AIT Package Level EMI/RFI Conformal Shielding Solutions

- EMC8660 applied to component packages before soldering for proven performance of over 90 dB EMI/RFI shielding effectiveness from MHz to GHz
  - Heat releasing pad (HRP-500M) for protecting contacts of BGA packages during coating processes

- EMC8130 applied to onboard level component packages for proven performance of over 90 dB EMI/RFI shielding effectiveness from MHz to GHz
  - Onboard component package edge insulation protection moisture barrier seal (OBS7130)

- Jetting dispense spray component package level EMI/RFI shielding coating
  - Partnered jet-dispense spray equipment and tooling system and solution
Wireless communication at higher frequencies from 3G to 5G demands the component packages to be in much closer proximity of and more interference between each other

High frequency mobile devices from 3G to 4G with components much closer and generating signals and electromagnetic radiation that affects each others processing or interference. With the advances of G5 and the coming 6G cellular and wireless Internet communication that operates at 6GHz and higher, the need of effective RF electromagnetic interference (RFI/EMI) shielding between the devices onboard of the cellular, computer and communication devices that have high shielding effectiveness, cost effective and spacing saving becomes more demanding.

The demand for higher frequency operations also dictates much closer spacing between component packages and thus traditional solder metal cans shielding is not applicable or effective. The package level shielding becomes a necessity. Highly conductive coating on the components from the top to all sides other than the soldering contact interface have been proven to be the most reliable and cost-effective solution.

With over 35 years in providing EMI/RFI shielding coating and sealant to military electronics, AIT has one of the most extensive experience in providing these component package level shielding applications. Besides providing the necessary micron level coating (4-8 micron thickness) with more than 90 dB shielding effective and if necessary with thicker coating to 110dB shielding can be achieved with AIT package level conformal conductive coatings.

These coating while mostly used to coat the component packages before they are attached to the circuit board, AIT also provides shielding solution that can be directly applied on the solder component packages for shielding enhancement or as manufacturing process.
From 3G to 5G and the coming 6G cellular and wireless Internet communication that operates at 6GHz and higher, the need of effective RF electromagnetic interference (RFI/EMI) shielding between the devices onboard of the cellular, computer and communication devices that have high shielding effectiveness, cost effective and spacing saving becomes more demanding.

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The package level shielding becomes a necessity. Highly conductive coating on the components from the top to all sides other than the soldering contact interface have been proven to be the most reliable and cost-effective solution.
EMI/RFI Shielding Effectiveness on Component Package Level with Soldered Lids are Not as Effective for Ultra-High Frequency Devices

With the advances of 5G that operates at 6GHz and higher, the need of effective RF electromagnetic interference (RFI/EMI) shielding between the devices onboard of the cellular, computer and communication devices becomes much more demanding.

- The demand for higher frequency operations also dictates much closer spacing between component packages and thus traditional soldered metal cans shielding is not applicable or effective. High vacuum sputtering deposition is much more expensive than jet spray dispensing.

- The package level shielding becomes a necessity. Highly conductive coating on the components from the top to all sides other than the soldering contact interface have been proven to be the most reliable and cost-effective solution.

- Conductive coating while mostly used to coat the component packages before they are attached to the circuit board, AIT also provides shielding solution that can be directly applied on the solder component packages for shielding enhancement or as manufacturing process.

### Comparative Technologies and Costs

<table>
<thead>
<tr>
<th></th>
<th>Vacuum Metal Sputtering</th>
<th>Jet Spray Dispensing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package Dimension</td>
<td>10mmx10mmx1.0mm</td>
<td>10mmx10mmx1.0mm</td>
</tr>
<tr>
<td>Relative Productivity</td>
<td>&lt;10,000 units per hour</td>
<td>&gt; 30,000 units per hour</td>
</tr>
<tr>
<td>Floor Space Requirement</td>
<td>15-30 sq meter</td>
<td>3-5 sq meter</td>
</tr>
<tr>
<td>Average Capital Investment</td>
<td>US$3-8 million</td>
<td>US$0.2-0.5 million</td>
</tr>
<tr>
<td>Estimated Cost Per Package</td>
<td>&gt;&gt;US$0.01</td>
<td>~US$0.01</td>
</tr>
</tbody>
</table>
EMI/RFI Shielding Effectiveness on Component Package Level with Direct Conductive Coating

