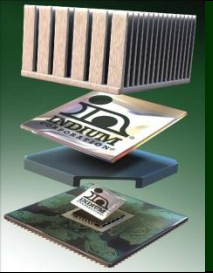
# Indium Corporation

**Feb 2nd 2012**


# IMAPs La Rochelle

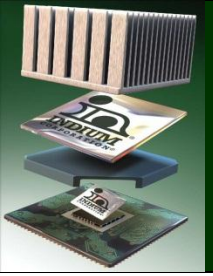
Graham Wilson
Applications Engineer
Tel: +44 (0)1908 580400
Mobile: +44 (0)7825 189554
E-mail: gwilson@indium.com
Web: www.indium.com





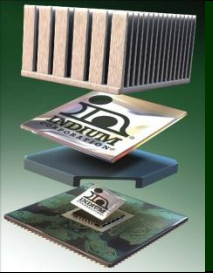
# Agenda

- Indium Corporation
- Market Sectors
- Focus on TIMs
- HeatSpring Data





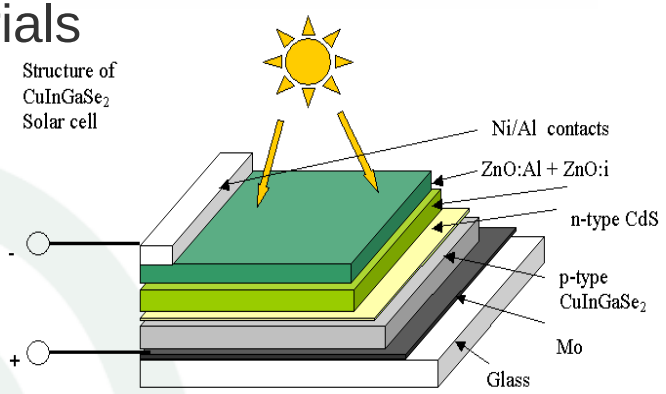
# Indium Corporation Worldwide: Manufacturing and Sales Offices

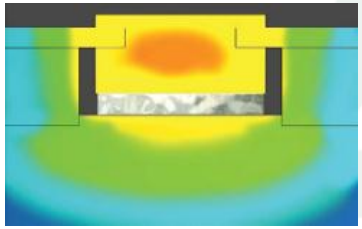


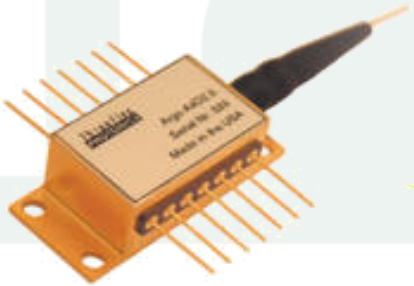


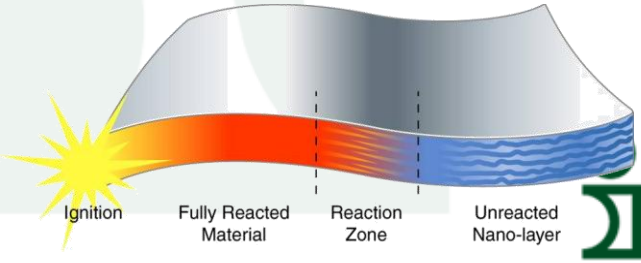
# Markets

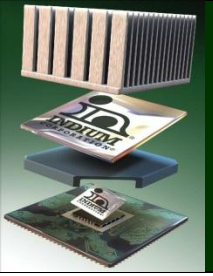
- **Solder & Energy Business Unit**
  - PCB Assembly Solder Materials
  - Engineered Solder Materials
  - Semiconductor Packaging Solder Materials
  - Thermal Interface Materials
  - Alternative Energy (PV) materials
  - NanoFoil® and NanoBond®





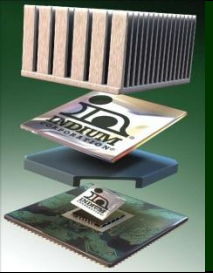






# Thermal...we want it cool!

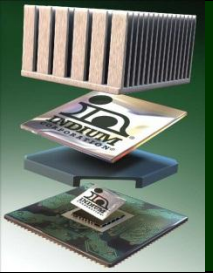
**Our Goal** is providing **High Quality Materials** that give **Extended Reliability** to **Applications** both in **Operation** and in **Service**





# Metal Thermal Interface Materials Forms

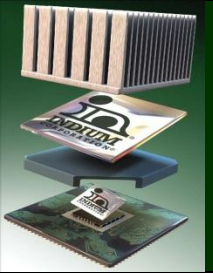
- **Solder**
  - Paste
  - Preforms
  - Wire
- **Types of Solder**
  - Indium
  - Indium Containing Alloys
  - Gold Tin, or Gold containing
  - Lead Containing and Lead Free





# General Review of Indium TIMs

- **Solder TIMs means the TIM**
  - reflowed
  - intermetallic is formed, sTIMs
- **SMA-TIMs, soft metal alloy, or compressible TIMs**
  - Flat Foil
  - Compressible Surface Altered Foil, Heat-Spring®
  - Not Reflowed
- **Phase Change TIMs**
  - applied as a solid and the heat-source changes the physical state of the TIM to a liquid metal.
- **Liquid TIMs**
  - Liquid at room temp and in operation

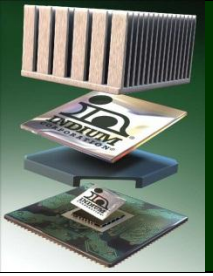




# Compressible Metal Thermal Materials

- **SMA-TIM, soft metal alloy thermal interface material**
  - Pure Indium Preforms
  - Indium Containing Alloy Preforms
  - Pure Gold
  - Pure Tin
  - Pure Silver
  - Indium with diffusion barrier TIMs for Burn-in

- **Heat-Spring® or surface altered TIMs**
  - Heat spring pattern D – (HSD)
    - min 76micron after full compression
    - Compensates up to 76micron non-planarity





# Compressible Metal Thermal Materials

## High thermal conductivity

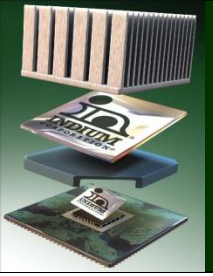
- Low bulk resistance—insensitive to BLT
- Heat spreading
- Metal to Metal

## Conformability

- Plastic deformation provides low contact resistance path, especially after time zero (burn-in period)
- Inherent gap filling for co-planarity issues: +/- 76um
- Complies with CTE mismatch

## Stability

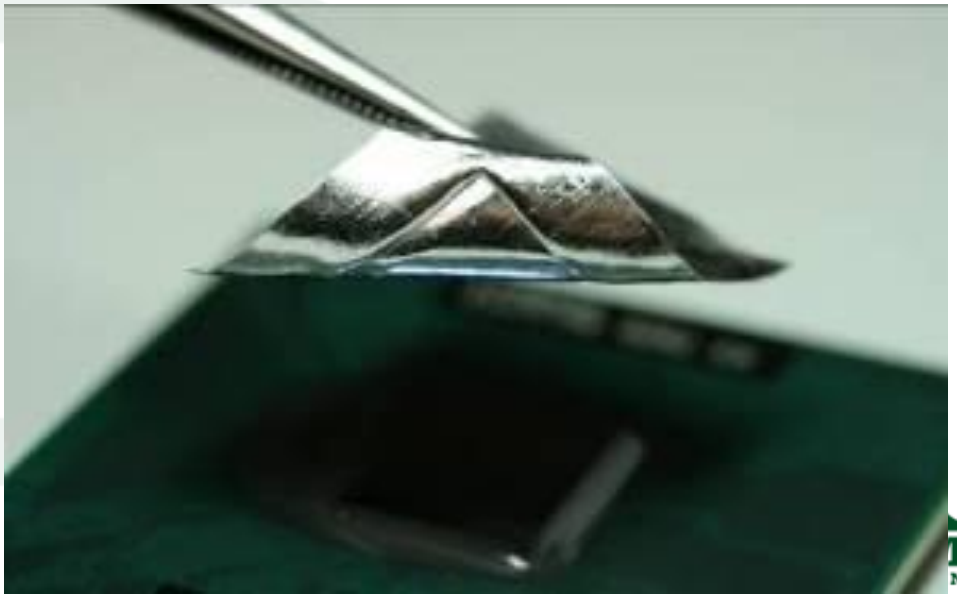
- No bake-out or pump-out issues

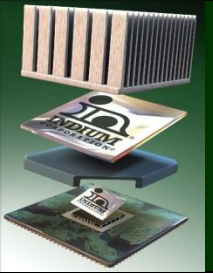




# Heat-Spring®: What is it?

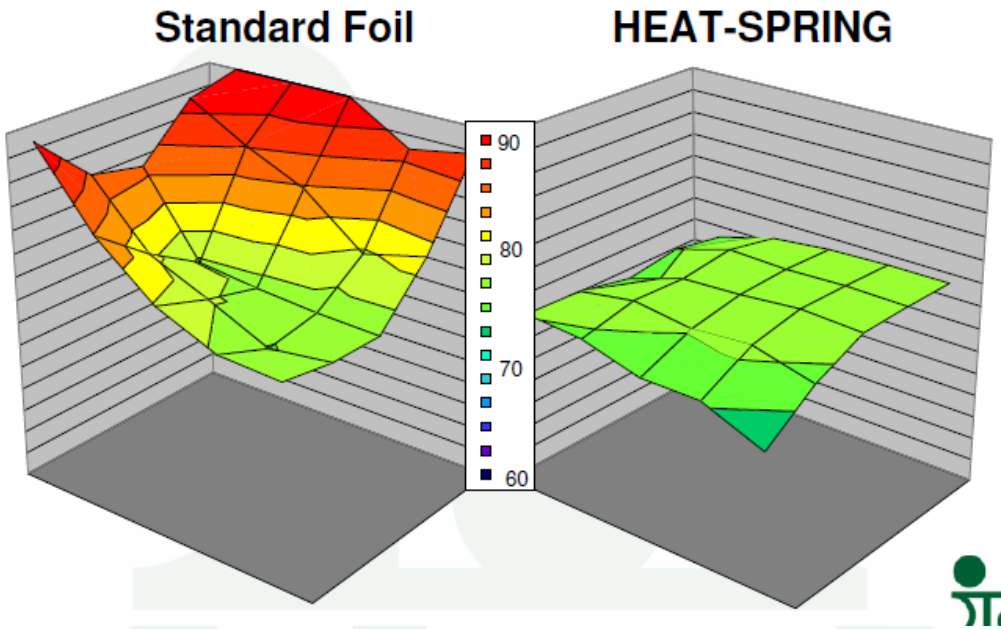
- **Material Description**
  - Made from Indium or Indium Tin as standard alloys
  - We alter the surface so contact resistance is reduced
  - We use high conductive metal  86w/mk
  - We custom package for your application
  - We standard pack in Tape and Reel
  - It's a "green" TIM



