Contag Day, Berlin
Metallkernleiterkarten - Thermische Lösungen und Einsatzmöglichkeiten

Michael Stoll
September 27, 2016
Electronics Assembly Materials
Market-Tailored Product Solutions

Henkel Solutions

- Die Attach Adhesives
- Molding Compounds
- Assembly Adhesives
- Liquids
- Inks & Coatings
- Solder Materials
- Thermal Materials

Market Needs

- Customer Mfg. Efficiency
- Sustainability
- High Reliability
- Miniaturization

- Low Pressure Molding
- Potting Compound
- Non-Conductive Pastes
- Liquid Gap Filler
- Conformal Coatings
- Electrically Conductive Pastes
- Gasketing
- Solder Materials
- Surface Mount Adhesives
- Electrically Insulating Film
- CSP Underfills (Cornerbond)
- Encapsulants (Glob Top)
- Assembly Film Adhesives
- Gap Pads
- Insulated Metal Substrate (IMS)
- Printed Inks

Solder Materials

Contag Day | Thermal Clad – Thermische Lösungen und Einsatzmöglichkeiten
Presentation Outline

1. Transport Method of thermal Energy
2. IMS Substrate Basics
3. IMS Substrate Comparison
4. Dielectric Comparisons
5. Product Qualification and Technical Properties
6. Cost influencing Factors
7. Discussion and Action Item Review
Henkel is the market leader in designing and manufacturing thermal solutions that quickly and efficiently transfer heat from hot components to the surrounding environment. Products using our Bergquist thermal materials last longer, are more reliable and operate at optimal performance.
# Insulated Metal Substrate (IMS) Technology

## Thermal Management

### Methodes to transport heat

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conduction</td>
<td>most efficient</td>
</tr>
<tr>
<td>Convection</td>
<td>Usually the way out</td>
</tr>
<tr>
<td></td>
<td>• Natural</td>
</tr>
<tr>
<td></td>
<td>• Forced air</td>
</tr>
<tr>
<td>Radiation</td>
<td>Generally negligible</td>
</tr>
</tbody>
</table>

![Diagram showing heat transfer methods](image)

It is important to focus on the exit for the thermal energy

Concentrate on Conduction and Convection

Source: OSRAM
Insulated Metal Substrate (IMS) Technology
Thermal Management

Thermal System Configuration

Thermal Resistor Network

Source OSRAM
Insulated Metal Substrate (IMS) Technology
Technology Overview

Wording Definition

- Thermal Clad (TCLAD)
- Insulated Metal Substrate (IMS)
- Metal Core PCB (MCPCB)
- Metal Clad / Copper Base Laminates
Insulated Metal Substrate (IMS) Technology
Technology Overview

Single Layer constructions

- Aluminum or Copper base metals → 0.5 – 5 mm thick
- Dielectric types HRT, MP, HT and HPL → 38µm - 225µm thick
- ED circuit (electrodeposited copper) → 17µm – 350µm
- Thermal performance based on → 1.5 – 7.5 W/m-K
Insulated Metal Substrate (IMS) Technology
Technology Overview

Two layer constructions
- Original designed for EMI shielding
- Increased circuits - More circuit routing area
- Thermal via’s – Allow for lower $T_R$

Circuit Layer 1
35µm to 350µm

Circuit Layer 2
35µm to 140µm

Dielectric Layer 1

Dielectric Layer 2

Base Layer
Aluminum or Copper
0.5mm-3.2mm

L1 copper
Dielectric
L2 copper
Dielectric
Base heat spreader

Heat source

Thermal Via’s

Efficient heat flow
to the base metal
with electrical isolation
**Insulated Metal Substrate (IMS) Technology Technology Comparison**

### What is Thermal Clad®

#### Influencing Factors
- Board material with higher thermal conductivity
- Attach to additional heat spreader (PCB on Aluminium)
- Solder pad layout and placement of other components
- Use of thermal vias

