ENERDYNE
SOLUTIONS

Processor Performance, Packaging and Reliability Utilizing a Phase Change Metallic Alloy Thermal Interface System

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Outline

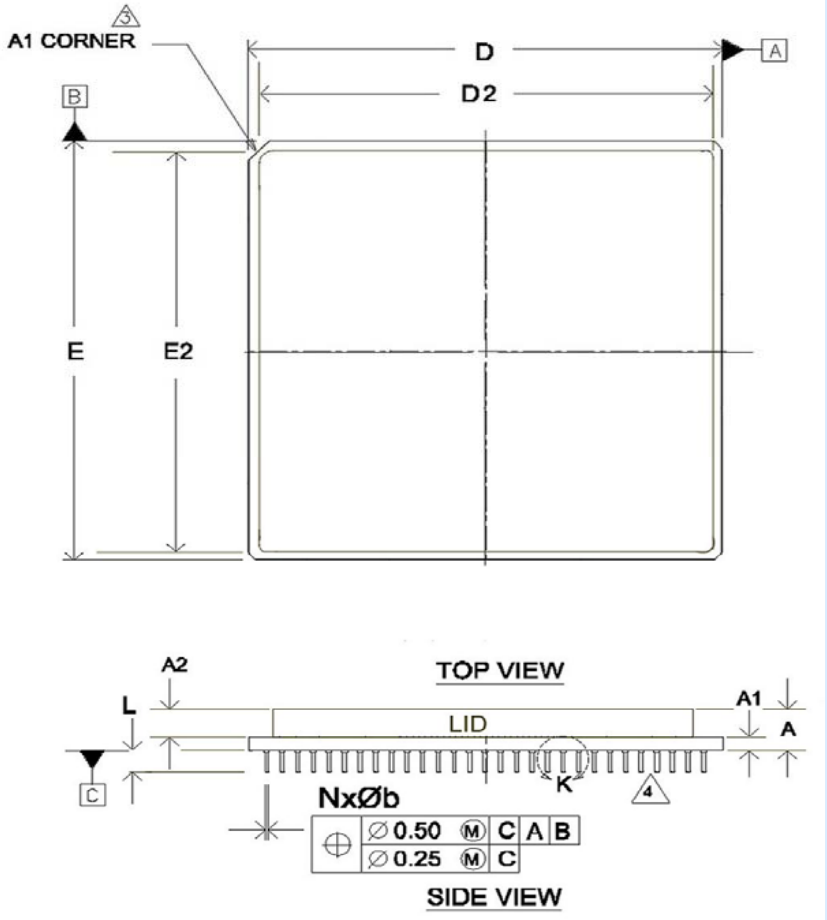
- Testing
- Performance Data
- Packaging & Reliability
- Next Steps
- Summary

Testing
Overview

- TIM1 interface tested
- Thermal Test Vehicles (TTVs)
- Θ_{jc} calculated
- Comparative data

Testing

Thermal Test Vehicles (TTVs)



- 1.4 cm^2 die area
- 80 Watts
- Uniform heat flux (57 W/cm^2)
- FCPGA package
- Ni-plated Cu lid

Testing

Value of TTV Testing

- Actual chip and lid surface finish, flatness and composition
- Simulate processor hot spots
- Test lid attach process qualities
- Assemblies can be environmentally stressed without disturbing interface

