Reliability and Performance of a Low Melt Alloy-based Thermal Interface System

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Outline
TIM1Thermal Interface System

The Problems and The Challenges
- Failure Mechanisms

Our System Approach - Indigo™
- Performance
- Mitigations

Case Example

Next Steps

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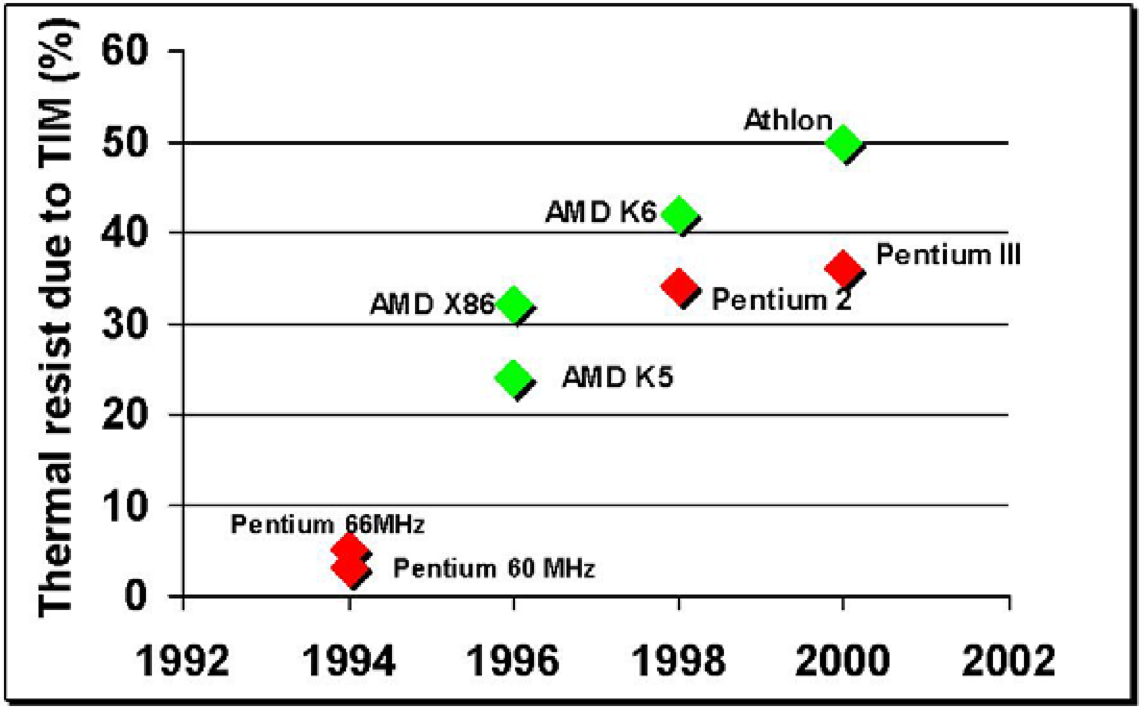
Industry Problems

Higher heat flux densities

More of overall thermal budget consumed by TIM1 interface

Heat sinks of higher efficiency required to offset TIM1 resistance



"Materials for Thermal Management", Dr. Nancy Dean, Advanced Packaging, March 2003, p. 16

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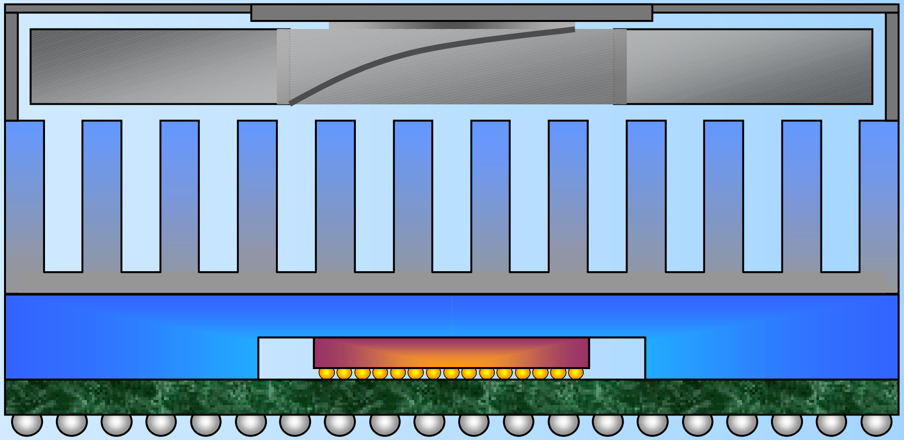
Development Challenges

- Ease of deployment
- High thermal performance
- Low cost
- Reliable



Development Challenges

What is a Low Melt Alloy (LMA) TIM?