---

**Source OSRAM**
## Insulated Metal Substrate (IMS) Technology Technology Comparison

### Materials Comparisons - Calculated

<table>
<thead>
<tr>
<th>Substrate Type</th>
<th>Dielectric Type</th>
<th>Dielectric Thickness</th>
<th>Thermal Conductivity</th>
<th>calculated Thermal Resistance (sqcm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCPCB</td>
<td>FR4/Al</td>
<td>0.150mm</td>
<td>0.3 W/mK</td>
<td>5.00 K/W</td>
</tr>
<tr>
<td></td>
<td>therm. Dielec</td>
<td>0.038mm</td>
<td>7.5 W/mK</td>
<td>0.05 K/W</td>
</tr>
<tr>
<td>DBC</td>
<td>Al2O3</td>
<td>0.230mm</td>
<td>24 W/mK</td>
<td>0.13 K/W</td>
</tr>
<tr>
<td></td>
<td>AlN</td>
<td>0.630mm</td>
<td>170 W/mK</td>
<td>0.04 K/W</td>
</tr>
<tr>
<td>Glass/Epoxy</td>
<td>FR4</td>
<td>1.000mm</td>
<td>0.3 W/mK</td>
<td>16.67 K/W</td>
</tr>
</tbody>
</table>

Thermal Resistance influenced by
- Dielectric thickness
- Conductivity.
**Insulated Metal Substrate (IMS) Technology**

**Technology Comparison**

<table>
<thead>
<tr>
<th>HB LED Submount # Concept 1</th>
<th>Rth(j-hs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCPCB # 7,5W/mK (3-Layer 1mm Copper core)</td>
<td>0,81 K/W</td>
</tr>
<tr>
<td>DBC AL2O3 # 24W/mK (0,5mm)</td>
<td>1,09 K/W</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HB LED Submount # Concept 2</th>
<th>Rth(j-hs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCPCB # 7,5W/mK (38µm Cu-base)</td>
<td>2,0 K/W</td>
</tr>
<tr>
<td>DBC # AlN # 170W/mK (0,5mm)</td>
<td>2,1 K/W</td>
</tr>
</tbody>
</table>
## Insulated Metal Substrate (IMS) Technology
### Technology Comparison

<table>
<thead>
<tr>
<th>Board Material</th>
<th>R\textsubscript{th}\textsubscript{SB}</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Copper; t = 35 µm</strong></td>
<td></td>
</tr>
<tr>
<td>Dielectric; t = 100 µm</td>
<td>IMS with enhanced dielectric</td>
</tr>
<tr>
<td>Aluminium; Plate t = 1.5 mm</td>
<td>IMS with FR4 dielectric</td>
</tr>
<tr>
<td><strong>Copper; t = 35 µm</strong></td>
<td></td>
</tr>
<tr>
<td>Dielectric PEN; t = 50 µm</td>
<td>Flexible PCB on Al with standard PSA</td>
</tr>
<tr>
<td>PSA; t = 50 µm</td>
<td>Flexible PCB on Al with enhanced PSA</td>
</tr>
<tr>
<td>Aluminium; Plate t = 1.5 mm</td>
<td></td>
</tr>
<tr>
<td><strong>Copper; t = 35 µm</strong></td>
<td></td>
</tr>
<tr>
<td>Dielectric FR4 t = 1 mm</td>
<td>FR4 with standard PSA and thermal Vias</td>
</tr>
<tr>
<td>PSA; t = 130 µm</td>
<td></td>
</tr>
<tr>
<td>Aluminium; Plate t = 1.5 mm</td>
<td></td>
</tr>
</tbody>
</table>

Source: OSRAM
# Insulated Metal Substrate (IMS) Technology Technology Comparison

A simple test to compare the benefit of various MCPCB substrates

<table>
<thead>
<tr>
<th>Bergquist HT</th>
<th>Bergquist MP</th>
<th>FR-4 / Al</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 4.1 W/m-K</td>
<td>• 2.5 W/m-K</td>
<td>• 0.30 W/mK</td>
</tr>
<tr>
<td>• 5270 lux</td>
<td>• 4750 lux</td>
<td>• 1310 lux</td>
</tr>
<tr>
<td>• 4x improvement</td>
<td>• 3.5x improvement</td>
<td></td>
</tr>
</tbody>
</table>

Light output of die on Bergquist IMS compared to FR-4/Al

Test set up: power up to max current to reach 50°C, measure light output
Insulated Metal Substrate (IMS) Technology
Technology Overview – Thermal Impedance