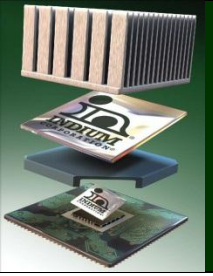




# Temperature Profiles- Indium Foil Vs HSD Both 76um Th

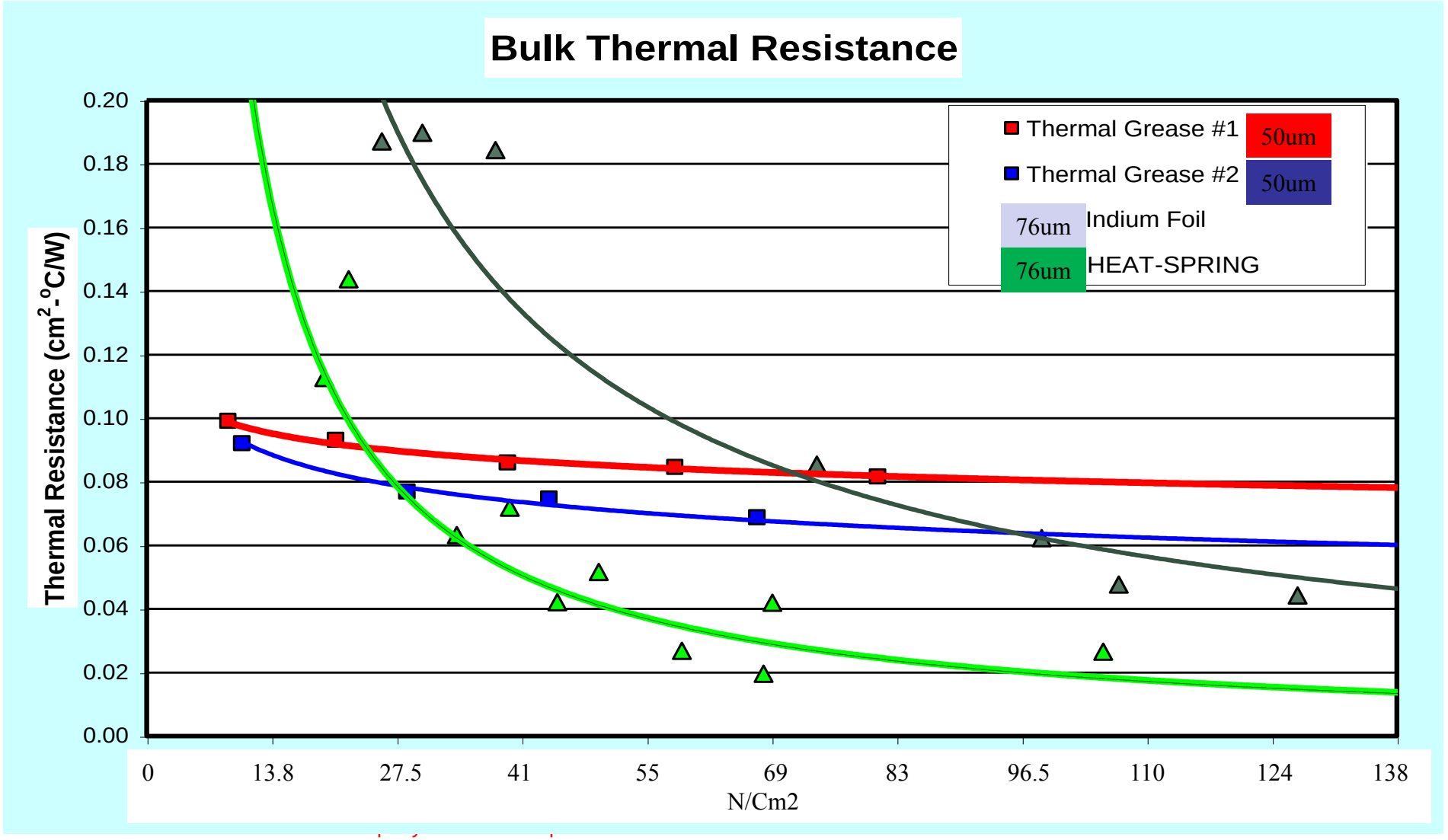



- At 70-75psi a flat foil has about 33% contact.
- This contact is not consistent.
- When the Indium is altered with the HSD process
- We have distributed the 33% contact across the entire area
- Giving consistent contact and lower contact resistance.