- Typically alloys of Indium, Bismuth, Gallium, Tin
- Contains no organics
- Liquid at operating temperature of component
- High bulk conductivity
- High degree of wetting yielding low contact resistance

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Development Challenges

Historic LMA Failure Mechanisms:

- Oxidation/Corrosion
- Intermetallic formation
- Migration

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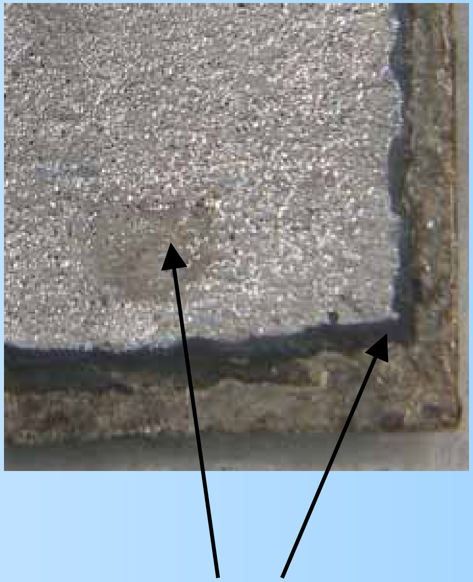
Development Challenges

The Prior Art

LMA foil

(as supplied)

24 hrs in 85 ^{0}C, 85% humidity



Corrosion products

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Development Challenges

The Prior Art

Foil-based LMA, 61.1 ^{0}C phase change

STRESS CONDITION	RELIABILITY DATA (R_{jp})
End of Line	0.27 (^{0}C/W) T = 0
T/C (-45 ^{0}C to +125 ^{0}C)	0.82 (^{0}C/W) After 50 cycles
Bake (125 ^{0}C)	0.35 (^{0}C/W) After 144 hours
HAST (130 ^{0}C/ 85% RH)	0.68 (^{0}C/W) After 50 cycles

- "Good Initial Performance"
- "Poor reliability due to oxidation"

S. Lee, P. Chen, "Development of High Performance Thermal Interface Material", Intel Technology Symposium, Seattle, Washington, September 27-28, 2001.

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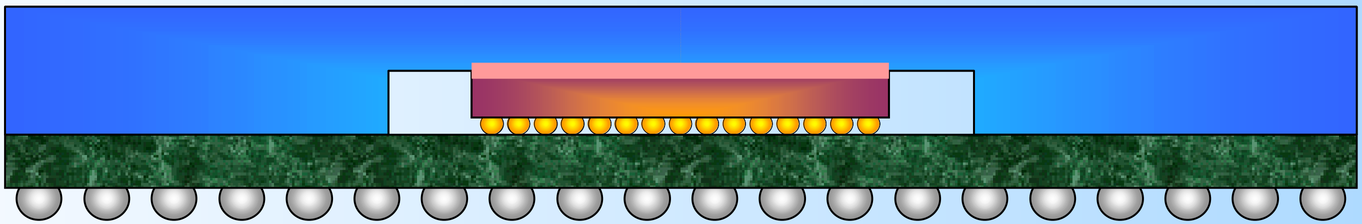
System Approach



- Combination heat spreader lid and TIM1
- Low Melt Alloy TIM1
- High conductivity heat spreader lid
- Proprietary modifiers

