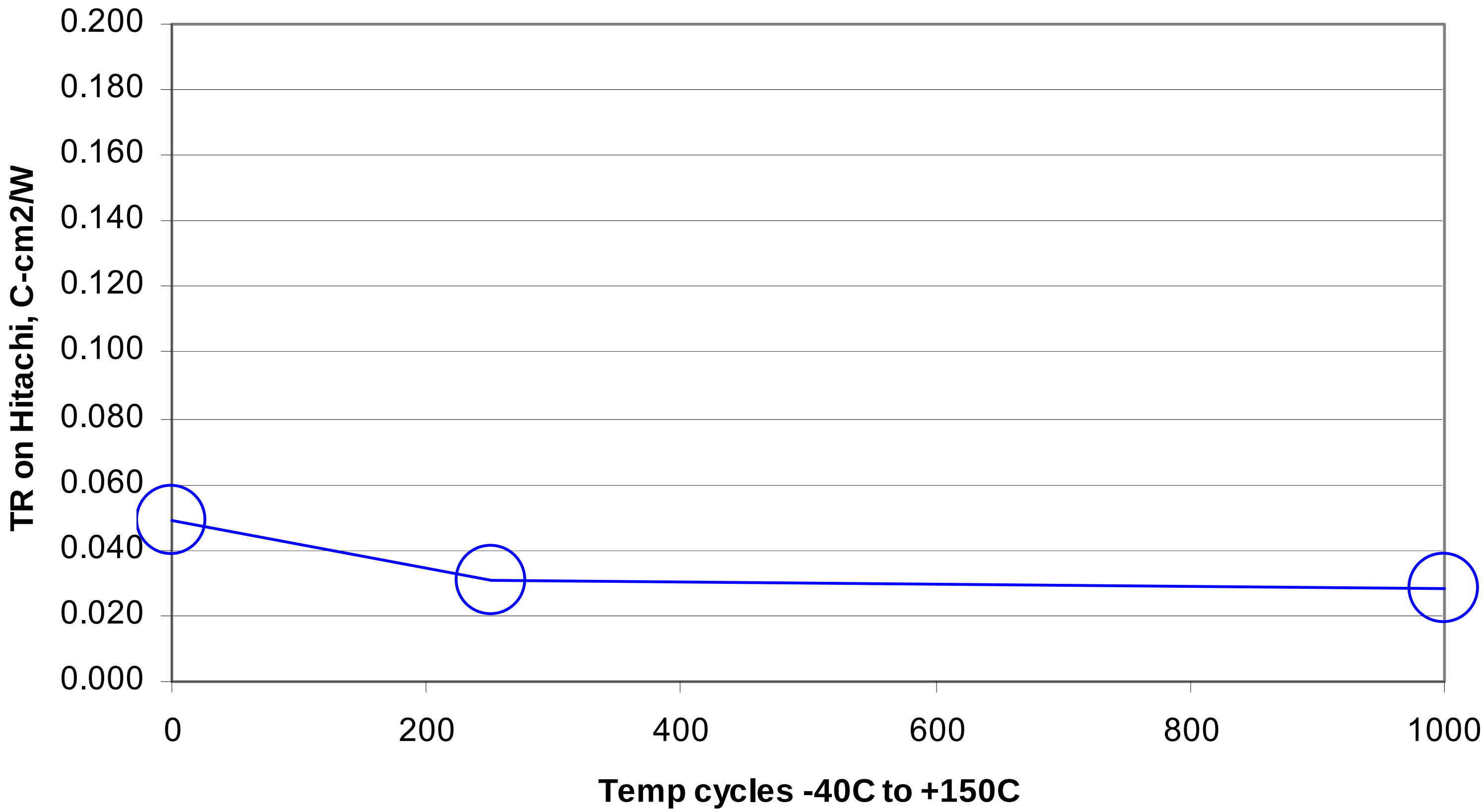
Power Cycle On TTV Tester

The results reported in this graph show that TC-5026 remains stable through 20,000 power cycles. This test is often used as a method of demonstrating pump-out. TC-5026 has very low end of life thermal resistance, indicating high reliability and stability. This graph is intended to illustrate reliability or change in TR, not baseline TR. Much lower TR can be realized than shown in graph.



