

Webinar

Component Level EMI Shielding for Semiconductor Packages

November 7, 2017

Henkel Electronic Materials



| Introduction



Speakers

- Jinu Choi | Market Segment Head
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For more information, please visit:

www.henkel-adhesives.com/loctite-emi-shielding

- Henkel solutions and value propositions
- Explainer videos
- Technical and marketing documentation for download

| Agenda

1	Electromagnetic Interference and Shielding Trends
2	Henkel's Market Enabling Solutions
3	Compartmental Shielding Process, Materials, and Performance
4	Conformal Shielding Process, Materials, and Performance
5	Shielding Effectiveness Testing Methods
6	Summary

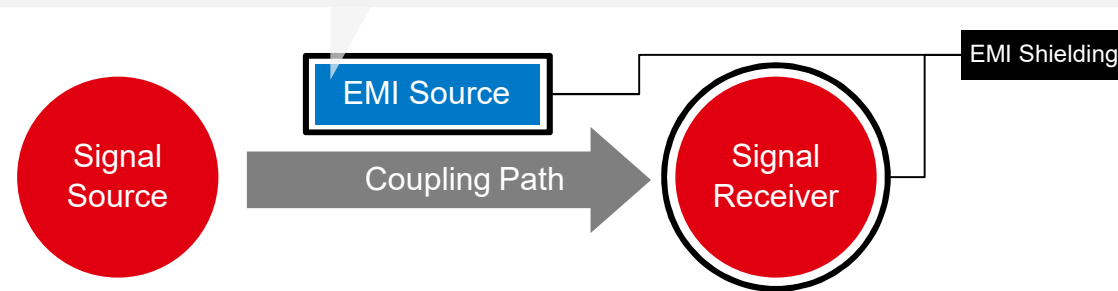
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| Electromagnetic Interference and Compatibility

Electromagnetic Interference (EMI)

- Operational disruption of electronic devices when in the vicinity of an electromagnetic field caused by another device.
- Unwanted signal (noise) emitted by electrical circuits carrying rapidly changing signals.



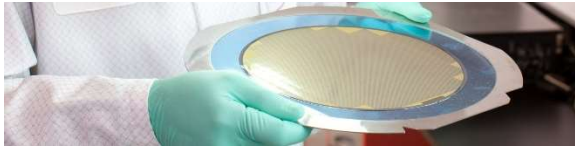
EMI Emission Examples

- High-speed clocking signals
- Digital noise from processors
- Digital power supplies (higher switching frequencies)
- Transmission interferences
- Buses, interconnects and networking interfaces

EMI Impact Examples

- Performance degradation of receiver signal processing circuits
- Unintended operation or malfunctions of electromechanical equipment, circuits, components
- Voltage breakdown or burnout of components and antennas

| Key Drivers for EMI Shielding Technology Advancements



Higher density semiconductor packaging structures

Sensitivity of next generation electronic systems to EMI is increasing due to growing popularity of complex stacked-chip and multi-chip packages.



Increasing electromagnetic pollution

Growing use of wireless communications is requiring digital equipment to be protected from unwanted radio-frequency interference.



Era of Internet of Things (IoT)

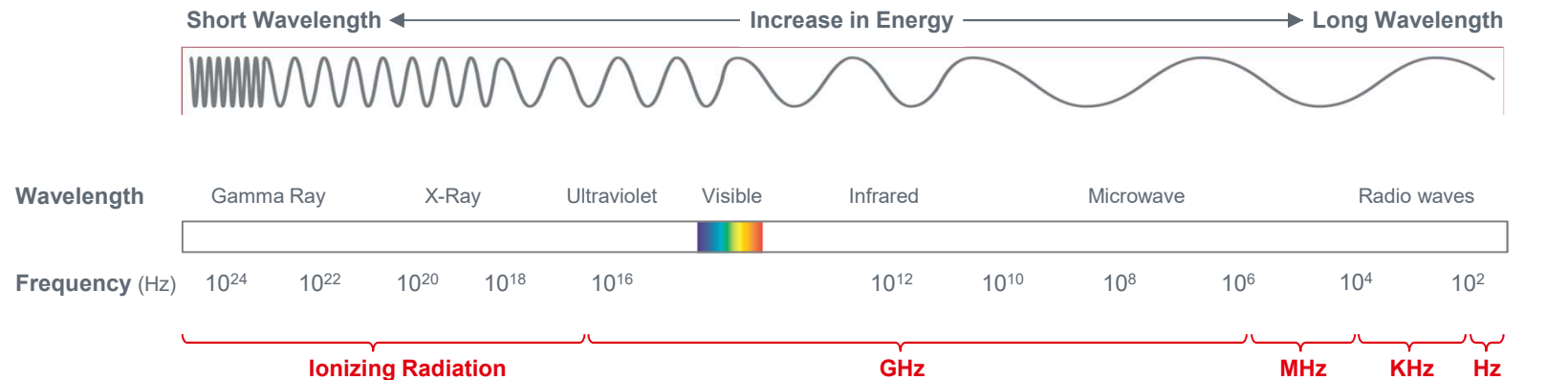
Lower tolerance to equipment failures and unreliability (mobile devices, wearables, transportation electronics, industrial controls and more)



Compliance with tightening EMC regulations

EMI is regulated at national and international levels to allow sensitive equipment to function without performance degradation.

| Electromagnetic Spectrum is a Limited Natural Resource



Examples of Typical Wireless Communication:

Wireless	Wi-Fi (802.11b/g/n/ac)	Bluetooth	4G Cellular (LTE, WiMax)	5G
• 500MHz+	• 2.4~5GHz	• 2.4~2.485 GHz	• 0.7~2.7GHz	• 6GHz+

- The EM spectrum is a limited natural resource that must be maintained to allow reliable radio frequency communications.
- EMC regulatory bodies regulate and enforce EMC compliance with national or international standards such as International Electrotechnical Commission (IEC), Federal Communications Commission (FCC), Verband Deutscher Elektrotechniker (VDE), International Special Committee on Radio Interference (CISPR), Comité Européen de Normalisation (CEN) and more.

| Devices Requiring EMI Shielding

Where is it required?

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



EMI shielding is applicable to various components.

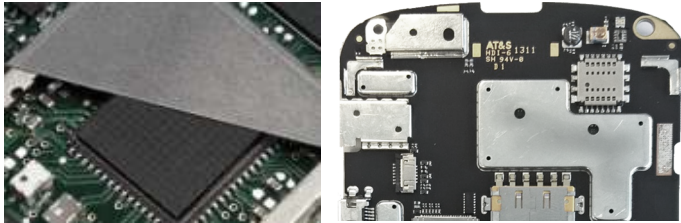
- System-in-Package (SiP)
- System-on-Chip (SoC)
- Microcontrollers (MCU)
- Application processors
- Power amplifiers
- Wireless modules (Wi-Fi, Bluetooth)
- Radio Frequency (RF) modules
- Memory
- Sensors
- Digital Signal Processors (DSP)
- Application-specific integrated circuits (ASIC)
- Field-programmable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

| Electronics EMI Shielding Progression

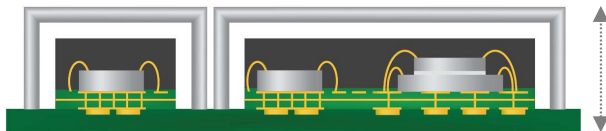
Board Level Moving to Package Level

Board Level Shielding

- Conductive enclosures soldered on the board



Requires large board space adding weight and thickness to the design with complex re-workability.

