REDUCING THE COST OF APPLYING ULTRA-THIN, PACKAGE-LEVEL EMI SHIELD COATINGS

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Overview

As highly sensitive circuit assembly components become more tightly packed, demand for cost-effective package-level EMI (electromagnetic interference) shielding arises. The process cost for applying a thin (less than 10µm) conductive metal EMI shielding layer to individual packages is substantial when traditional sputtering and plating methods are used.

An advanced technology has been developed for the application of new, sprayable high-performance coatings that provide the required EMI package-level shielding effectiveness. T-CAT (ultra-Thin Coating Application Technology) is a proven application method that applies a uniform, ultra-thin layer of EMI shield material, while reducing process cost by up to 60%.

T-CAT Spray Coating Technology

The need for EMI shielding has become increasingly important as highly-sensitive components have become more tightly packed in circuit assemblies. To accommodate the move toward miniaturization and to reduce weight and thickness, each individual package requires EMI shielding. Sputtering and plating are commonly used to apply component-level EMI shielding layers between 3 and 6 µm thick. Unfortunately, these methods involve substantial capital cost and complexity, and are limited to moderate throughput. New EMI shield coating materials have recently become available in the market: high-density slurries with proprietary formulations that produce a continuous conductive layer on the substrate when applied in a thin, uniform layer. These materials have excellent EMI shielding characteristics that are equivalent to traditional sputtering and plating. The combination of the new EMI shield materials and T-CAT gives manufacturers a simpler, faster, more scalable and economical method for applying package-level EMI shielding.

T-CAT is a method for applying an ultra-thin, uniform, and conformal layer on the top and side surfaces of individual components. T-CAT utilizes “nozzle-less” ultrasonic spray technology combined with a precision metering pump liquid delivery system, both of which are part of a coating system platform with a motion and positioning system for the spray head, and a transport system for the substrates to be coated.

The EMI Shield Coating Process Steps

This direct spray application process for the new EMI shield materials is simple and easy. It consists of the following steps as shown in *Figure 1:*

- Place components on carrier
- Load carrier into coating system
- Activate spray coating process
- Cure coated substrate with components in oven
- Remove components from carrier after curing.

There are no special pretreatment processes required for the components other than normal cleaning.

