ENERDYNE
SOLUTIONS

Phase Change Metallic Alloy TIM2 Performance, Reliability and Deployment

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Outline

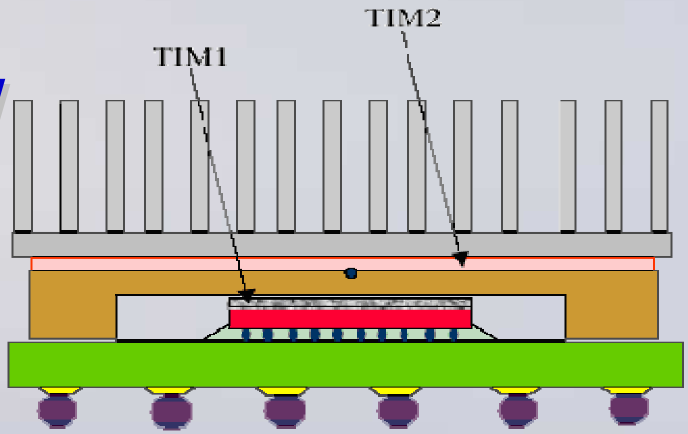
- PCMA & TIM2 Overview
- Testing
- Performance
- Reliability
- Interface Quality
- Deployment
- Next Steps

PCMA Overview

What is a PCMA?

- Phase Change Metallic Alloy or Low Melt Alloy (LMA)
- Alloys of Indium, Bismuth, Gallium, Tin
- Phase change typically 60-80°C
- Contains no organics
- May have a composite layer structure
- Typically in film/foil form
- High bulk conductivity
- High degree of wetting yielding low contact resistance

TIM2 Overview
Historic Qualities



Material	*Advantages*	*Disadvantages*
Thermal Grease	**High bulk conductivity** **Conforms to surface irregularities** **No cure** **Reworkable**	**Pump-out** **Phase separation** **Migration**
Polymer-solder Hybrid (PSH)	**Good bulk conductivity** **Conforms to surface irregularities**	**Cure needed** **Reflow needed** **Delamination** **Non-reworkable**
Phase-Change Metal Alloy (PCMA)	**High (metal) bulk conductivity** **Easy handling** **Reworkable**	**Reflow needed** **Pump-out** **Migration** **Voiding** **Oxidation**

Source: A. Dani, J. Matayabas, P. Koning, "Thermal interface material technology advancements and challenges—an overview", ASME InterPACK 2005, San Francisco, CA., July 17-22, 2005

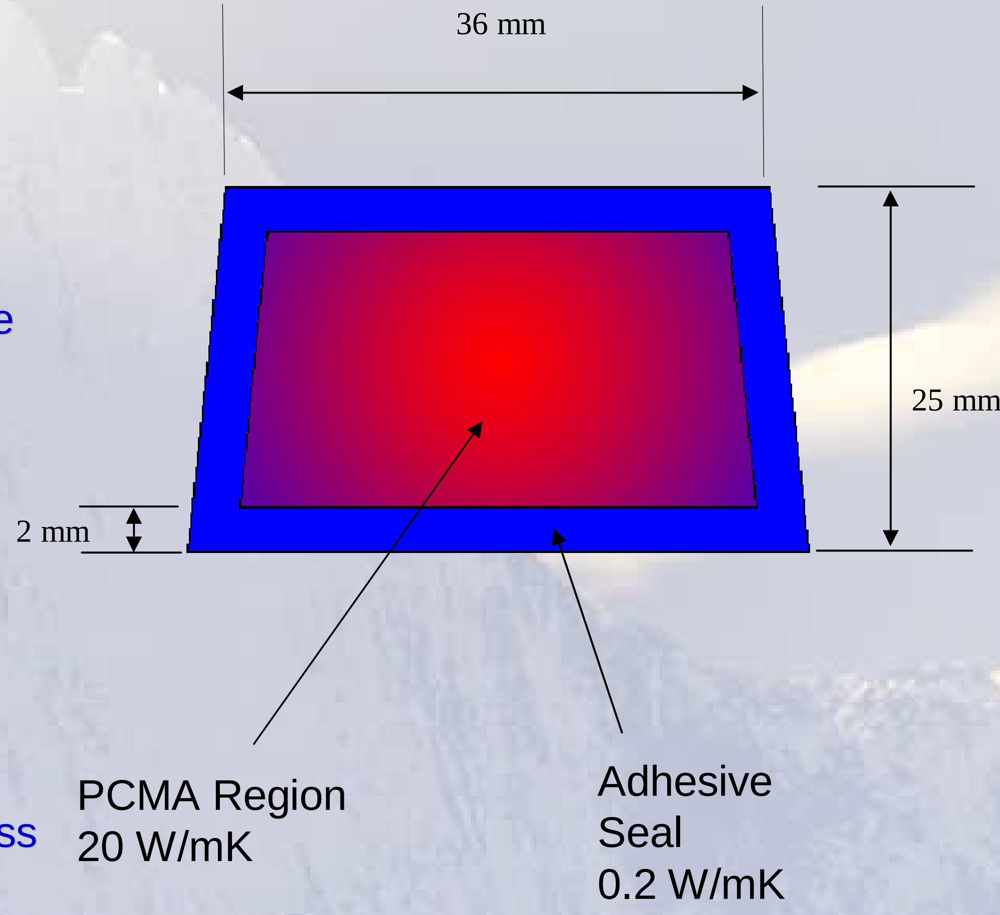
Testing—Overview

- Packaged Thermal Test Vehicles (TTVs)
  - EOL performance data
- In-situ Test Vehicles (ITVs)
  - Reliability testing