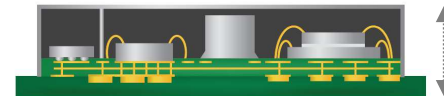


Package Level Shielding

- Conductive materials integrated into the package

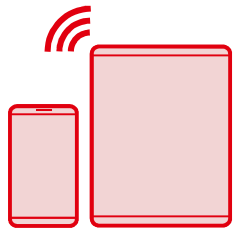


Enables higher board density, design flexibility, simplified BOM for smaller, thinner, lighter device designs



| End Application Examples

- Package level EMI shielding is already used in many applications, and has expansive growth potential with increase in wireless devices.



Smartphones/Tablets

Mobile computer with an operating system with features for handheld use



Wearables

Smart electronic devices that can be worn on the body for added functions to daily activities



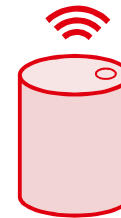
Action Cameras

Digital camera designed for filming action while being immersed in it.



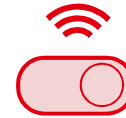
Drones/UAV

Small aircraft under remote control by a human operator or autonomously by onboard computers.



Smart Speakers

Wireless speaker and smart device that extend usage beyond audio playback for automation features.



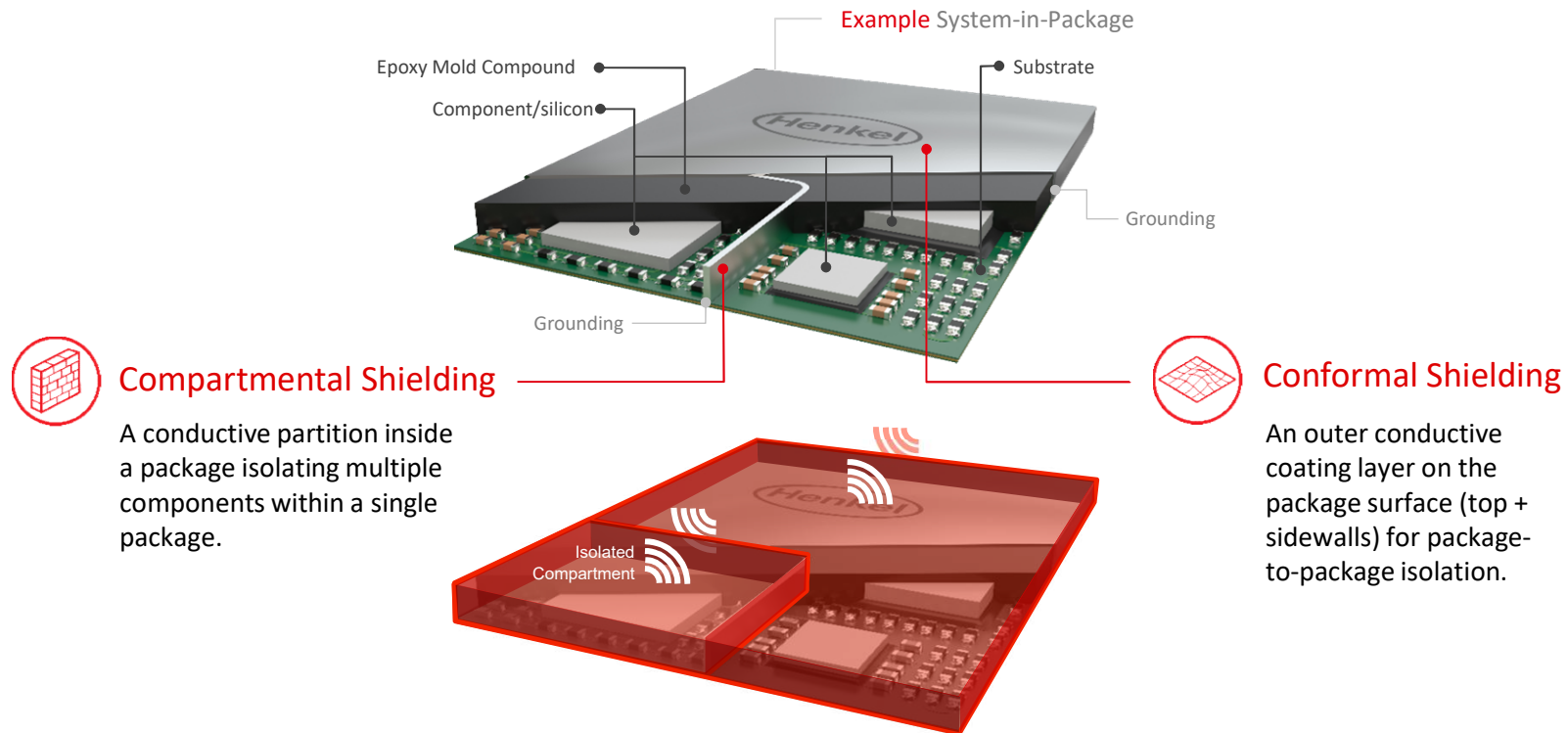
Smart Services

Connected hardware bridging online services to physical experiences such as making a purchase.

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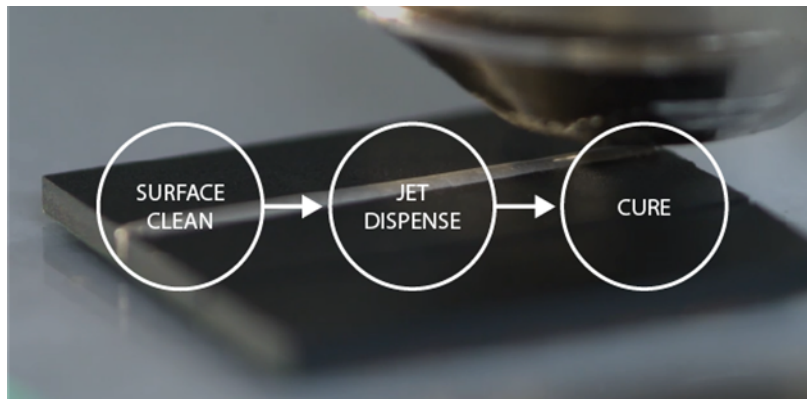
| Henkel's Market Enabling Solutions



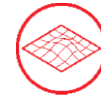
| Advantages of Henkel Solutions



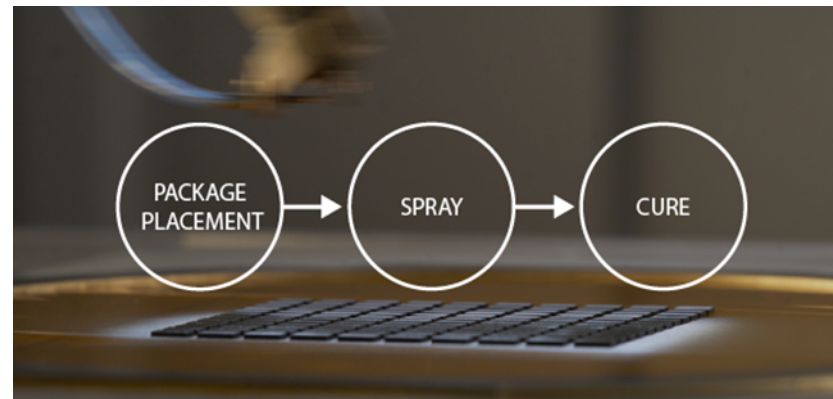
Compartmental Shielding



- Advanced/custom “partition” path/shape designs
- Flexible trench-filling material formulations (e.g. low frequency shielding, color variations, process-specific properties, application-specific properties)
- Established process with proven performance