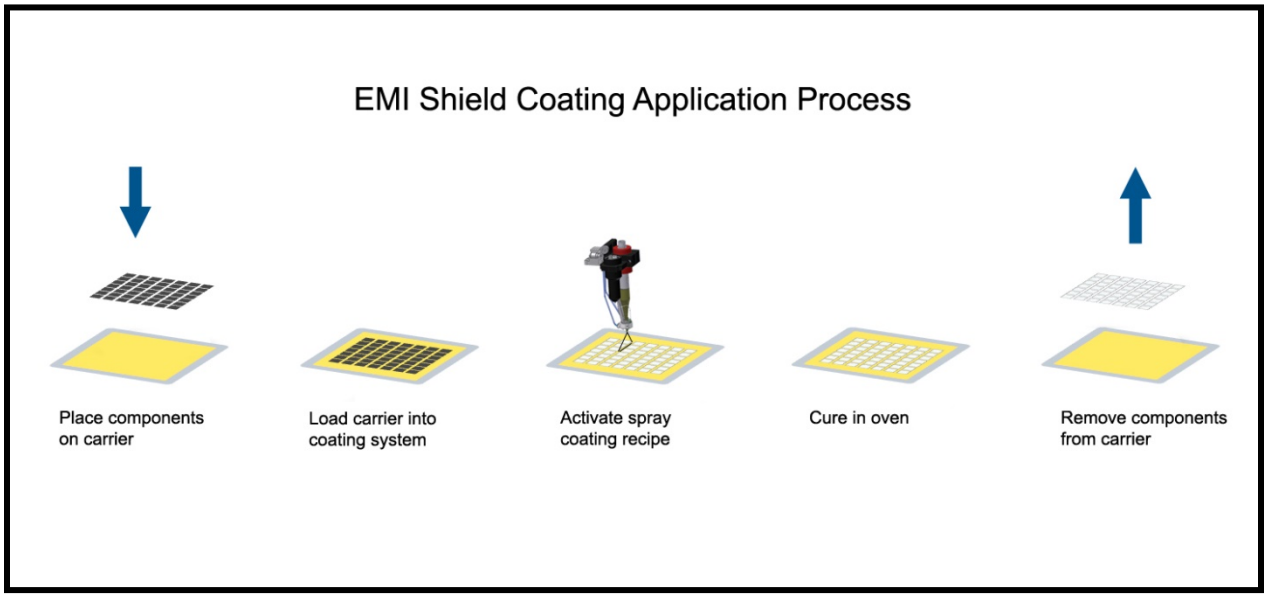

Figure 1–Coating Process Steps

Highly Efficient Coating Application

T-CAT is a highly efficient coating application method that enables a very small amount of EMI shield coating to be applied to the components on a large carrier. For example a carrier with a "coating area" of 35 cm x 35 cm can hold up to 2,025 components that are 7 mm x 7 mm x 0.8 mm in size. In order to apply a coating layer that is 6 µm (*Figure 2*) on the top surfaces of the components, only about 2.5 ml of coating liquid is required. This translates to about **0.0012 ml** of EMI shield coating for each individual component to provide the required EMI shield effectiveness.

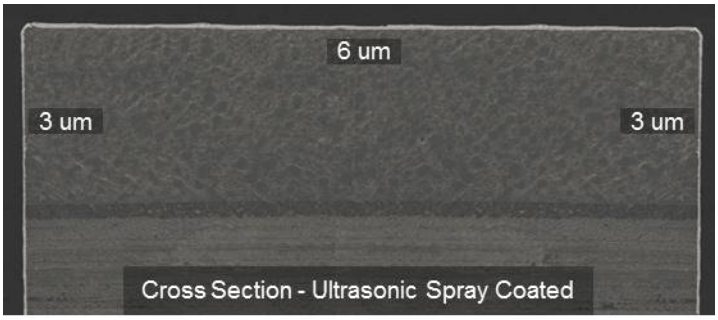

Figure 2 – Coating Thickness on Component Top and Side Surfaces
(data provided by Henkel Electronic Materials)

The EMI shield coating is sprayed with a *nozzle-less* ultrasonic spray technology that is very efficient. Liquid is applied to a spray forming tip and broken into small drops by ultrasonic energy, then accelerated and expanded by an adjustable-velocity air stream to produce a uniform, rectilinear coating pattern.

This technology is capable of spraying a wide variety of materials, from pure solutions to suspensions and slurries, while producing a uniform coating layer on the substrate. *Figure 3* shows the nozzle-less ultrasonic spray head assembly, which consists of an ultrasonic transducer with a spray forming-tip, an integrated liquid applicator, and air director.