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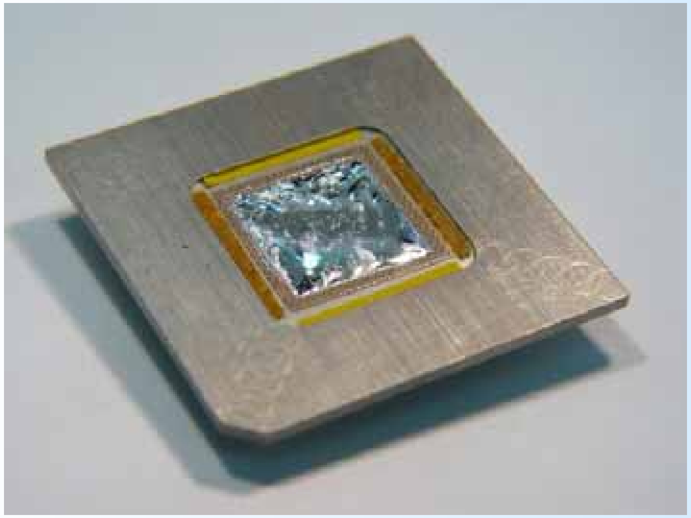
Performance



- TIM1 conductivity >20 W/mK*
- TIM1 Impedance < 0.04 C-cm^2/W*
- Lid conductivity = 390 W/mK

*Conductivity measured by Laser Flash method

*Impedance measured by ASTM D5470 method (@ 20psi)

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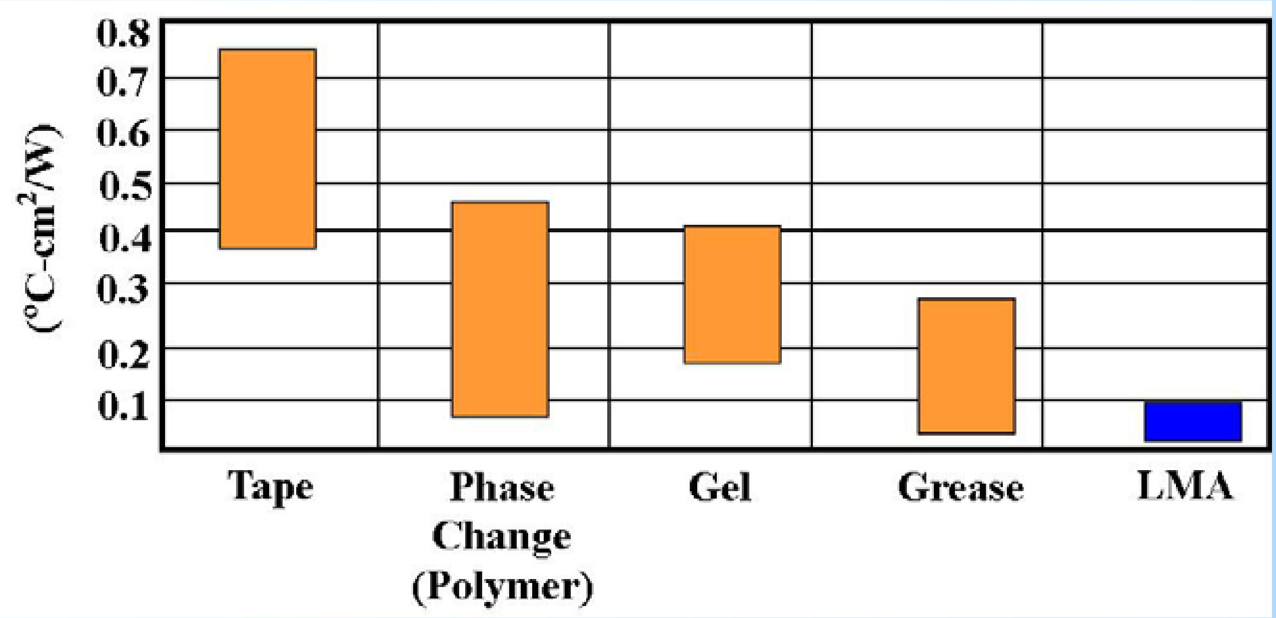
Performance