Conformal Shielding



- Adaptable process (in air, room temp, strip, singulated, etc.)
- Flexible coating material formulations (e.g. low frequency shielding, color variations, process-specific properties, application-specific properties)
- Simple process with high UPH and low maintenance
- Low cost of implementation

Comparison: Sputtering vs. Specialized Spraying

Material + Application

		Provisional Solution		Henkel Solution	
Adv.	Criteria	Sputtering		Specialized Spraying	
O	Capital Investment	High		Low	
O	Equipment Footprint	Large: 12.5~35 m ²		Small: 2.5~4.5 m ²	
O	Equipment Maintenance	High		Low	
O	Production Scalability	Low		High	
P	Coating Material Selection	Restricted selection (metal, alloy)		Flexible metal and polymer selection	
O	Substrate Surface Quality Control	Tight. Requires specific surface treatment		Less sensitive to surface contamination	
O	Process Flow	Complicated, vacuum, heating + cooling		Simple, no vacuum, room temperature, in air	
P	Low Frequency Shielding	Thickness >5 um challenging		Reliable thickness >10 um	
O	Cost of Ownership	High		Low (up to 60% lower)	
P	Sidewall Coverage	30~40% of top		50~60% of top	
O	Throughput (UPH)	~10 carriers per hour		~40 carriers per hour (up to 400% higher)	
O	Surface Treatment	Plasma required		None needed	
P	EMI SE / Electrical Performance	50~80 dB with 5um layer		50~80 dB with 5um layer	
P	Coating Thickness Control	Good		Good	
P	Uniformity	Good - physical vapor deposition		Good - fine mist atomized spray deposition	
P	Typical Final Thickness	Thin coating (3~6 um) layer		Thin coating (3~6 um) layer	
O	Market Awareness	High		Low	

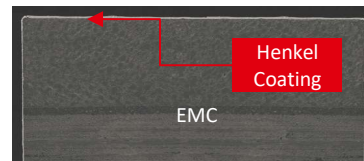
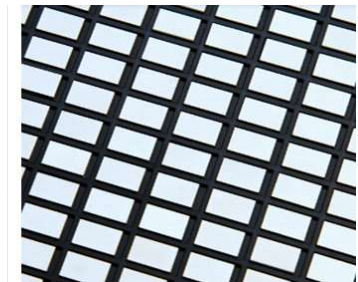
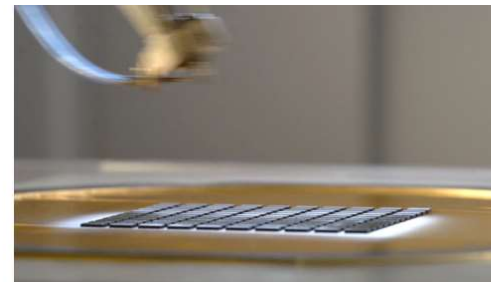
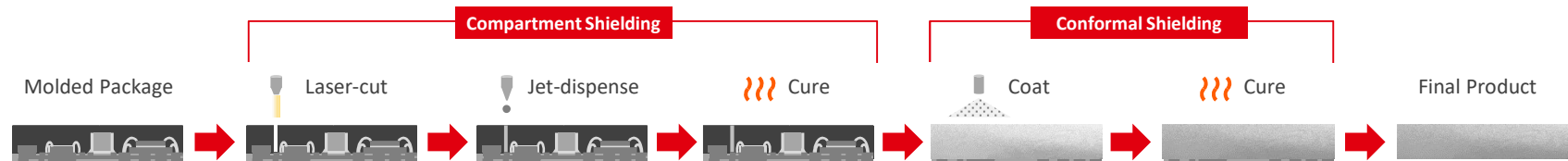
O Operational
P Performance
Good
Moderate
Poor

| Agenda

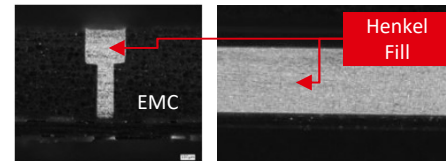
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Package Level EMI Shielding Implementation Process

Compartment and Conformal Shielding



Cross Section - Side

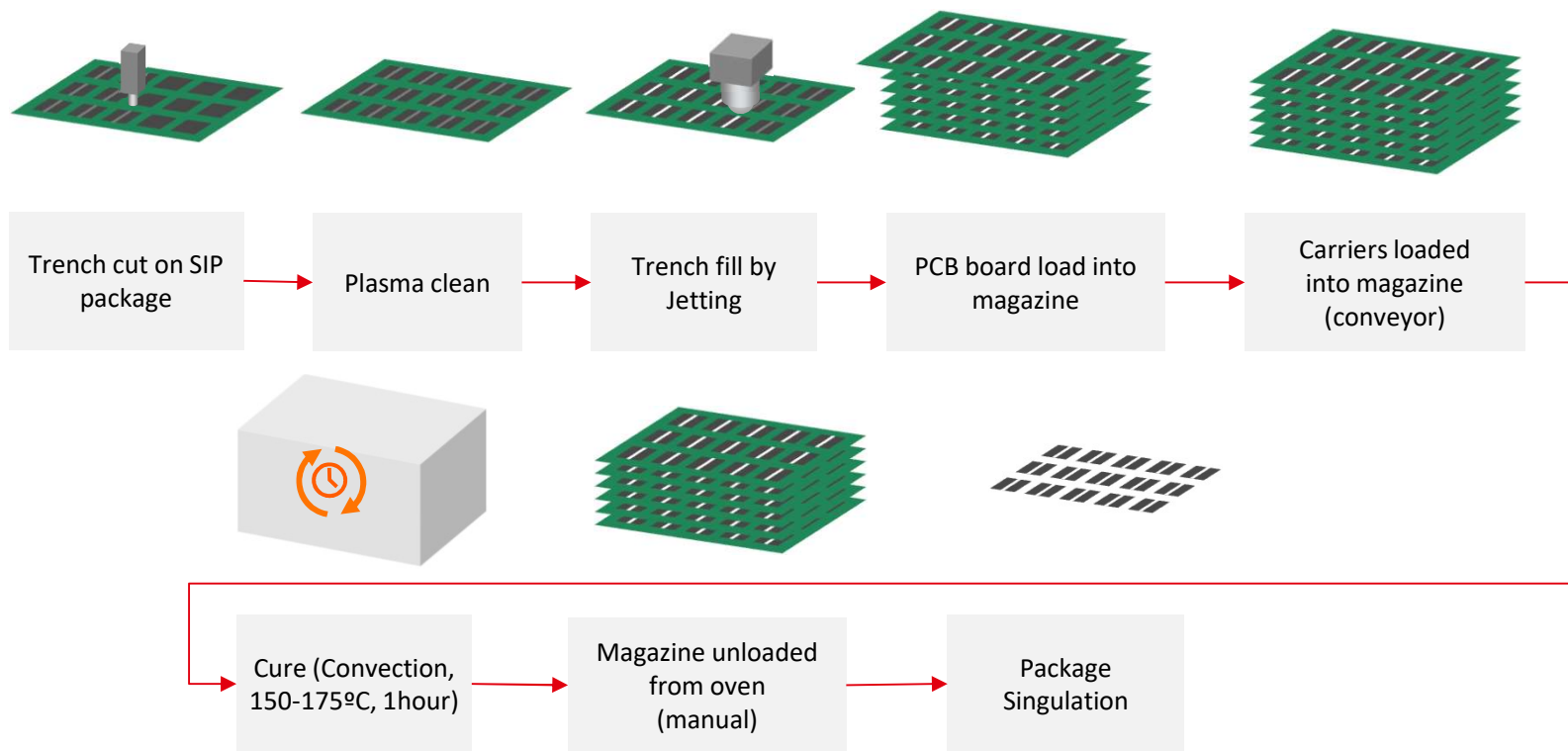


Cross Section (Front)