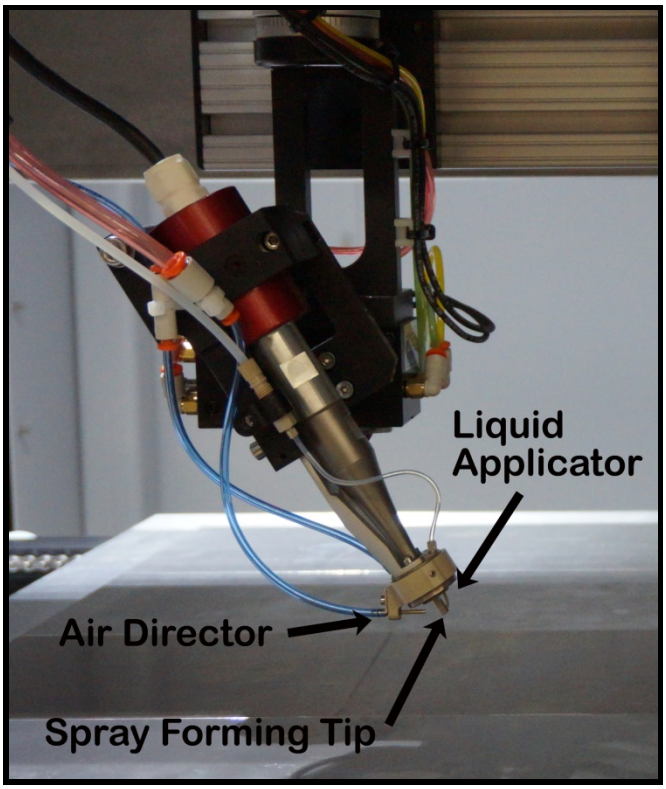

Figure 3 – Nozzle-Less Ultrasonic Spray head Assembly

The T-CAT Liquid Delivery System

A highly accurate liquid delivery system has been developed that incorporates a positive displacement metering pump as shown in *Figure 4*. The liquid flow rate is controlled by micro-stepping drive ensure that the coating material is delivered to the ultrasonic spray head at a precisely controlled flow rate.

Since some coating liquids used for EMI shielding have suspended particles that can settle this liquid delivery system has the capability to keep the coating mixed while maintaining an accurate and repeatable flow rate of the coating to the spray head.

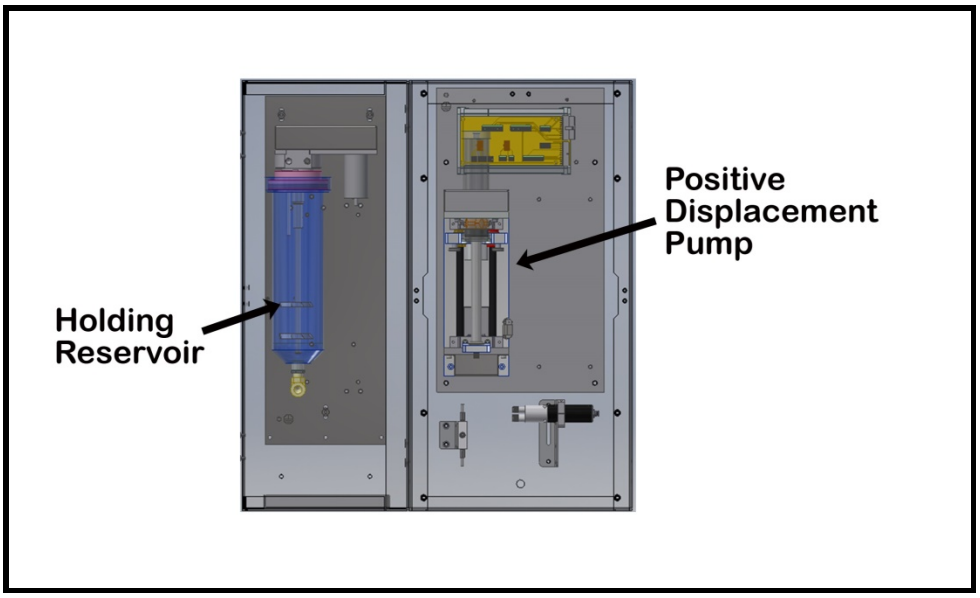

Figure 4 – Precision Metering Pump Liquid Delivery System

A dual pump version is also available that allows continuous operation, without the need to wait for the single pump to refill. With this configuration, as one pump is being used to feed the spray head, the other pump is being filled from the holding reservoir. The dual pump can also be configured to recirculate and stir the coating liquid to prevent suspended particles from settling out of the liquid in the feed lines or holding reservoir; see *Figure 5*.

