TestConX 中国™ China

November 13, 2025
Shanghai

www.testconx.org

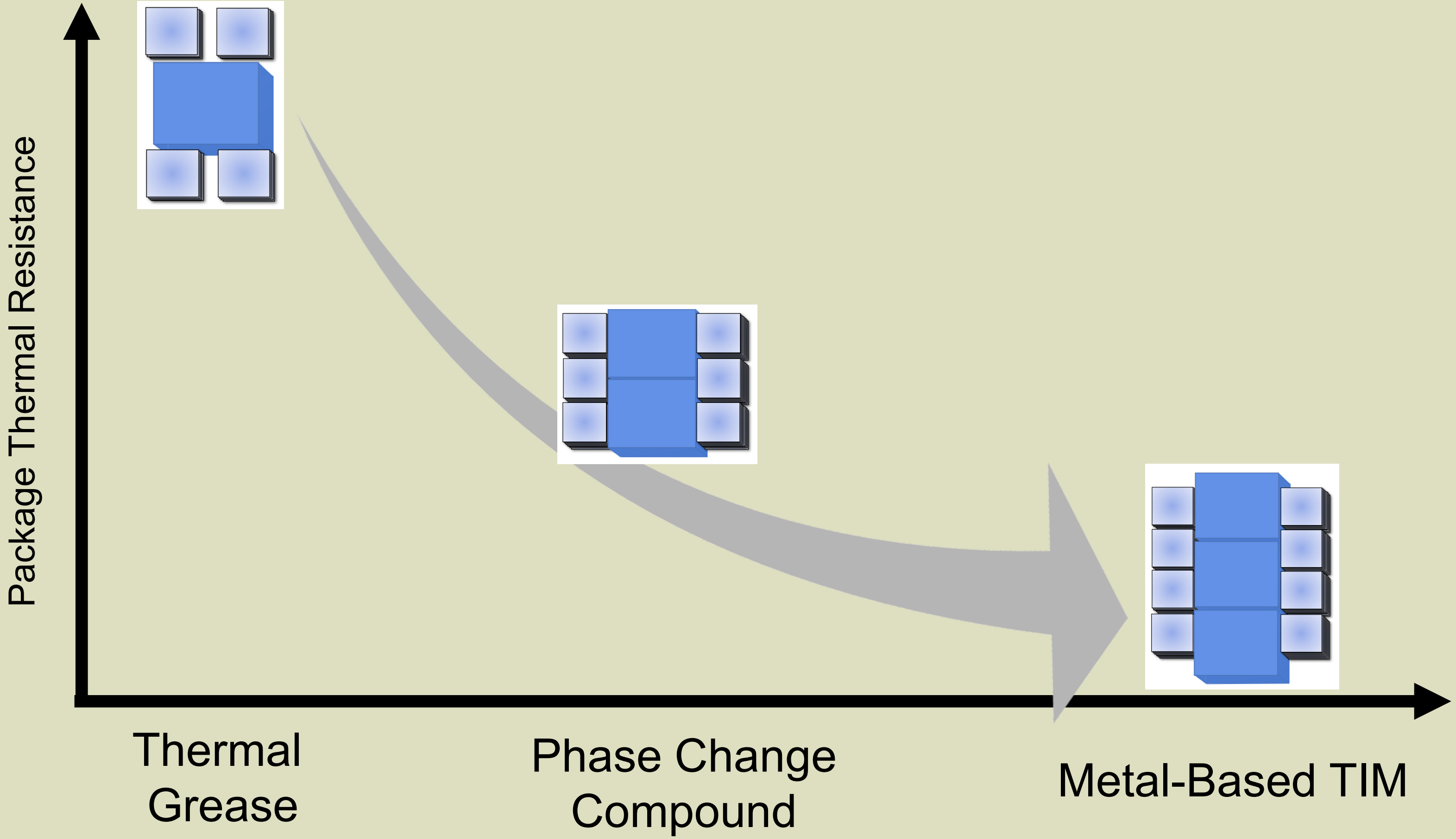
Solving Warping Issues with Next Generation Metal Compressible TIM

Foo Siang Hooi
Miloš Lazić
Bob Jarrett
Ricky McDonough
Carson Burt

TestConX中国™
China
Shanghai ▪ November 13, 2025

INDIUM CORPORATION®

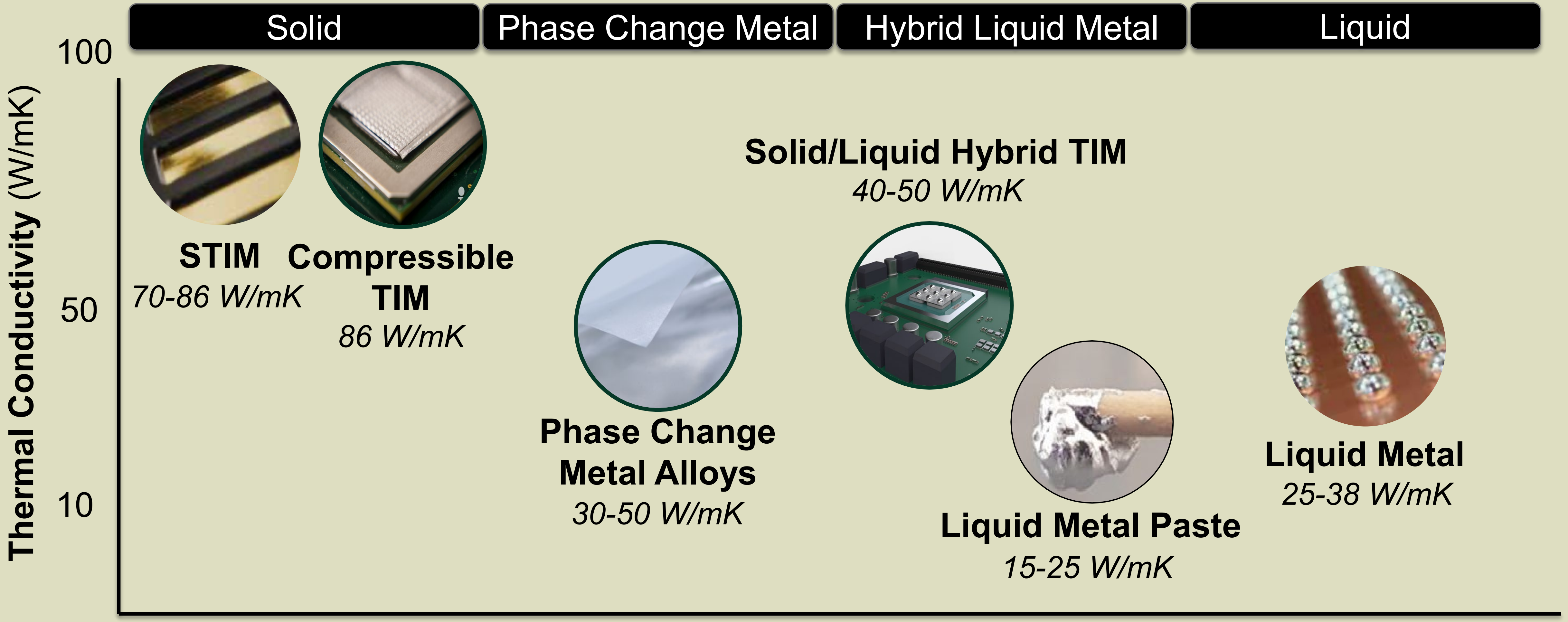
TIMs Overview



Air	.025	*W/m-K*
Polymers	~.10	*W/m-K*
Grease	*<5 - 10*	*W/m-K*
PCM	~2 - 8	*W/m-K*
Gallium	31	*W/m-K*
Tin	73	*W/m-K*
Indium	86	*W/m-K*
Copper	~400	*W/m-K*

Metals offer high bulk thermal conductivity as compared to the modest conductivity of organic thermal interface material.