TC-5026 Temperature Cycling

The results reported in this graph show that TC-5026 remains stable through thermal cycling. The thermal resistance actually decreases over time.



Spreadability Study

Multiple greases were applied between glass slides in 0.05 ml samples. The slides were then compressed together at a force of 5 psi. The diameter of the resulting sample was measured revealing the ability of different greases to spread under minimal pressure. TC-5026's unique formulation exhibits continuous stability at room temperature and allows it to reach minimal bond line thickness with minimal force even after aging. It's unique spread-ability makes TC-5026 appropriate for a variety of non-traditional applications.

TC-5026

Fresh Sample
Spreads to 28mm

Aged 7 days at
23 °C 50% RH
Spreads to 28mm

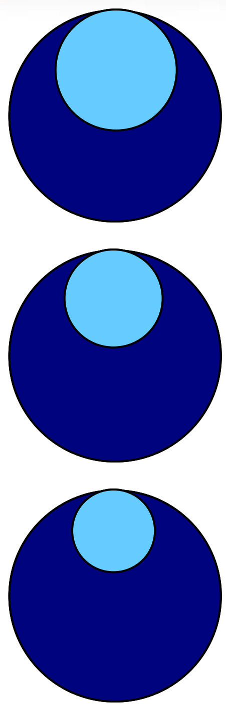
X23-7783

Fresh Sample
Spreads to 16mm

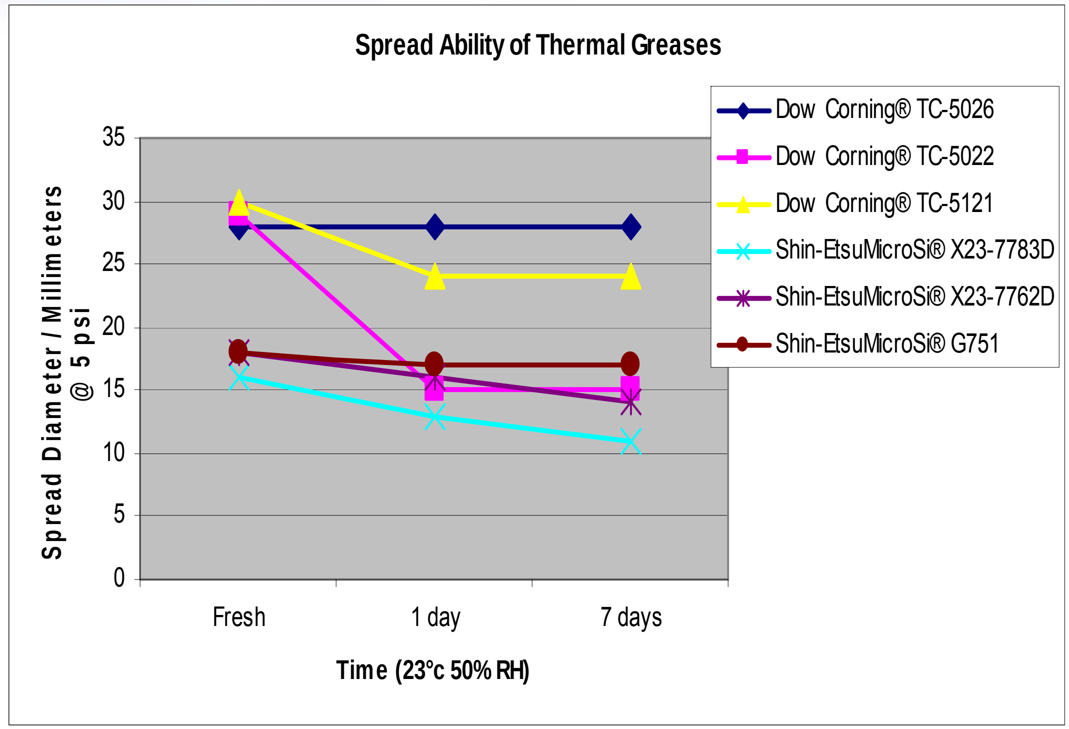
Aged 1 day at
23 °C 50% RH
Spreads to 13mm