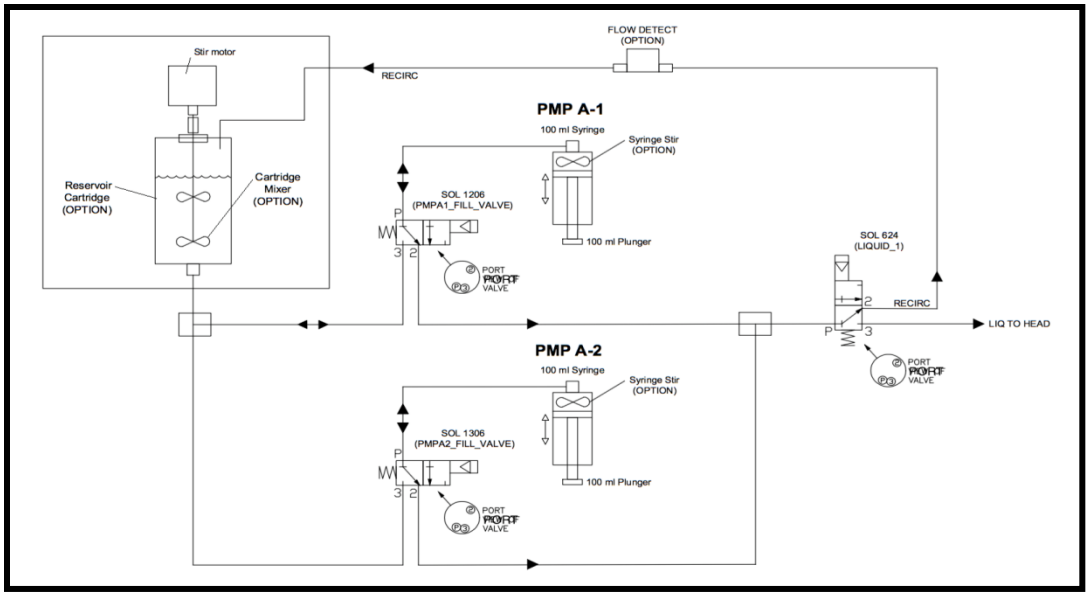

Figure – 5 Dual Pump Liquid Delivery System

The T-CAT Coating System Platform

The coating system platform, as shown in *Figure 6*, consists of an X-Y-Z-Θ-Ø gantry system for the motion and positioning of the nozzle-less ultrasonic spray head, as well as integrated control of the precision metering pump liquid delivery system, and transport mechanism for the carriers. All critical process parameters are managed by the platform software and control system. Additionally, a log of the critical process data is recorded and stored in a process log file.

Figure 6 – Coating System Platform

In general, the uniformity and thickness of the applied coating layer are directly related to the following factors:

- Uniformity of the spray pattern produced by the ultrasonic spray head
- Stability of the coating flow rate delivered to the ultrasonic spray head
- Consistency of the speed of the ultrasonic spray head relative to the substrate
- Programmed coating recipe – number of applied layers, the application path, and the coating flow rate

The uniformity of the coating layer for EMI shield materials can be determined by cross-sectioning the components and measuring the thickness of the coating layer on the surface.

The speed and motion path of the ultrasonic spray head is controlled by a closed-loop servo drive system. The servo drive is tuned for uniform head speed so the variation of the head speed is negligible. The liquid flow rate is determined by the rate of displacement of a piston in the pump. The motion of the piston is controlled by a micro-stepping drive system so the variation of liquid flow rate is also negligible.

For a given coating recipe, the variation in the total amount of liquid applied to the substrate is less than ±0.1%. This can easily be verified since the system software logs the total amount of liquid applied to each substrate that is coated. Any variations in the head speed and the liquid flow rate are accounted for in the process log.

Spray Coating Application Sequence

When the carrier with the components enters the coating system the coating is applied in a defined sequence to ensure that all component surfaces are uniformly coated. In order to coat the top and side surfaces of the components on the carrier, four (4) coating layers are applied with the approach angle and direction of the spray head changed for each layer as illustrated in *Figures 7 and 8*. The ultrasonic spray head is mounted on a 5-position rotate and tilt mechanism so that all component surfaces can be coated. The tilt angle is adjustable for process optimization.