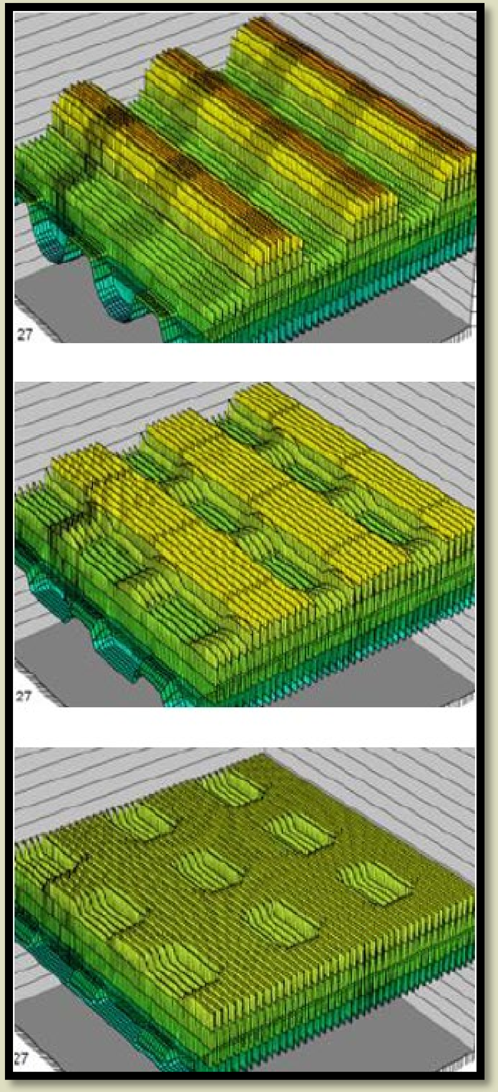
Metal TIMs



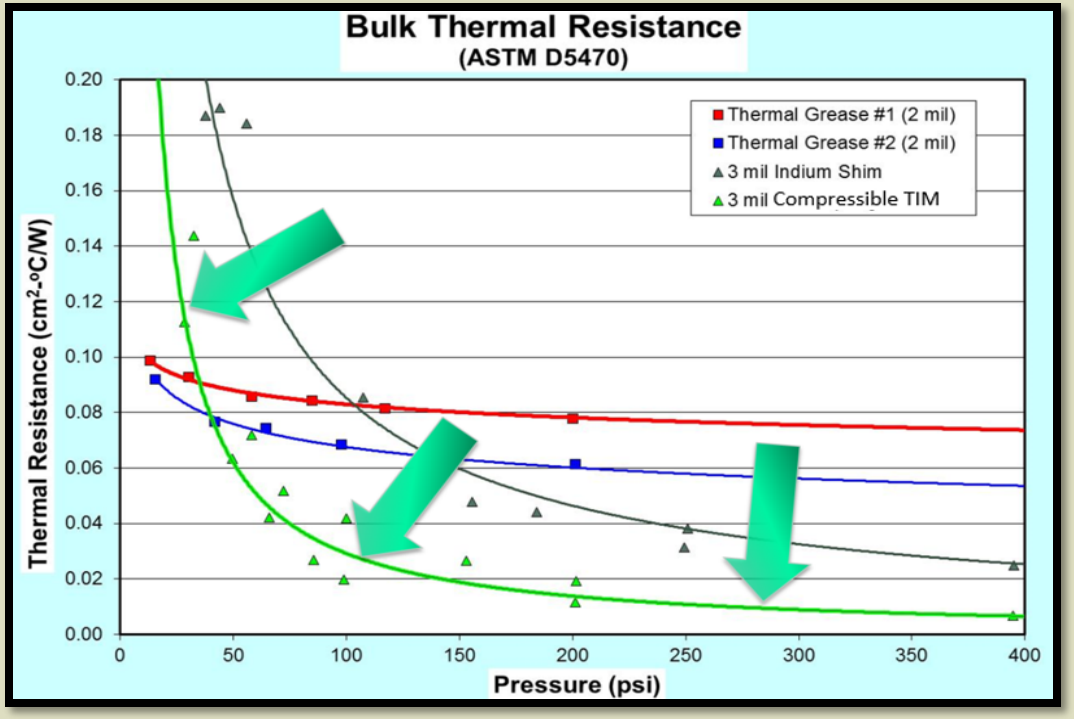
Thermal Conductivity Range Metal TIMs from 15 – 86 W/m-K

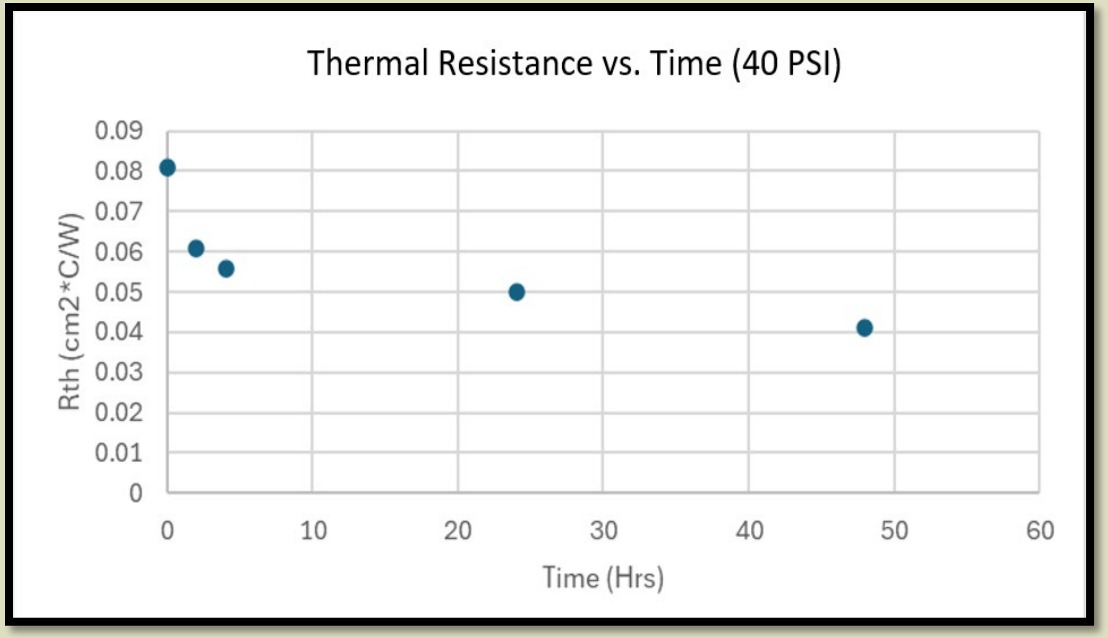
Compressible Metal TIMs - Principles

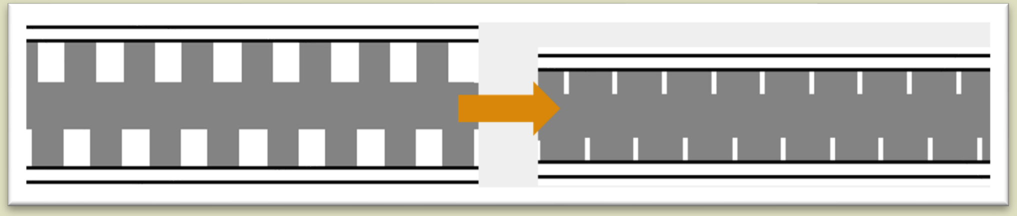
- Pattern applied to metal shim to form array of compressible columns
- Metal TIMs possess high thermal conductivity
  - Pure indium: 86 W/mK
  - TIM thickness has weak impact on thermal resistance
- Metal plastically deforms to the interfaces, thermal resistance decreases
  - Deformation through creep or optional preload



Compressible Metal TIMs - Principles







Compressible Metal TIMs - Attributes

High thermal conductivity 86W/mK

- ✓ Low bulk resistance—insensitive to BLT
- ✓ Thermal performance as low as solder at 75psi
- ✓ Surface altered to reduce contact resistance

Conformability

- ✓ Plastic deformation provides low contact resistance, especially after time zero (burn-in period)
- ✓ Inherent gap filling for coplanarity issues
- ✓ Complies with CTE mismatch

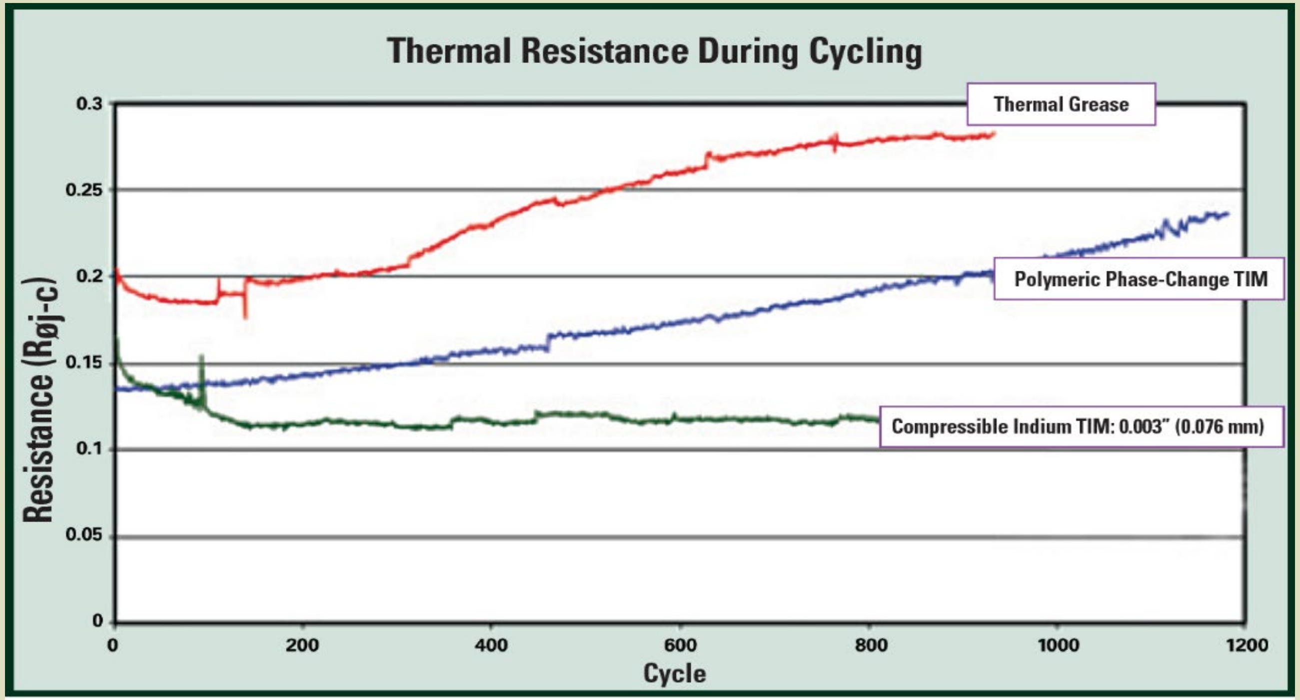
Stability Advantages

- ✓ No out-gassing
- ✓ No bake-out or pump-out
- ✓ Easy to handle, won't rip or tear
- ✓ Reclaimable/recyclable