Component package conductive coating must attached to the molding compound:

- To form thin conductive coating conformal to the molded component package
  - 4-8 micron coating for up to 90dB shielding effectiveness
  - 15-25 micron coating for up to 110dB and up for shielding effectiveness
- Covering all 5 sides without affecting contact interconnection interface surface
- Jet-spray coating on component package level, or judicial and selectively on radiating component package on board level
Rapid Low Temperature Curing for Low Stress and No Warpage:
- 150°C for 10-30 minutes, or
- 125°C for 45-60 minutes, or
- 100°C for 2+ hours
- Lower temperature curing for lower stress on packages and ultra low shrinkage

Uniform Conductive Coating with Programmable Jet Spray:
- Outstanding Conductivity: < 2x10^-5 Ω-cm Resistivity
- 4-10µ for >90 dB shielding effectiveness
- 15-25µ for >110 dB shielding effectiveness

Fast Air Drying into Dry Film on Component Packages for Ease of Handling:
- Ambient drying as soon as spraying is finished
- Solid and dry film before curing

Molecular Structure Designed to Absorb Thermal Stresses:
- Outstanding thermal cycling compatibility from -65°C to 150°C
- No Crack
- No Voids

No Bleed Coating with Controlled Thixotropy for Defined Edge Flow:
- Outstanding adhesion onto molding compound surfaces
- Controlled flow for onboard direct application
- No bleeding onto neighboring board areas and underneath the component

EMC8660 and EMC8130 Package Level Conductive Spray Coating with Unparalleled Performance
Component Package Level Conductive Spray Coating Requires a Sealing Pad for Protection and Handling

Jet-Spray conductive coating onto molding compound:

- Covering all 5 sides without affecting contact interconnection interface surface
- Solder balls and contact pins on interconnection interface side must be sealed off from jet-spray coating:
  - Needs a conformable sealing pad allowing the package solder balls and pins submerged. To withstand coating curing at temperature up to 175°C.
  - The component package must be easily picked for board attachment
  - Heat releasing pad (HRP-500M) for protecting contacts of BGA packages during coating processes
Component Package Level Conductive Spray Coating Requires a Sealing Pad for Protection and Handling

Jet-Spray conductive coating onto molding compound:
- Covering all 5 sides without affecting contact interconnection interface surface
- Solder balls and contact pins on interconnection interface side must be sealed off from jet-spray coating:
  - Needs a conformable sealing pad allowing the package solder balls and pins submerged to withstand coating curing at temperatures up to 175°C.
  - The component package must be easily picked for board attachment.

Conductive Coating Parameters and Properties

<table>
<thead>
<tr>
<th>Product Identification</th>
<th>AIT EMC8660</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Technology</td>
<td>Electrically Hyper-conductive Coating</td>
</tr>
<tr>
<td>Application and Dispensing Method</td>
<td>Jet Spraying, Ultrasonic Spraying</td>
</tr>
<tr>
<td>Conductive Fillers</td>
<td>Proprietary sub-micron silver particulates</td>
</tr>
<tr>
<td>Volume (Bulk) Resistivity</td>
<td>&lt;2x10^-5 Ω-cm</td>
</tr>
<tr>
<td>Recommended Coating Thickness for 90dB SE</td>
<td>4-10 micron</td>
</tr>
<tr>
<td>Recommended Coating Thickness for &gt;110dB SE</td>
<td>15-25 micron</td>
</tr>
<tr>
<td>Viscosity at 5 rpm</td>
<td>300-500 cps</td>
</tr>
<tr>
<td>Thixotropic Index</td>
<td>~1.5</td>
</tr>
<tr>
<td>Curing Temperature and Condition</td>
<td>100°C(120 min.) to 150°C (&lt;30 min.) circulating air</td>
</tr>
<tr>
<td>Adhesion on Molding Compound and FR4</td>
<td>&gt;5B (ASTM Cross Hatch Method)</td>
</tr>
<tr>
<td>Recommended &quot;Street Width&quot; to Package Height in Carrier Supporting Pad</td>
<td>1:1</td>
</tr>
</tbody>
</table>

“Height” of Component Package should determine the “Street” of Carrier Pad (Ability to Absorb the Solder Balls of BGA Packages) should be spaced to allow adequate coating of the edges of the Component Package.

