5G: THE FUTURE OF EMI SHIELDING IN MOBILE PHONES

Franz Vollmann, September 2019
5G mobile networks are game changers

- > 10 Gbps Peaks → enhanced mobile broadband
- < 1ms latency and ultra high reliability → ultra reliable low-latency communication
- > 1 million connections per km² → massive machine-type communications

In order to ensure a reliable performance, an ever increasing number of electronics packages require shielding against electromagnetic interferences.
Faster data transfer
Shorter contact time between connected devices (IoT + autonomous driving)

Higher frequencies within chips and on-board SiPs cause problems with electro-magnetic interference

Solution:
Create compartmental shielding per SiP

Metal gaskets on PCB level is inadequate

Picture Courtesy of Harwin
### Existing Technology

<table>
<thead>
<tr>
<th>Technology</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal gaskets on PCB level</td>
<td><img src="image1.png" alt="Image" /></td>
</tr>
</tbody>
</table>

- Not possible for 5G SIP packages due to formfactor requirements (space and weight)

### Next Gen Technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVD Sputtering</td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td>Ag Nano Ink Spray</td>
<td><img src="image3.png" alt="Image" /></td>
</tr>
<tr>
<td>Ag MOD Inkjet</td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
</tbody>
</table>

**Ag Nano Ink Spray**
- Expensive (hi capex, low UPH, large footprint, clean-room requirement)
- Low material efficiency
- No selective coating possible
- Aspect ratio of 1:0.9 not possible
- Nozzle clogging due to nano particles
- EHS risk due to nano particles
- Low material efficiency
- Sidewall coverage very challenging
- No selective coating possible
HERAEUS SOLUTION FOR ELECTROMAGNETIC SHIELDING SHOWS SUPERIOR PERFORMANCE

Advantages of Heraeus solution compared to sputter

-60 dB
shielding performance

- Factor of 5
less capex, smaller footprint

~ 1
ratio between side wall and top coating thickness

0 Zero Waste
accurate and targeted deposition, selective shielding

50%
lower cost of ownership

Factor of 5
higher process speed
HERAEUS SOLUTION IS BASED ON DIGITAL PRINTING OF PARTICLE FREE SILVER INK

Heraeus Complete System Solution approach for product and process

MOD Ink
› Particle-free Ag ink
› No EHS concerns
› No clogging

Inkjet Printing Process
› High-speed digital printing
› Up to 15,000 UPH (10 x 10 mm SiP)
› Full set of optimized printing parameters

Complete Curing Process
› Curing system (IR, UV, Flash)
› Optimal Ag crystal structure and conductivity
› Full set of optimized curing parameters
TECHNOLOGY COMPARISON DEMONSTRATES SUPERIOR PERFORMANCE OF DIGITAL PRINTING VERSUS SPUTTERING AND SPRAY

<table>
<thead>
<tr>
<th>Customer key requirements</th>
<th>Sputtering (Cu coating)</th>
<th>Spray (Nano Ag inks)</th>
<th>Digital Printing MOD Ag-ink (Ink-jet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Investment</td>
<td>Very high ($2-3 mn)</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Equipment Footprint</td>
<td>Large</td>
<td>Small</td>
<td>Small</td>
</tr>
<tr>
<td>Material Efficiency</td>
<td>Very low (≈35%)</td>
<td>Low (60-70%)</td>
<td>High (98-99%)</td>
</tr>
<tr>
<td>Total Cost of Ownership</td>
<td>Very high</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td>Throughput (UPH)</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Production Scalability</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Required Coating Thickness</td>
<td>5-9 µm</td>
<td>3-6 µm</td>
<td>1-2 µm</td>
</tr>
<tr>
<td>Aspect Ratio (Top vs Sidewall)</td>
<td>1: (0.4-0.5)</td>
<td>1: (0.4-0.5)</td>
<td>1:(0.8-0.9)</td>
</tr>
<tr>
<td>Overspray/Overcoating</td>
<td>High</td>
<td>High</td>
<td>Very low</td>
</tr>
<tr>
<td>Selective Coating (partial printing)</td>
<td>✗ masking necessary</td>
<td>✗ masking necessary</td>
<td>✓</td>
</tr>
<tr>
<td>Inkjet Marking (replace laser marking)</td>
<td>✗ masking possible</td>
<td>✗ masking possible</td>
<td>✓</td>
</tr>
</tbody>
</table>
Expertise in recipes & mass production of inks and coatings

Expertise in inkjet printing systems & process know-how

Expertise in curing lamp systems & process know-how
SHIELDING EFFECTIVENESS IS ABOVE -40 DB FOR THE ENTIRE FREQUENCY RANGE

- Absolute shielding performance starts at < -40 dB
- Reaches < -60 dB for frequencies above 2.6 GHz
- Continues between -60 dB and -90 dB up to 9GHz

- No decrease of shielding performance above 10 GHz
DIGITAL PRINTING RESULTS IN VERY HOMOGENEOUS SILVER LAYER

FIB results show a very homogeneous layer on the EMC
HERAEUS SOLUTION ALLOWS SELECTIVE SHIELDING

**Example**
- Silver ink printed on epoxy mold part
- Sharp edge between printed and not printed area
- 4 layers printed on top

**Result**

**Detail**
- Width of transition area: < 100 µm
- Includes positioning between layers
ASPECT RATIO TOP SIDE THICKNESS VS. SIDE WALL THICKNESS

Microscope Picture of Top and Side Thickness

- Results of tests on glass dummies (ultra-smooth surface)
- Achieved aspect ratio approx. 1 : 0.9
THE DEMONSTRATOR EQUIPMENT FOR TESTS AT CUSTOMER SITE IS AVAILABLE Q4/2019 AND THE MANUFACTURING SOLUTION Q2/2020

- Development
  - Data Validation
  - Customer Joint Project
    - Q3 2019 today
    - Q4 2019
  - Commercial Availability
    - Q2 2020

- Joint projects with lead customers commenced
- Ramp up project team in Asia

- In-line solution
- At-line solution
OUR EMI SHIELDING SOLUTION CAN BE USED FOR A BROAD RANGE OF APPLICATIONS

Where is it required?

› Tightly packed highly sensitive components
› Constant move toward miniaturization
› Growing wireless technology applications

Heraeus solution is applicable to various components

› System-in-Package (SiP)
› System-on-Chip (SoC)
› Microcontrollers (MCU)
› PCB
› Power amplifiers
› Wireless modules (Wi-Fi, Bluetooth)
› Radio Frequency (RF) modules
› Memory
› Sensors
› Digital Signal Processors (DSP)
› Application-specific integrated circuits (ASIC)
› Field-programmable gate arrays (FPGA)
› Analog-Digital Converters (ADC)
VISIT US @:

Visit us @ Booth #I2408
(1st Floor)

OR CONTACT US AT:
printed-electronics@heraeus.com