Process Advantages:

- ✓ No reflow needed
- ✓ Clean, recyclable, and reworkable
- ✓ No need for any surface preparation, easy-to-apply, easy-to-rework material
- ✓ Unused material can be credited
- ✓ Tray Pack or Tape & Reel

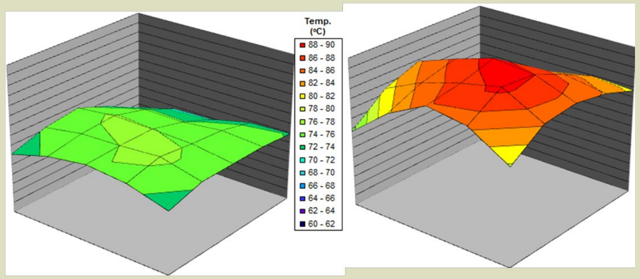
Compressible TIMs Power Cycling Performance



Comparative thermal resistance under clamped condition with power cycling over time - 1,000 power cycles

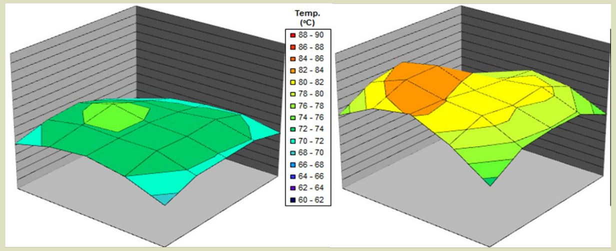
Compressible TIMs will not dry out and will not get pumped out. After initial plastic deformation performance will be very stable.

Standard PCM



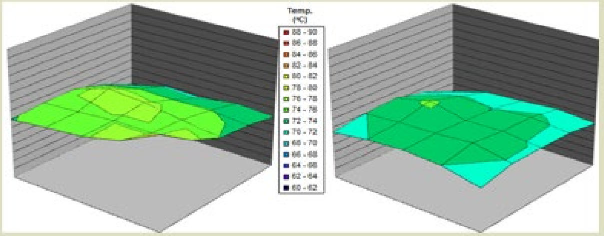
1st Cycle 1000 Cycles

Standard Thermal Grease



1st Cycle 1000 Cycles

Compressible TIM



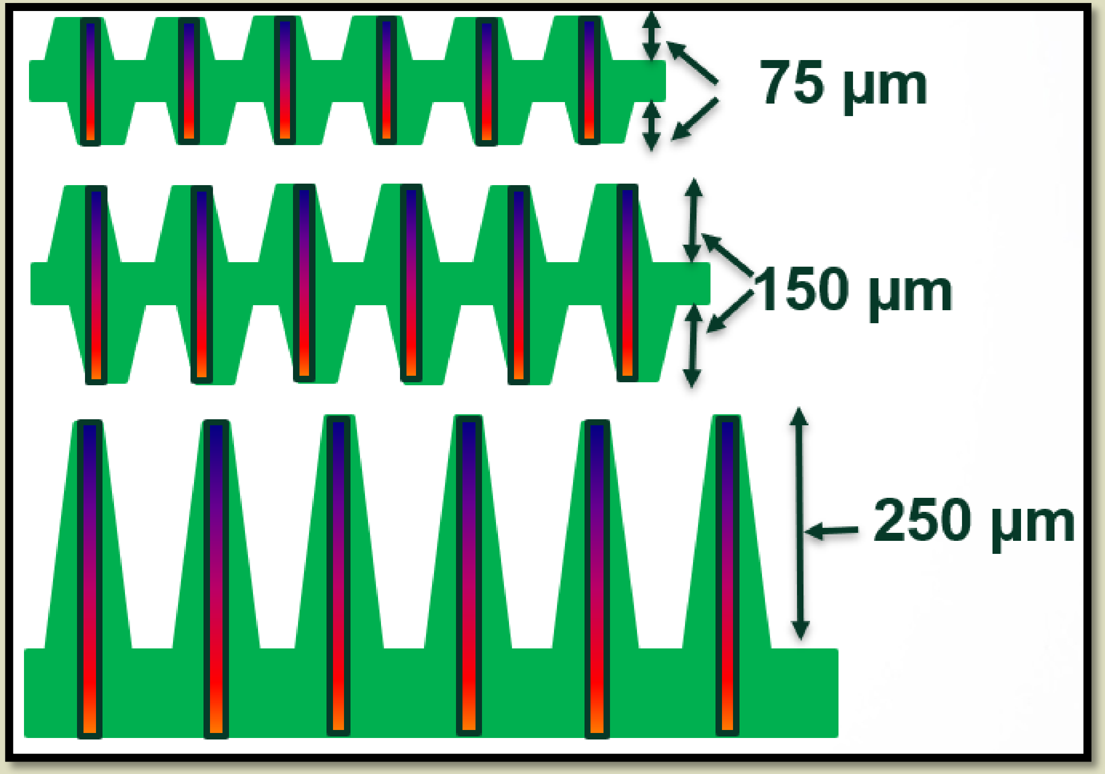
1st Cycle 1000 Cycles

Compressible Metal TIMs - Patterns

Pattern A

Pattern B

Next Generation Pattern X



- **Pattern A**: Designed for parallel interfaces with tight surface control
- **Pattern B**: Higher profile variant of Pattern A with 2X compressibility
- **Pattern X**: Alternative pattern geometry for optimized compressibility at lower pressures

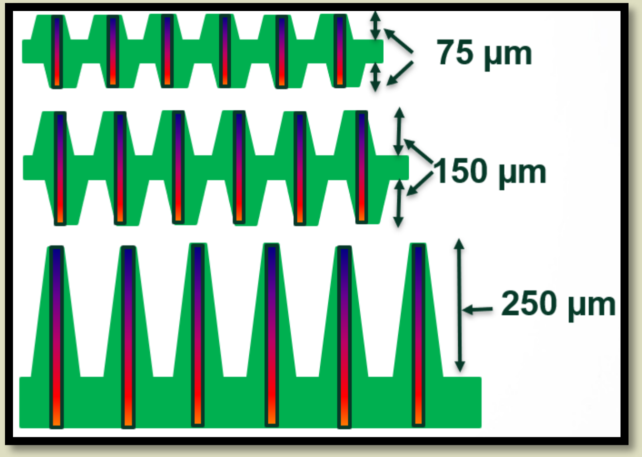
Compressible Metal TIMs - Patterns

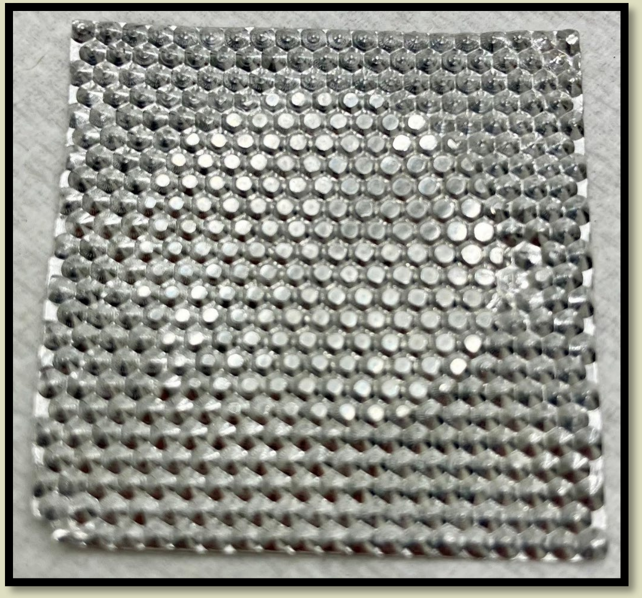
- Next Generation Pattern X is more compressible at lower pressures
- Recommended for nonplanar/curved surfaces and applications with high CTE mismatch