Thermal Performance
MET-5.4-01-40000-

°C/W

- CML 152µm: 1.10
- HRT 76µm: 0.90
- MP 76µm: 0.65
- HT 76µm: 0.45
- HPL: 0.30

Performance getting better
## Insulated Metal Substrate (IMS) Technology

### Technology Comparison – Dielectric Characteristic

#### Performance Characteristics

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Thickness(^1) [&quot;,000'/µm]</th>
<th>Thermal Performance(^2) [°C/W]</th>
<th>Impedance(^3) [°C in²/W] / [°C cm²/W]</th>
<th>Conductivity(^4) [W/m-K]</th>
<th>Breakdown(^5) [kVAC]</th>
<th>Permittivity(^6) [Dielectric Constant]</th>
<th>Dielectric Conductivity(^4) [W/m-K]</th>
<th>Glass Transition(^7) [°C]</th>
<th>Peel Strength(^8) [lb/in] / [N/mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPL-031015</td>
<td>1.5/38</td>
<td>0.30</td>
<td>0.02 / 0.13</td>
<td>7.5</td>
<td>5.0</td>
<td>6</td>
<td>3.0</td>
<td>185</td>
<td>5 / 0.9</td>
</tr>
<tr>
<td>HT-04503</td>
<td>3/76</td>
<td>0.45</td>
<td>0.05 / 0.32</td>
<td>4.1</td>
<td>8.5</td>
<td>7</td>
<td>2.2</td>
<td>150</td>
<td>6 / 1.1</td>
</tr>
<tr>
<td>HT-07006</td>
<td>6/152</td>
<td>0.70</td>
<td>0.11 / 0.71</td>
<td>4.1</td>
<td>11.0</td>
<td>7</td>
<td>2.2</td>
<td>150</td>
<td>6 / 1.1</td>
</tr>
<tr>
<td>MP-06503</td>
<td>3/76</td>
<td>0.65</td>
<td>0.09 / 0.58</td>
<td>2.4</td>
<td>8.5</td>
<td>6</td>
<td>1.3</td>
<td>90</td>
<td>9 / 1.6</td>
</tr>
<tr>
<td><strong>MULTI-LAYER</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HT-09009</td>
<td>9/229</td>
<td>0.90</td>
<td>0.16 / 1.03</td>
<td>4.1</td>
<td>20.0</td>
<td>7</td>
<td>2.2</td>
<td>150</td>
<td>6 / 1.1</td>
</tr>
<tr>
<td>HT-07006</td>
<td>6/152</td>
<td>0.70</td>
<td>0.11 / 0.71</td>
<td>4.1</td>
<td>11.0</td>
<td>7</td>
<td>2.2</td>
<td>150</td>
<td>6 / 1.1</td>
</tr>
<tr>
<td>CML-11006*</td>
<td>6/152</td>
<td>1.10</td>
<td>0.21 / 1.35</td>
<td>N/A</td>
<td>10.0</td>
<td>7</td>
<td>1.1</td>
<td>90</td>
<td>10 / 1.8</td>
</tr>
<tr>
<td><strong>LAMINATE ONLY</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HR T30.20</td>
<td>3/76</td>
<td>0.9</td>
<td>0.15 / 0.97</td>
<td>1.5</td>
<td>7.5</td>
<td>7</td>
<td>1.0</td>
<td>90</td>
<td>9 / 1.6</td>
</tr>
</tbody>
</table>

**Product Performance** = The entire material stack-up including the aluminum base plate + dielectric + copper circuit foil

**Dielectric Performance** = Characteristic testing done of dielectric only, not the entire stack-up of material or laminate

Note: For applications with an expected voltage of 480 Volts AC or above, Bergquist recommends a dielectric thickness greater than 0.003” (76µm).

Note: Circuit design is the most important consideration for determining safety agency compliance.

Breakdown Voltage does not represent max operating or proof test voltage.

*CML is available in prepreg form only

### Method Description

1. Optical
2. MET-5.4-01-40000-Test Thermal Performance of Insulated Metal Substrates (IMS)
3. Calculation from ASTM 5470
4. Extended ASTM 5470
5. ASTM D149, see page 16
6. ASTM D150
7. MET-5.4-01-7800
8. ASTM D2861
Insulated Metal Substrate (IMS) Technology
Technology Comparison – Dielectric

Data Sheet Thermal Conductivity (ext. ASTM 5470 and other Methods)

Comparison
• Values from Data Sheet >> ext. ASTM 5470 and many others
• Measured Values with similar stackup (Alu / Co)
• Dielectric Thickness 75µm - 100µm (HPL 38µm)
Insulated Metal Substrate (IMS) Technology
Technology Comparison - Dielectric