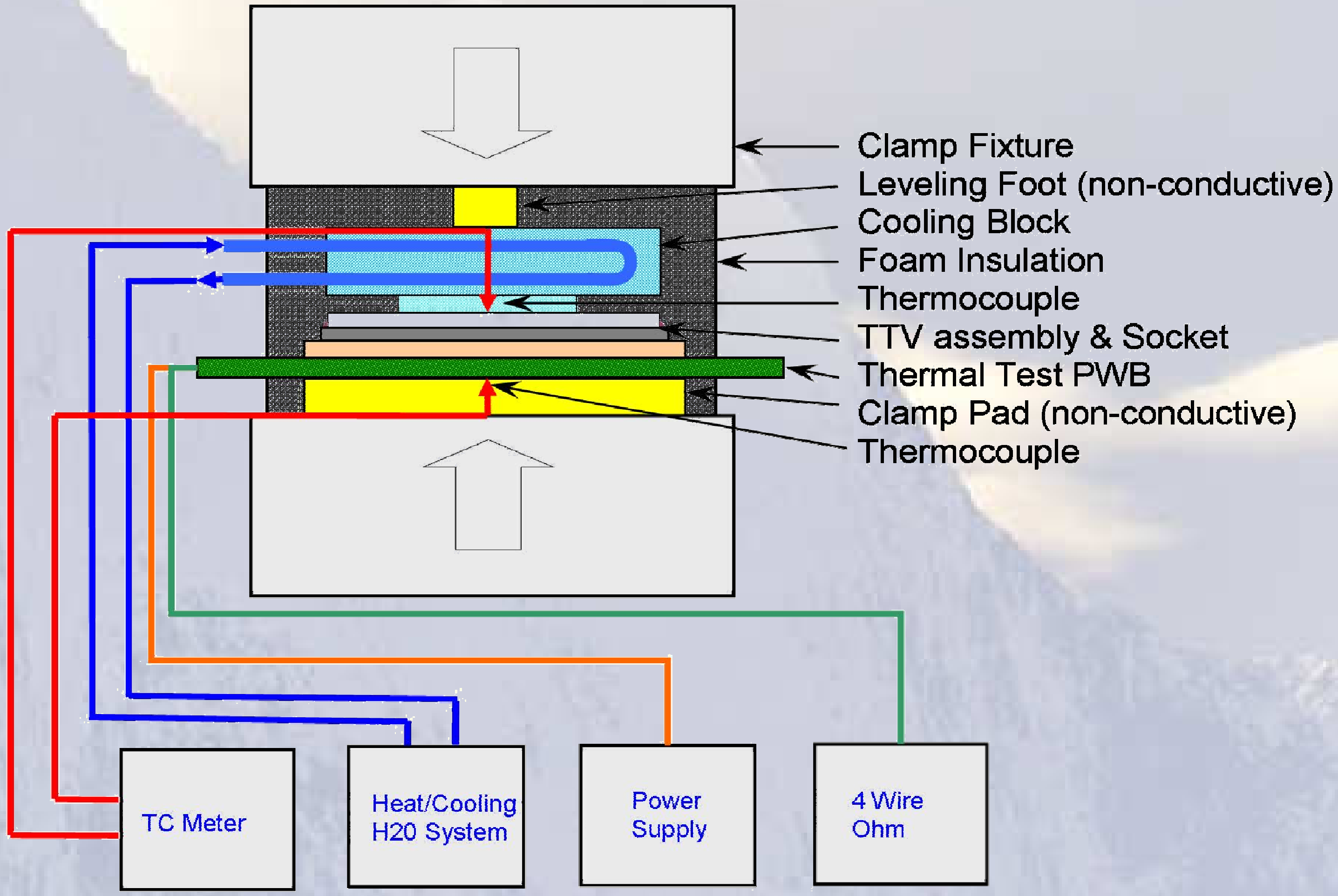
Testing—Indigo test part

Indigo Interface Dimensions:

- Parts used for testing based on specific customer implementation
- Indigo requires moderate clamping force between heat sink and component (~ 20psi)
- BLT is between 3 and 4 Mils
- Indigo design includes adhesive seal around perimeter (~2mm)
- Studies show that heat distribution across a heat spreader forms a bell curve (majority of the heat near the center)