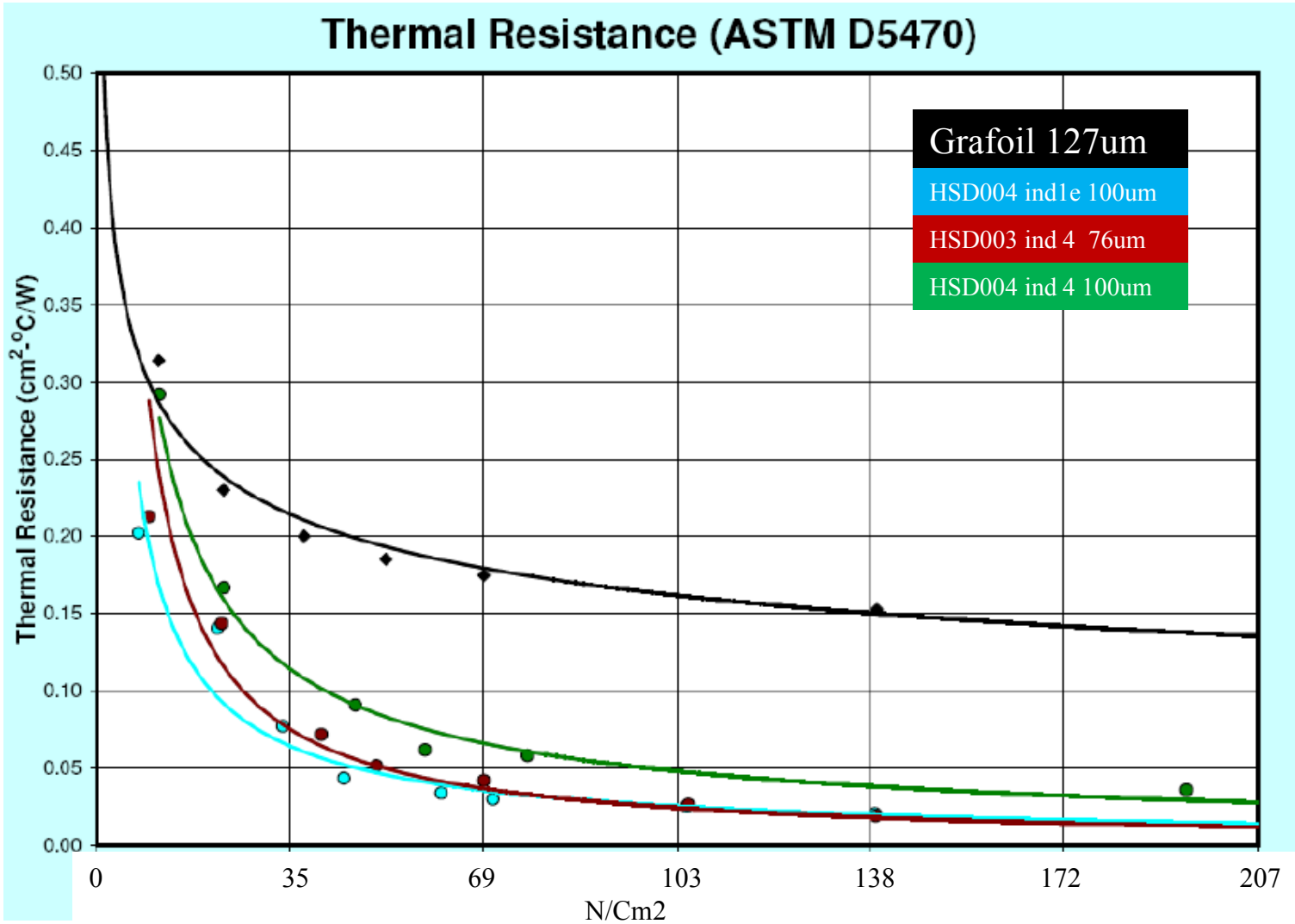


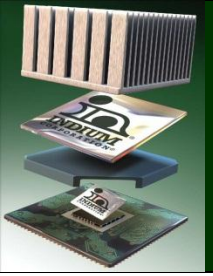


# Material Comparison: Grease, Foil, Heat-Spring

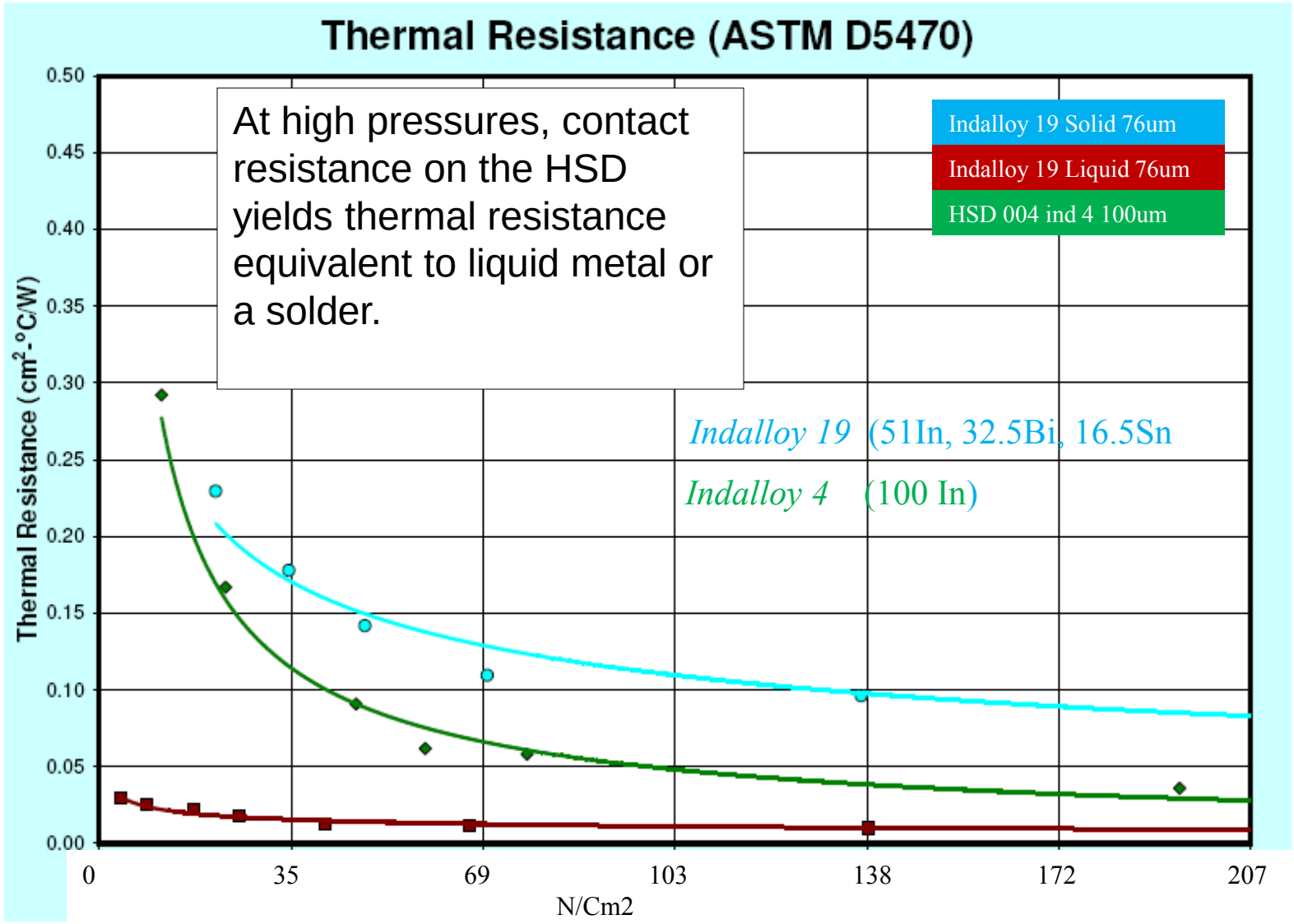


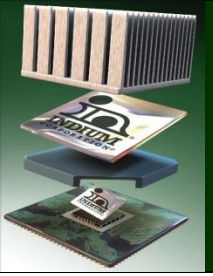
# Heat Spring vs. Graphite Foil





# PCM (solid) vs. PCM (liquid) vs. Heat Spring

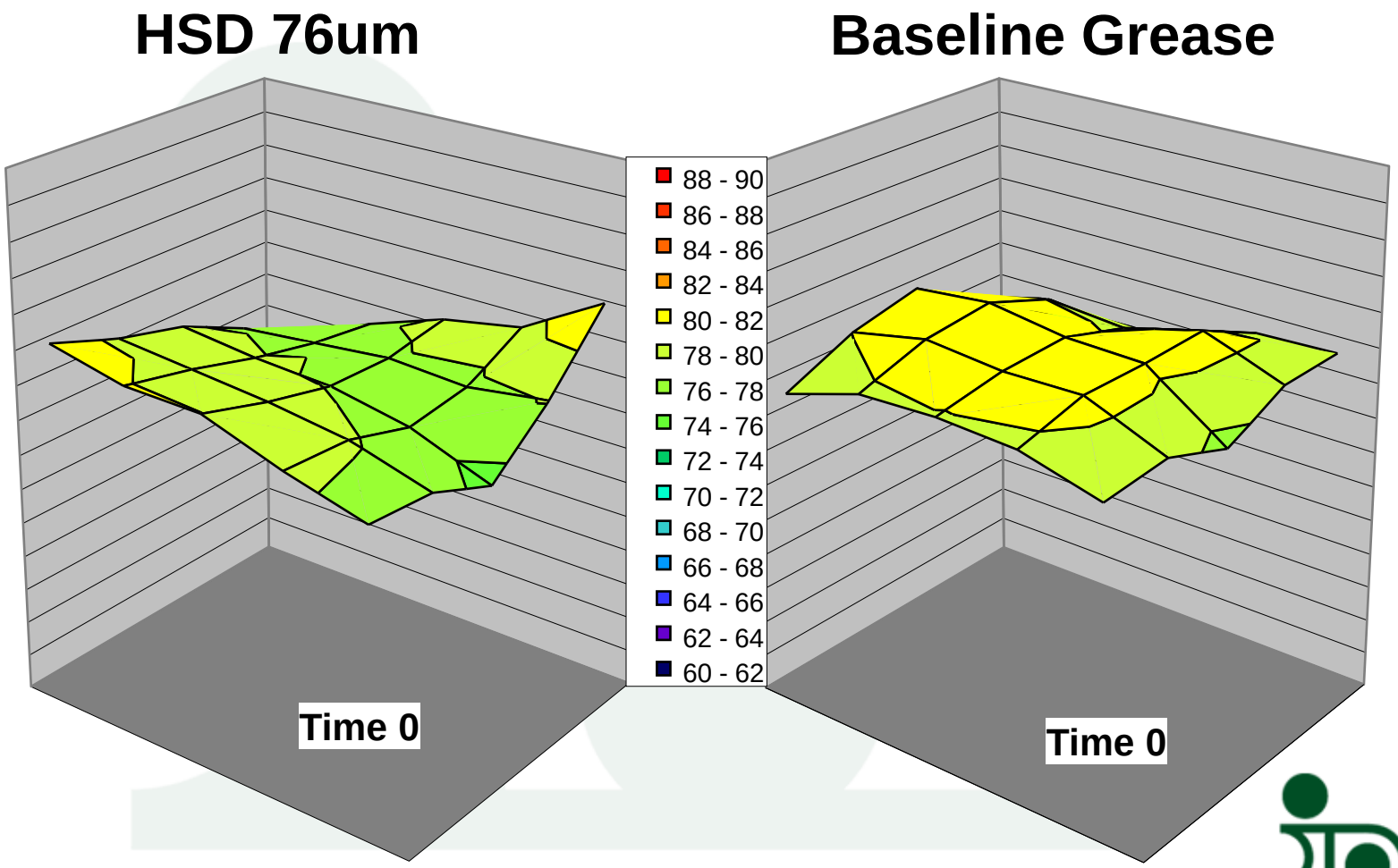


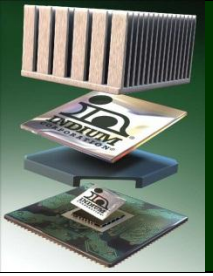




# Reliability Testing

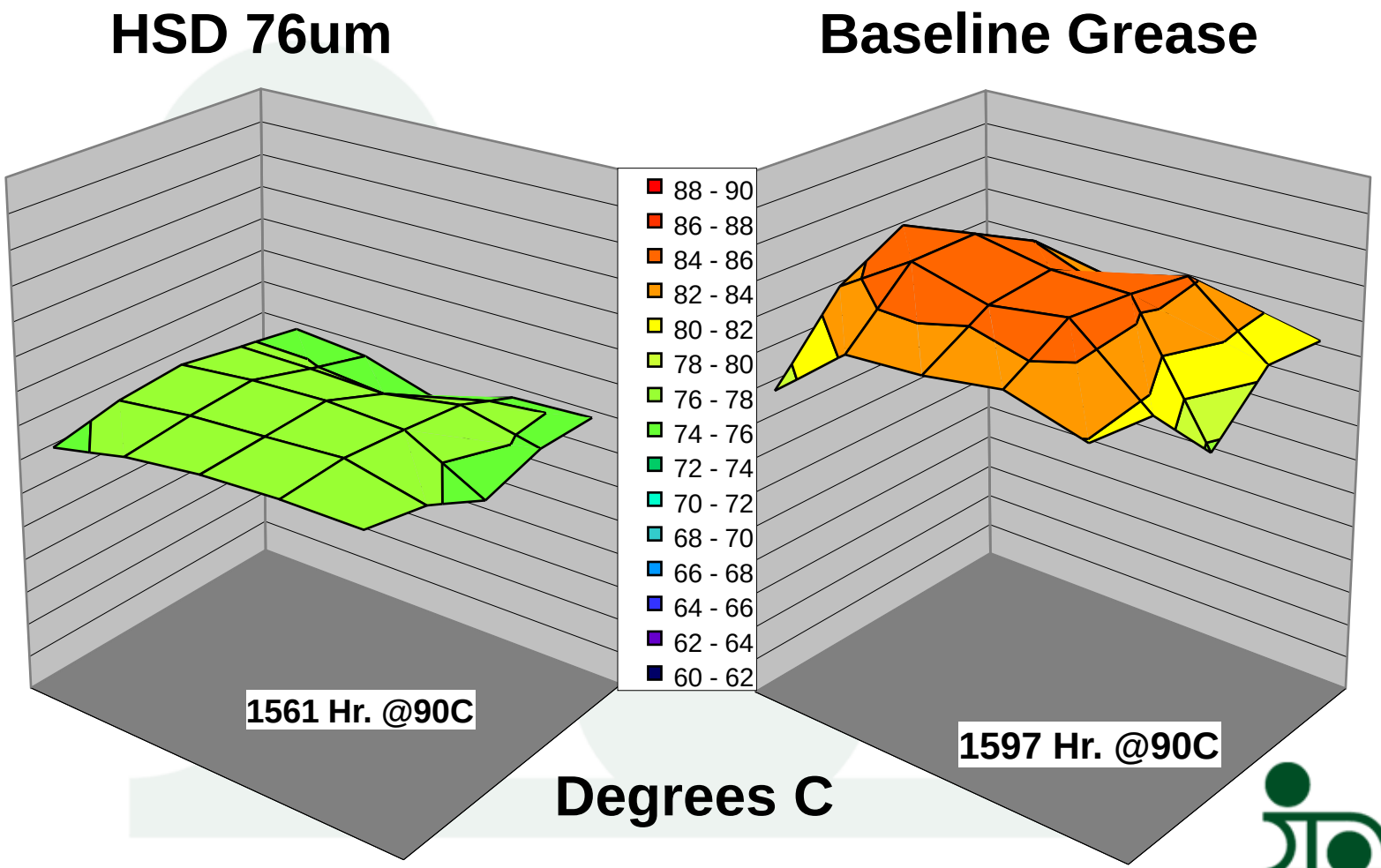
# Time Zero for HeatSpring (HSD) vs. Grease; Heat-Spring is running cooler at time zero