Pattern A

Pattern B

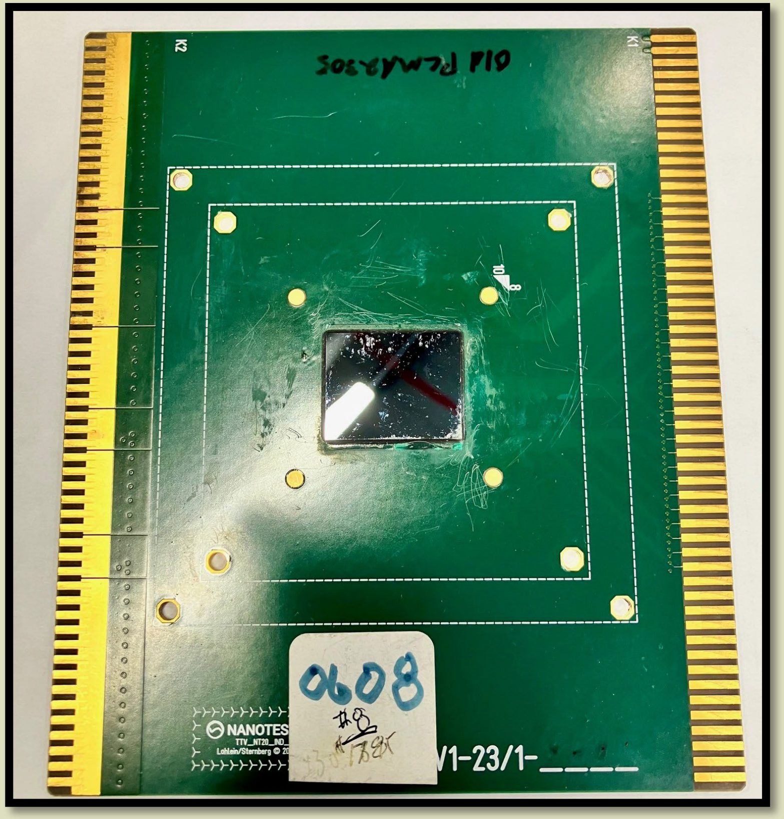
Next Generation Pattern X

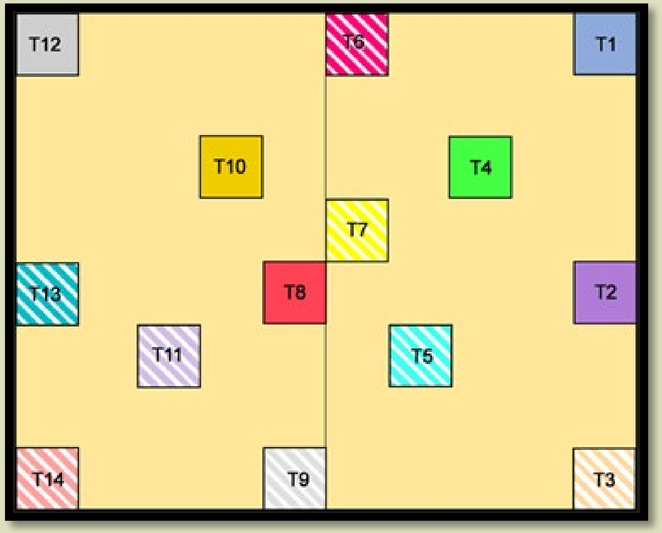




Thermal Test Vehicle (TTV) Assembly

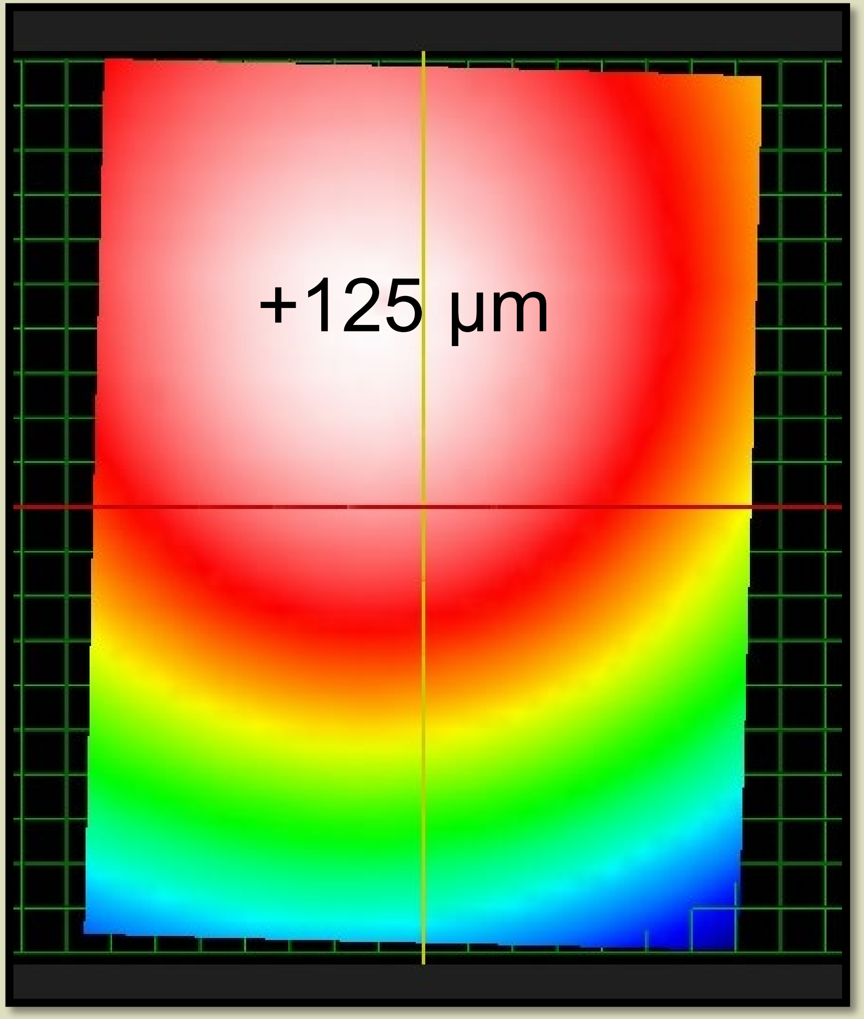
- 20 x 25mm die
- Cycling power up to 1400W
- Heat-sink & chiller used for heat removal
- ~20 seconds/cycle (300W), ~40 seconds/cycle (1000W)
- 14 RTD locations





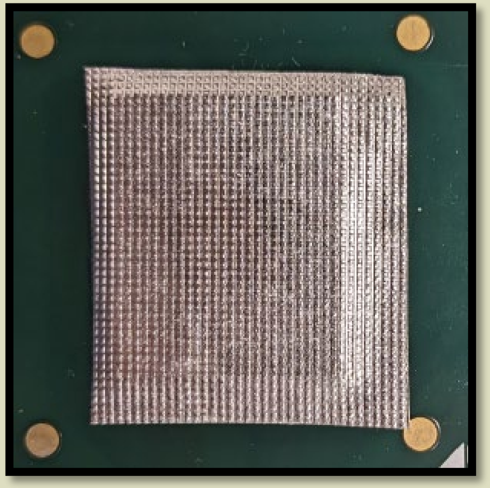
TTV Assembly – Die Profile

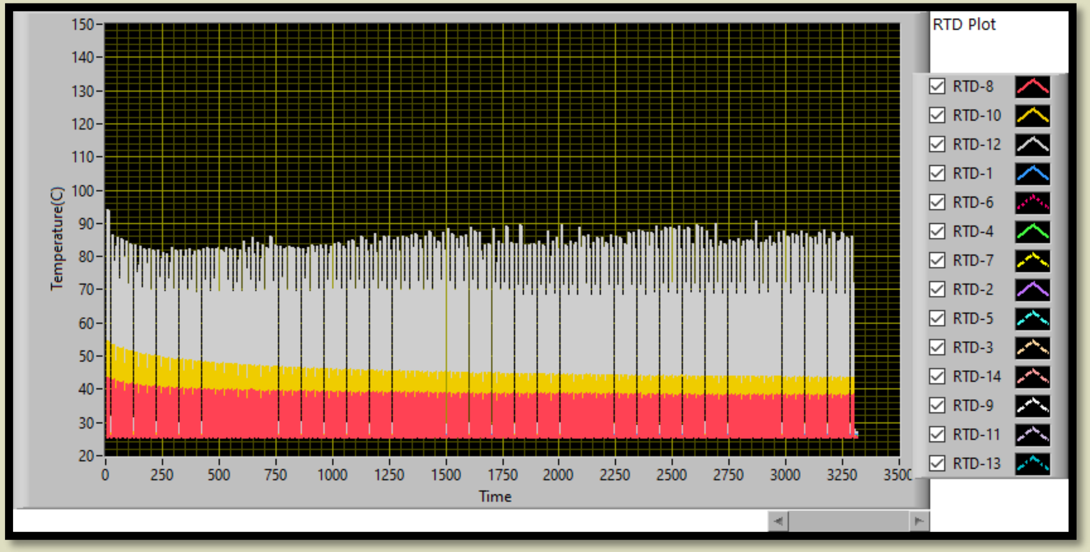
- Maximum crown 125 µm (5 mil)
  - Simulates non-coplanarity of production dies



