Insulated Metal Substrate (IMS): a portrait

Webinar on 2nd of February 2016

Speaker: Bert Heinz
Insulated Metal Substrate (IMS): a portrait

Motor control, power conversion and LED technology - applications with high temperatures. This is precisely where it is essential to ensure heat dissipation from the components to increase the reliability.

One possible solution is the use of IMS boards.

In this webinar WE will show you:
- basics and design parameters
- which materials are used
- how to optimize the PCB layout by doing a thermal simulation
Drivers for ever more effective thermal management concepts

- Further miniaturisation of components
- Increasingly powerful components
- Thermal dissipation per unit area is rising
- Higher clock frequencies, higher packaging densities
- Installation of populated PCBs on warm assembly units and machine parts or in hermetically sealed housing

The need for circuit carriers with carefully planned thermal management is increasing

PCBs play an important role in the development of efficient thermal management
In order to solve thermal problems analyse the whole system (component, circuit board, assembly, housing and environment)

Heat cannot be “destroyed” the only possibility is to dissipate it from the hot component

Cooling strategies depend on different requirements of electronic systems
- Amount of thermal output
- Available space / size of elements
- Assembly technologies for components used
- Complexity of circuit

Cooling concepts have to meet specific demands
- Guarantee sufficient reliability
- Provide for cost-benefit ratio
Types of heat dissipation

- **Conduction:** Heat dissipation via solid objects
- **Convection:** heat transfer through gases or fluids
- **Radiation:** Emission of photons

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Thermal Management Basics
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**Thermal Management Basics**

- Heat sources: power components, configuration
- Heatsinks: Where can / where should the heat flow to?
- What does the thermal path look like?
- Which thermal resistances are on this path?
- Better distribution and / or removal of the heat
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Capabilities

Numerous Applications

- LED technology → illuminated signs, display, lighting
- Automobile industry → LED headlights, motor control units, servo steering
- Power electronics → D.C. generator, inverter, engine control
- Switch and semiconductor relay
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**Structure**

![Diagram of IMS structure]

**Typical Structure**

- **Copper foil**
- **Insulating layer**
  - Generally consisting of pre-preg or a thermally conductive resin compound
  - **Metal substrate**
  - Generally consisting of aluminum, copper or stainless steel
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Structure

- Insulating layer made from polymers and a large proportion of ceramic, which is an excellent thermal conductor
- Thereby up to 5 times better thermal conductivity than standard pre-preg
- Whilst at the same time increased dielectric strength, in comparison to standard FR4 material
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Manufacture

- Select material, aluminum or copper, in rare cases stainless steel
- Pre-clean and brush material
- Roughen aluminum and press together with the desired dielectric and copper foil
- To protect the aluminum from scratches and chemicals (acid or alkaline etching), the panel may be coated with a protective film
- Apply film and expose layout, etch thereafter
- Apply the solder mask
- Drill the NPT holes, mechanical finishing, notches, milling or punching
- Apply surface finish (ENIG, HAL, OSP ...)
- E-test, final inspection, shipping
# Insulated Metal Substrate (IMS): a portrait

## Design Rules

<table>
<thead>
<tr>
<th>Brand</th>
<th>Bergquist; Laird; Arlon; DENKA; Ventec; KinWong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laminate Type</td>
<td>Aluminum; Copper; Stainless steel</td>
</tr>
<tr>
<td>Metal Type</td>
<td>Aluminum: 1100H14, 5052H34, 6061T6</td>
</tr>
<tr>
<td></td>
<td>Copper: C1100, C1220</td>
</tr>
<tr>
<td></td>
<td>Stainless steel: SUS430</td>
</tr>
<tr>
<td>Material Size</td>
<td>General: 600*457 mm</td>
</tr>
<tr>
<td></td>
<td>Maximal: 1200*550 mm</td>
</tr>
<tr>
<td>Board Thickness</td>
<td>0.4 - 3.2 mm</td>
</tr>
<tr>
<td>Standard Board Thickness</td>
<td>+/- 0.10 mm</td>
</tr>
<tr>
<td>Standard Metal Thickness</td>
<td>0.3mm; 0.4mm; 0.5mm; 0.6mm; 0.8mm; 1.0mm; 1.2mm; 1.5mm; 2.0mm; 2.5mm; 3.0mm</td>
</tr>
<tr>
<td>Dielectric Thickness</td>
<td>0.05 ~ 0.20 mm</td>
</tr>
<tr>
<td>Thermal Conductivity</td>
<td>1 W/mK ~ 8 W/mK</td>
</tr>
<tr>
<td>Breakdown Voltage</td>
<td>6 kV AC</td>
</tr>
<tr>
<td>Copper Thickness</td>
<td>18 µm; 35 µm; 70 µm; 105 µm</td>
</tr>
</tbody>
</table>
## Insulated Metal Substrate (IMS): a portrait