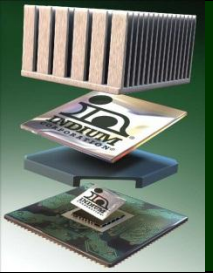






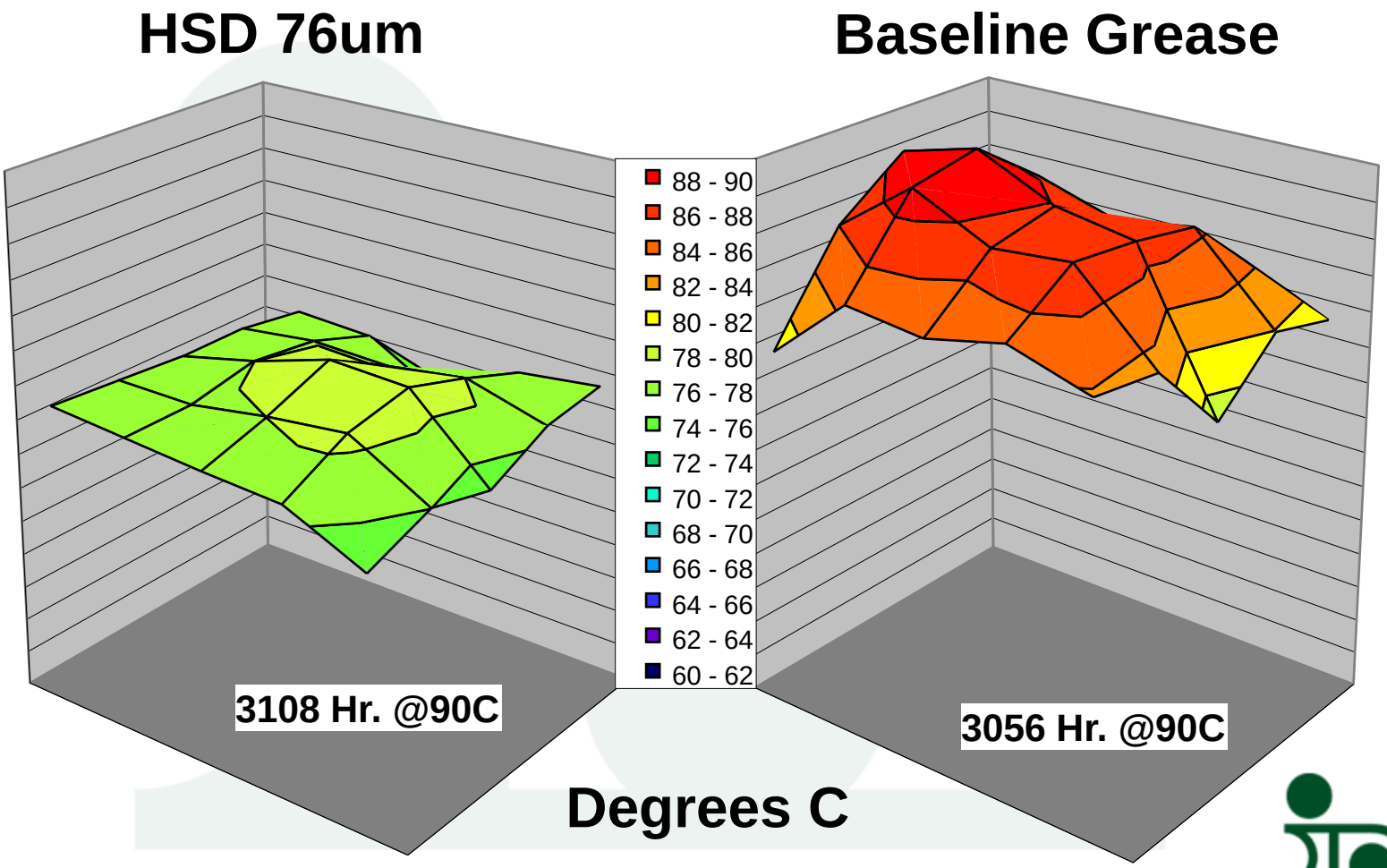
# TTV Comparison Bake 1500hrs

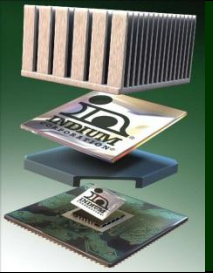






# TTV Comparison Bake 3000hrs

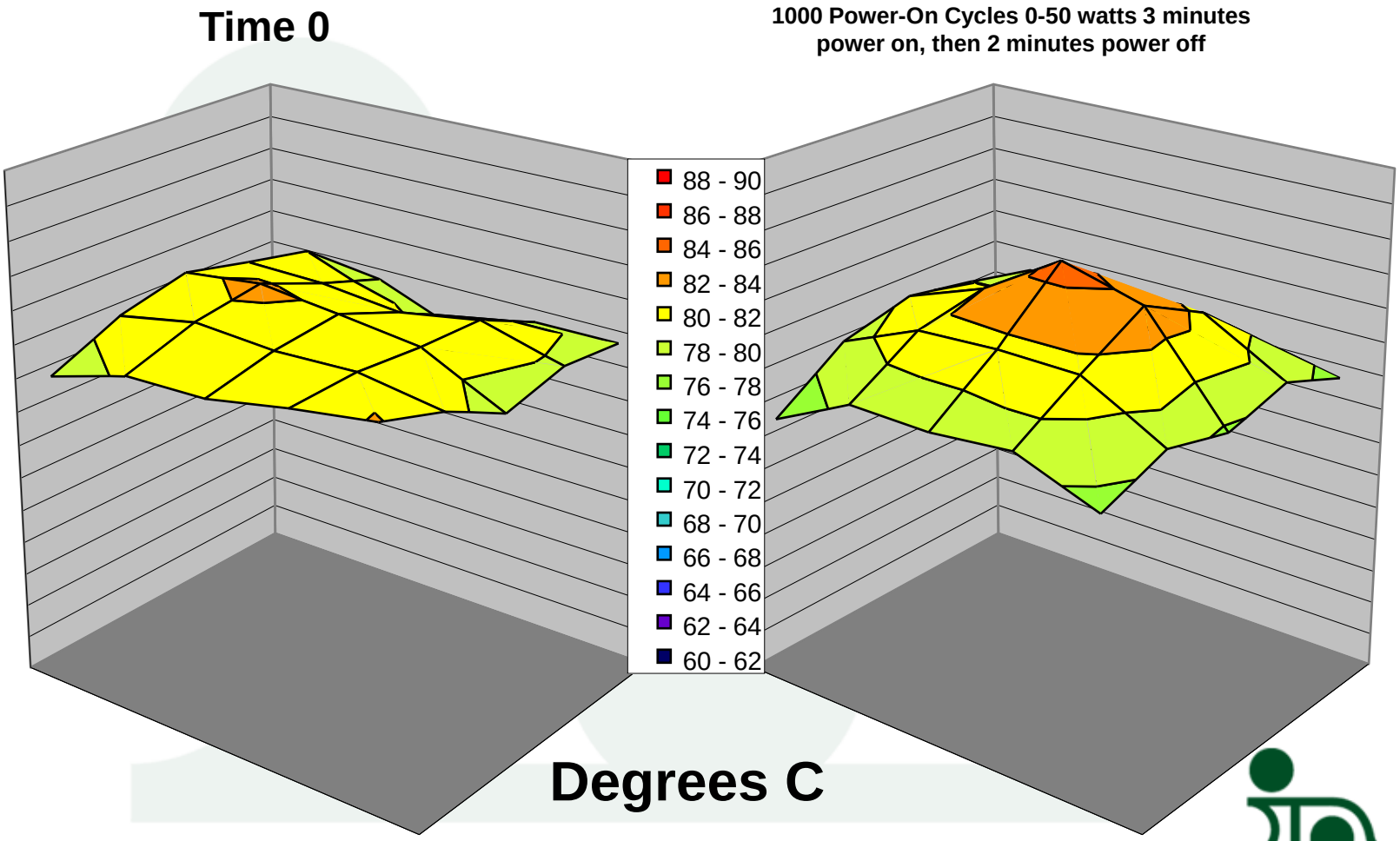


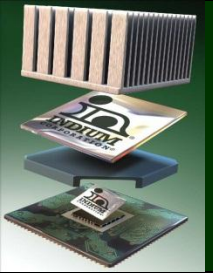




# TTV Power Cycling

## Baseline Thermal Grease shows Pump-out

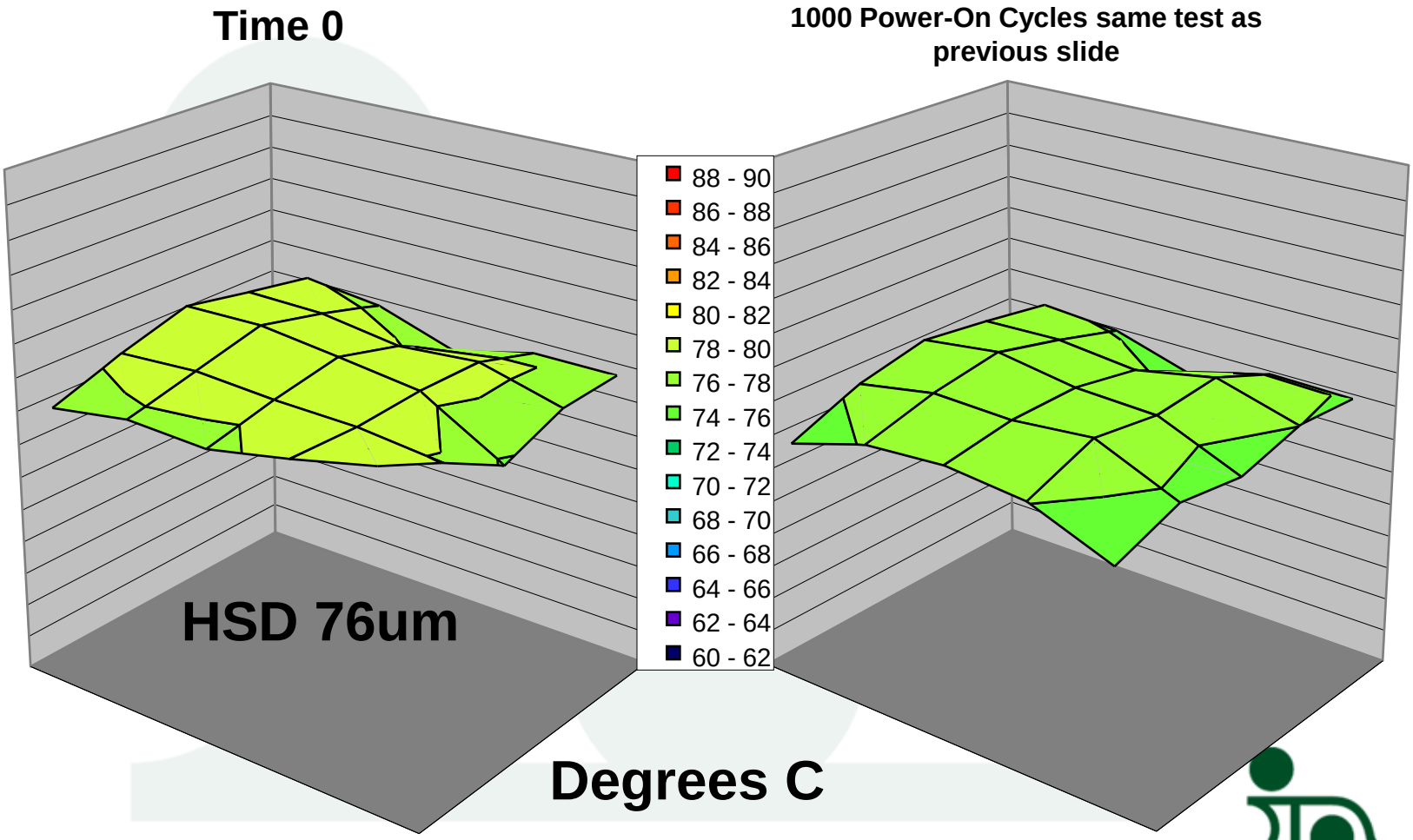




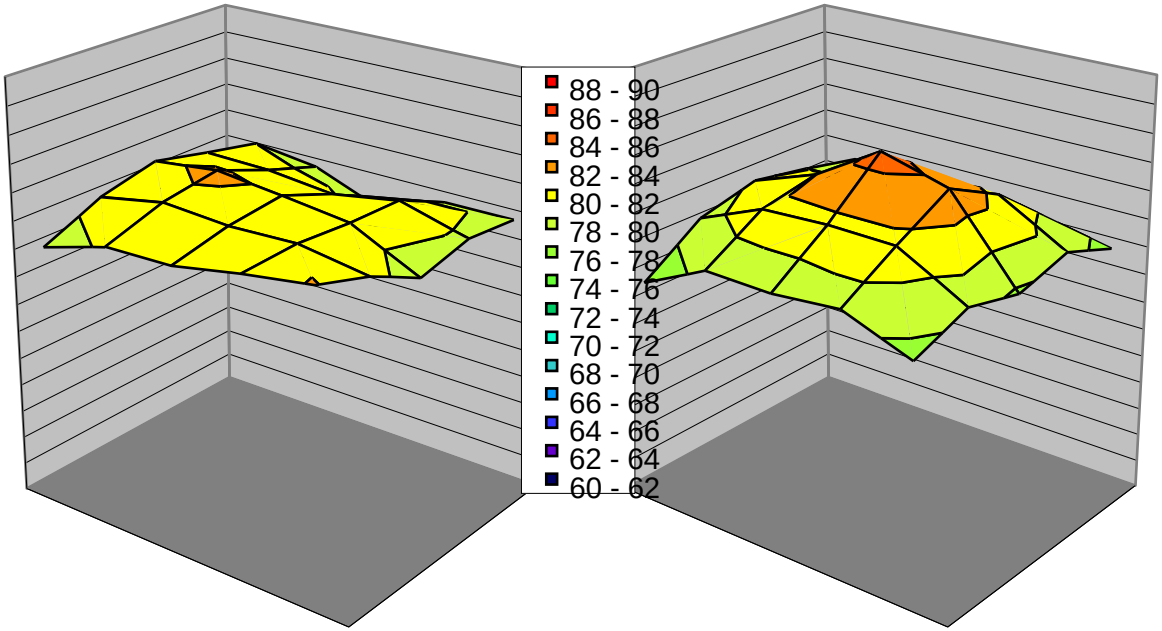


# TTV Power Cycling

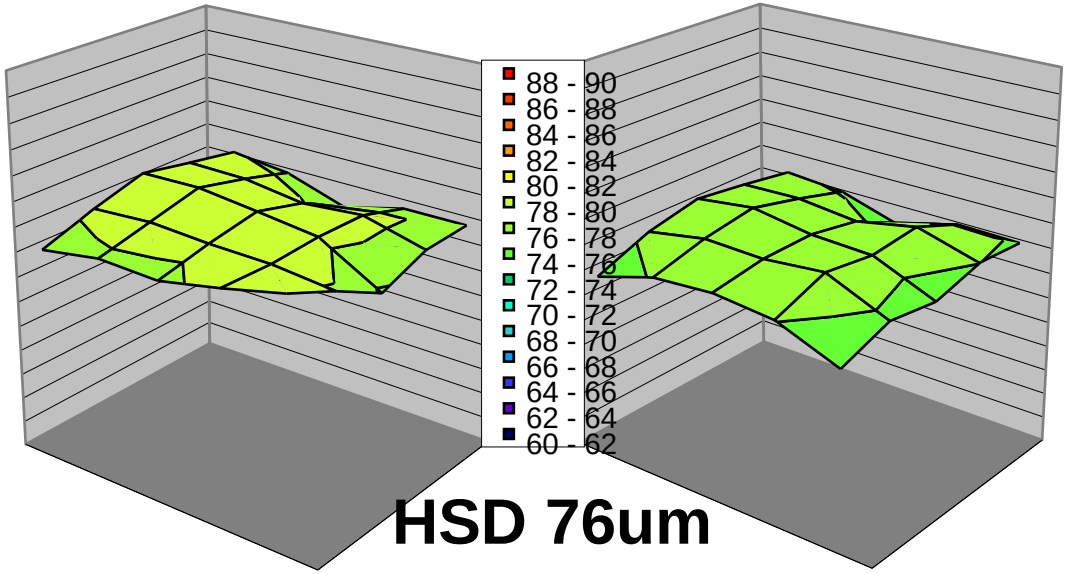
## HSD 76um Heat-Spring performs better after multiple cycles



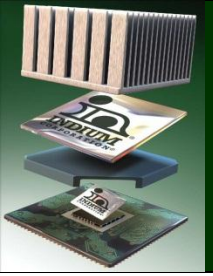
## Time zero vs. 1000 cycles: Thermal Grease