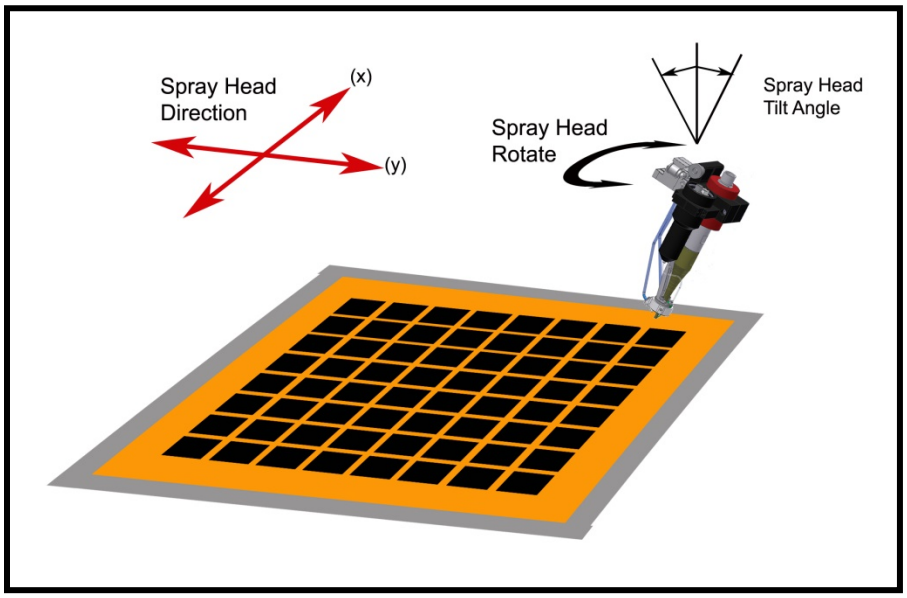

Figure 7 – Ultrasonic Spray Head with Tilt & Rotate

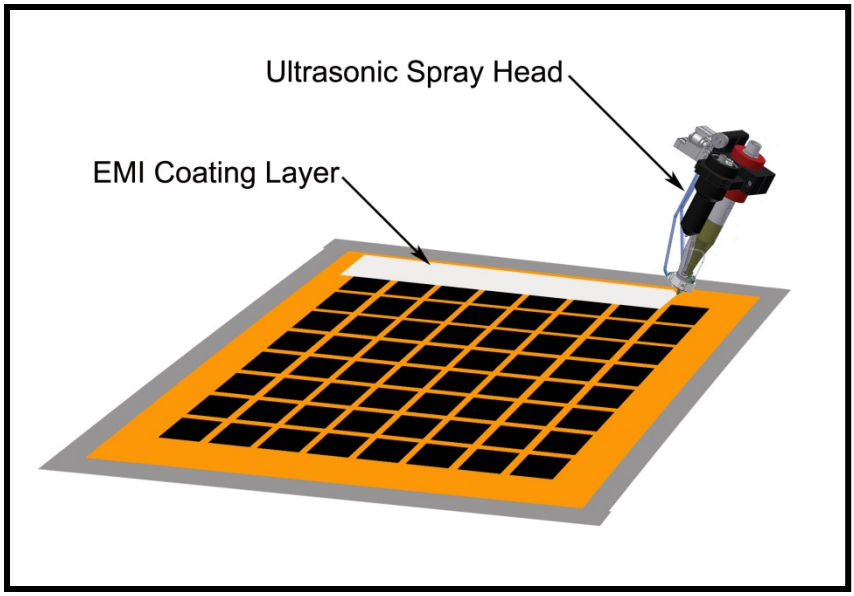

Figure 8 – Beginning of the First Coating Layer

Coating Uniformity Data

The EMI shield coating thickness on the top and side surfaces of the components can be measured after the component is cross-sectioned. The average side surface thickness is approximately 50 to 60% of the top surface thickness as shown in *Figure 2*. The process is also very repeatable as shown in *Figure 9*.