Aged 7 days at
23 °C 50% RH
Spreads to 11mm

Over Lap Comparison
Scale Illustration

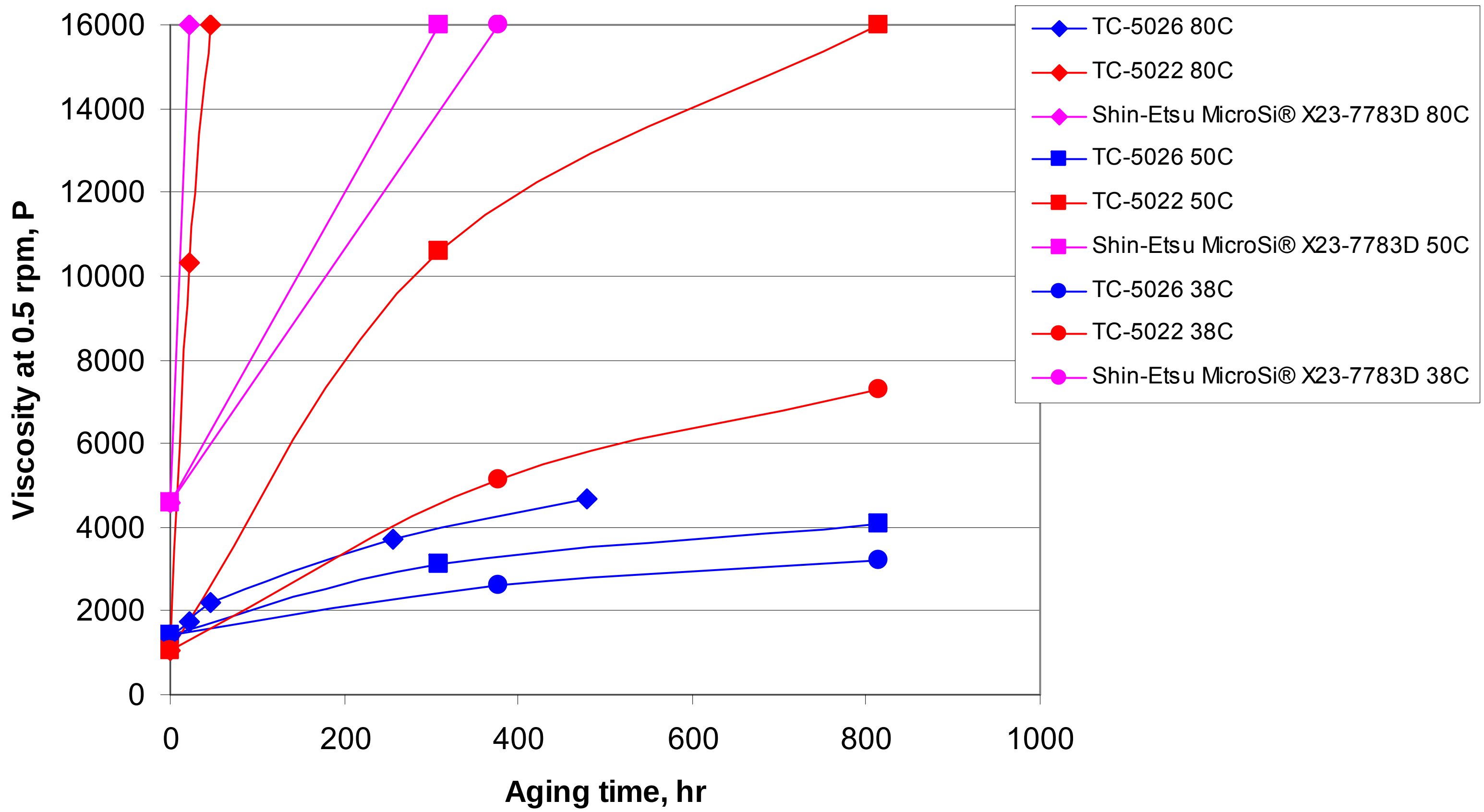


TC – 5026
X23-7783



Grease Print Aging

In this test, a pad of grease is screen printed onto an aluminum substrate and then aged at various temperatures. The grease is then removed and the viscosity re-tested. TC-5026 exhibits superior stability. This feature is useful when the grease is applied to a heat sink and shipped prior to assembly. The stable viscosity would enable the grease to compress to a thin bond line during assembly and properly wet the surface, thus optimizing thermal performance.



DOW CORNING Electronics Solutions

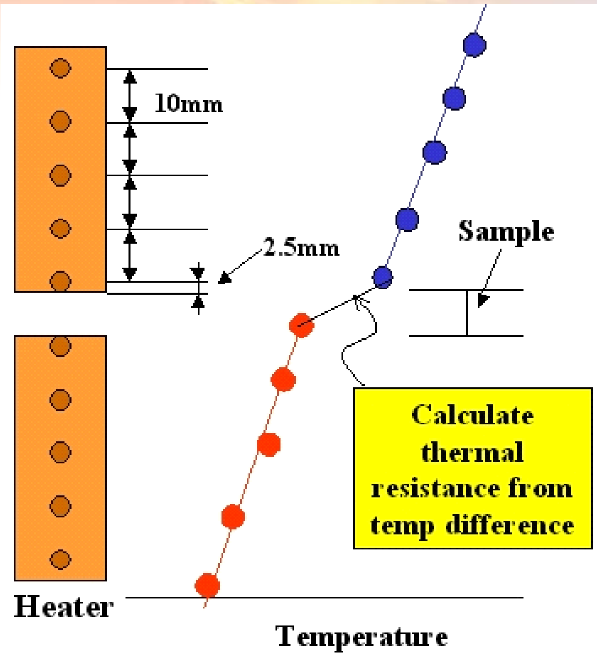