LMA thermal performance exceeds all organic TIM materials



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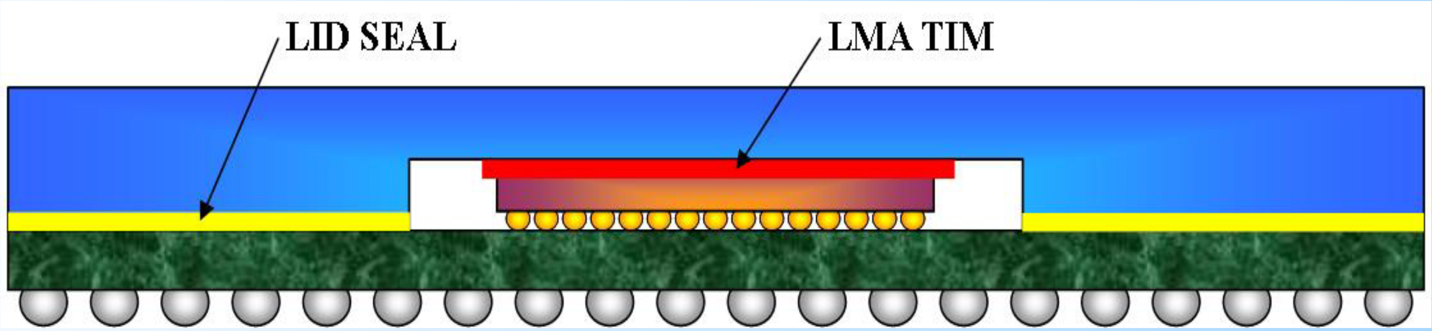
Oxidation/Corrosion



3 layers of mitigation:

- Reduce the amount of moisture penetrating package
- Neutralize remaining moisture in cavity
- Reduce corrosion activity of LMA by surface modification

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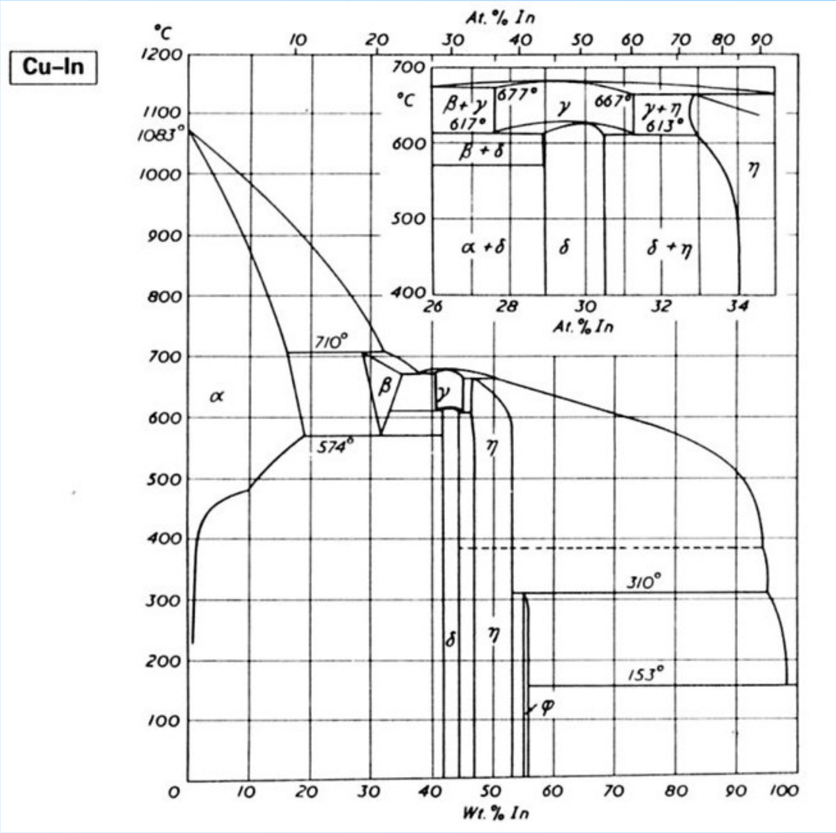
Intermetallics

- Indium-based LMAs are incompatible with copper surfaces
- LMAs containing Gallium are incompatible with Aluminum and Copper
- Nickel plating or other deposited materials necessary