## Time zero vs. 1000 cycles: HSD

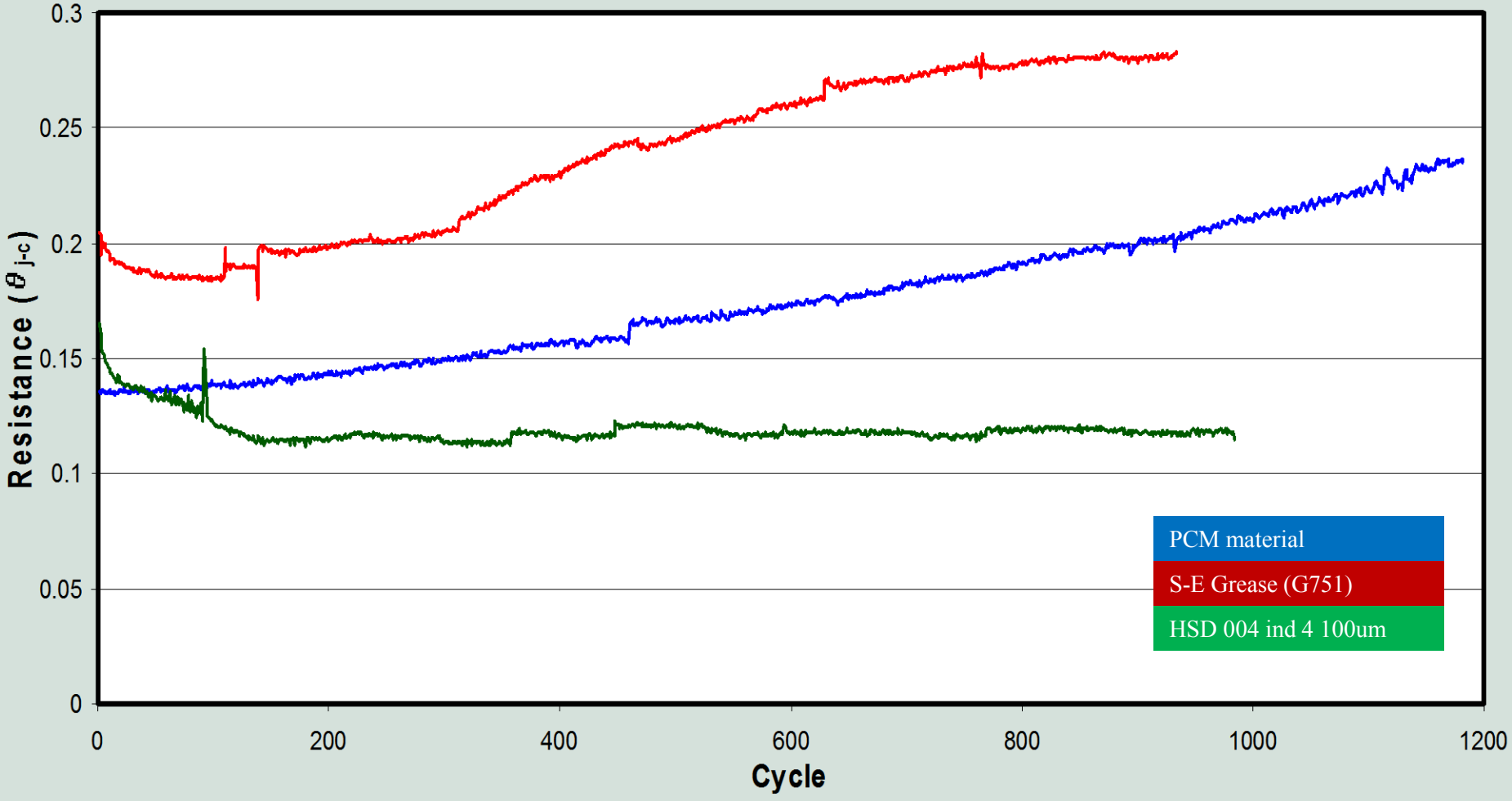


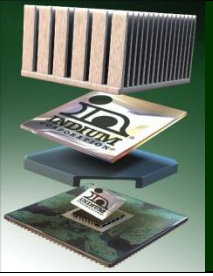

**HSD 76um**





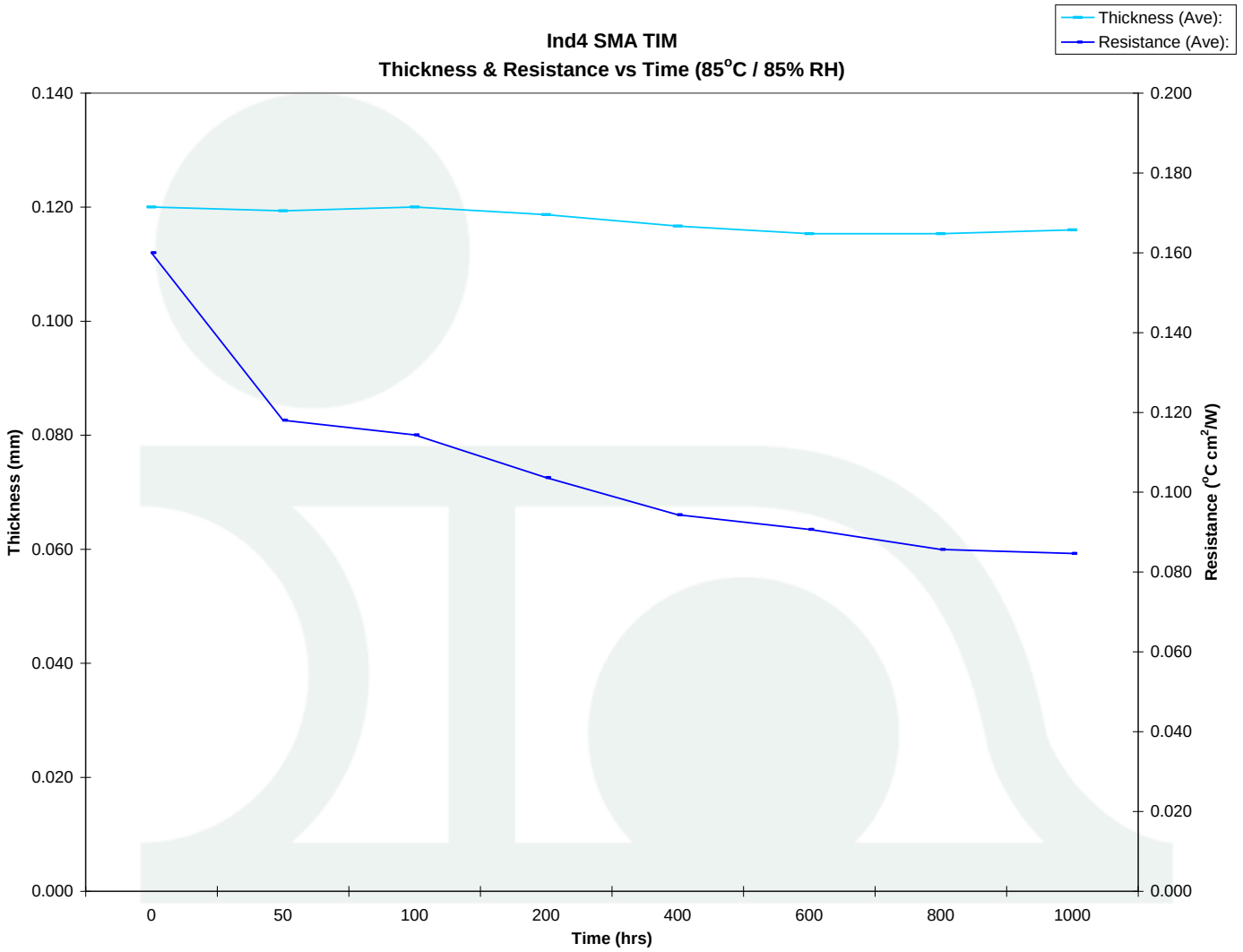
# Thermal Resistance- Grease Vs Heat-Spring Vs Polymer PCM

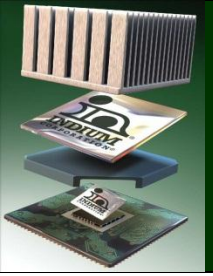






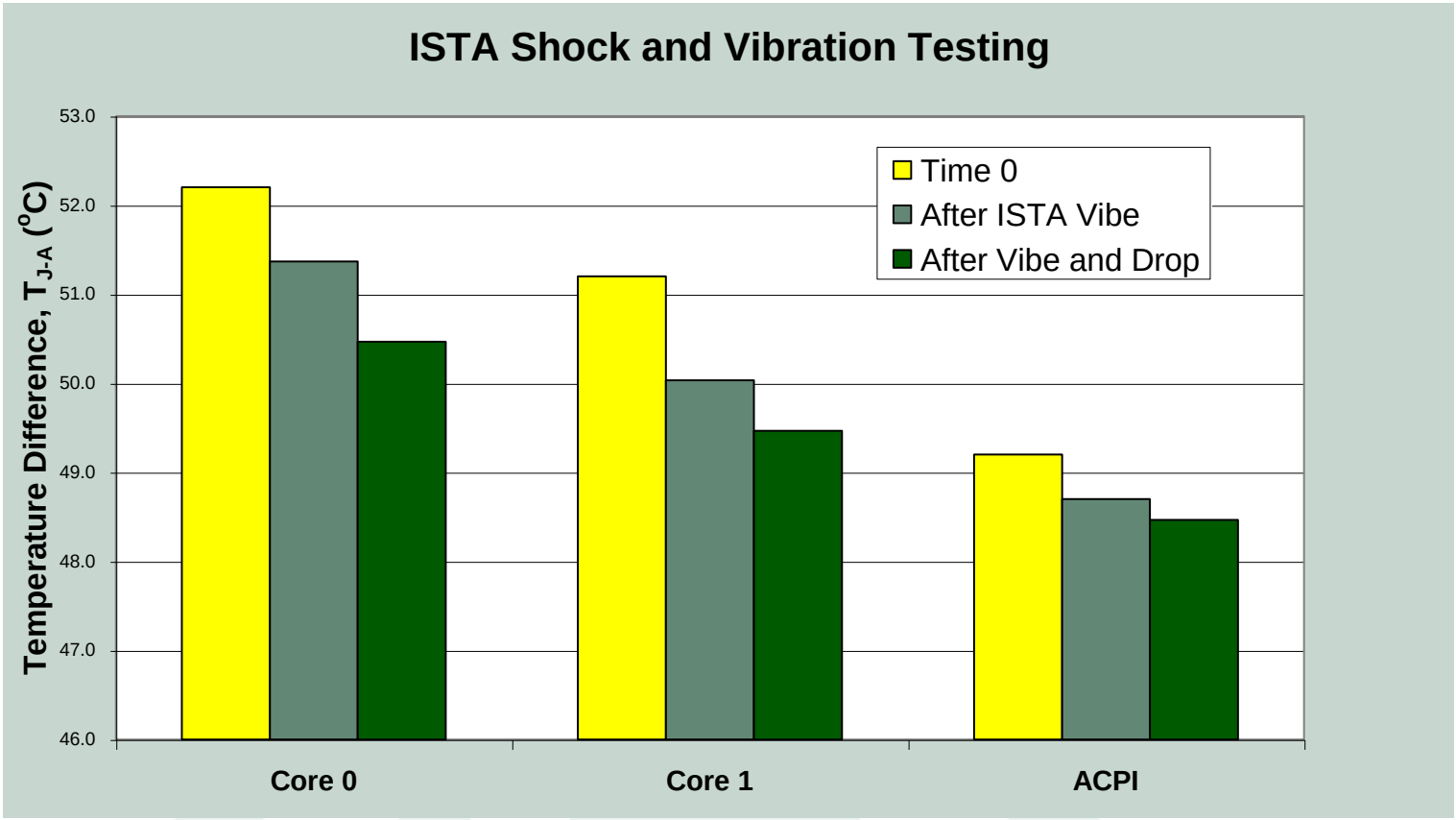
# 85/85 Hast Testing- Heat Spring

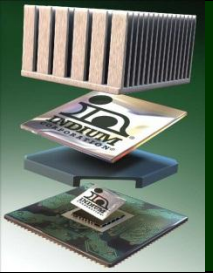






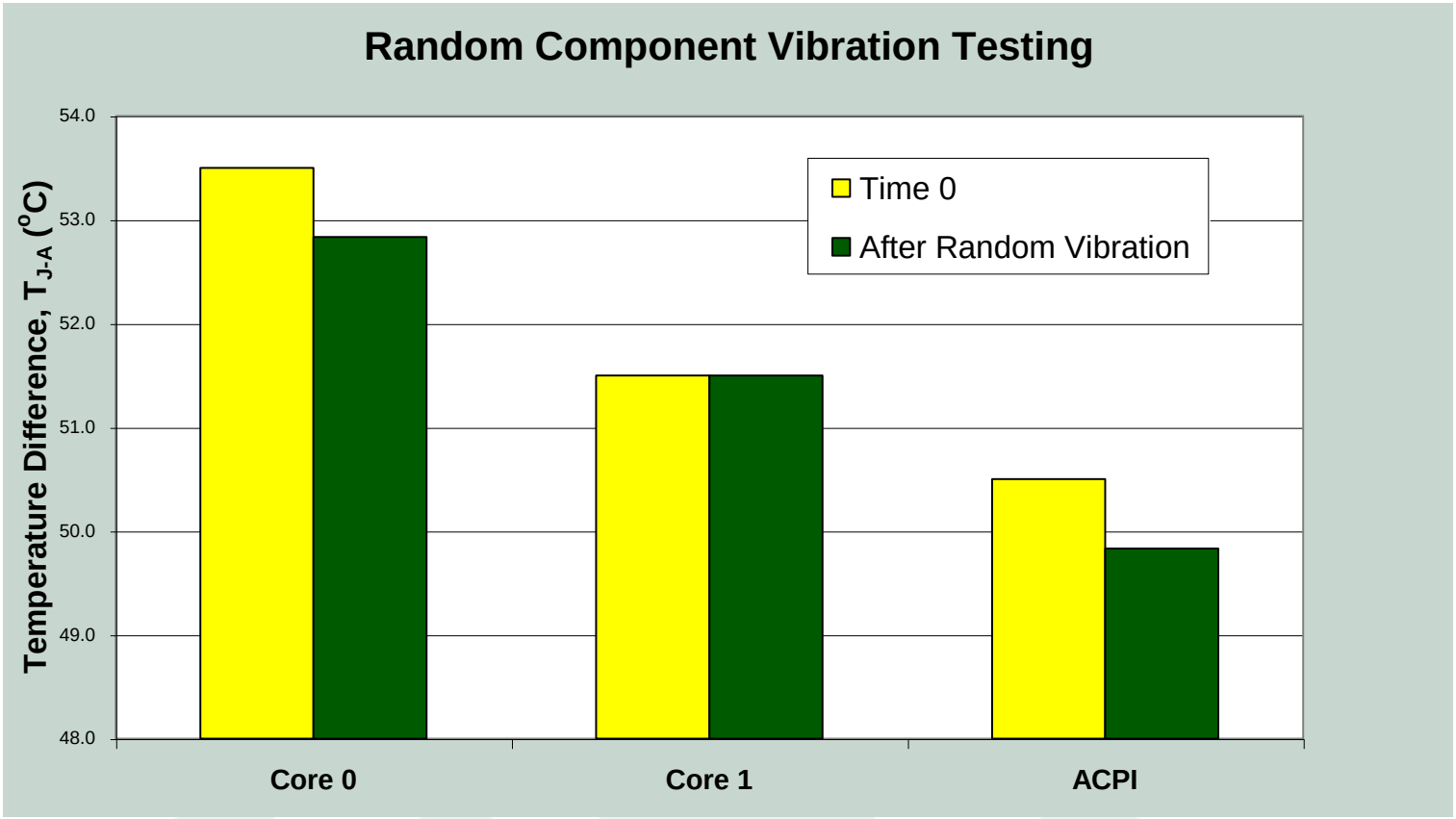
# ISTA Laptop Vibration Testing

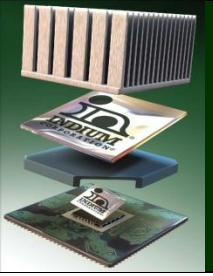






# Laptop Random Frequency Vibration Testing

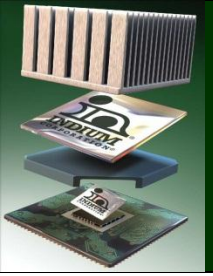






# Heat-Spring Benefits.

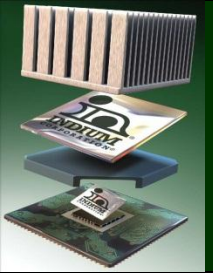
- Re-workable
- Pick and Place-able
- Clean Application, no residue
- Passes Shock and Vibe
- Passes Thermal Cycling
- Passes Bake Test
- Passes Power Cycling
- High Volume Tape and Reel Packaging
- Foil TIM can be placed and moved before clamping force is applied
- Indium Corporation Thermal Lab can do additional required testing if needed