We help you invent the future.™

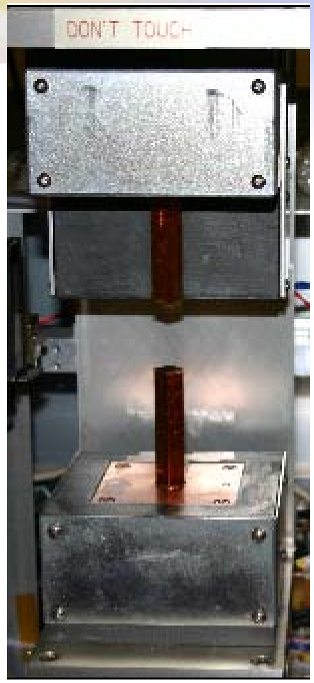
Product Testing

- Thermal Resistance
  - Hitachi Guarded Hotplate (ASTM # D5470).
    - Measures thermal resistance through TIM at different bond lines and pressure loads
  - Desktop TTV
    - Measures thermal resistance in a "real world" application as the TIM for a computer microprocessor
- Power Cycling
  - Laptop TTV
    - Simulates laptop microprocessor
    - TIM is situated between heat sink and bare die
    - Bare die flexes due to CTE mismatch creating an environment to induce pump-out
    - Test indicates long term reliability

Guarded Hotplate System

For Thermal Testing (ASTM # D5470).