Testing

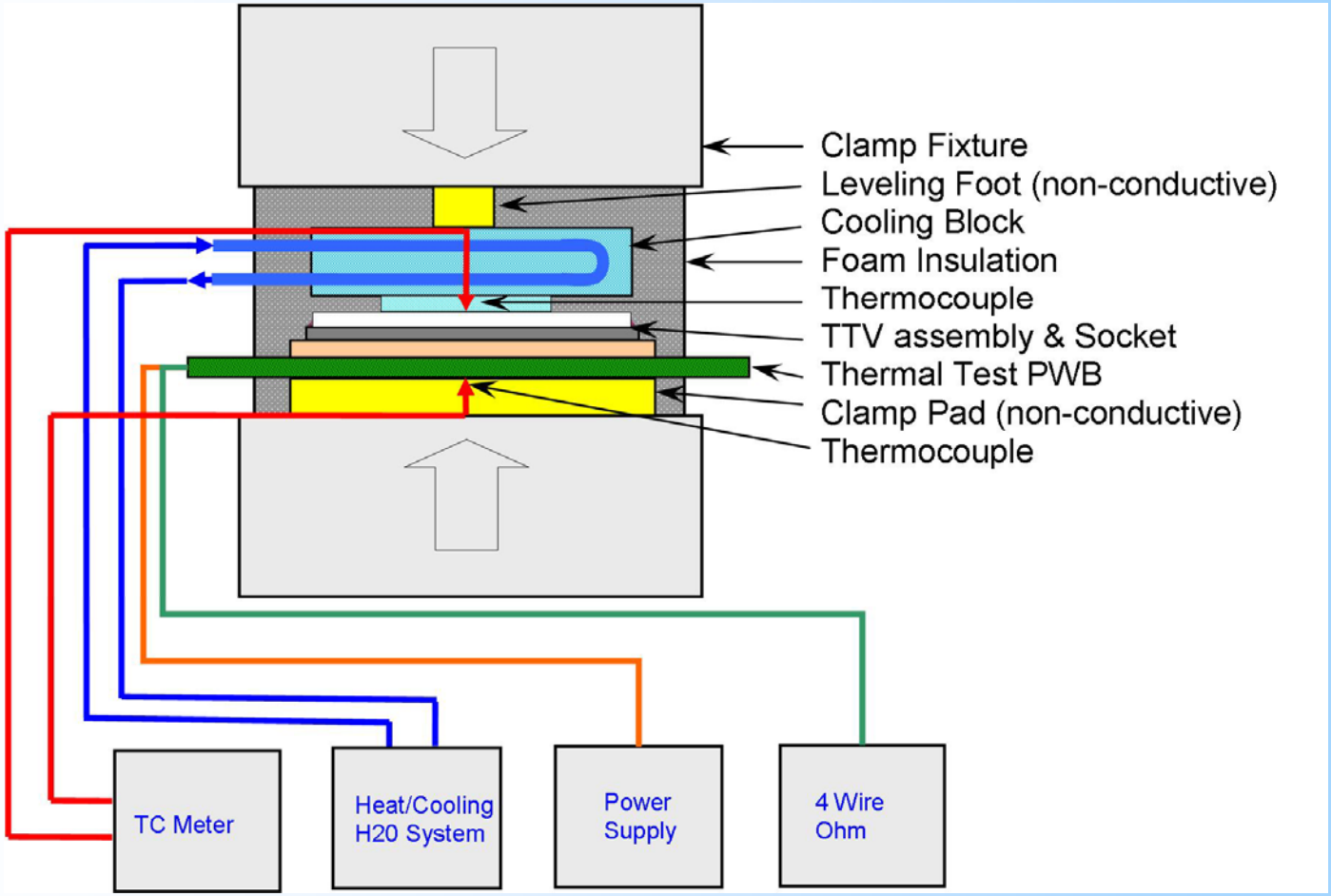
TIMs

	Shin-Etsu X23-7783D	*Chomerics T557*	*Enerdyne Indigo1*	*Indium Solder*
TIM Type	Grease	PSH	PCMA	Solder
Composition	Al-filled polymer	PCMA within polymer	Indium-based	Indium
Phase Change Temperature (°C)	N/A	43 / 65	~65	156
Impedance (°C-cm^2/W)	~ 0.07 (1 mil BLT*)	0.0625 (70°C, 50 psi)	< 0.04 (80°C, 40 psi)	0.07-0.08 (8-9 mil BLT)
Conductivity (W/mK)	6.0	3.0	> 20	80