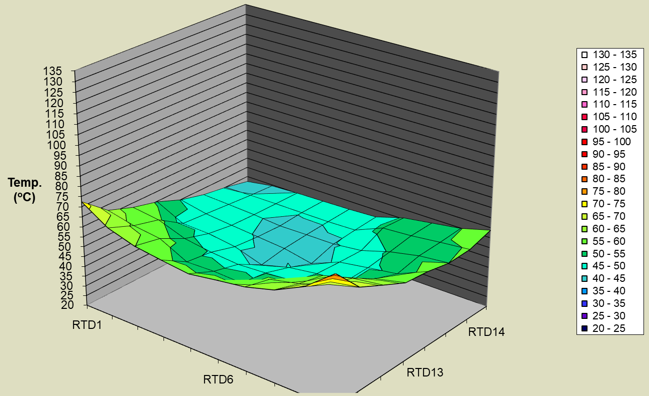
TTV - Pattern A, 50 psi, 0 – 300 W

- Good baseline resistance
- Limited compliance, corners never make contact

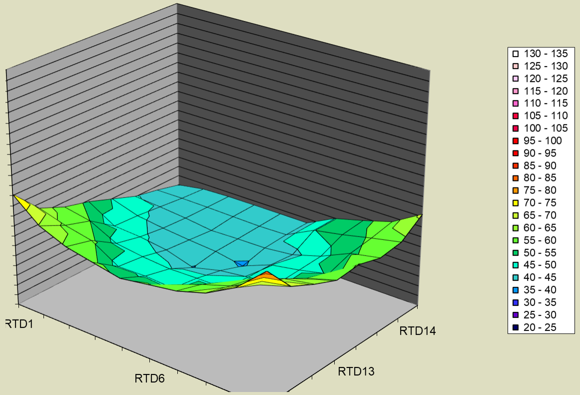




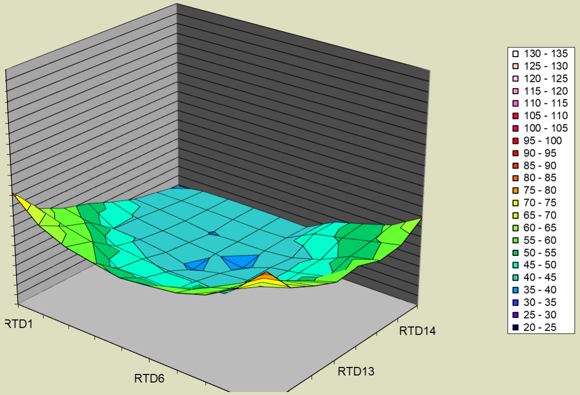
10 Cycles



50 Cycles

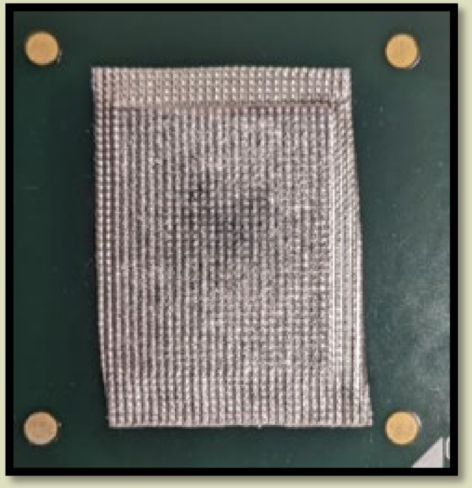


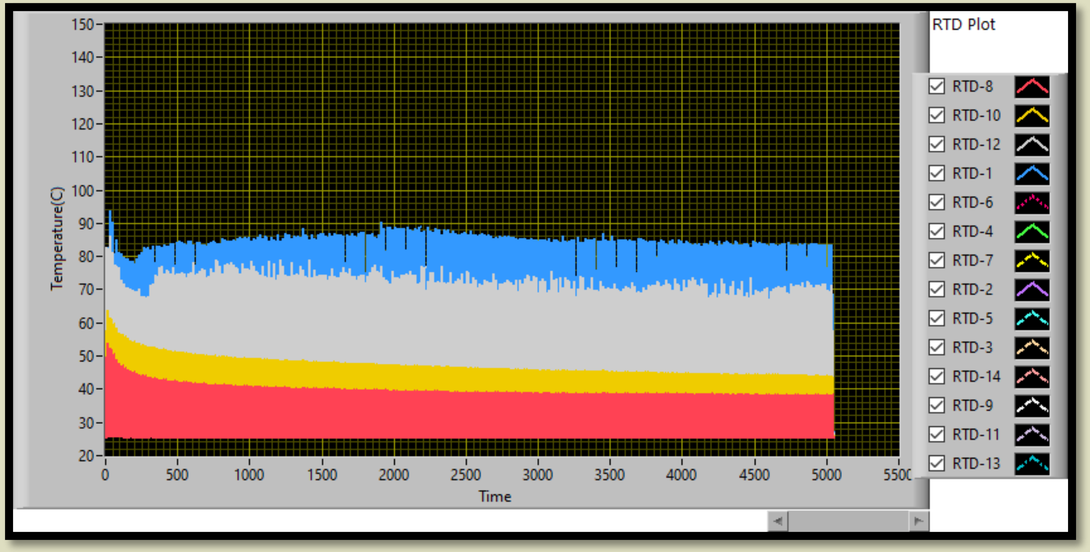
150 Cycles



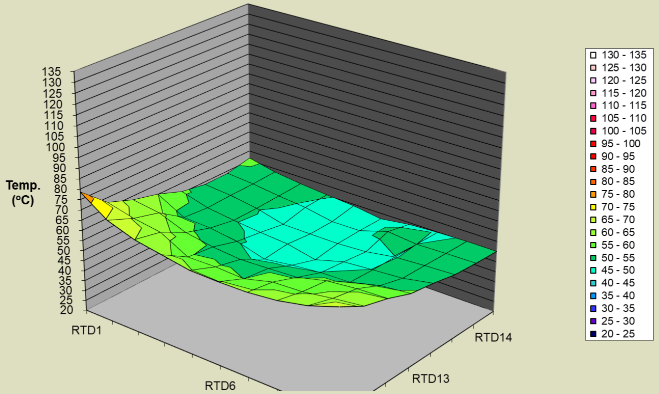
TTV - Pattern B, 50 psi, 0 – 300 W

- Good baseline resistance
- Improved compliance, corners never make contact

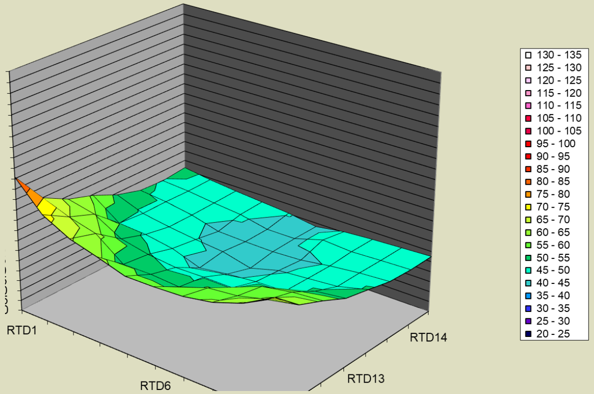




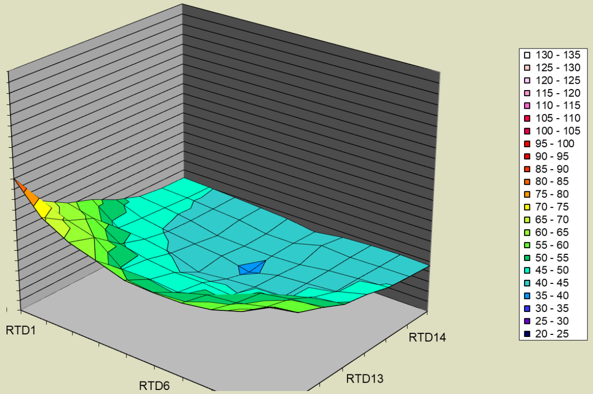
10 Cycles



50 Cycles

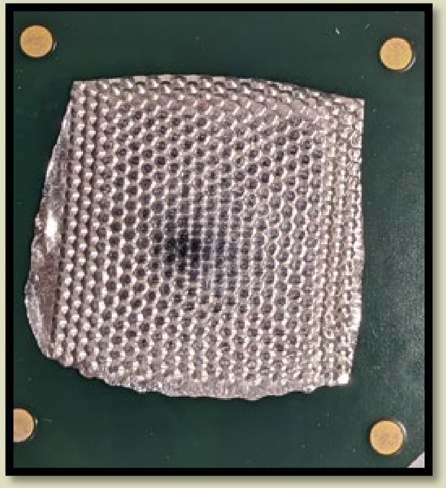


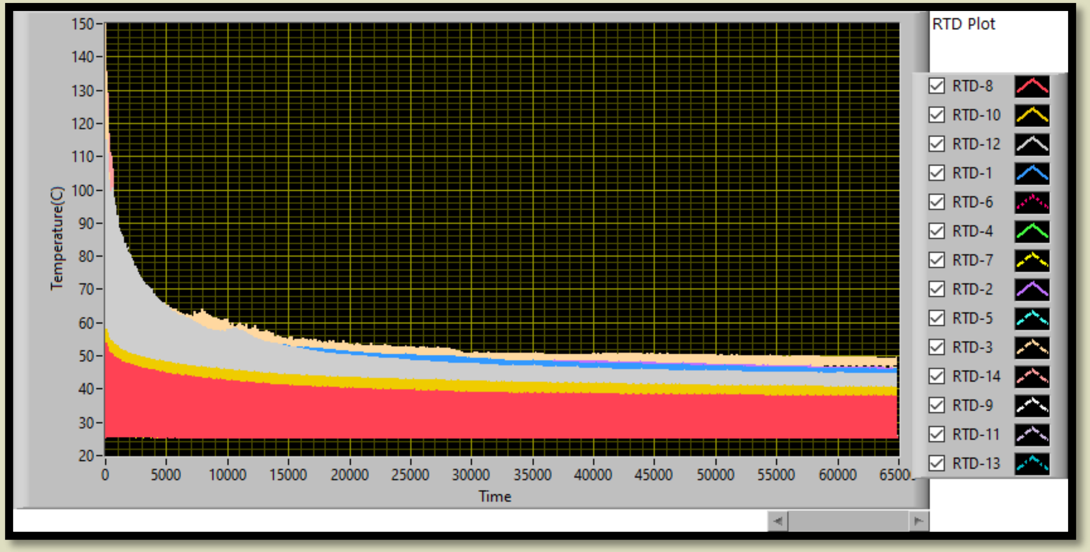
150 Cycles



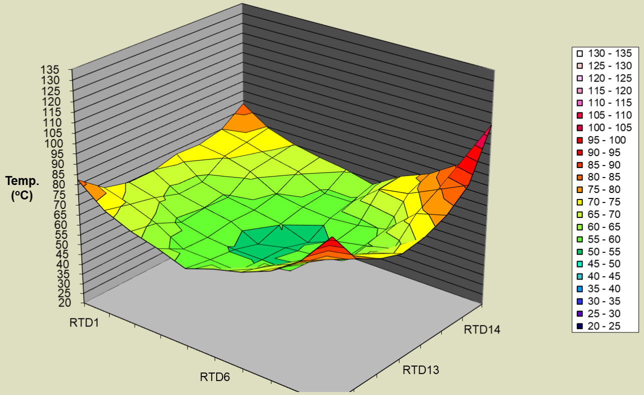
TTV - Pattern X, 50 psi, 0 – 300 W

- Improved baseline resistance
- High compliance, corners make efficient contact through cycling