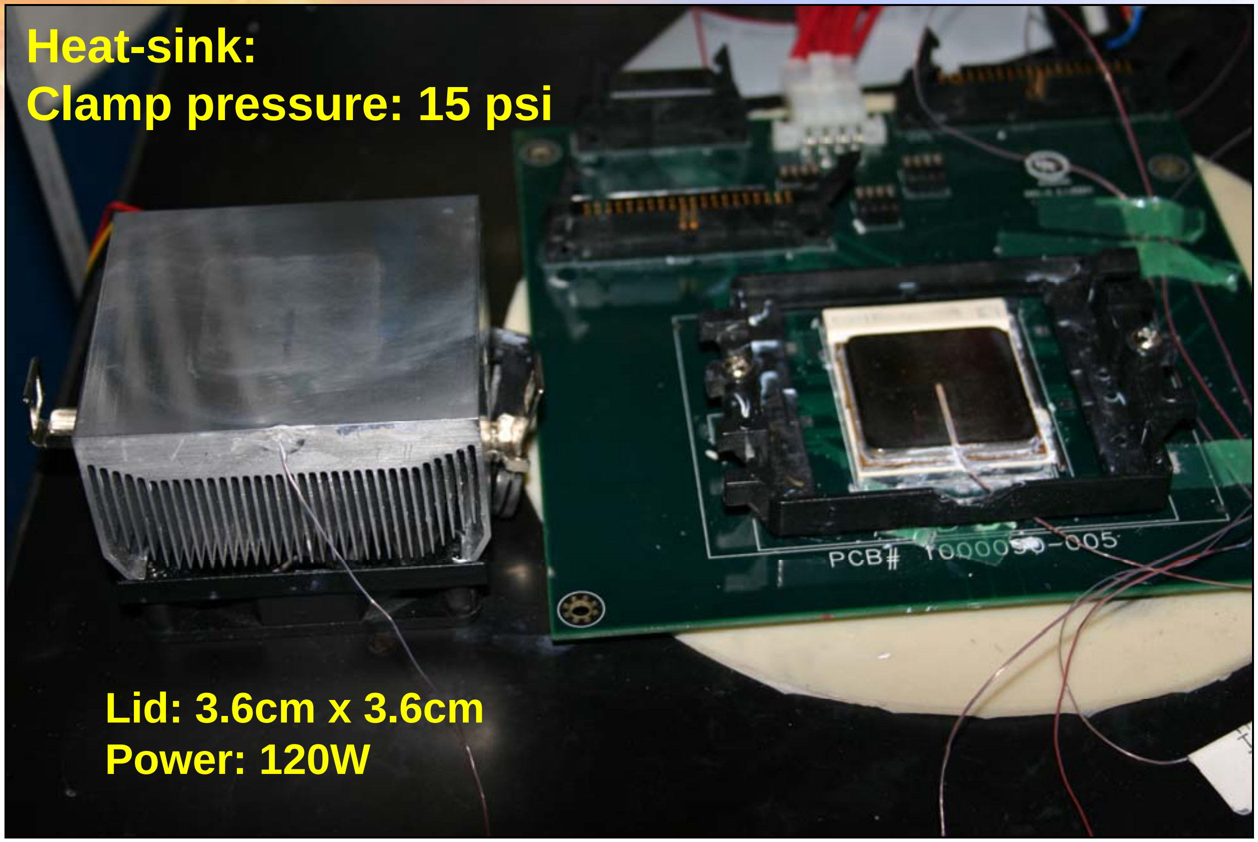


Thermal resistance testing critical for TIM development:

- Steady state method
- Handles complex materials
- Load or Thickness can be controlled
- Measurable at 40~140C

Probe: precision-machined 1 cm X 1 cm Cu blocks.