* Extrapolated from BLT vs. impedance graph

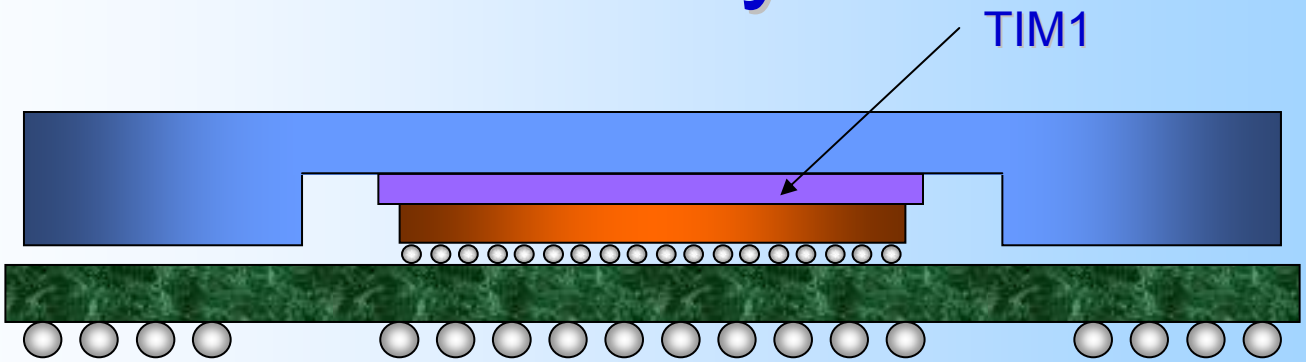
Testing

Platform



Testing

TTV Assembly



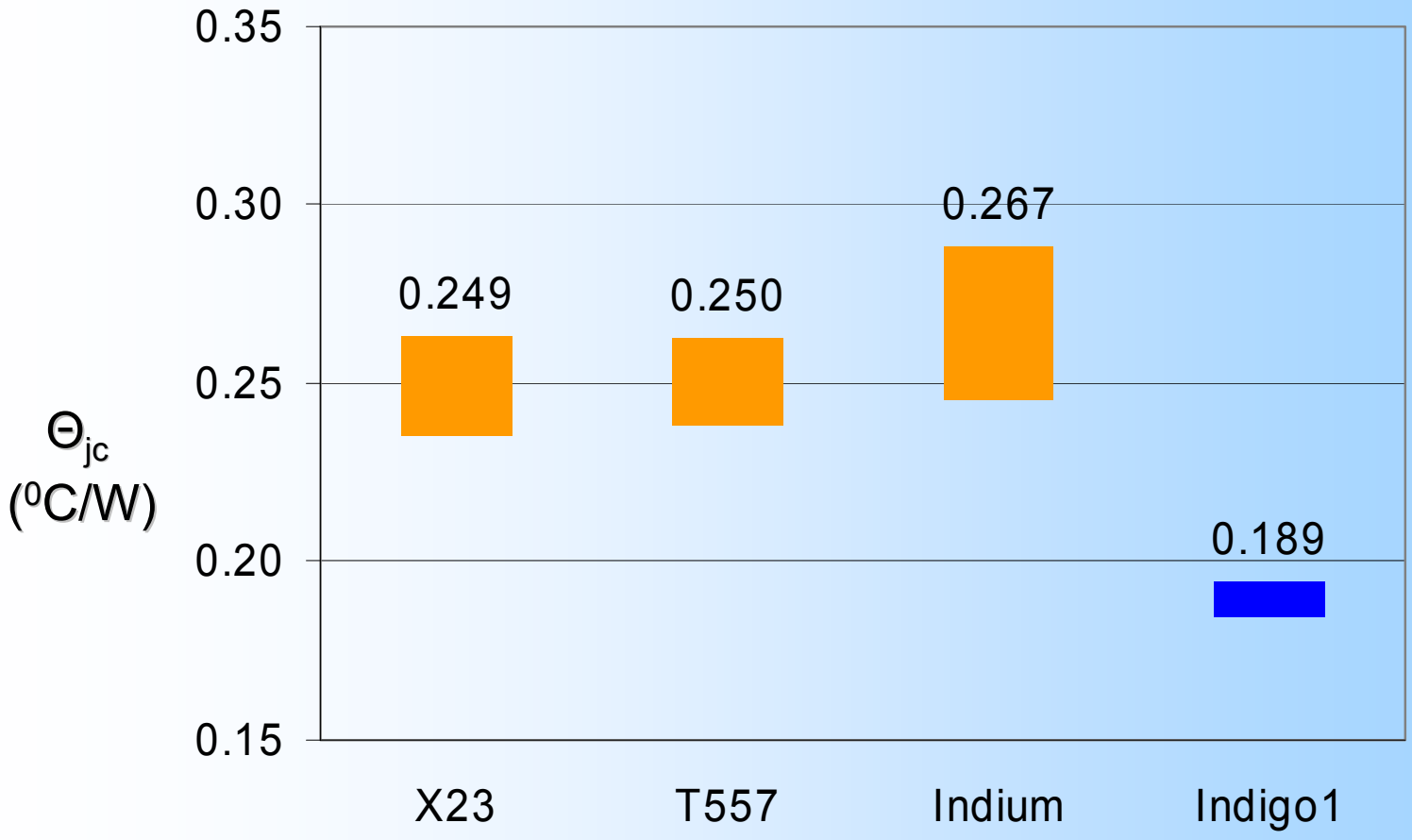
- 10 lbs force
- No lid seal
- Minimum Bondline Thickness (BLT)
- Gold metallization on Indium TTV