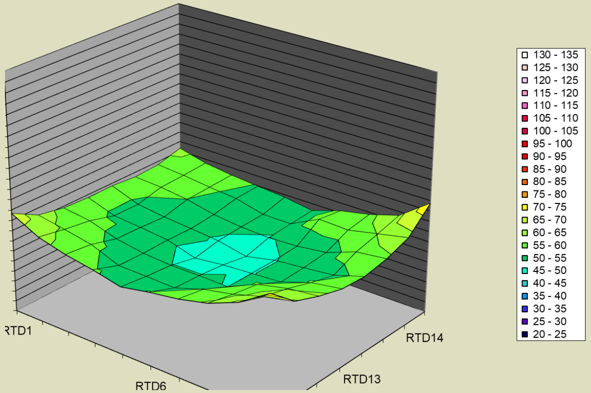




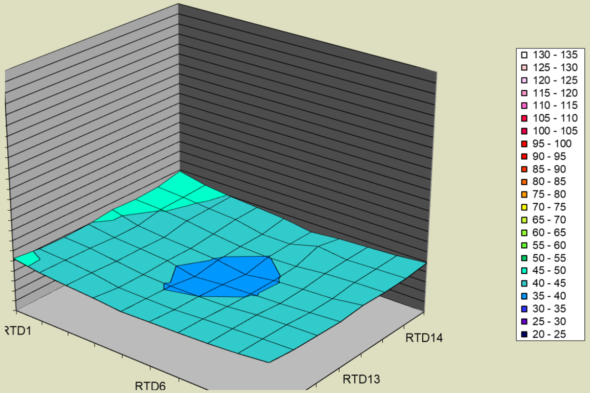
20 Cycles



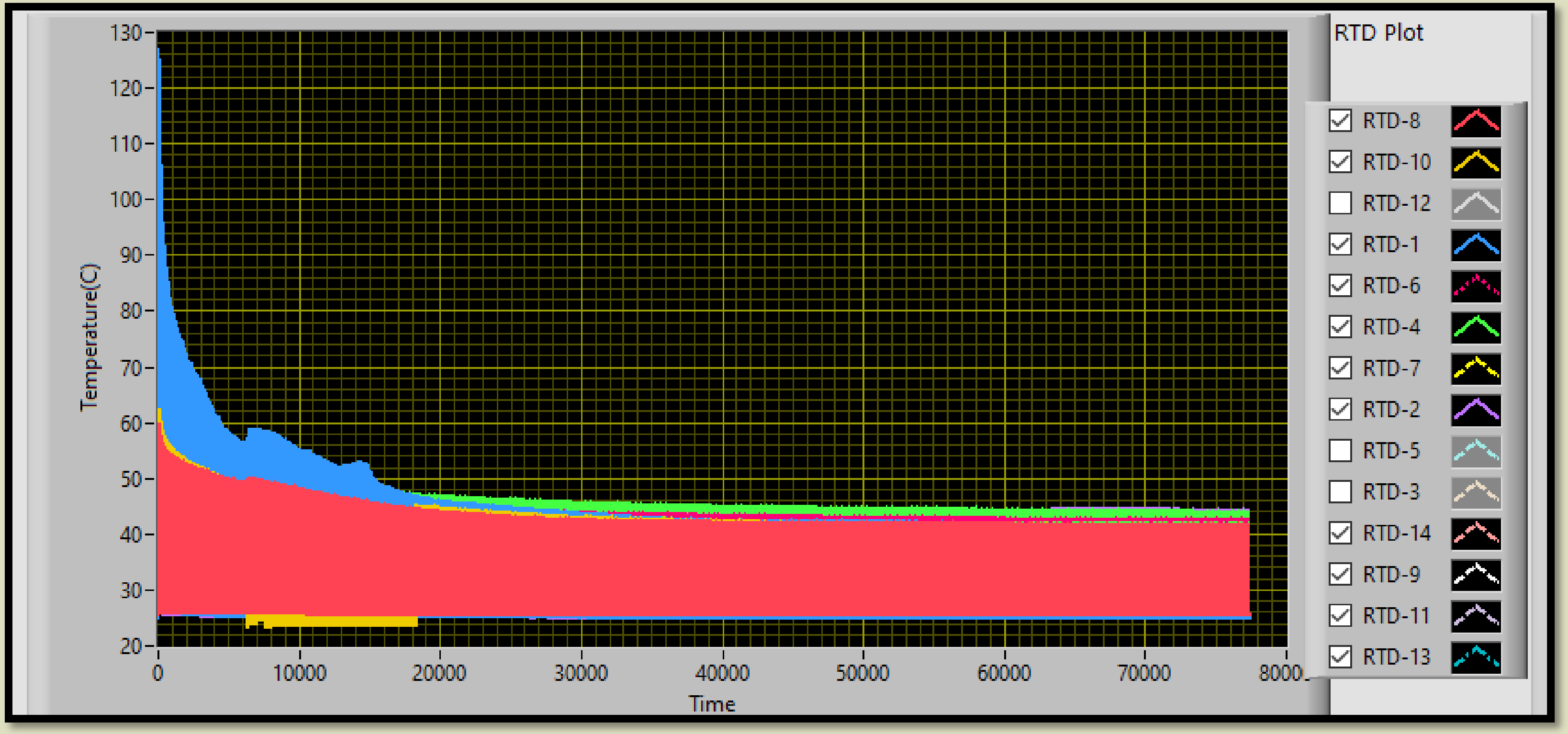
124 Cycles



3240 Cycles

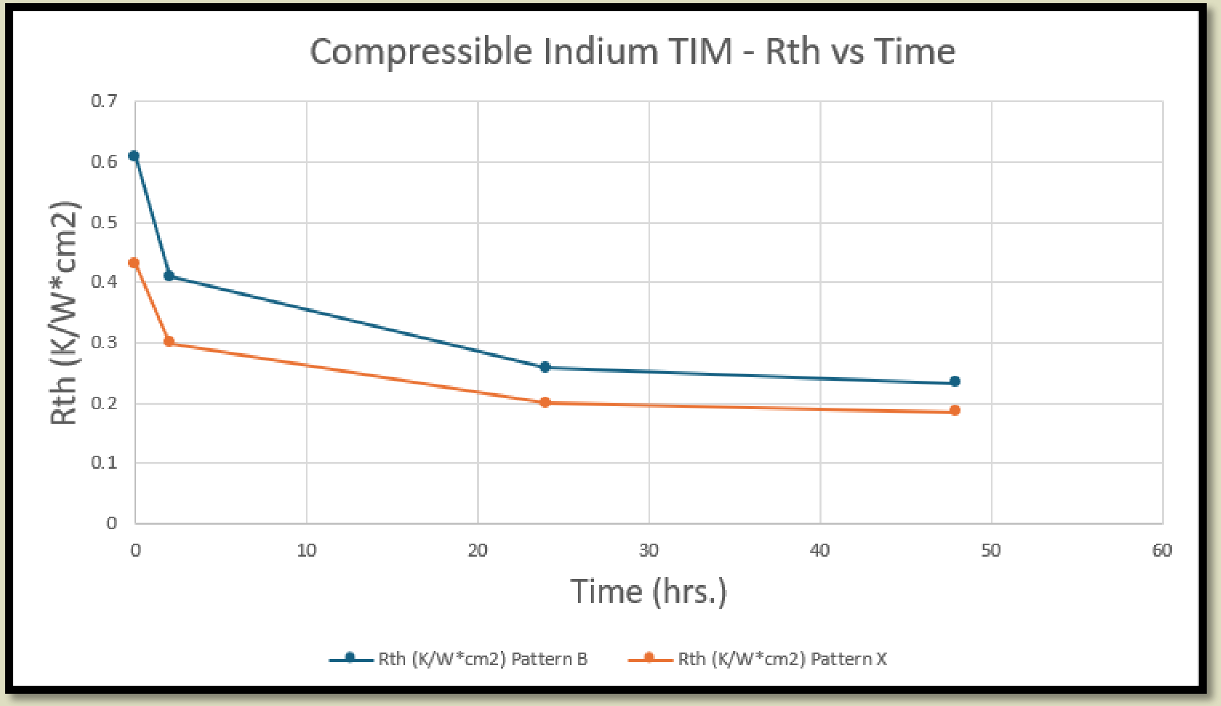


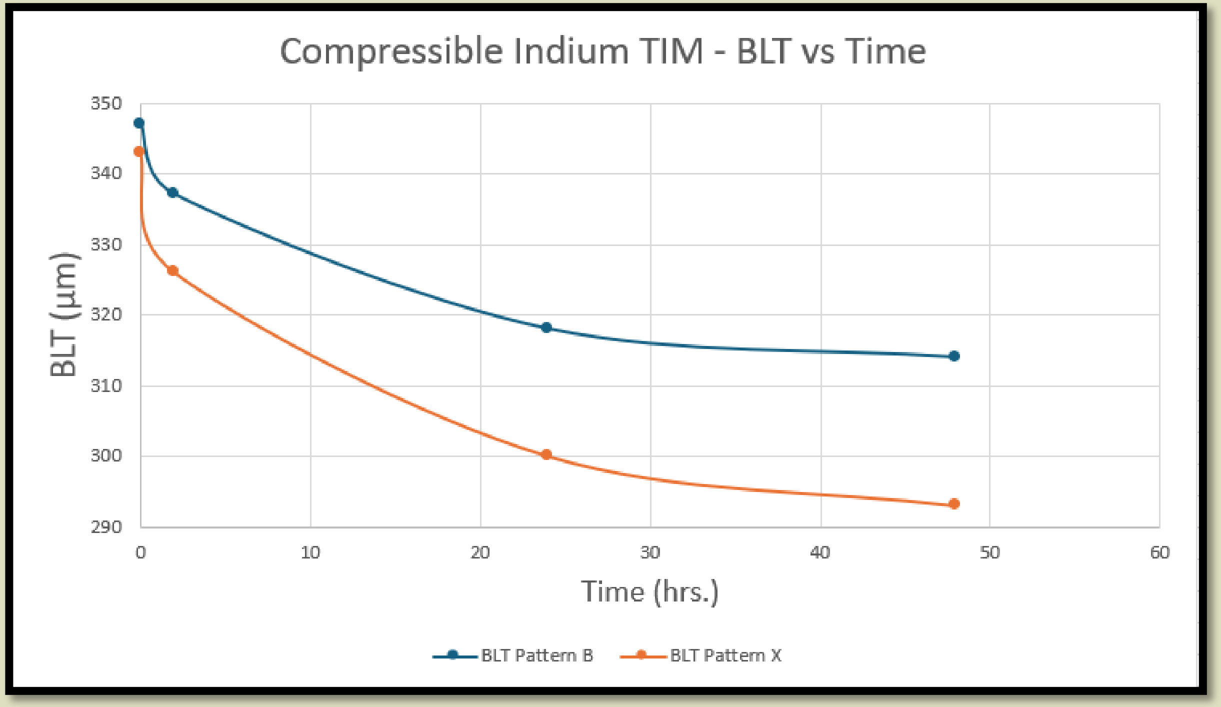
TTV - Pattern X, 30 psi, 0 – 300 W



- At lower pressure, Pattern X exhibits lower, consistent temperature across die

TIM Pattern Compression



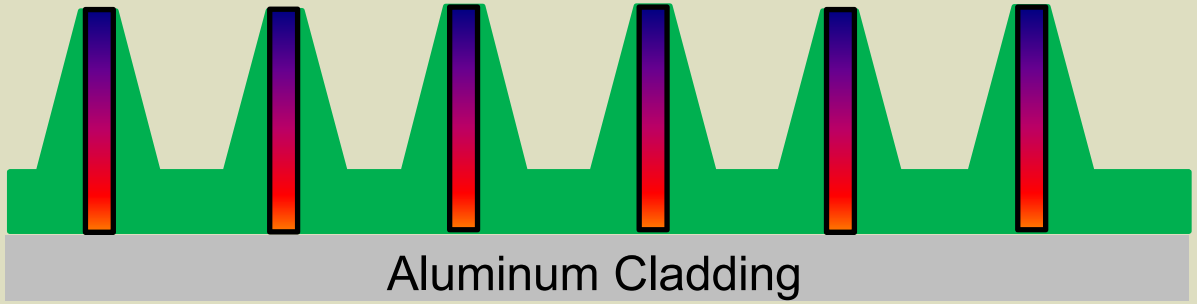


- 20 psi, 85°C, 0.012” overall thickness
- Next Generation Pattern X exhibits and maintains lower Rth and BLT over time
- Suitable for TIM1.5 applications

Compressible Metal TIMs - Applications

Semiconductor Test and Burn-in

- Thin aluminum cladding added to TIM