Desktop TTV Tester Set-Up



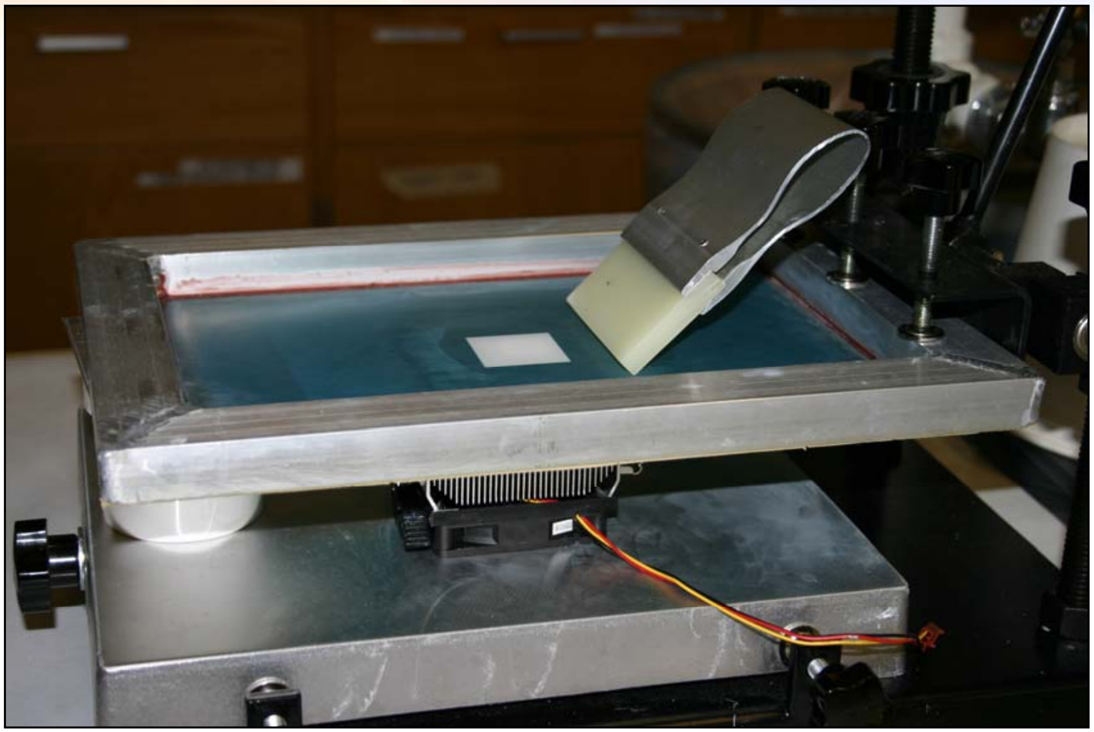
Product Processing

- Screen Printing
  - High volume processing
  - Applies a controlled amount of material to substrate
  - Produces consistent bond lines and patterns

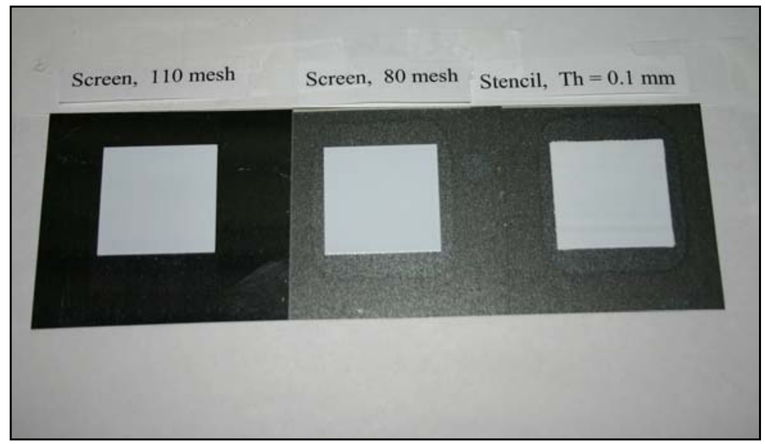
- Dispensing From Syringe
  - High volume, low volume and rework
  - Applies a controlled amount of material to substrate
  - Apply minimal amount of material to cover substrate

Screen Printing of Grease

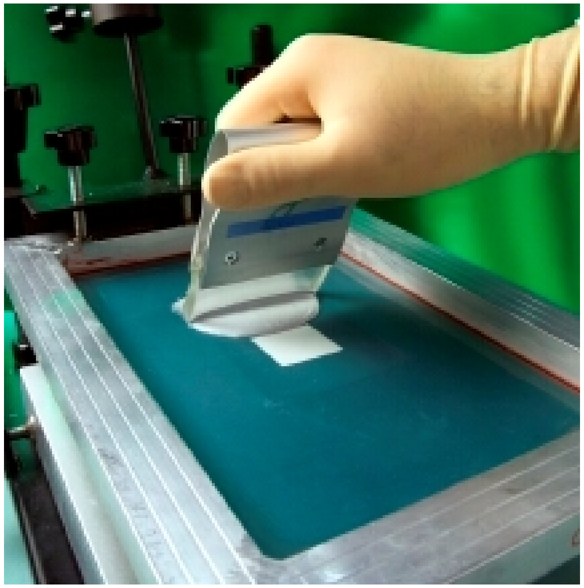
Typical manual screen printing equipment.