Thermal Performance the “Stack up”

Test using TO220 package to determine thermal performance of MCPCB substrates (Method: MET 5.4-01-40000)

Thermo couple Locations

Thermal grease used in interface

Power in 40W

Force 60psi (0.4MPa)

Typical IMS stack up
• 70µm Circuit
• Dielectric
• 1.6mm Base

Shortest thermal path from die to heat sink

\[ \Delta T = T_C - T_S \]

result is described in °C/W
Insulated Metal Substrate (IMS) Technology Technology Comparison - Dielectric

TO-220 Thermal Impedance Test (MET 5.4-01-40000)

Result: Thermal Resistance / Impedance
- Lower Thermal Impedance = Lower Junction Temperature
- Thermal Resistance calculated from Data Sheet Value
- Interfacial Resistance not included

Result: Thermal Conductivity
- Test Methods won’t give same values
- Data Sheet values are not comparable

Product Performance gives more competitive comparison values!
IPC Standards for Metal Clad PCBs is about to emerge:

**IPC/CPCA-4105A**

IPC standards will enable product designers to make accurate and confident comparisons between insulated metal substrates for design projects where superior thermal performance is an imperative.

IPC/CPCA-4105A joint standard covering IMS will serve product designers seeking reliable solutions to their thermal management challenges, by empowering them to identify products that will meet their requirements, and make accurate comparisons in order to ensure the most satisfactory and cost-effective solution.

Source: Pinnacle Marketing Communications Ltd.
Insulated Metal Substrate (IMS) Technology
Dielectric Qualification

Other Points which must be considered are:

- Product Qualification and Reliability
- Electrical Properties / Hi-Pot Testing
- Peel Strength and Interconnect
- Mechanical Requirements in the Design
- Cost Driver

Thermal Mgmt is not Lambda only!
## Insulated Metal Substrate (IMS) Technology

### Dielectric Qualification

**Typical Qualification Programs**

<table>
<thead>
<tr>
<th>Physical Properties</th>
<th>Electrical Properties</th>
<th>Other Properties Evaluated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peel Adhesion</td>
<td>Breakdown voltage</td>
<td>Thermal Shock</td>
</tr>
<tr>
<td>Full Strength</td>
<td>DC and AC</td>
<td>Sand Bath</td>
</tr>
<tr>
<td>Sequential Aging</td>
<td>Sequential Aging</td>
<td>10 Cycle Solder Shock</td>
</tr>
<tr>
<td>Thermal Stress</td>
<td>Thermal Stress</td>
<td>Thermal Conductivity</td>
</tr>
<tr>
<td>230°C / 10 min</td>
<td>230°C / 10 min</td>
<td>Flamability</td>
</tr>
<tr>
<td>Thermal Aging</td>
<td>Thermal Aging</td>
<td></td>
</tr>
<tr>
<td>125°C / 2000 hours</td>
<td>125°C / 2000 hours</td>
<td></td>
</tr>
<tr>
<td>Temperature Cycling</td>
<td>Temperature Cycling</td>
<td></td>
</tr>
<tr>
<td>500 cycle / -40°C to +150°C 350 hours</td>
<td>500 cycles / -40°C to +150°C 350 hours</td>
<td></td>
</tr>
<tr>
<td>Temperature / Blas</td>
<td>Temp / Humid / Blas Aging</td>
<td></td>
</tr>
<tr>
<td>85°C / 85% RH / 100V 2000 hours</td>
<td>85°C / 85% RH / 100 V 2000 hours</td>
<td></td>
</tr>
<tr>
<td>Chemical Soak</td>
<td>Chemical Soak</td>
<td></td>
</tr>
<tr>
<td>Loncoterge – 15 min</td>
<td>Loncoterge – 15 min</td>
<td></td>
</tr>
<tr>
<td>Alcohol – 15 min</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Physical Properties

- Peel Adhesion
- Thermal Stress
  - 230°C / 10 min
- Thermal Aging
  - 125°C / 2000 hours
- Temperature Cycling
  - 500 cycle / -40°C to +150°C 350 hours
- Temperature / Blas
  - 85°C / 85% RH / 100V 2000 hours
- Chemical Soak
  - Loncoterge – 15 min
  - Alcohol – 15 min