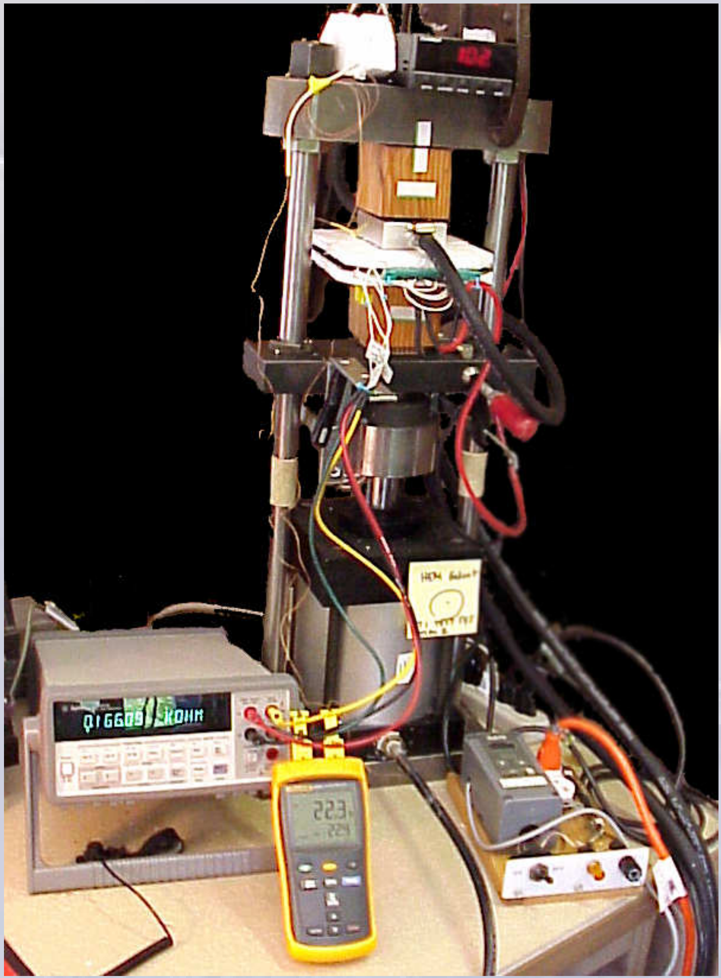
Testing—TTV Platform



Testing—TTV Details

Ceramic TTV
for Performance Data:

- 4.84 cm² die area
- 100 Watts
- 2 Mil BLT (shims)
- Ni plated Cu lid
- Uniform heat flux

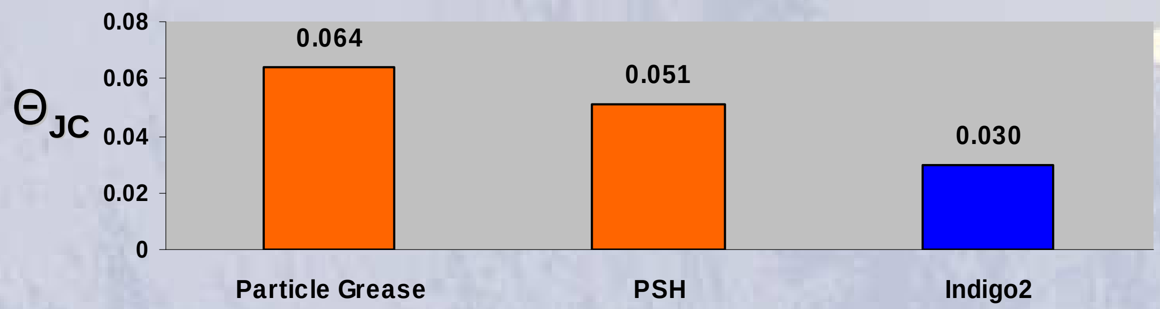


Performance

	Particle Grease	PSH	Indigo2
Composition	AL-filled polymer	PCMA within polymer	Indium-based
Phase Change Temperature (°C)	N/A	~30	~60
Thermal Conductivity (W/mK)	6	4	~ 20