# Heat-Spring Availability

- **minimum thickness of 76um**
- **max thickness of 6mm**
- **Max width on a Heat-Spring is ~203mm.**
  - Can be laid ‘side by side’.
- **Sample Bundles (20-100pc) are available in the following:**
  - 12.7mm, 25.4mm, 38.1mm” and 50.8mm squares
  - 100um thick
  - Ind4 (99.99In) and ind1e (52In48Sn)
- **Over 2000 dies available in house**
- **Custom dies available**



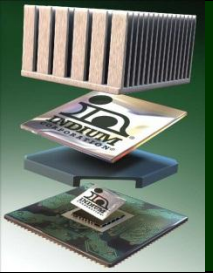


Graham Wilson
Applications Engineer
Tel: +44 (0)1908 580400
Mobile: +44 (0)7825 189554
E-mail: gwilson@indium.com
Web: www.indium.com


# Thank you

# Coffee Break!!!

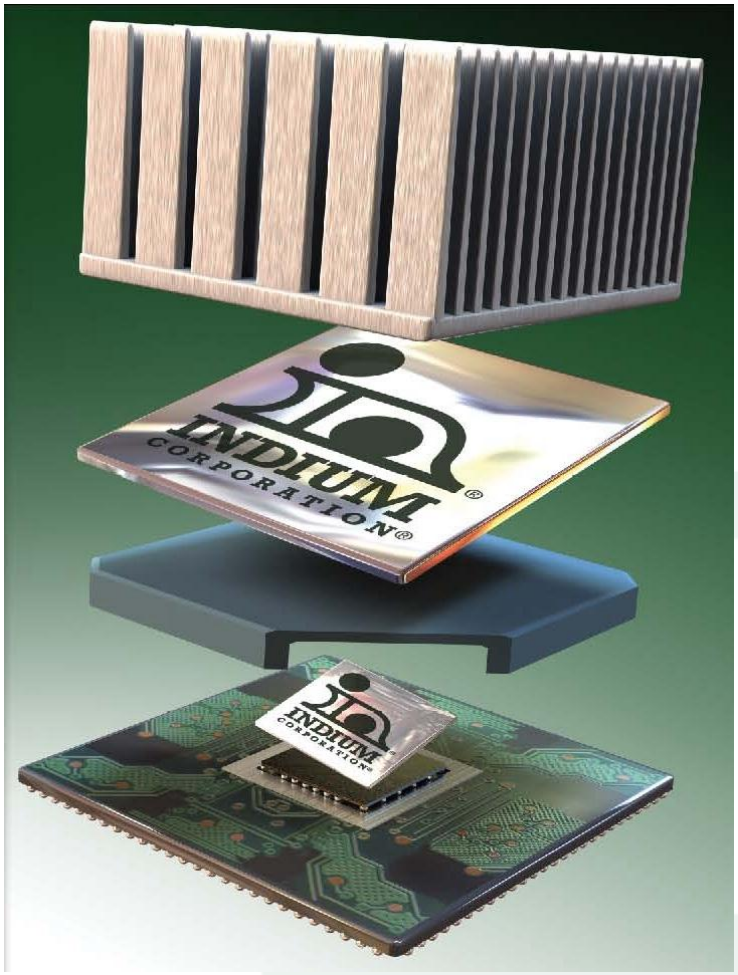
INDIUM CORPORATION





# Some Typical Applications for Indium TIMs

# CPU's and GPU's




TIM1: Indium Solder Preforms

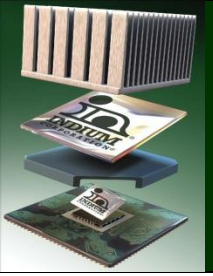
TIM1.5: Heat-Spring®, Liquid Metal

TIM2: Heat-Spring®, Liquid Metal

- **CPU examples**
  - Intel Celeron ~50 watts
  - Intel Sandy Bridge ~130 watts
- **GPU example**
  - nVidia Tesla 180 watts

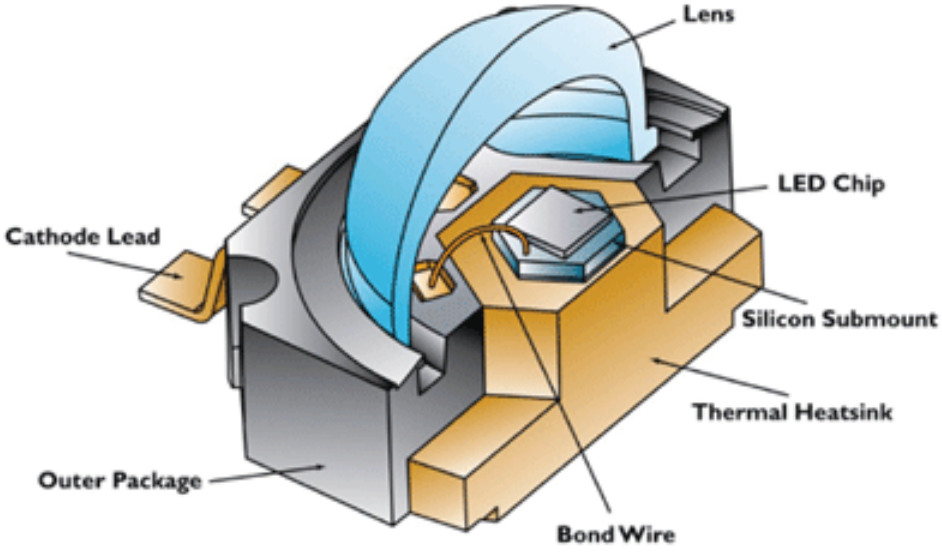
# Liquid Metal on Desktop for TIM2

http://forums.macrumors.com/showthread.php?t=297084





# Hi Power LED's

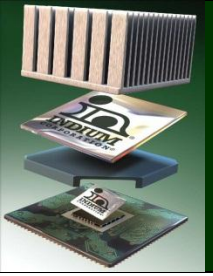



Die Attach: Gold Tin

Module Attach: BiSn or PbFree Paste, wire

High Power LED Heat-Sinking: Heat-Spring®

Applications range from automotive through to advertising and building lighting



# Luminus Devices Application Note:

APPLICATION NOTE

PhlatLight

## PhlatLight® Thermal Characteristics

PhlatLight LEDs have been engineered from the ground up to provide the industry's lowest package thermal resistance. This incredibly low thermal resistance - 0.73 °C/W from junction to heat sink for the CBT and PT120 modules - enables unprecedented input power and flux emitted from the LED. As a result, a new class of LEDs has been created, enabling lighting designers to build the next generation of lighting products.

This application note serves to provide the designer with the tools necessary to create an efficient, well designed thermal system around PhlatLight LEDs. The general theory of thermal design, as well as practical methodology for managing the thermal system around PhlatLight LEDs is discussed.

In addition to this document, ample resources are available to aid the designer and clear a path to an efficient, practical and well performing solution.

Table of Contents



LUMINUS


PDS-0011W Rev 02

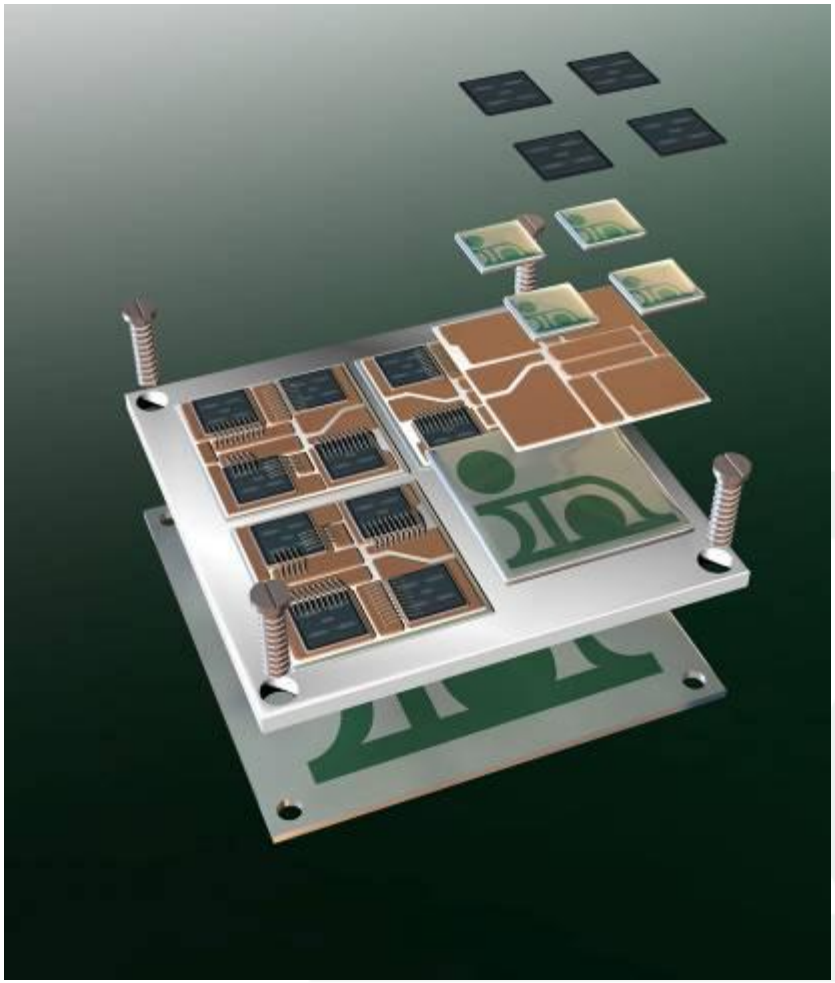
| Vendor | Part | Type | Thermal Conductivity | Thickness | Electrical Isolation |
|---|---|---|---|---|---|
| Graf-Tech | eGraf 1205 | Foil | 10 | 0.254 | No |
| Indium Corp | InSn foil | Foil | | 0.125 | No |

PhlatLight® Thermal Characteristics

Since no surface is ever perfectly smooth and there is always some amount of structure, two surfaces cannot be 100% in contact. Without a filler material, this interstitial space will be filled with air, which when static, is a very poor conductor. As a result, the heat will not be able to bridge the gap between the core-board and the heat sink and the LED junction temperature will rise, adversely impacting performance. A smoother surface will increase the amount of contact area and thereby improve thermal transfer. However, this comes at the cost of increased manufacturing time to improve the surface quality. The best way to improve the thermal transfer is to add a thermal interface material.