### Electrical Properties

- Breakdown voltage
  - DC and AC Sequential Aging
- Thermal Stress
  - 230°C / 10 min
- Thermal Aging
  - 125°C / 2000 hours
- Temperature Cycling
  - 500 cycles / -40°C to +150°C 350 hours
- Temp / Humid / Blas Aging
  - 85°C / 85% RH / 100 V 2000 hours
- Chemical Soak
  - Loncoterge – 15 min

### Other Properties Evaluated

- Insulation Impedance
  - 85°C / 85% RH / 100V 2000 hours
- Thermal Blas Aging
  - 125°C / 100V / 2000 hours
- Thermal Blas Aging
  - 125°C / 480V / 2000 hours
- Thermal Blas Aging
  - 175°C / 100V / 2000 hours
- Thermal Blas Aging
  - 125°C / 100V / 2000 hours
- Thermal Blas Aging
  - 125°C / 480V / 2000 hours
- Thermal Blas Aging
  - 175°C / 100V / 2000 hours
- Thermal Blas Aging
  - 125°C / 100V / 2000 hours
- Thermal Blas Aging
  - 125°C / 480V / 2000 hours
- Thermal Blas Aging
  - 175°C / 100V / 2000 hours
- Thermal Blas Aging
  - 125°C / 100V / 2000 hours
- Thermal Blas Aging
  - 125°C / 480V / 2000 hours
- Thermal Blas Aging
  - 175°C / 100V / 2000 hours

### Insulation Impedance

- 85°C / 85% RH / 100V 2000 hours
- Thermal Aging
  - 125°C / 2000 hours
- Temp / Humid / Blas Aging
  - 85°C / 85% RH / 100 V 2000 hours
- Chemical Soak
  - Loncoterge – 15 min
  - Alcohol – 15 min
Insulated Metal Substrate (IMS) Technology
Dielectric Qualification

Lifetime table of Thermal Clad MP (from UL 746 B Method)

<table>
<thead>
<tr>
<th>Material</th>
<th>RTI – Electro / Mechanical per U.L 746 E</th>
<th>CTI*</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPL</td>
<td>140°C / 140°C</td>
<td>0 / 600</td>
</tr>
<tr>
<td>HT</td>
<td>140°C / 140°C</td>
<td>0 / 600</td>
</tr>
<tr>
<td>MP</td>
<td>130°C / 140°C</td>
<td>0 / 500 (425)</td>
</tr>
<tr>
<td>CML</td>
<td>130°C / 130°C</td>
<td>NA / NA</td>
</tr>
<tr>
<td>HR T30.20</td>
<td>150°C / 155°C</td>
<td>0 / 600</td>
</tr>
</tbody>
</table>

Electrical (example of Dielectric MP)

<table>
<thead>
<tr>
<th>Time (hours)</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100000</td>
<td>129</td>
</tr>
<tr>
<td>50000</td>
<td>136</td>
</tr>
<tr>
<td>25000</td>
<td>143</td>
</tr>
<tr>
<td>20000</td>
<td>146</td>
</tr>
<tr>
<td>10000</td>
<td>154</td>
</tr>
<tr>
<td>5000</td>
<td>164</td>
</tr>
</tbody>
</table>

Mechanical and Electrical Lifetime Prediction
Bare Dielectric Aged in Air in Laboratory Conditions

Analyzed by an Extrapolation to UL 746E
Assuming 50% Initial Values = Material Lifetime

Mechanical (Example of Dielectric MP)

<table>
<thead>
<tr>
<th>Time (hours)</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100000</td>
<td>138</td>
</tr>
<tr>
<td>50000</td>
<td>145</td>
</tr>
<tr>
<td>25000</td>
<td>153</td>
</tr>
<tr>
<td>20000</td>
<td>155</td>
</tr>
<tr>
<td>10000</td>
<td>164</td>
</tr>
<tr>
<td>5000</td>
<td>174</td>
</tr>
</tbody>
</table>

+CTI=Comparative Tracking Index – ASTM D3638 / IEC 60112
Insulated Metal Substrate (IMS) Technology
Dielectric Performance - Electrical

- Breakdown Voltage
- Test destroys Dielectric
- ASTM test under Oil and Dielectric only
- Applications in Air will have lower Results