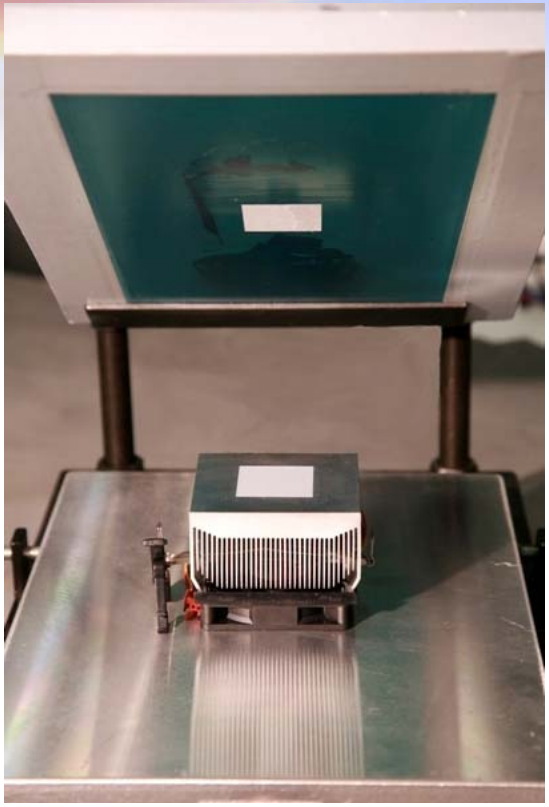


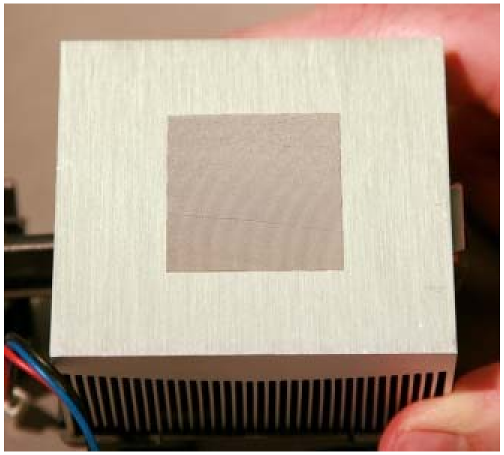
Grease Prints



Screen Printing – Process Steps



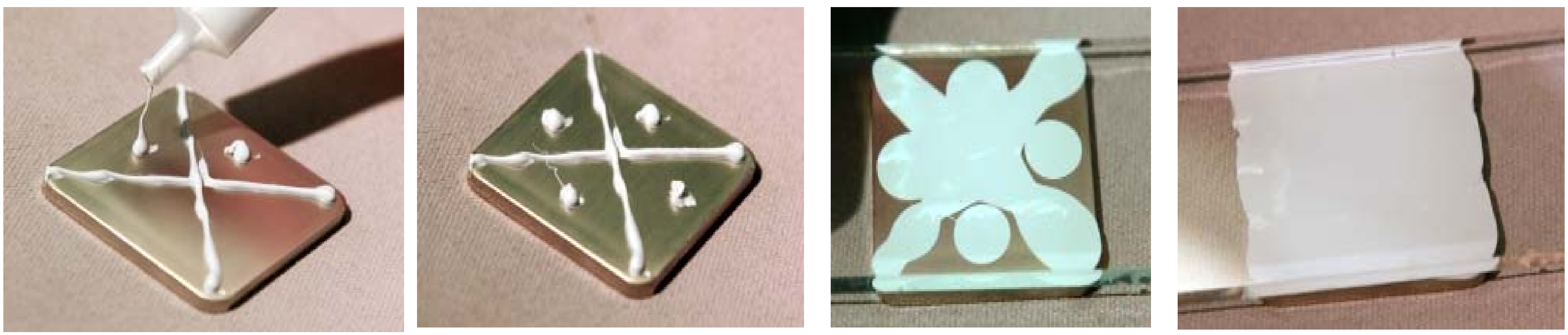




Syringe Dispensing

- Ease of spreadability = reliable surface coverage
- Syringes are easy to carry for rework