These materials can take the form of thermal grease, thermal pads, phase change materials, graphite or indium foil, and in the most extreme cases, diamond. However, as with heat sink design, there are trade-offs associated with the type of thermal interface, as higher surface quality will increase cost, but lower surface quality will require a thicker layer of interface material, thereby reducing performance. A general guideline to use is to improve the surface quality as much as is economically feasible, then add a thermal interface material.

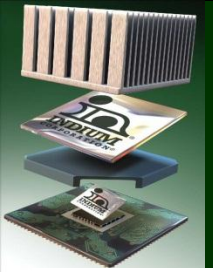
# IGBT Power Modules



Die and Diode Attach: Paste and preforms
(High Sn or AuSn)

DBC Substrate attach: Ribbon, Preforms and possible Paste

Base Plate Heat-Sinking: Heat-Spring®





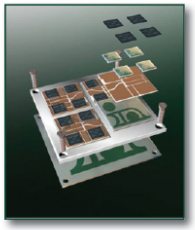
# Infineon PrimePack™ App Note.

INDIUM CORPORATION®

## Heat-Spring® Metallic Thermal Interface Materials for Application to Infineon Technologies PrimePACK™ IGBT Modules

APPLICATION NOTE

Metallic thermal interface materials are designed specifically as alternatives to thermal grease prior to the attachment of Infineon Technologies PrimePACK IGBT modules to heat-sinks or liquid cold plates. Indium Corporation's Heat-Spring® product was developed as a compressible metallic shim that can be used in IGBT mounting applications, exceeding 3.1 Bar (45 PSI) in clamping force applied.



### Product Design

Heat-Springs are a non-reflowed indium-based metal. They are supplied as preforms, die-cut to meet specific PrimePACK and other Infineon IGBT module baseplate footprints and mounting hole patterns. Heat-Spring TIM preforms are easily handled and placed in position prior to mounting and torqueing the IGBT. The preforms are compressible, adapting to irregularities in the mounting surface.

Heat-Springs are stable, easy-to-handle, and require no special mounting procedures. The product is highly conductive both thermally and electrically. (See Indium Corporation Application Note 98380)

Heat-Spring products are available in two standard indium alloys and multiple preforms configurations. Refer to Table 1.

| Indium Corporation Alloy Designation | Alloy Composition | Thermal Conductivity | Melting Point |
|---|---|---|---|
| Indalloy 4 | 99.99% Indium | 86W/m-K | 157°C |
| Indalloy 1E | 52% Indium/48% Tin | 40W/m-K | 118°C |

Table 1: Standard Heat-Spring alloys

### Product Thermal Impedance

Performance testing several TIM materials appropriate for IGBT modules is shown in Figure 2. Using test performance data per ASTM D 5470-06, Indium Corporation's Heat-Spring TIM preforms are tested against a comparable flat indium shim and two typical silicone-based thermal greases, using clamping forces greater than 3.1 Bar (45 PSI). The improved performance of the Heat-Spring is evident.

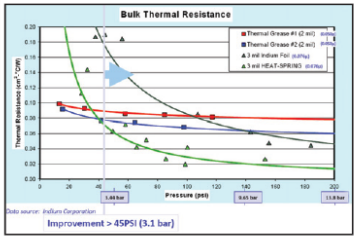



Figure 2: Comparative test data, thermal resistance and clamping force applied (ASTM D-5470-06)

### Reliability

Heat-Spring metallic TIM preforms are made in two standard configurations, Heat-Spring Pattern D (HSD) and Heat-Spring Pattern G (HSG). These two configurations are distinguished by the characteristics of the intended application surfaces, as shown in Table 2.

| Configuration | Maximum Surface Non-Planarity | Maximum Bond Line Thickness |
|---|---|---|
| HSD | 0-75 µm | 75 µm |
| HSG | 0-150 µm | 150 µm |

Table 2: Heat-Spring standard configurations

As a solid metal preform, the Heat-Spring metallic TIM does not exhibit a pump-out phenomenon, which may occur with viscous TIM materials. In addition, there is no silicone oil content or silicone migration from the interface.

Form No. 98520 R0

www.indium.com askus@indium.com

ASIA: Singapore, Cheongju: +65 6268 8678
CHINA: Suzhou, Shenzhen, Liuzhou: +86 (0)512 628 34900
EUROPE: Milton Keynes, Torino: +44 (0) 1908 580400
USA: Utica, Clinton, Chicago: +1 315 853 4900



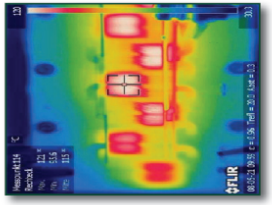
INDIUM CORPORATION®

Heat-Spring® Metallic Thermal Interface Materials for Application to Infineon Technologies PrimePACK™ IGBT Modules

APPLICATION NOTE

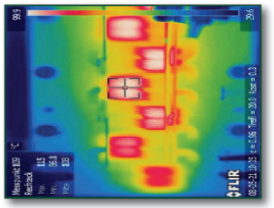
### Application Testing with Infineon Technologies PrimePACK™ IGBT Modules

The development by Infineon Technologies of the PrimePACK IGBT module included an increase in the number of fasteners employed for each module, with reduced spacing between fastener locations. The increased number of fasteners applies more uniform clamping force to the TIM2 material at the interface between the module baseplate and the cold plate. The Heat-Spring TIM2 preforms have been tested for the latest PrimePACK configurations and have been optimized to reduce thermal resistance below that of other more traditional thermal interface materials. Operating die temperatures recorded during testing are shown in Figures 7, 8, and 9.



*Shown here is the temperature of the PrimePACK Die in normal use with a standard Thermal Grease. The temp of the die is 115°C*

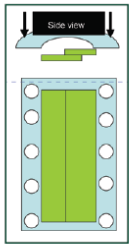
Figure 7: Thermal imaging temperature profile, Infineon PrimePACK module, with a single Heat-Spring Indalloy 4 metallic TIM preform (100mm thickness). Die operating temperature: 108°C.



*Shown here is the temperature of the PrimePACK Die in normal use with a 100um thick Pure Indium Heat-Spring®. The temp of the die is 108°C*

Figure 8: Thermal imaging temperature profile, Infineon PrimePACK module, with two Heat-Spring Indalloy 4 metallic TIM preforms (100mm thickness). Die operating temperature: 106°C

Indium Corporation has developed an optimized Heat-Spring preform for use with PrimePACK modules which consists of a prepackaged preform with two overlapping foils. The general arrangement of this preform is shown in Figure 9. The overlapped area corresponds with the centerline area of the PrimePACK IGBT module.




*Shown to the left is an example of how the Heat-Spring® would be placed on the base plate before securing down using the PrimePACK Specification method. Because there is known deflection to the IGBT before and after mounting. The overlapping of the HSD compensates for this gap. The Heat-Spring is packaged in trays and is 100% reclaimable and recyclable. Please refer to Application note 98380 for handling application note.*

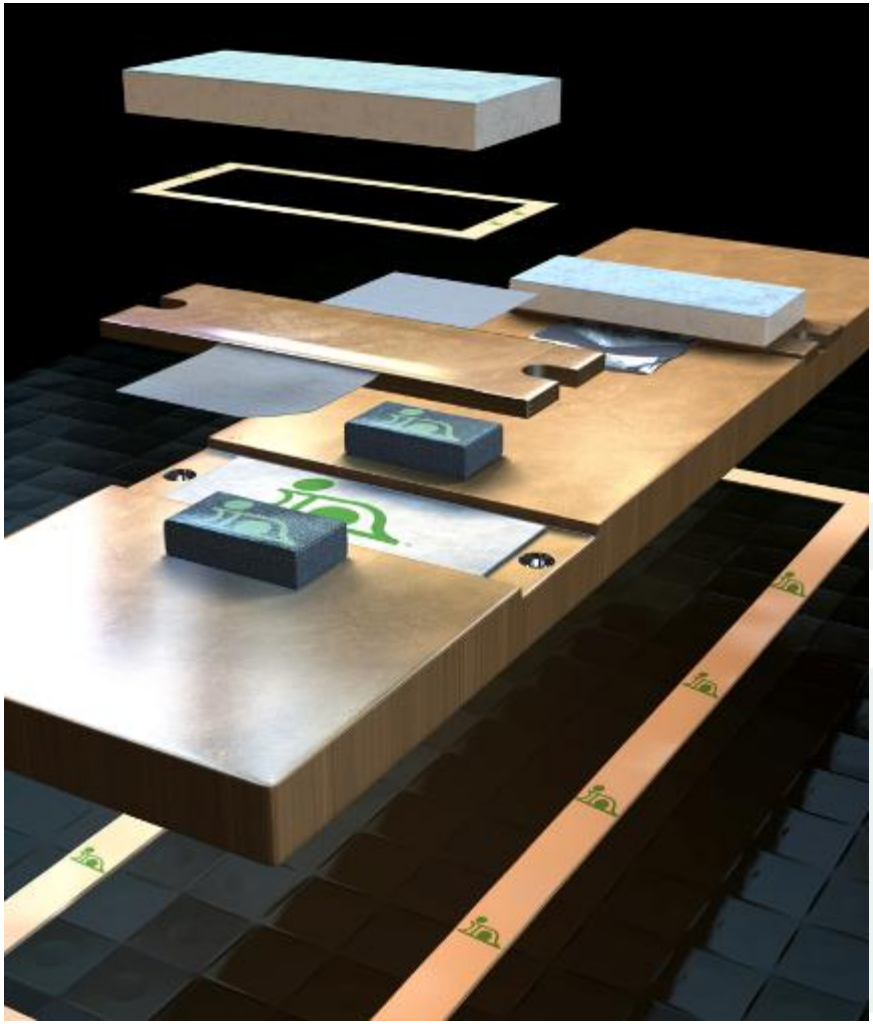
Figure 9: Indium Corporation Indalloy 4 Heat-Spring HSD,overlapped for Infineon PrimePACK IGBT module.

www.indium.com askus@indium.com

ASIA: Singapore, Cheongju: +65 6268 8678
CHINA: Suzhou, Shenzhen, Liuzhou: +86 (0)512 628 34900
EUROPE: Milton Keynes, Torino: +44 (0) 1908 580400
USA: Utica, Clinton, Chicago: +1 315 853 4900

©2008 Indium Corporation

# Power RF

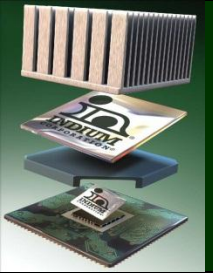


Die attach =  AuSn or SAC alloy

Hermetic Sealing = AuSn

Lead Attach = SAC Paste or
SAC Flux coated preform

Power Amp Heat-Sinking with
Solder attach or Heat-Spring®



# Burn-in: Ideal for multi height packages