Cross Section (Side)

| Compartment Shielding Materials

Overall process Flow



| Compartment Shielding Materials

Typical Trench Filling Parameters

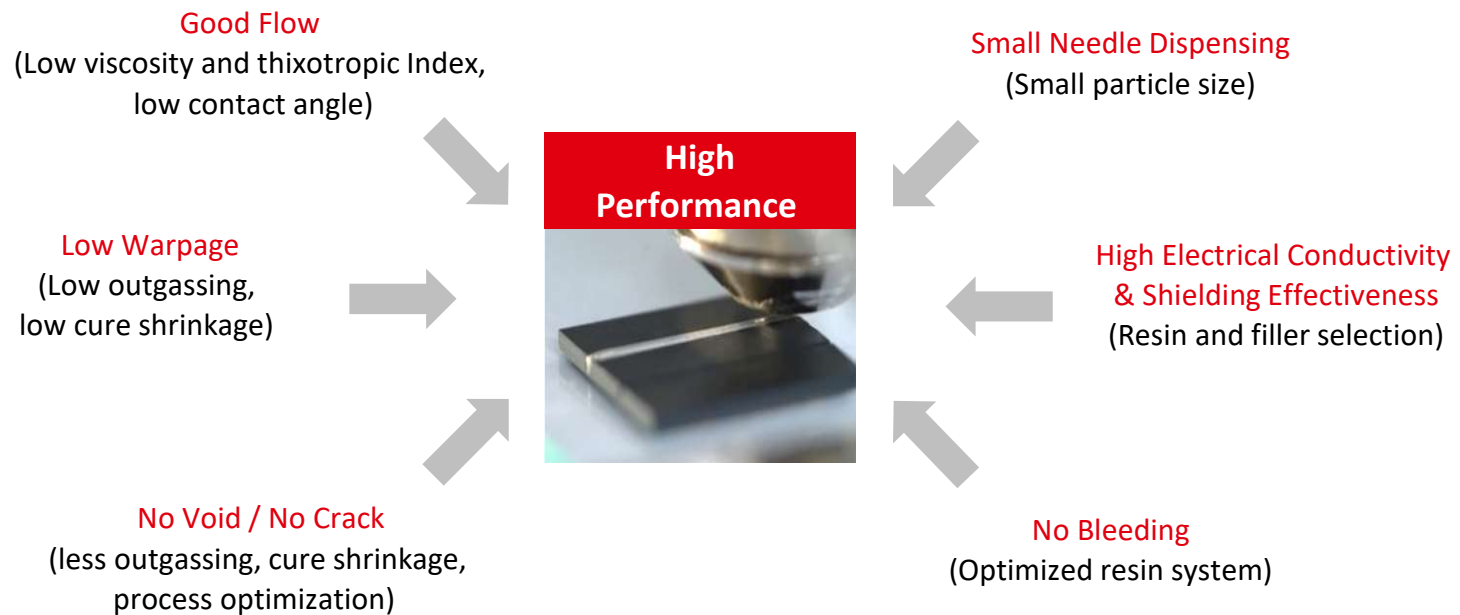
Parameter	Typical Value
Nozzle size	3-4mil
Needle size	Long – 1.6
Fluid pressure	~10 psi
Dispense temperature	40°C
Stage temperature	50°C
Dispense gap	0.800mm
Valve set on/off	5/5 sec
Line type	Weight control
Dispensing paths	3 with 5:3:1 weight ratio

- Jet-dispensing parameters can be adjusted for optimal results depending on the trench design and the compartment shielding material.



| Compartment Shielding Materials

Technical Approach for High Performance

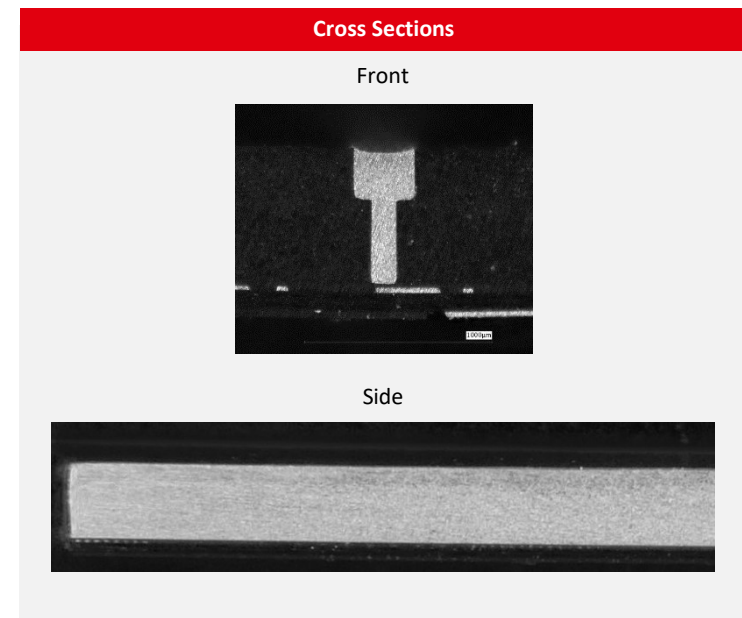


Compartment Shielding Materials

Latest Addition to Henkel's EMI Shielding Portfolio

Physical Properties		LOCTITE ABLESTIK EMI 3620
Technology		Electrically conductive
Application Method		Jet dispensed
Viscosity, 5rpm 25°C (cps)		4950
Thixotropic Index		1.3
Curing Condition		30 min to 175°C, hold 60 min
Conductivity	Volume resistivity (ohm·cm)	1X10 ⁻⁴
	DSC on set temperature (°C)	123
	DSC peak temperature (°C)	136
DSC	DSC delta H (J)	25
	Modulus (25degC) / Mpa	4173
	Modulus (150degC) / Mpa	1395
DMA	Modulus (250degC) / Mpa	510
	DSS surface	Molding compound
Adhesion	DSS die size	3x3mm
	DSS at 25C after cure	9.5
Sample Availability		Now

- Henkel material technology provides optimal performance.