“Street” of Carrier Pad (Ability to Absorb the Solder Balls of BGA Packages) should be spaced to allow adequate coating of the edges of the Component Package.
Board Level Component Conductive Spray Coating Requires a Sealant for Component Edges’ Protection

Jet-Spray conductive coating onto onboard compound:

- Covering all 5 sides without affecting contact interconnection interface surface and nearby board areas
- Solder balls and contact pins on interconnection interface side must be sealed off from jet-spray coating:
  - Needs a dispensable sealant sealing all 4 sides component package edges from coating sipping into contacting with solder balls and pins.
  - Sealant capable to withstand all board level functional testing without negatively affecting its performance.
  - Sealant preferably enhances the protection against moisture, acid rain laden moisture, salt-fog moisture and other negative impact environment.
- EMC8130 applied to onboard level component packages for proven performance of over 90 dB EMI/RFI shielding effectiveness from MHz to GHz
  - Onboard component package edge insulation protection moisture barrier seal (OBS7130)
Board Level Component Conductive Spray Coating Requires a Sealant for Component Edges’ Protection

- **Conformal EMI/RFI Shielding Solution**

  **Board Level Component Conductive Spray Coating**

  Requires a Sealant for Component Edges’ Protection

  - Insulating sealant (AIT OBS7130) protective from conductive jet-spraying contacting interconnections

**Conductive Coating and Insulating Sealant Parameters and Properties**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>AIT EMC8130</th>
<th>AIT OBS7130</th>
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<tbody>
<tr>
<td><strong>Product Identification</strong></td>
<td>AIT EMC8130</td>
<td>AIT OBS7130</td>
</tr>
<tr>
<td><strong>Material Technology</strong></td>
<td>Electrically Hyper-conductive Coating</td>
<td>Electrically Insulating Sealant</td>
</tr>
<tr>
<td><strong>Application and Dispensing Method</strong></td>
<td>Jet Spraying, Ultrasonic Spraying</td>
<td>Needle-Tip Dispensing</td>
</tr>
<tr>
<td><strong>Conductive Fillers</strong></td>
<td>Proprietary sub-micron silver</td>
<td>Insulating Moisture Barrier Sealant</td>
</tr>
<tr>
<td><strong>Volume (Bulk)</strong></td>
<td>&lt;2x10⁻¹⁵ Ω-cm</td>
<td>&gt;1x10¹⁴ Ω-cm</td>
</tr>
<tr>
<td><strong>Recommended Coating Thickness for 90dB SE</strong></td>
<td>4-10 micron</td>
<td>Apply to seal the edges of package to board interfaces</td>
</tr>
<tr>
<td><strong>Recommended Coating Thickness for &gt;110dB SE</strong></td>
<td>15-25 micron</td>
<td>Apply to seal the edges of package to board interfaces</td>
</tr>
<tr>
<td><strong>Viscosity at 5 rpm</strong></td>
<td>300-500 cps</td>
<td>50,000 cps</td>
</tr>
<tr>
<td><strong>Thixotropic Index</strong></td>
<td>~1.5</td>
<td>~3.5</td>
</tr>
<tr>
<td><strong>Curing Temperature and Condition</strong></td>
<td>Ambient air drying</td>
<td>Ambient air drying</td>
</tr>
<tr>
<td><strong>Adhesion on Molding Compound and FR4</strong></td>
<td>&gt;2B (ASTM Cross Hatch Method)</td>
<td>Seal and bond to molding compound and board surfaces</td>
</tr>
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</table>
Summary of AIT Package-Level EMI/RFI Shielding Coatings and Solutions for 5G and Ultra High Frequency Devices:

- **EMC8660** applied to component packages before soldering for proven performance of over 90 dB EMI/RFI shielding effectiveness from MHz to GHz
  - Heat releasing pad (GD-TR-200M, GD-TR-450M) for protecting solder balls contacts of BGA packages during coating processes

- **EMC8130** applied to onboard level component packages for proven performance of over 90 dB EMI/RFI shielding effectiveness from MHz to GHz
  - Onboard component package edge insulation protection moisture barrier on-board seal (OBS7130)

- **AIT** has more than 35 years of expertise in providing EMI/RFI shielding coating and sealant solutions

- **Jetting dispense spray component package level EMI/RFI shielding coating**
  - Partnered with jet-dispense spray equipment and tooling system and solution providers