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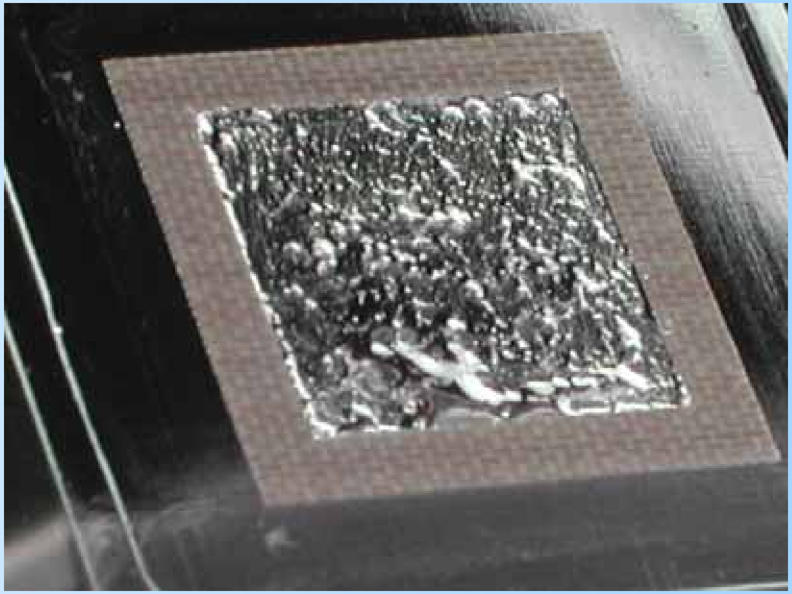
Migration

- Deployment of perimeter barrier
- Optimize surface finish to increase surface tension
- Modification of LMA viscosity
- Secondary containment by lid seal



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Reliability Requirements

RELIABILITY REQUIREMENTS	
ENVIRONMENTAL STRESS	**TEST CONDITION**
Temperature Cycling	Test Condition "B" (-55 °C to +125 °C) (JEDEC No. 22-A104-B)
Power/Temperature cycling	40 °C to 80 °C, 6 min/cycle, avg. RH= 65%
Bake	@ 125 °C
Shock	Service condition E (drop height 33cm, velocity change 254 cm/sec, peak acceleration (G) 340, pulse duration 1.2 ms (JESD22- B104-B)
Vibration	Service condition 4 (peak acceleration (G) 1.0, peak- peak displacement (in/mm) 0.020, frequency range (Hz) 5-500 (JEDEC No. 22-B103-B)
Temperature Humidity life test	(85 °C, 85% RH)

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Test Results

TEST RESULTS	
ENVIRONMENTAL STRESS	**θ_{jc} IMPEDANCE CHANGE**
Temperature Cycling	< 5% after 50 cycles
Power/Temperature cycling	< 5% after 5,000 cycles
Bake	< 5% after 100 hours
Shock	< 5% after 6 drops
Vibration	< 5% after 4 minutes
Temperature Humidity life test	< 10% after 750 hours

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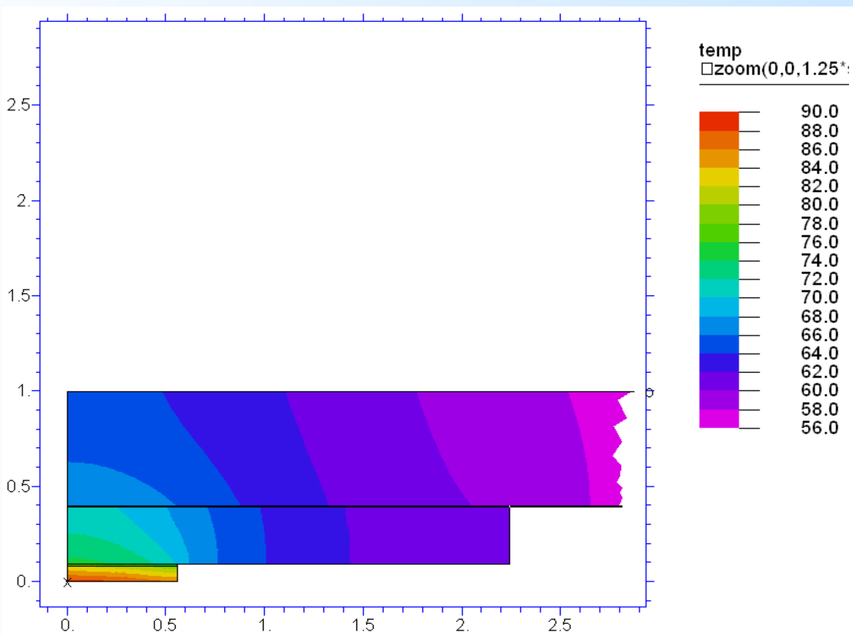
Microprocessor with LMA System