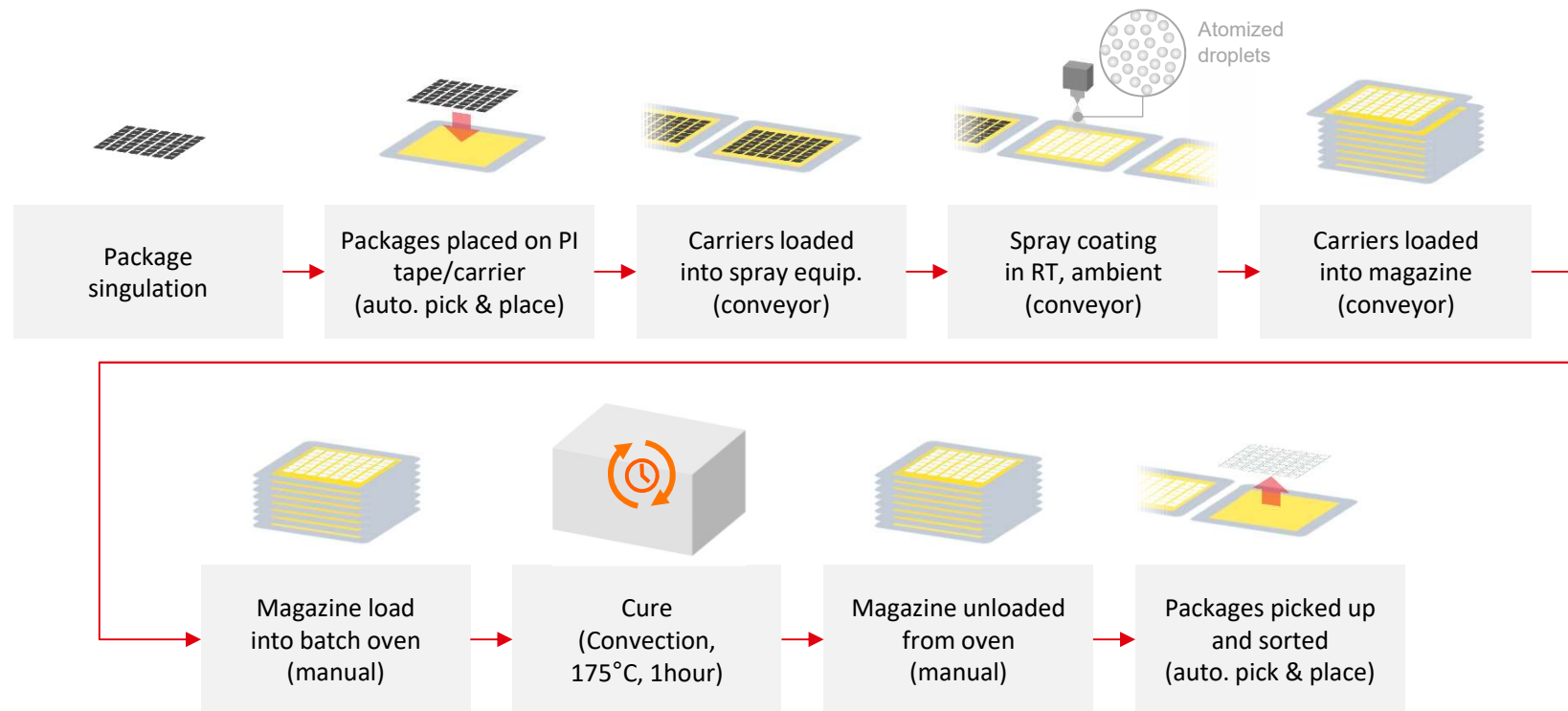


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Conformal Shielding Implementation Process

Overall Process Flow



| Atomizing Spraying Technology

Ultrasonic Spray Atomization

Henkel
Material

!
Spray
Technology
Agnostic

Compatible with Various Spray Technologies

- Henkel materials are compatible with all types of spray equipment.
- Atomizing spray technology provides most advantages for package level EMI shielding.



Ultrasonic Spray Coating Technology

- Ultrasonic energy atomizes material into small droplets
 - Droplet size is related to material and ultrasonic energy
 - Droplets are finer and more uniform than from conventional air spray
- Air pressure sprays and shapes the droplet configuration



Note

Henkel can provide test data and recommendations on optimal spray technologies for various applications, however, Henkel does not directly sell or distribute spray machines.

Ultrasonic Spray Atomization

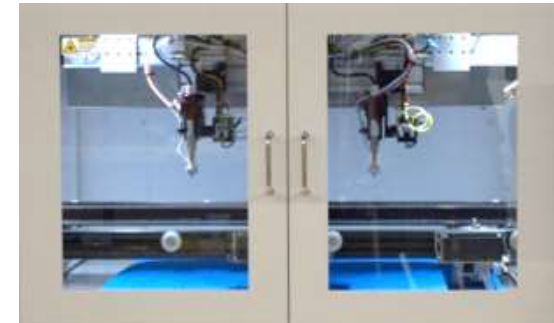
Process, Parameters, and Advantages

Parameters

- Ultrasonic frequency
- X-Y-Z motion
- Spray head height
- Spray head angle
- Spray speed
- Flow rate / pressure
- Interval + Pass

Key Advantages

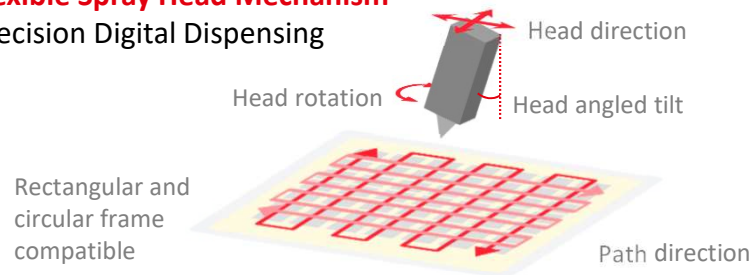
- Tight thickness control (single μm level)
- Room temperature in air process
- Low material wastage (precision coating)
- No cooling required
- No special surface treatment required
- Adjustable parameters + angle for sidewall
- No moving parts in head for stable liquid delivery



Dual spray head system

Flexible Spray Head Mechanism

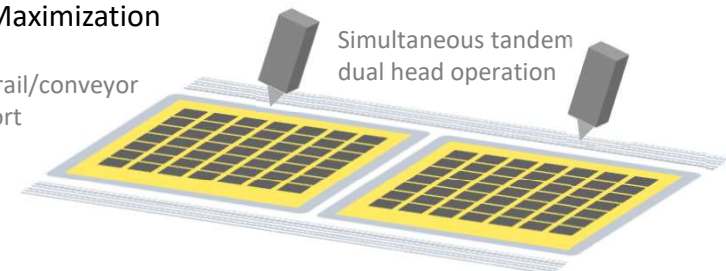
Precision Digital Dispensing



Prism 800 Dual Spray Head System

UPH Maximization

In-line rail/conveyor transport



Spray Coating for Sidewall Coverage

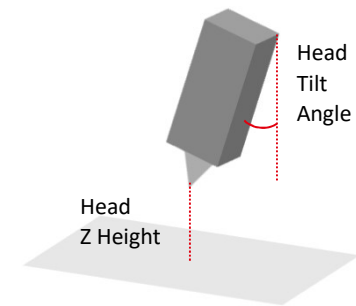
Parameters for Full Four Sidewall Coverage