- Top surface coating uniformity is 6 µm ±0.5 µm.
- Side surface coating uniformity is 3 µm ±0.5 µm.

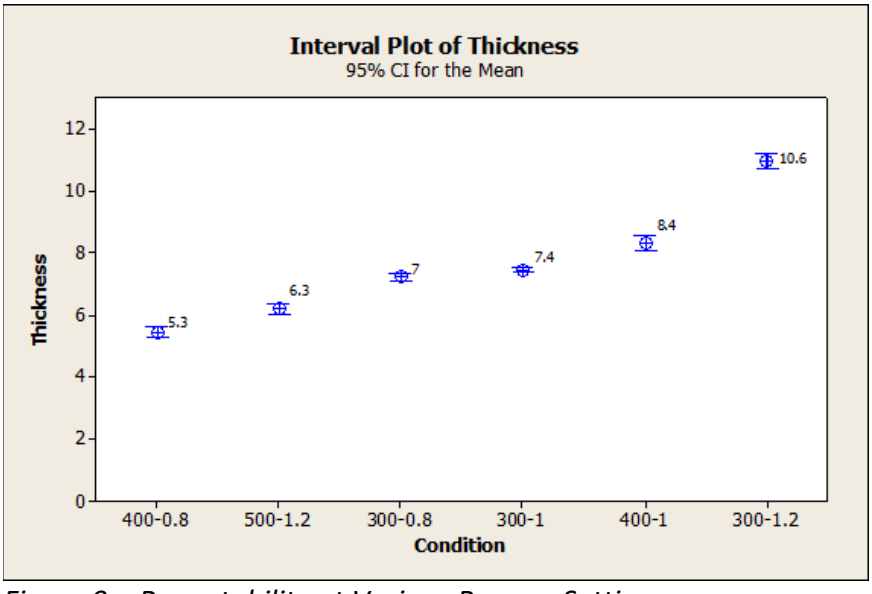

Figure 9 – Repeatability at Various Process Settings
(data provided by Henkel Electronic Materials)

Process Performance and Cost

Table 1 is a summary of the process performance and cost between typical sputtering and T-CAT spray for the application of an EMI shield layer to individual packages. The sputtering process involves a complex, multi-step process and requires costly equipment that occupies a large amount of floor space. Alternatively, T-CAT is a simple process that requires much less capital investment and occupies much less floor space.

The capital investment for equipment of T-CAT vs. sputtering is up to 90% less and the throughput is up to 5 times higher.

Item	**Performance Data**	
	Typical sputtering	**T-CAT Spray**
Carrier Shape	Ring, square or rectangle	Ring, square or rectangle
Carrier Size	350 mm x 350 mm	350 mm x 350 mm
Package Dimensions	7 mm x 7 mm x 0.8 mm	7 mm x 7 mm x 0.8 mm
Carriers / hour	~10	~40
Packages / hour	~14,000	~72,000
Floor Space	12.5 to 35 m^2	2.5 to 4.5 m^2
Ave Equipment Cost	$3M to $8M*	$0.25M to $0.5M*
Cost per Coated Part	>>$0.01*	<$0.01*

Table 1 – Process Performance and Cost

*depending upon options and target performance; provided by Henkel Electronic Materials

A New Level of Cost-Effective EMI Shielding

New, sprayable coatings and application methods are revolutionizing the cost-effectiveness of EMI shielding for individual components. T-CAT combines nozzle-free ultrasonic spray technology with a precision liquid handling and delivery system and advanced coating system platform to provide reliable and consistent coating applications and a significantly more cost-effective manufacturing process.