Testing

Methodology

- Calibration
- Bias of die
- Power, diode resistance & case temperature measured
- 3 measurements / sample
- Θ_{jc} calculated

Performance Data



Packaging & Reliability

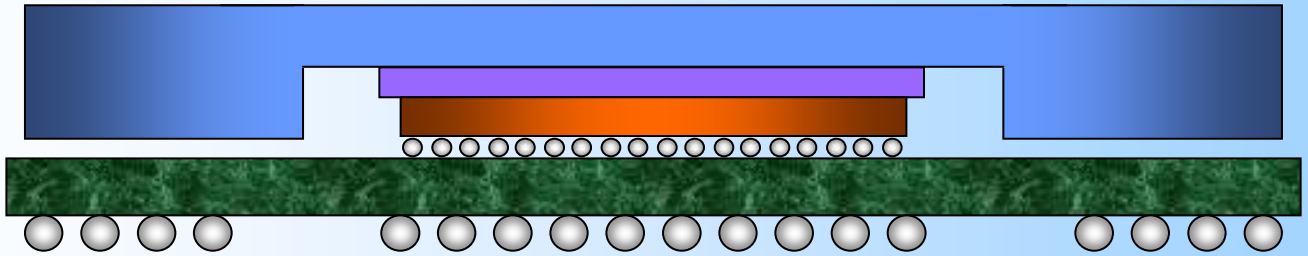
Historic TIM Qualities

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
Indium solder	▪ High (metal) bulk conductivity ▪ Easy handling ▪ No pump-out ▪ No migration	▪ Needs Au-plate for wettability ▪ Reflow needed ▪ Stress cracking, delamination ▪ Voiding