**Dielectric Strength**
ASTM D149

<table>
<thead>
<tr>
<th>Material</th>
<th>Breakdown kVAC</th>
<th>Dielectric Thickness Inches (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CML 152µm</td>
<td>10.0</td>
<td>0.002 (51)</td>
</tr>
<tr>
<td>HRT 76µm</td>
<td>7.5</td>
<td>0.004 (102)</td>
</tr>
<tr>
<td>MP 76µm</td>
<td>8.5</td>
<td>0.006 (152)</td>
</tr>
<tr>
<td>HT 76µm</td>
<td>8.5</td>
<td>0.008 (203)</td>
</tr>
<tr>
<td>HT 152µm</td>
<td>11.0</td>
<td>0.010 (254)</td>
</tr>
<tr>
<td>HPL</td>
<td>5.0</td>
<td>0.012 (305)</td>
</tr>
</tbody>
</table>

**Breakdown Voltage in Oil with 2” (51mm) Probe**
ASTM D149

- HT
- MP
- CML
- HR T30.20
IMS Substrate Technology
Dielectric Performance - Electrical

• Proof Testing to validate electrical integrity of Design
• Test shouldn’t damage System
  • Guideline test < 50% of breakdown
  • Layout must include creepage distance
  • Recommended ramp 500V/sec
  • DC voltage preferred

“Proof Test” fixture to test multiple number of finished circuit boards at one time.
Insulated Metal Substrate (IMS) Technology
Dielectric Performance – Peel Adhesion

Peel Strength of IMS
• Adhesion Influenced by Temperature
• Similar to FR4 - BUT
  • No through hole connectors
    Only SMD
  • Mechanical Force creates risk for Delamination
    • Consider Stress Relieve for Connectors
  • Connector Selection
    • Mechanical Board-lock
    • Surface Mount Hold-down

Circuit Peel Adhesion of Bergquist Materials
ASTM 2861 (Typical Test Value)

<table>
<thead>
<tr>
<th>Temperature [°C]</th>
<th>HT</th>
<th>MP</th>
<th>CML</th>
<th>FR-4</th>
<th>HR T30.20</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>18</td>
<td>15</td>
<td>12</td>
<td>9</td>
<td>6</td>
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<tr>
<td>50</td>
<td>3.0</td>
<td>2.5</td>
<td>2.0</td>
<td>1.5</td>
<td>1.0</td>
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<tr>
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<td>1.0</td>
<td>0.5</td>
<td>0.0</td>
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<tr>
<td>150</td>
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</tbody>
</table>
Insulated Metal Substrate (IMS) Technology
Material Configuration – Connection Techniques

Connection Techniques
• Pin Connector
• Power Connector
• Edge Connector
• Wire Bonding – Direct Die Attach
• Custom Connector

Flex attachment on Thermal Clad

Manufacturers such as AutoSplice and Zierick have off the shelf pins ideal for IMS applications. Custom pins and connectors are also available.

This Tyco Electronics™ SMT thru-board connector provides a way to bring power from the underside of a Thermal Clad IMS board, eliminating issues of dressing wires on the top side of LED boards.

Close up view of a direct die attachment in a power application
Insulated Metal Substrate (IMS) Technology

Material Configuration – Base Layer

Base Metal Thickness

- 1.57mm (0.062in) Standard
- 1.00mm (0.040in) Standard

<table>
<thead>
<tr>
<th>Inches</th>
<th>Millimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aluminum - Thicknesses</strong></td>
<td></td>
</tr>
<tr>
<td>0.020</td>
<td>0.51</td>
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<tr>
<td>0.032</td>
<td>0.81</td>
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<tr>
<td>0.040</td>
<td>1.02</td>
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<td>0.062</td>
<td>1.57</td>
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<tr>
<td>0.080</td>
<td>2.03</td>
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<tr>
<td>0.125</td>
<td>3.18</td>
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<tr>
<td>0.160</td>
<td>4.06</td>
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<tr>
<td>0.190</td>
<td>4.83</td>
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</table>

*Standard thicknesses highlighted

<table>
<thead>
<tr>
<th>Inches</th>
<th>Millimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Copper - Thicknesses</strong></td>
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<td>0.020</td>
<td>0.51</td>
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<tr>
<td>0.031</td>
<td>0.79</td>
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<tr>
<td>0.040</td>
<td>1.02</td>
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<tr>
<td>0.060</td>
<td>1.52</td>
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<tr>
<td>0.080</td>
<td>2.03</td>
</tr>
<tr>
<td>0.125</td>
<td>3.18</td>
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</table>
Insulated Metal Substrate (IMS) Technology
Material Configuration – Base Layer