.54 grams of TC-5026 dispensed in x-pattern on 37mm x 37mm substrate



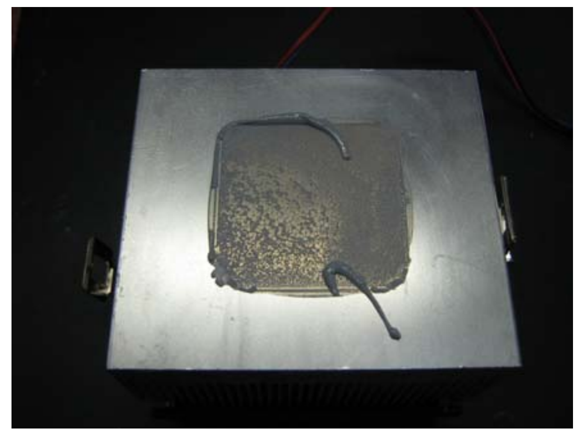
TC-5026 For Fieldwork

In this example, a small drop of grease is dispensed from a syringe onto a microprocessor located on a computer motherboard. The heat sink is then clamped into place using the existing clamping system on the motherboard. After a few minutes, the heat sink is removed. It is clearly visible that grease has spread out to a thin bond line covering entire surface. Some thicker commercial greases can be cumbersome to apply but Dow Corning greases are formulated with a target viscosity to enable versatile processing.

1) Grease drop on microprocessor

2) Heat sink mounted on motherboard

3) Grease spread out over microprocessor



4) Grease spread out onto heat sink

Frequently Asked Questions

Question: I occasionally see greases and other TIMs that advertise thermal conductivity in the high teens, why doesn't Dow Corning make any materials like that?

Answer: In many applications, thermal resistance is more important that bulk conductivity. There are many factors that affect thermal resistance, including: bulk conductivity, contact resistance, filler size, shape and distribution. Dow Corning's TC-XXXX greases have optimized formulations that out perform other greases on the market with expensive exotic fillers and high bulk thermal conductivity. Before making a purchase based on thermal conductivity, you should test the product performance in your particular application. You will be pleasantly surprised by Dow Corning performance. Order a test sample today!

Question: I currently use a phase change pad. Much of our device failure is due to thermal issues so I would like to use a grease to get better performance, but it is too messy for rework and its not realistic for us to train all of our technicians how to use grease in the field. Do you have any alternatives?

Answer: It is surprising to many customers to learn how easy a modern grease can be to use. As far as the mess goes, used grease can usually be wiped from the substrate quite easily. For extra cleaning a small amount of nontoxic Dow Corning OS-XX solvent can be used to remove residue. A grease such as DOW CORNING® TC-5026 can easily be used for rework situations. A technician merely dispenses a predetermined amount of grease from a syringe onto the substrate. When the pieces are fastened together the grease easily spreads out to a thin bond line with minimal pressure. Many customers believe this process to be just as simple as using a pad. Fewer device failures and the lower cost of grease more than justify any switching costs.

Question: I have always heard that greases have problems with "pump-out" and degradation. How can I confidently use a grease in an important application where reliability is key?

Answer: Dow Corning next generation greases are formulated with unique silicone fluids that interact with filler particles and actually help bind the filler to the matrix. This prevents the separation and "pump-out" often associated with greases. As for degradation, you can see from power cycling data that even after 20,000 power cycles the performance is stable and in some situations even improved. For the highest stability, use solvent free DOW CORNING® TC-5026