Software-Controlled Spray Parameters

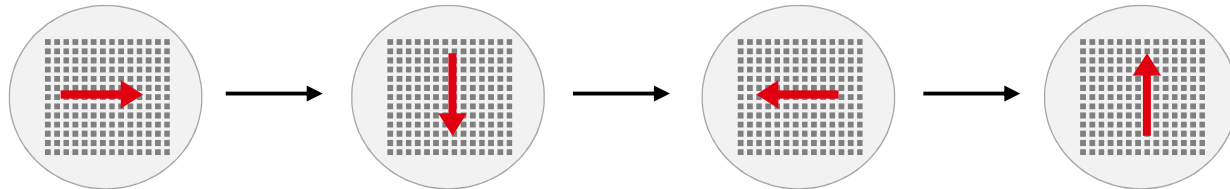
Parameter	Type	Standard Value
Flow rate	Variable	0.8 – 3 ml/min
Speed		200 – 600 mm/sec
Spray Pitch	Constant	10 mm
Air Pressure		400 K Pa
Z-height		40 mm
Head angle		30°
Spray Direction (# of Pass)		4

Used for
coating
thickness
control

Spray Head Parameters



Spray Head Directions For 4 Sidewall Coverage



Conformal Shielding Material

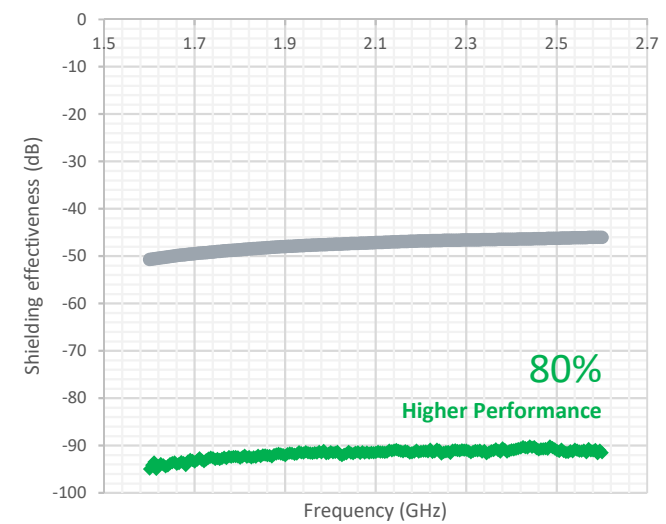
New Material vs. Conventional Material

Conventional Material vs. Henkel's Proprietary Material

Key Requirements	Conventional Spray Material	Henkel's New Spray Material
Technology	Conductive	Conductive
Spray Technology Compatibility	Agnostic	Agnostic
Shielding Effectiveness (dB)	Poor (~50 dB)	Excellent (~90 dB)
Volume Resistivity (ohm·cm)	1×10^{-4}	7.9×10^{-6}
Coating Uniformity	Moderate	Good
Fine Atomization	Poor	Excellent
Required Coating Thickness	10 ~ 20 um	3 ~ 6 um
Capable Coating Thickness	10 ~ 30 um	3 ~ 30 um
Silver Settlement During Spray	Yes	No
Adhesion to EMC	5B	5B

■ Good
 ■ Moderate
 ■ Poor

Shielding Performance (Using ASTM D5568-14)



● Conventional Ink
 ◆ Henkel Formula (EMI 8880S)

| Conformal Shielding Materials

Latest Addition to Henkel's EMI Shielding Portfolio

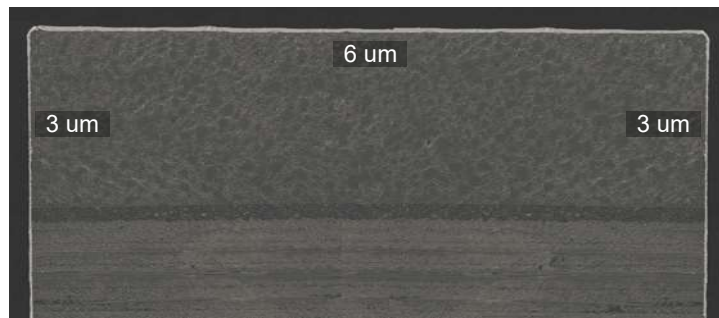
General Properties	Material Requirements	LOCTITE ABLESTIK EMI 8660S	LOCTITE ABLESTIK EMI 8880S
Application Method	Compatible spray technology	Agnostic	Agnostic
Technology	High EMI shielding performance	High electrical conductivity	High electrical conductivity
Viscosity, 5rpm (cps)	Optimal resistance to flow for application method	250	550
Thixotropic Index	Ability to hold its shape with external stress	1.2	1.3
Curing Condition	Cured in convection oven with no ramp	175°C, 1 hour in air (no ramp)	175°C, 1 hour in air (no ramp)
Filler Type	Filler technology with high conductivity	Proprietary silver	Proprietary silver
Volume Resistivity (ohm·cm)	Extremely low resistivity similar to pure metal	1.5 x10 ⁻⁵	7.9 x10 ⁻⁶
Shielding Effectiveness (dB)	Bulk material shielding performance	~90	~90
Supported Thickness (µm)	Supported frequency and shielding effectiveness	Up to 30	Up to 30
Recommended Coating Thickness (µm)	500MHz<: Ultra-thin layer with good uniformity	3~6	3~6
Adhesion (Cross Hatch Test)	Adhesion and reliability using ASTM 3349 standard	Classification 5B (0% peel)	Classification 5B (0% peel)
Compatible Surface	Good adhesion to various package surface types	Mold compound (Wide range)	Mold compound (Narrower range)
Target Frequency Range	Targeting shielded frequency ranges	500 MHz ~ 10 GHz	10 MHz ~ 10 GHz
Sample Availability	-	Now	Now

- Henkel's new conformal shielding materials are designed to provide great electrical and reliability performance, while compatible with various spray technologies.

| Conformal Shielding Materials

Henkel Material + Ultrasonic Spray Performance

Good Coating Uniformity (Top & Sidewalls)



- Uniform thickness on top and sidewalls



Good Coating Quality (Non-coated vs. Coated)



- Typical mold compound



- Atomizing spray-coated with unique material

Good Laser Marking Visibility



- Material applied after laser marking.
- Good visibility of laser marking with coating layer.