<table>
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<tbody>
<tr>
<td>Copper</td>
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<td>17</td>
<td>8.9</td>
<td>44.1</td>
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<tr>
<td>Aluminum 5052</td>
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<td>25</td>
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<td>25.9</td>
<td>215</td>
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<tr>
<td>Aluminum 6061</td>
<td>170</td>
<td>25</td>
<td>2.7</td>
<td>26</td>
<td>230</td>
</tr>
</tbody>
</table>

- **Alu**
  - Alu is Commodity
  - Thickness increase mechanical strength
  - Flatness >> recommend Ratio 10:1 (Alu / Copper)
  - Lower weight

- **Copper**
  - Lower CTE - good for sensitive components and high Temp Delta
  - Higher thermal Conductivity to transport heat faster
Insulated Metal Substrate (IMS) Technology
Material Configuration – Circuit Layer Selection

Circuit Layer Thickness

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight (oz/ft²)</th>
<th>Reference inches</th>
<th>Thickness µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper (Zinc Treatment)</td>
<td>0.5</td>
<td>0.0007</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0.0014</td>
<td>35</td>
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<tr>
<td></td>
<td>2</td>
<td>0.0028</td>
<td>70</td>
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<tr>
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<td>3</td>
<td>0.0042</td>
<td>105</td>
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<tr>
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<td>4</td>
<td>0.0056</td>
<td>140</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>0.0070</td>
<td>175</td>
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<tr>
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<td>6</td>
<td>0.0084</td>
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<tr>
<td></td>
<td>8</td>
<td>0.0112</td>
<td>280</td>
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<tr>
<td></td>
<td>10</td>
<td>0.0140</td>
<td>350</td>
</tr>
</tbody>
</table>

NOTE: Copper foil is NOT measured for thickness as a control method. Instead, it is certified to an area weight requirement per IPC-4562. The nominal thickness given on 1 oz. copper is 0.0014" (35 µm).
CAUTION!: Values in IPC-4562 (Table 1.1) are not representative of mechanical thickness.
Insulated Metal Substrate (IMS) Technology
Material Configuration – Circuit Layer Selection

Temperature Rise in Circuit due to Current Resistive Heating
1" by 0.125" (25mm by 3.2mm) trace on 0.003" (76µm) HT dielectric or 0.006" (152µm) FR-4 dielectric

Relative temperature rise comparison graph depicts the significant difference between Bergquist Dielectric HT and FR-4. Additional comparison charts regarding all Bergquist Dielectrics are available. Note: No base metal used in calculation.

**Improved Thermal allow for higher Current Carrying on a Circuit Compared to FR4**

- Thinner Copper can be used selected
- Less Circuit Area required
Insulated Metal Substrate (IMS) Technology
Material Configuration – Laminate Format

Good Material Usage?
Insulated Metal Substrate (IMS) Technology
Material Configuration – Laminate Format

Panel Sizes - Standard
• 457mm x 610mm (18in x 24in)
  usable area 432mm x 584mm (17in x 23in)
• 508mm x 610mm  (20in x 24in)
  usable area 482mm x 584mm (19in x 23in)

Panel Sizes – Special
• 508mm x 635mm  (20in x 25in)
  usable area 482mm x 610mm (19in x 24in)
• 457mm x 635mm  (18in x 25in)
  usable area 432mm x 610mm (17in x 24in)

Other Panel Formats and Base Metals available on request
Thermal Clad (TCLAD) Substrate Technology
Material Configuration – Cost Driver

- BOM
  - AL vs. CU, & Base plate thickness
  - Circuit foil weight 18µm vs. 350µm
  - Dielectric type and thickness
- Form Factor
  - Number of layers
  - Shape – round vs. square
- Panel Utilization
  - What percentage of the panel is utilized
- Non Standard holes
  - counter-sinks
  - Threaded
- Surface finishes
- Single piece or panelized array

Material utilization is key in reducing cost
Thank You!

Contact: Michael.Stoll@henkel.com

Webinar website: www.globalhenkelelectronics.com/webinars