### Design Rules

<table>
<thead>
<tr>
<th>Conductor</th>
<th>Track Width</th>
<th>&gt;=150 µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductor Spacing</td>
<td>&gt;=150 µm</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hole Size</th>
<th>Final Hole Size</th>
<th>0,5 mm ~ 6 mm</th>
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<tbody>
<tr>
<td>Hole Tolerance</td>
<td>+/- 0,075 mm</td>
<td></td>
</tr>
<tr>
<td>Tolerance of Hole Position</td>
<td>+/- 0,10 mm</td>
<td></td>
</tr>
<tr>
<td>Aspect Ratio</td>
<td>5 : 2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Solder Mask</th>
<th>Solder Mask Web</th>
<th>&gt;=100 µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solder Mask Clearance</td>
<td>&gt;=50 µm</td>
<td></td>
</tr>
<tr>
<td>Via - Opening</td>
<td>&gt;=100µm</td>
<td></td>
</tr>
<tr>
<td>Solder Mask Coverage</td>
<td>50 µm</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Tolerance of Outline Dimension</th>
<th>+/- 0,10 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finish of max. Dimension</td>
<td>Length: 1200 mm Width: 530 mm</td>
<td></td>
</tr>
</tbody>
</table>

| Surface Finish | HAL; LF-Hal; OSP; ENIG; Imersion Silver; Immersion Tin; ENEPIG | |

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**Insulated Metal Substrate (IMS): a portrait Simulation**

- **Size of the pcb 45 x 45 mm**
- **Power loss of the LED 3W**
- **Ambient temperature 20 °C**
- **Pcb vertical free-standing in laboratory**
- **Heat transfer to the air 12 W/m²K**
**Insulated Metal Substrate (IMS): a portrait Simulation**

**Variant 1**

Copper Layer: 35 µm  
Dielectric Layer: 100 µm /1.3 W/mK  
Aluminum: 1.5 mm

**Layout**
Insulated Metal Substrate (IMS): a portrait
Simulation
**Insulated Metal Substrate (IMS): a portrait**

**Simulation**

**Variant 2**

- **Copper Layer:** 35 µm
- **Dielectric Layer:** 100 µm / 1.3 W/mK
- **Aluminum:** 1.5 mm

**Improved Layout**
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Simulation
**Insulated Metal Substrate (IMS): a portrait**

**Simulation**

**Variant 3**

- **Copper Layer**: 35 µm
- **Dielectric Layer**: 100 µm / 2.2 W/mK
- **Aluminum**: 1.5 mm

**Improved Layout**
Insulated Metal Substrate (IMS): a portrait Simulation

Variant 3
**Insulated Metal Substrate (IMS): a portrait**

Simulation

**Variant 4**

Copper Layer: 105 µm  
Dielectric Layer: 100 µm / 2.2 W/mK  
Aluminum: 1.5 mm

**Improved Layout**
**Insulated Metal Substrate (IMS): a portrait**

**Simulation**

![Simulation Diagram]

**Variant 4**

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03.02.2016
**Insulated Metal Substrate (IMS): a portrait**

**Simulation**

- **Variant 5**
  - **Copper Layer**: 105 µm
  - **Dielectric Layer**: 100 µm / 3.0 W/mK
  - **Aluminum**: 1.5 mm

**Improved Layout**
Insulated Metal Substrate (IMS): a portrait
Simulation
Insulated Metal Substrate (IMS): a portrait
Simulation
**Insulated Metal Substrate (IMS): a portrait**

**Simulation**

**Variant 6**

- Copper Layer: 35 µm
- Dielectric Layer: 100 µm / 2.2 W/mK
- Aluminum: 1.5 mm

- Improved Layout
  - Heatsink 3mm larger all around
Insulated Metal Substrate (IMS): a portrait
Simulation
**Insulated Metal Substrate (IMS): a portrait**

Simulation

- Copper Layer: 35 µm
- FR 4: 1500 µm / 0.3 W/mK
Which factors influence the price?

- Brand laminate are more expensive compared to self-produced laminates
- Copper is more expensive than aluminum
- The higher the thermal conductivity of the material the higher the price
- The thicker the dielectric, the more expensive the board
- The delivery panel of customer should be adapted to the best utilization of the manufacturer
- Outlines are whenever possible punched or notched, milling is more complex and therefore more expensive
- Thread and deep milling in metal increase the price