6°C (~11°F) reduction over Cu lid with best silver greases

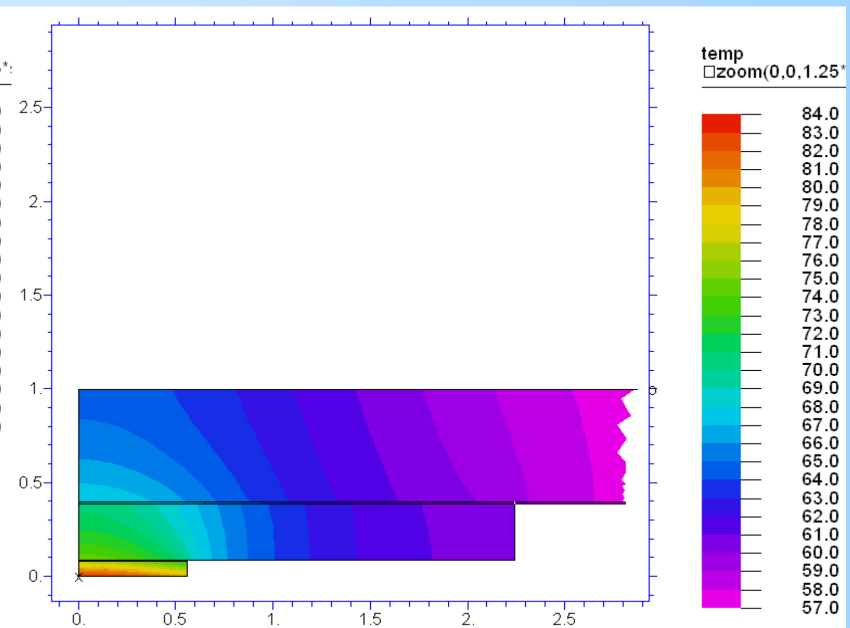
LMA TIM1

1 cm² 80 W die

Ag Grease TIM1



1 mil BLT, 20 W/mK



2.5 mils BLT, 5 W/mK

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Next Steps to Commercialization

- Additional cycling, bake, HAST data
- Evaluation samples
- Manufacturing considerations
- Customer qualification

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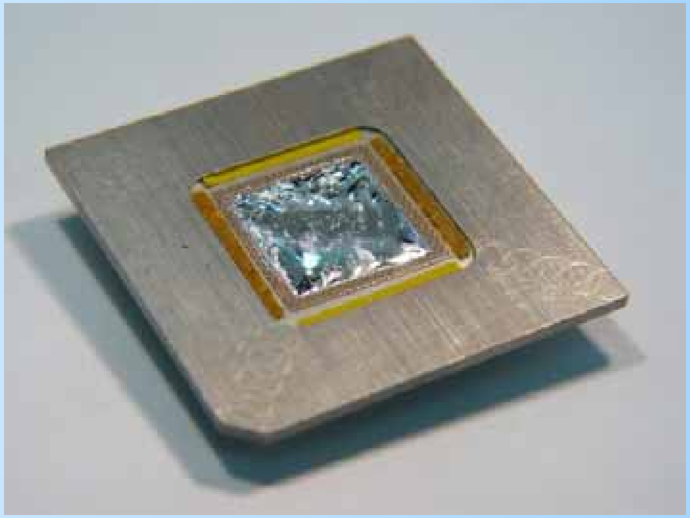
LMA Thermal Interface System Summary

- Outstanding thermal performance
- Modest cost
- Low adoption risk
- Robust
- Simplified deployment



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Thank you.

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