| Conformal Shielding Materials

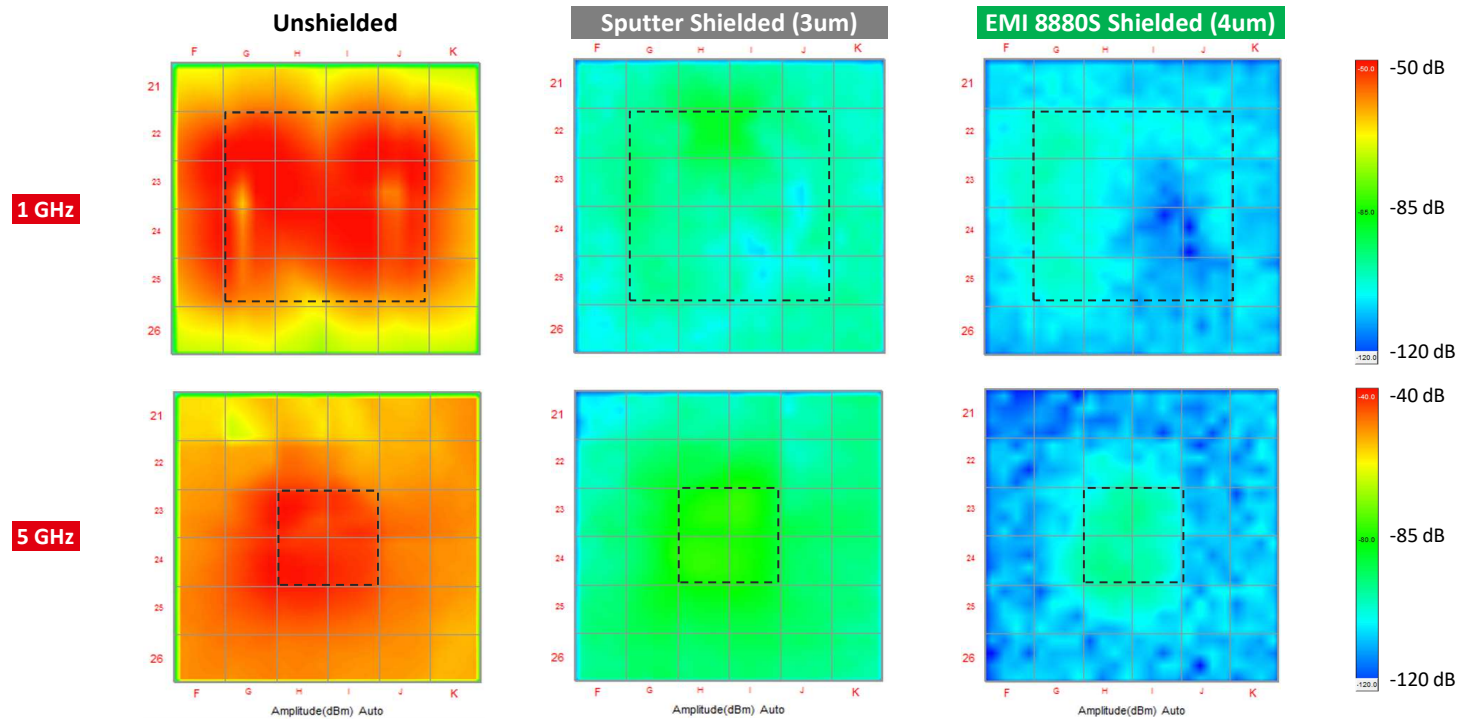
Adhesion Performance | Initial and After Reliability Testing



- All of the parts tested provide 5B adhesion results at time 0
- No adhesion degradation after MSL3 + 1000hr at 150°C
- No adhesion degradation after MSL3 + 1000TCTs

Conformal Shielding Materials

Shielding Effectiveness Comparison | Near Field Probe Measurements



Conformal Shielding Materials

Shielding Effectiveness Test Results vs. Coating Thickness

Method	Coating Layer	Coating Speed	Flow rate	Top thickness	Side thickness	EMI Shielding Effectiveness at 5G	EMI Shielding Effectiveness at 1G
Spray	LOCTITE ABLESTIK EMI 8880S	400	0.8	5 µm	3 µm	48.2	45.9
		500	1.2	6 µm	3 µm	49.2	-
		300	0.8	7 µm	4 µm	48.2	45.2
		400	1.2	8 µm	4 µm	51.3	46.6
		300	1.2	10 µm	5 µm	52.7	47.8
Sputter	Ti-Cu-Ti	N/A	N/A	3 µm	1 µm	43.0	41.2

- Henkel's thin coating layer provides comparable to better EMI shielding performance than typical sputtering, with the flexibility to support a wide range of thicknesses adjusted with spray parameters.
- Unlike sputtering, Henkel's materials can also be coated thicker to provide higher shielding performance for lower frequencies with higher skin depths.

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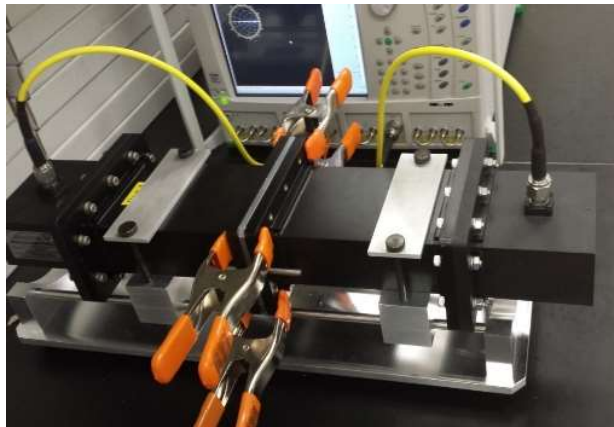
| Shielding Effectiveness Testing Methods 1

Material Level Testing

ASTM standards are great for comparative material performance analyses. However, they have constraints in delivering representative application-level performance.

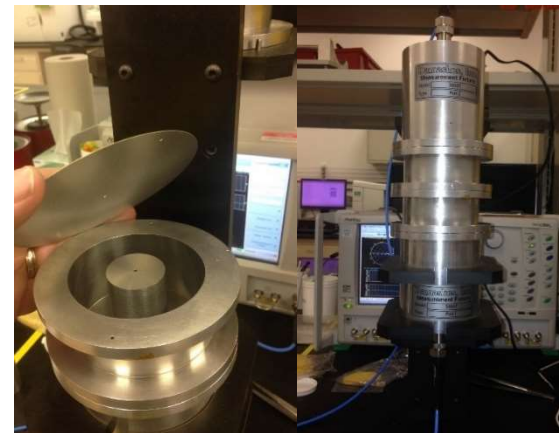
ASTM D5568-14

- Standard test method for measuring relative complex permittivity and magnetic permeability of solid materials at microwave frequencies using waveguides.
- Wide frequency bands 1MHz-50GHz



ASTM D4935-10

- Test method providing a procedure for measuring the EMI shielding effectiveness (SE) of a planar material for a plane, far-field EM wave.
- Low frequency 30MHz-1.5GHz

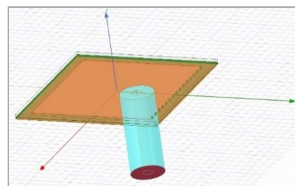


Shielding Effectiveness Testing Methods 2

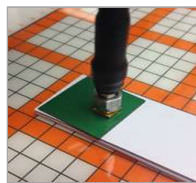
Component Level Testing

Antenna

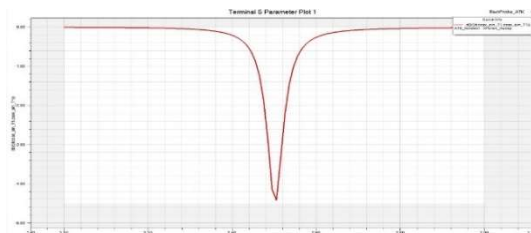
Mid-to-high frequency performance



HSFF Model



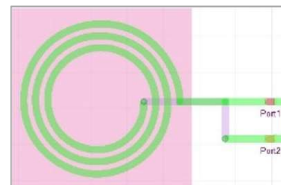
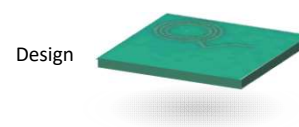
Measurement