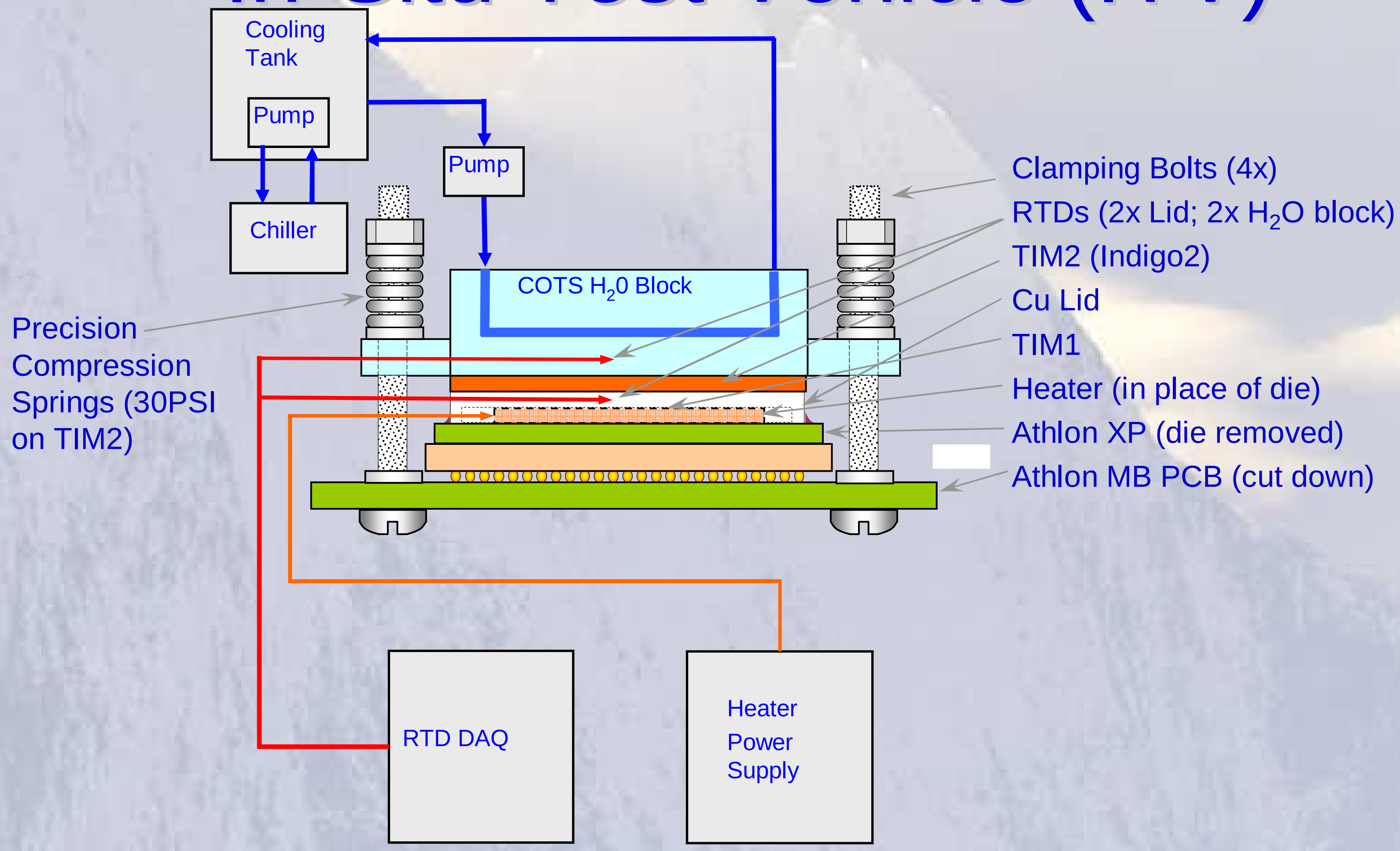
In-situ performance data

40-50% reduction of Θ_{JC}



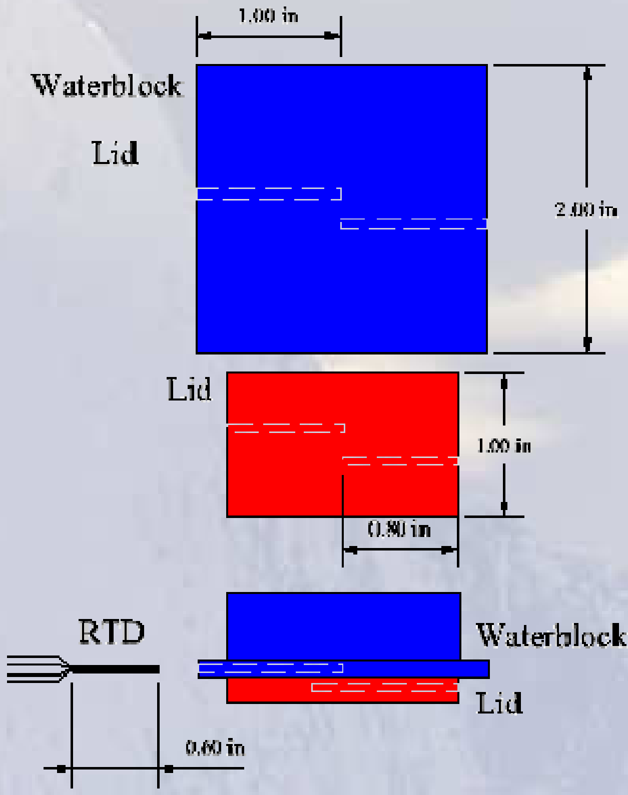
Reliability

In-Situ Test Vehicle (ITV)



Reliability
In-Situ Test Vehicle (ITV)

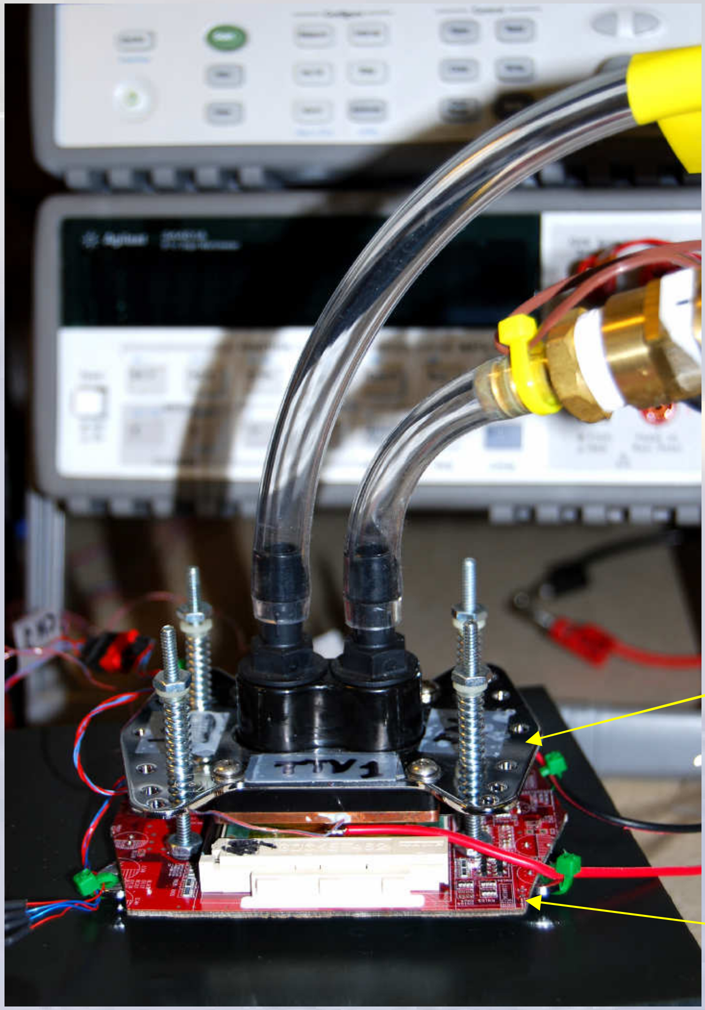
- Wells drilled into lid and waterblock to accommodate RTDs
- 2 wells in lid, 2 in waterblock
- Precision 4-wire RTDs