- Prevents indium diffusion into device under test (DUT)



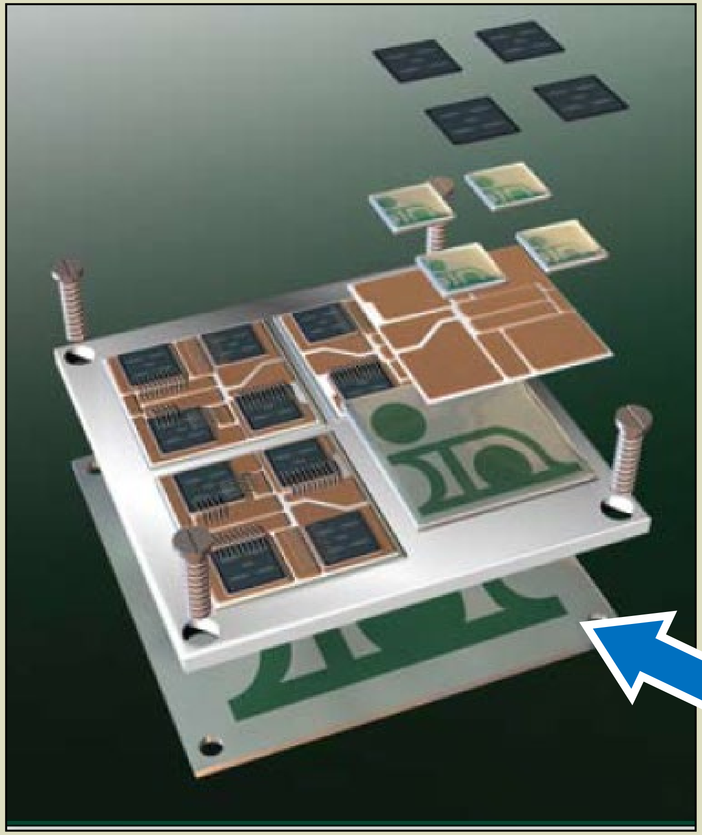
Compressible Metal TIMs - Applications

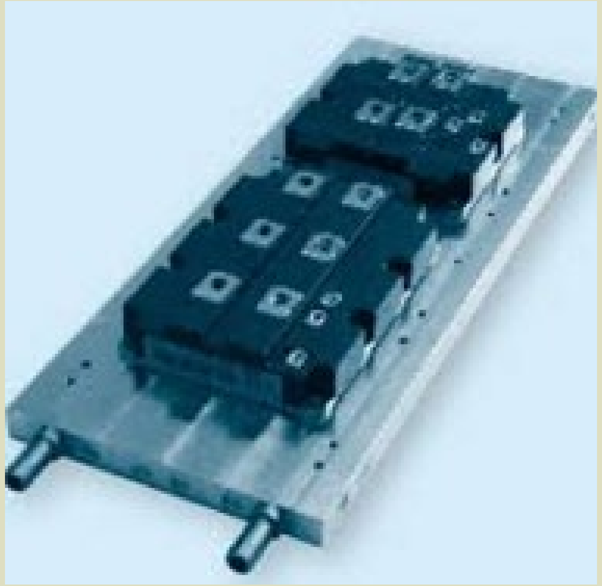
Immersion Cooling

- Indium compressible TIMs will not dissolve in or contaminate immersion fluid

Compressible Metal TIMs - Application

IGBT: base plate to liquid cold plate





Compressible Metal TIM at Base plate to Heat-sink

Compressible Metal TIMs - Considerations

Alloy Selection

Alloy	Solidus (°C)	Conductivity (W/mK)	Estimated Flow Stress (PSI)	Suggested Pressure (PSI)
100 In	157	86	175	30 - 40
52In48Sn	118	41	310	30 - 40
90In10Ag	143	71	700	60-80
Sn+	232	73	1000-2000	80-100