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

Packaging & Reliability

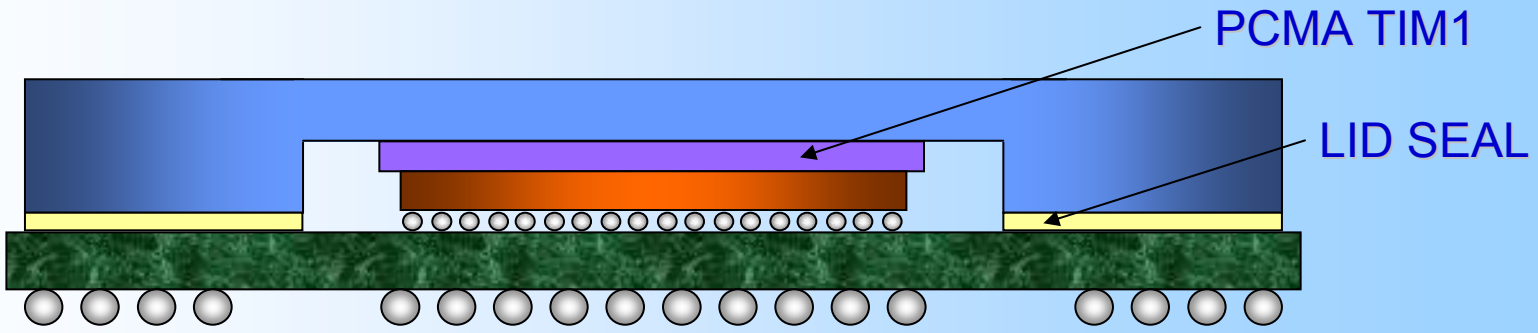
Overview



- Corrosion
- Migration
- Diffusion

Packaging & Reliability

Corrosion Mitigation

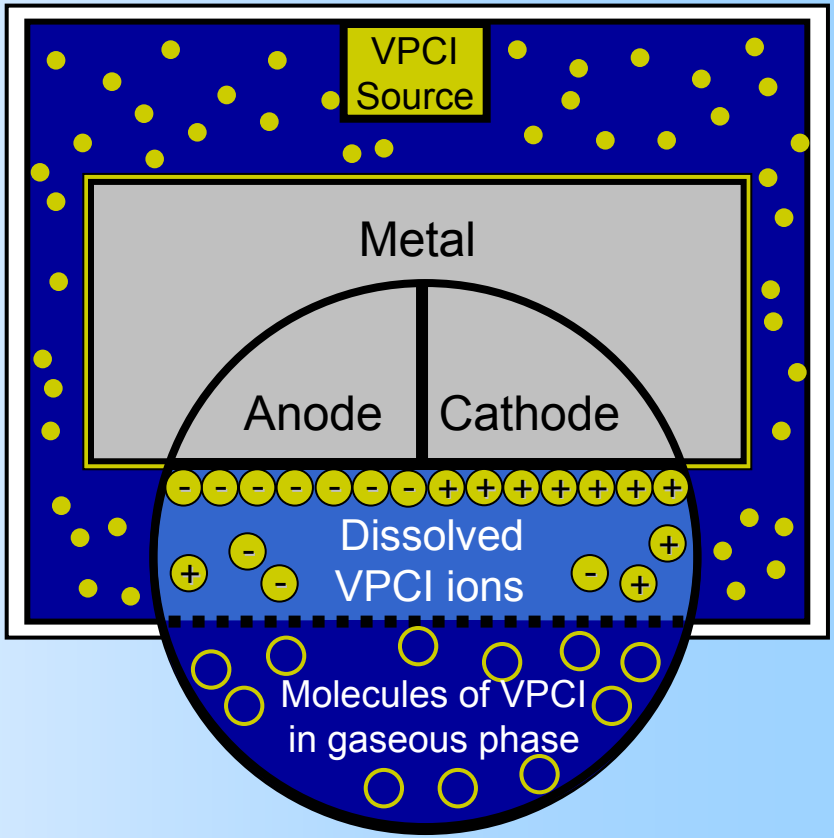


- Vent-free continuous lid seal
- Sealant with low vapor transmission rate
- Compatible with PCMA burn-in during lid attach

Packaging & Reliability

Corrosion Mitigation

- Lid seal facilitates controlled environ. within lid cavity
- Vapor Phase Corrosion Inhibitor (VPCI)
- VPCI ions on PCMA surface interrupt corrosion cell



Packaging & Reliability

Corrosion Mitigation

Indigo

1800 temp cycles

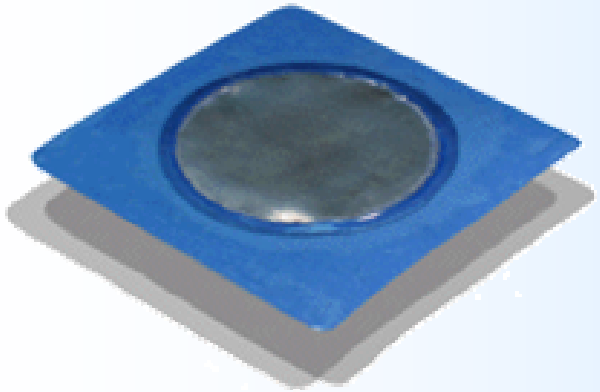
PCMA without mitigants

50 temp cycles

Temperature cycling—Service Condition “B”
-55°C to +125°C

Packaging & Reliability

Migration Control



- Deployment of perimeter barrier
- Secondary containment by lid seal
- Passed shock test (Service Condition “E”)
- Passed vibration test (Service Condition “4”)

Packaging & Reliability

Diffusion

Material	$D_{100°C}$ (cm^2/sec)	Penetration Depth after 10 Years
Aluminum	4.06×10^{-47}	<1 nm
Copper	1.22×10^{-15}	~ 10 µm
Gold	1.50×10^{-18}	< 1 µm
Indium	3.30×10^{-52}	<1 nm
Bismuth	7.23×10^{-60}	<1 nm

- Insufficient energy at typical operating temperatures for measurable diffusion
- Significantly more diffusion of AuSn from eutectic die bonding

Next Steps

- Complete TTV environ. tests
- Reduce voids to <2%
- Further customer qualification
- TIM2 development

PCMA Thermal Interface Summary

- 25-30% reduction of Θ_{jc}
- No chip metallization required
- Corrosion mitigation demonstrated
- Migration controlled
- Negligible diffusion in Silicon

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Thank you.

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