Reliability

In-Situ Test Vehicle (ITV)

- Vehicle Designed to simulate specific clamping force and heat source parameters during in-situ reflow
- Replicates CTE and thermomechanical forces on interface throughout environmental testing



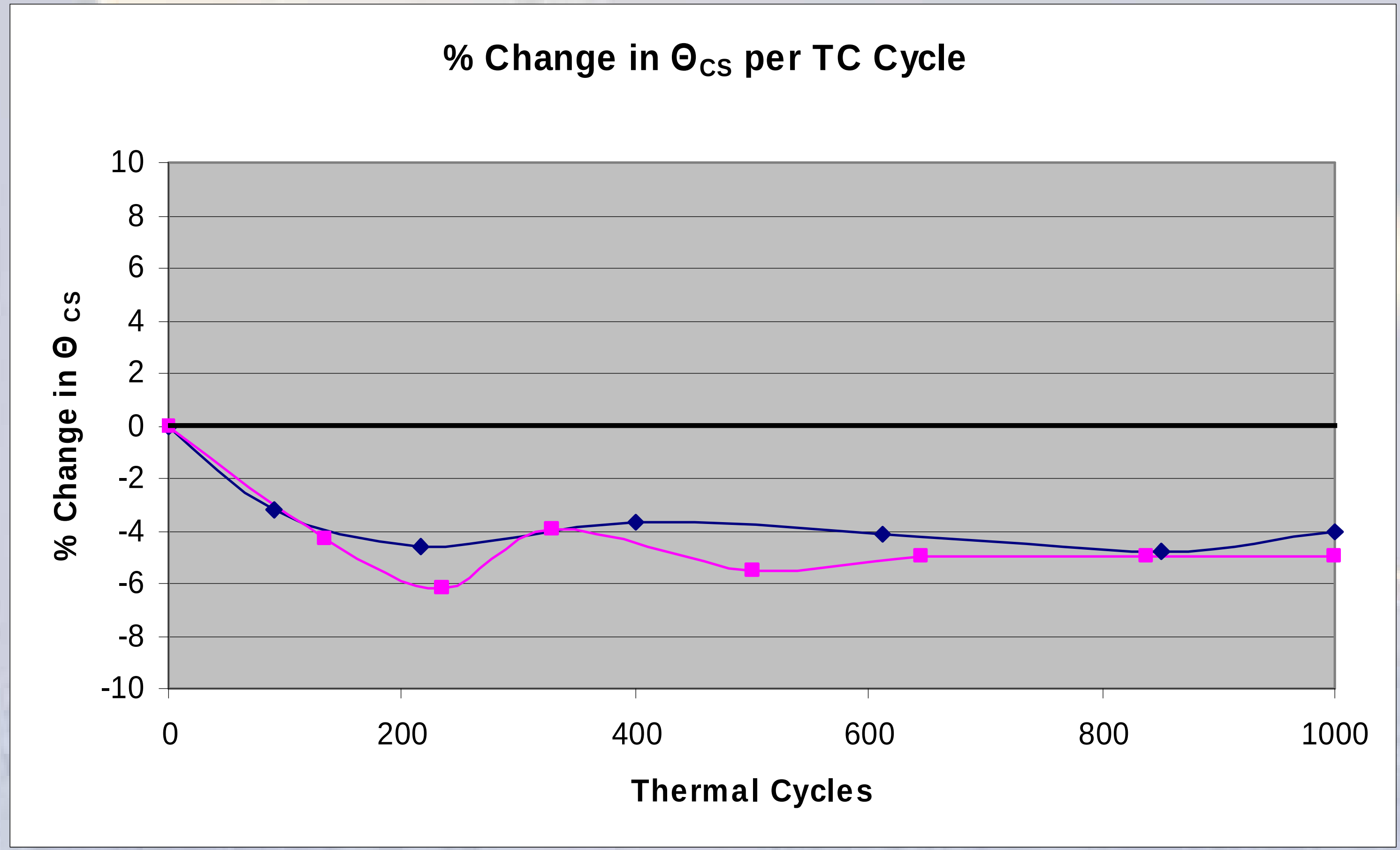
Reliability
Environmental Test Goals

Qualification Test	Test Condition
Temperature Cycling	0°C to 100°C, 10°C/min. ramp, 10 min. dwell, 1000 cycles
Elevated Temp. Bake/Soak	125°C, 500 hrs
Temperature and Humidity	85°C/85% RH, 500hrs
Cold Cycle	24°C to -30°C, 10°C/min. ramp, 30 min. dwell, 3 cycles

S. Pecavar, D. Kearns, M. Stern, J. Dunn, V. Gektin, B. Ong, T. Chen, “TIM2 Engineering Qualification Guidelines”, IMAPS Thermal ATW, 2005.