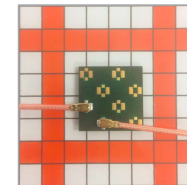
S11

Coil/Inductor

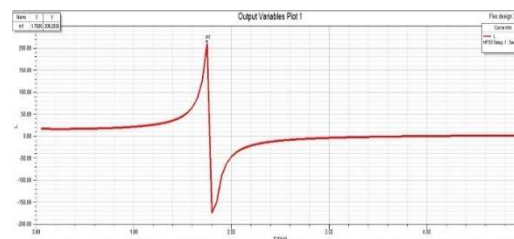
Low frequency performance



HSFF Model



Measurement

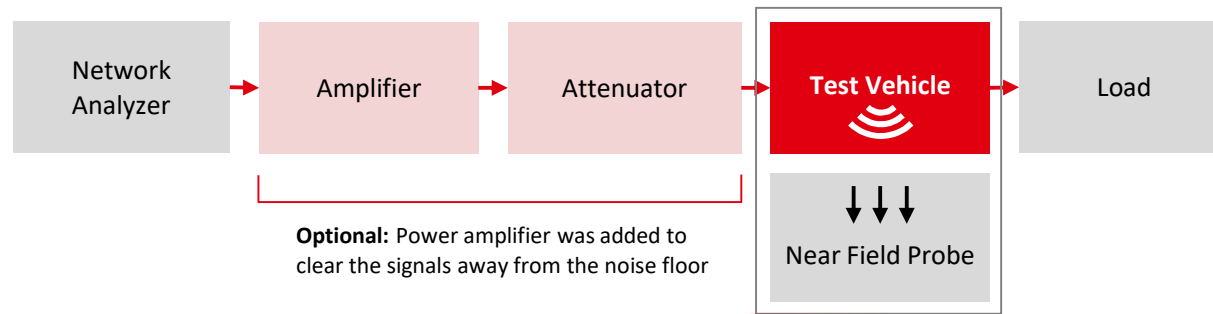


Inductance

- This method aligns with the IEEE 299 standard. Through the use of a custom radiating source(patch, pifa antenna, and inductor structures) and a scanner comprised of an array of loop antenna, the magnetic field at a fixed distance can be measured for a custom test vehicle or a customers application.
- Different design approaches made to target specific frequencies for testing.

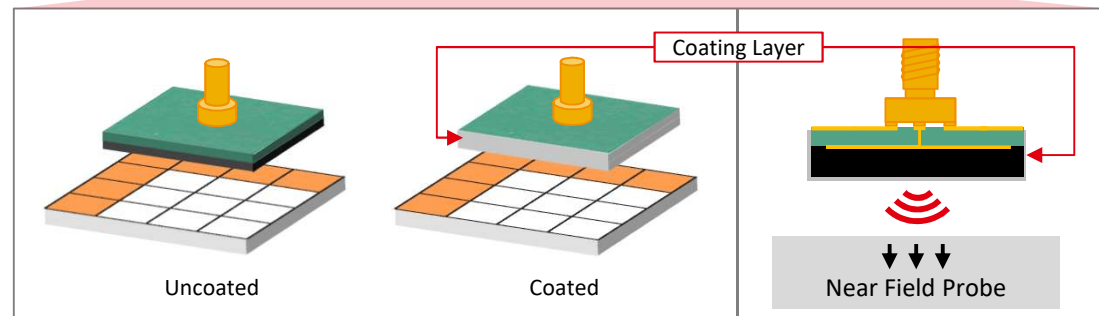
Component Level Testing

Test Configuration with Near Field Probe



Procedure

1. Measure uncoated components
2. Measure coated components
3. Confirm measurements are above noise floor

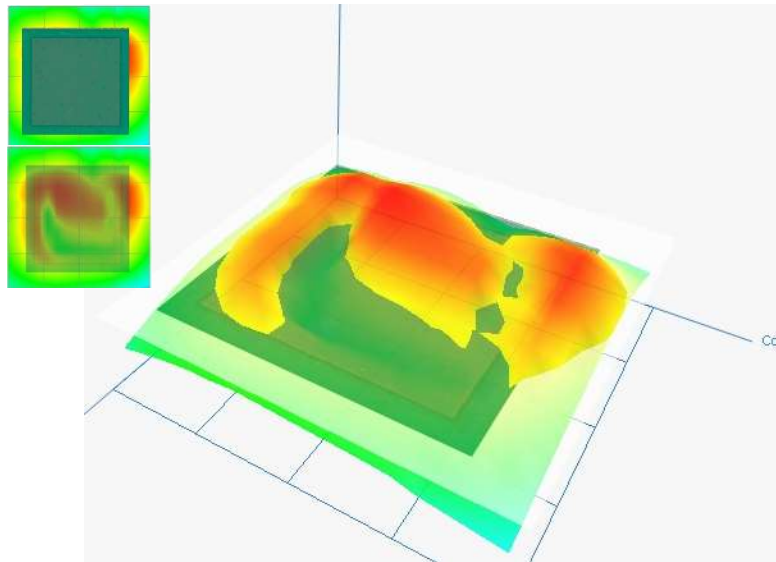


| Component Level Testing

Near Field Probe Measurements

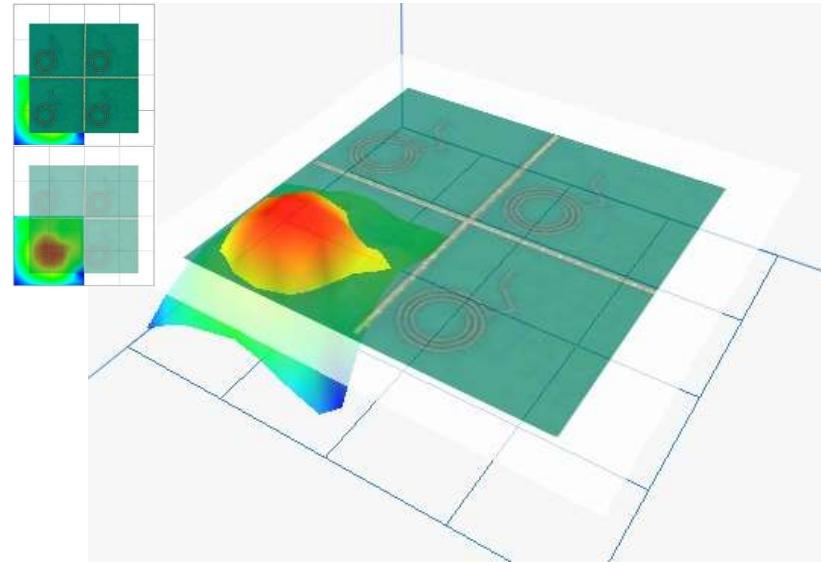
Antenna (Patch)

Sample measurement



Coil (Inductor)

Sample measurement



| Agenda

1	Electromagnetic Interference and Shielding Trends
2	Henkel's Market Enabling Solutions
3	Compartmental Shielding Process, Materials, and Performance
4	Conformal Shielding Process, Materials, and Performance
5	Shielding Effectiveness Testing Methods
6	Summary

| Summary and Next Steps

Henkel's EMI shielding materials are optimal for package level protection enabling higher board density, design flexibility and simplified BOM for electronics miniaturization.

We want to be your solution partner of choice.

Key Benefits

- **Package Level EMI shielding**
 - Electronic design miniaturization
- **Material technology**
 - Single layer with formulation flexibility
 - Excellent reliability and adhesion performance
- **Spray-coating and dispensing solutions**
 - Minimal capital investment and cost of ownership
 - Easy scalability with simple process

Next Steps

- **Work with Henkel as your solution partner**
 - Coating trials by Henkel
 - Material sampling for customer site trials
 - Test vehicle design recommendations
 - Other consultations

| Introduction



Speakers

- Jinu Choi | Market Segment Head
- Xinpei Cao | Sr. Principal Engineer
- Dan Maslyk | Sr. Application Engineer



For more information, please visit:

www.henkel-adhesives.com/loctite-emi-shielding

- Henkel solutions and value propositions
- Explainer videos
- Technical and marketing documentation for download

Thank you