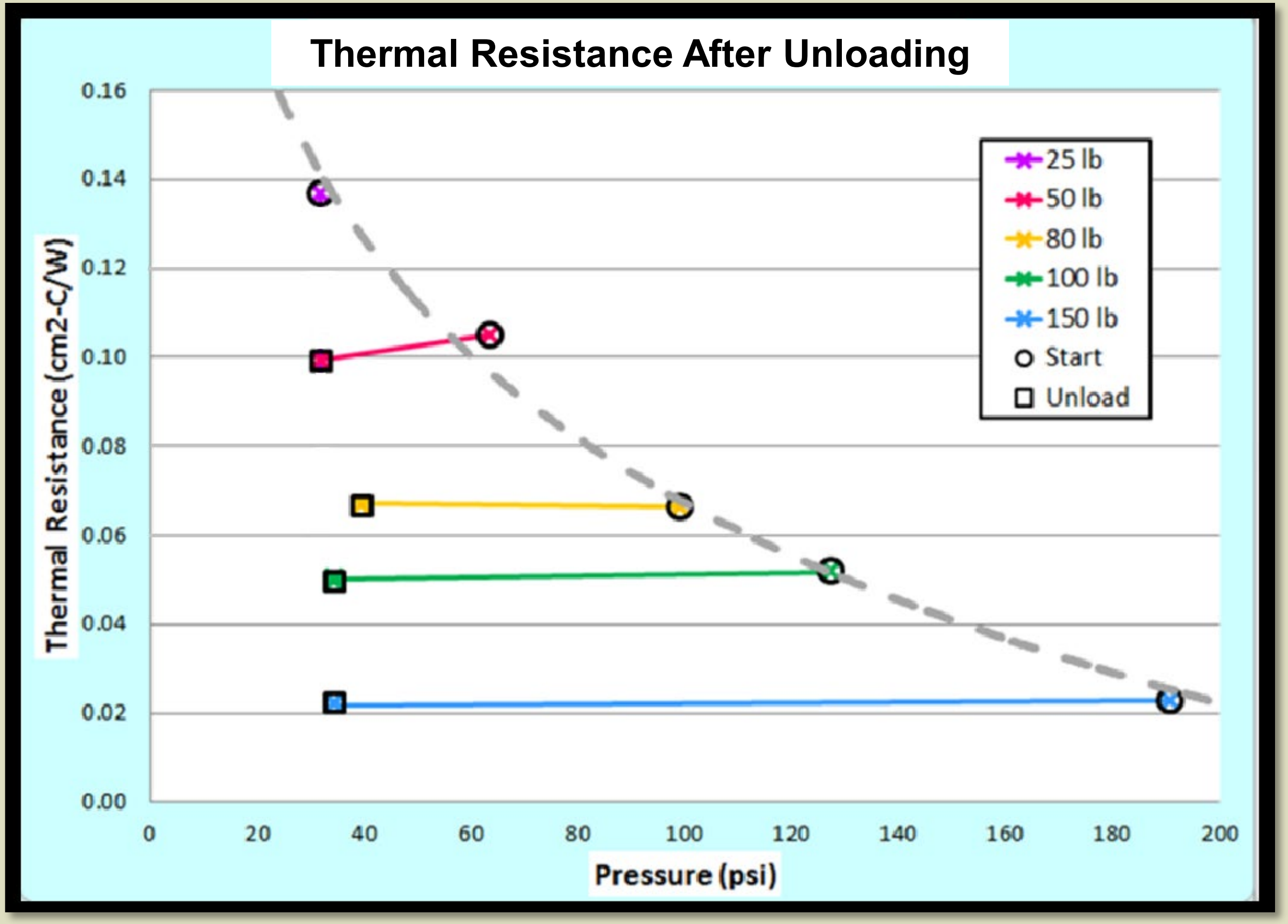
- Pure indium recommended for most applications

- Alternative alloy considerations:
  - TIM area and mechanism of compression
  - Maximum TIM operating temperature

Compressible Metal TIMs - Considerations

Pre-load Effects

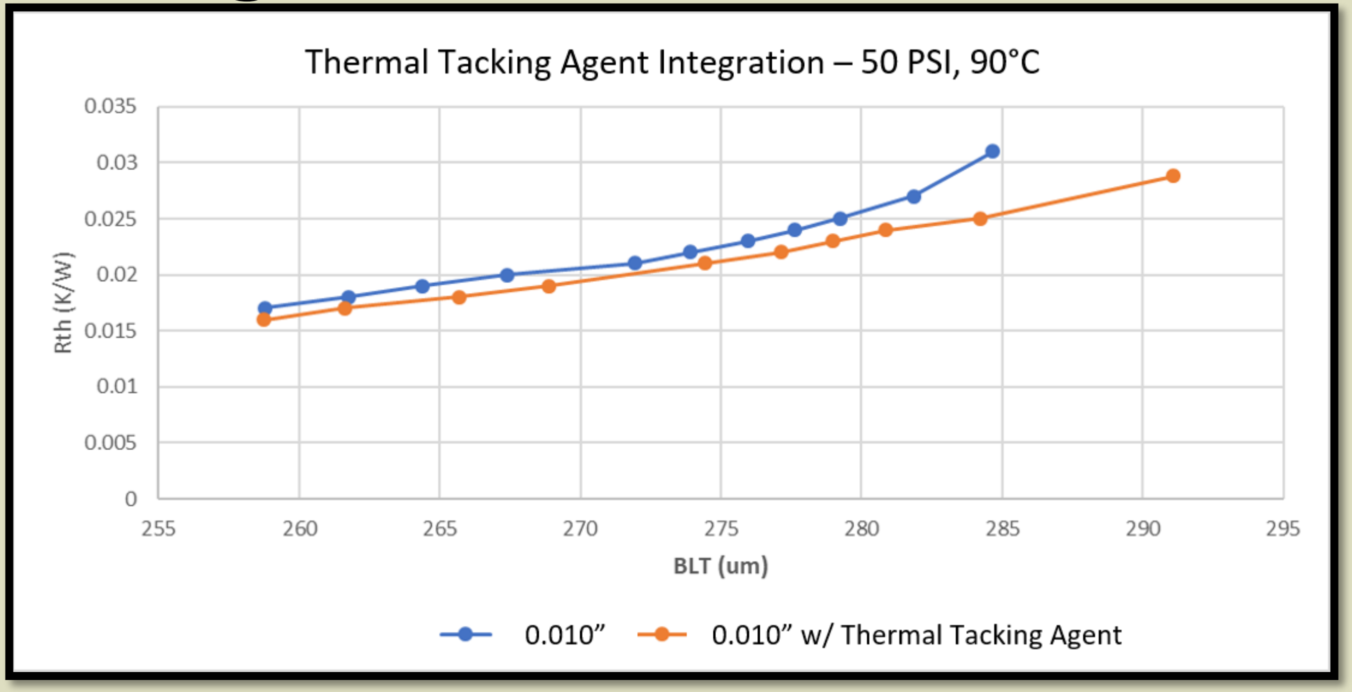
- Samples pre-loaded and unloaded
- Thermal resistance is determined by the contact formed at the peak load pressure
- Plastic deformation is maintained

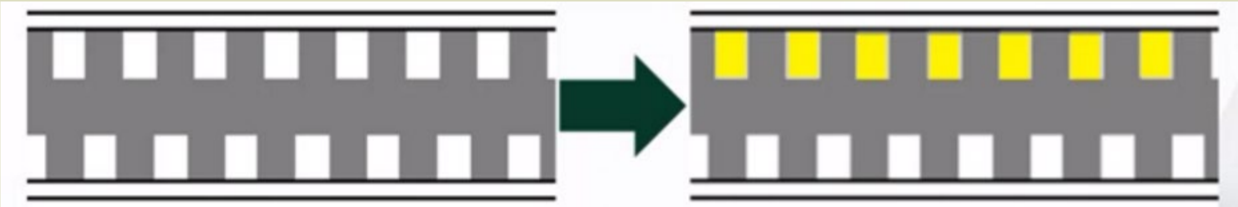


Compressible Metal TIMs - Considerations

Thermal Tacking Agent Integration

- Thermally conductive – improves thermal resistance (initial cycles)
- Maintains assembly alignment
- Not electrically conductive





Compressible Metal TIMs - Summary

- High-power applications require high-performing thermal interface materials
- TIM1.5 applications require metal compressible TIMs to have higher compliance at lower pressures
- Next Generation Pattern X TIM offers high compressibility, producing lower thermal resistance at lower pressures observed with curved, nonplanar surfaces

Contributions/Acknowledgements

[1] M. Lazić, S. Agarwal, “Liquid Metal Jetting for High-Performance Computing Applications”, iMAPS 2024

[2] M. Lazić, “Liquid Metal TIMs,” SEMI-THERM 2019.

[3] M. Lazić, R. McDonough, “High-Performance Phase Change Metal TIMs,” IPC APEX Expo 2023

[4] M. Lazić, A. Mackie, T. Jensen, D. Socha, “Solid Liquid Hybrid TIMs”, PCB Carolina

TestConX中国™ China

2025