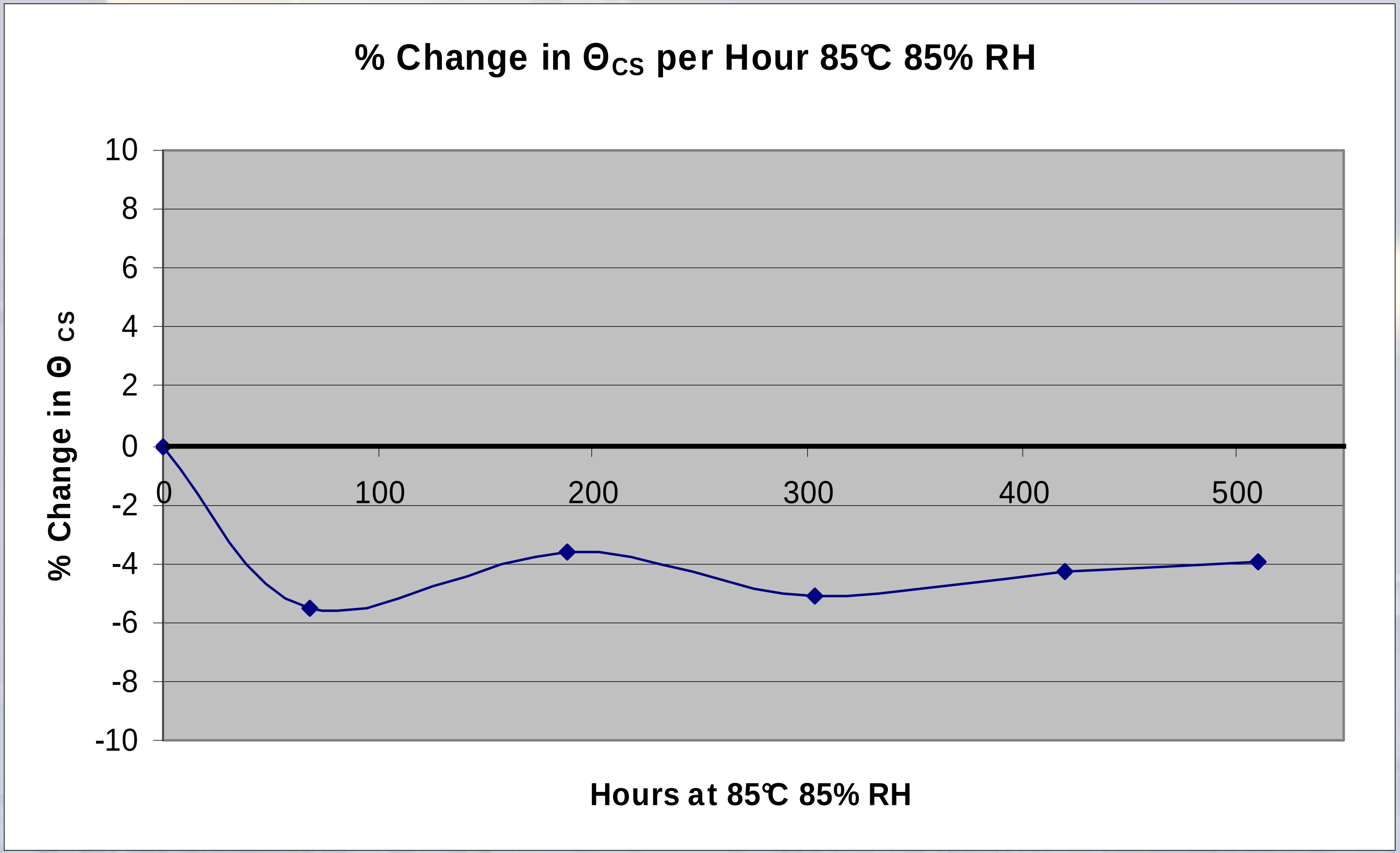
Reliability
Results-T/C

- JEDEC-J, 0-100°C 1000 Cycles
- Results for 2 parts
- BLT is reduced during first 100 hot cycles
- Measurement error < 5% between RTD, meter and comparative measurements



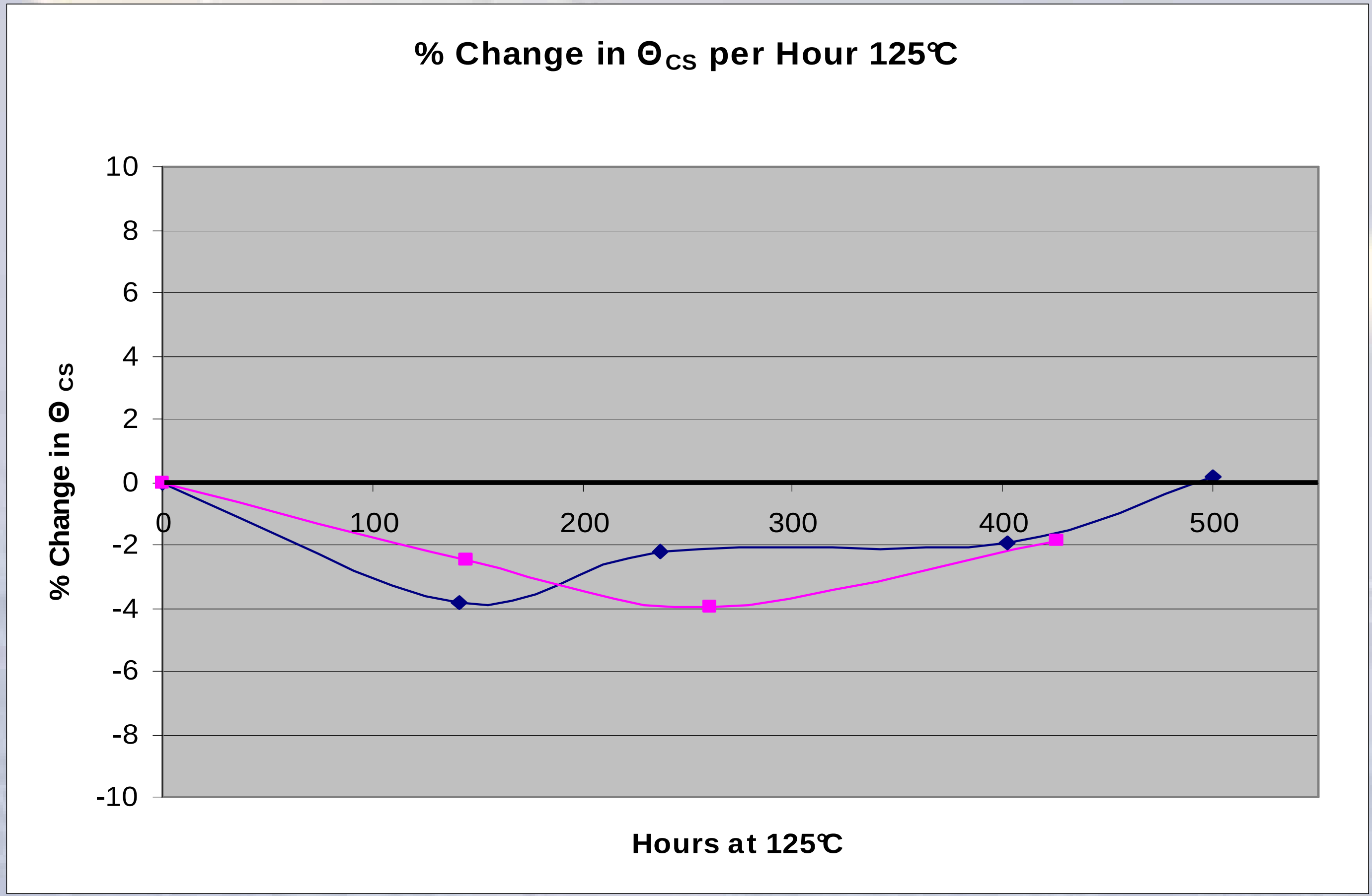
Reliability
Results-85°C/85% RH

- 85°C/85% RH for 500 Hours
- BLT is reduced during first 100 hours



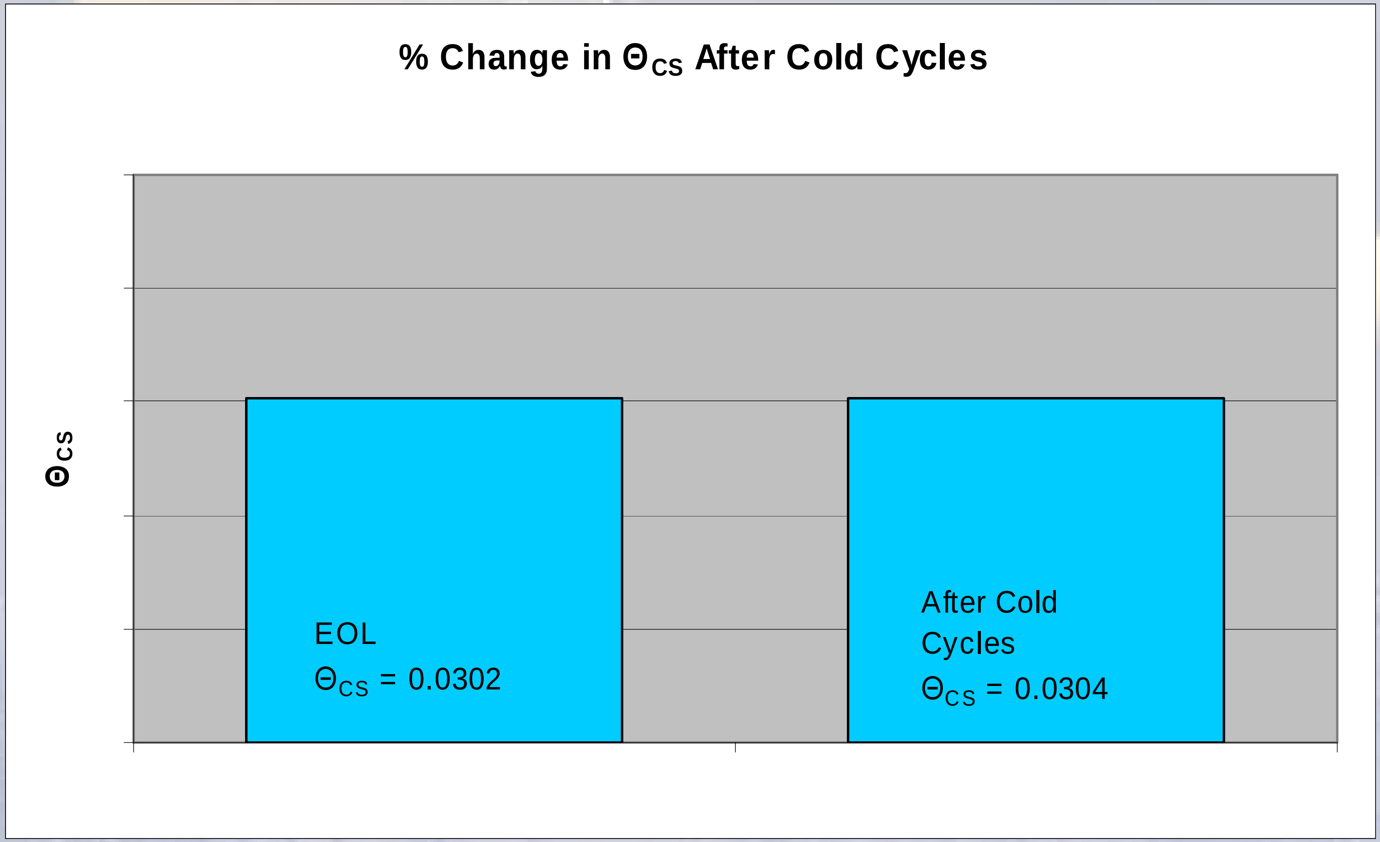
Reliability
Results- 125C Bake

- 125°C for 500 Hours
- BLT is reduced initially
- Actual degradation from EOL (<1%)
- Minor intermetallic formation



Reliability
Results-Cold Cycle

- Cold Cycle
- -30 to 24°C, 10°C/min ramp 30 min dwell 3 cycles total
- 0.6% change in Θ_{CS} within measurement error



Interface Quality
Void Fraction—EOL

- Typical void fraction < 2%
- On close examination of surface, texture of lid and heat sink visible on interface surface

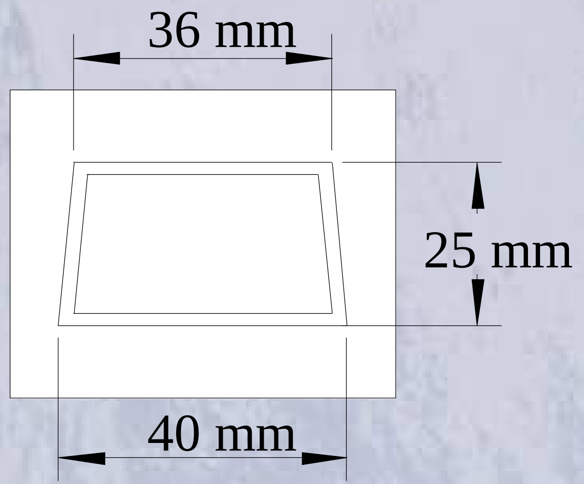
Interface removed from ITV at EOL

Corner torn during ITV disassembly

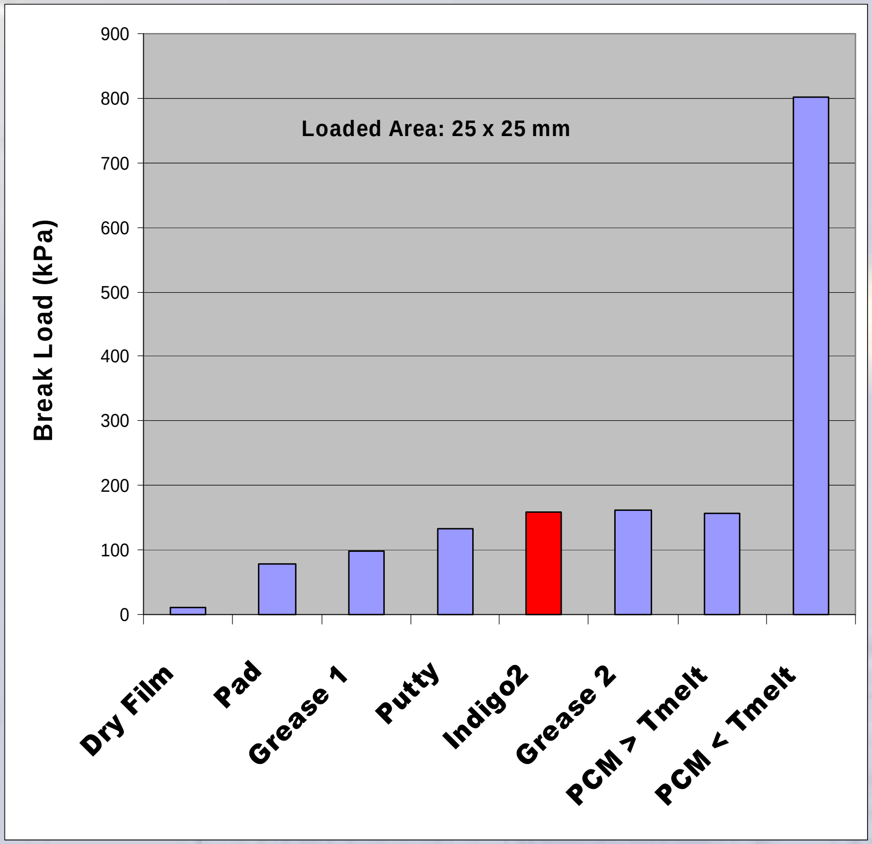
Deployment

Reworkability

- **1.5 in^2 component area**
- **Ambient temperature**
- **7 lbs/min. ramp (tensile loading)**
- **23.3 psi (160 kPa) break load**
- **Similar to PCM >Tmelt**



Test joint break load for a range of TIM types



M. Stern, D. Kearns, B. Ong, "Adhesion of Thermal Interface Materials for Cpu Heatsinks, an Overlooked Issue", Electronics Cooling Magazine, Feb. 2007.

Next Steps

- Shock/Vibe Testing
- Corroborate existing data with larger lot size
- Extend proven architecture to new applications: Lasers, power semiconductors, RF amplifiers, microprocessors, etc.

PCMA TIM2 Summary

- Design meets performance goal of 40-50% reduction of Θ_{CS} over greases or PSHs
- Qualifies TIM2 environmental testing
- Void fraction <2%
- Historic disadvantages of PCMAs have been overcome
- Reworkable
- Scalable to other applications

Thank you.

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