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An aircraft inspector examines the wiring on an MQ-8B Fire Scout. Multi-pin cable harnesses that route discrete signals between avionics equipment often use twisted shielded pairs with triaxial connector pin inserts, as the concentricity ensures the polarity of cables from two different vendors is not reversed. (U.S. Navy Photo/Released)

The Latest Word from PVA ...

Supplement to *Aerospace & Defense Technology*

Developing a Conformal Coating Process for Aerospace Applications

onformal coatings protect electronic circuits from harsh environments via a chemical film that "conforms" to a circuit board's topography. These coatings protect against moisture, chemicals, contamination, vibration, corrosion, and thermal stress while improving product reliability by reducing failures. The benefits conformal coating can provide often vary in importance by industry. In aerospace electronics there is an emphasis on benefits of protection from corrosive gasses, outgassing, tin whiskers, and radiation. For the purpose of this article, we will focus on liquid coating materials.

Coating Specifications

A good first stop for new conformal coating users is two widely used coating specifications. MIL-I-46058 is the military specification on conformal coating. This document is still widely referenced today, although it has been inactive for new board designs developed within the last 20 years. This doesn't necessarily stop end users from trying to conform to this standard however, even today.

The more recent specification is IPC-CC-830, which also has a valuable sister handbook (IPC-CC-830-HDBK) documenting best practices. Most manufacturers use one of these specifications as a baseline to guide coating selection and compliance of their application process.

Coating Selection

There are various coating types and application methods. Both the IPC and MIL specifications note coating types that include silicones (SR), acrylics (AR), urethanes (UR), and epoxy (ER). The selection of the proper coating for a specific application is a very personal decision based on the pros and cons of each coating type, and the corresponding protection provided by each chemistry. As an end user you must know your market, the use environment for the end product, anticipated life of the product, and subsequently what protection best positions you to pass testing parameters you, or your customer, have established. Of particular note, MIL-STD-883, MIL-STD-810, and DO-160 all provide testing guidelines relevant to the aerospace industry.

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Acrylic	25-75 µm [0.98-2.95 mil]
Urethane	25-75 µm [0.98-2.95 mil]
Epoxy	25-75 µm [0.98-2.95 mil]
Silicone	50-200 µm [1.97-7.87 mil]

Defining a Process

Prior to determining the preferred application method for your conformal coating process, it is often critical to evaluate the coverage requirements for your circuit boards. Some components such as connectors, test points, RF shielding, and switches are often not coated. Understanding the required coverage area, keep-out areas, and having an understanding with your customer on how to approach "optional" areas are all important aspects of establishing your coating process.

Optional areas are often non-metal components or bare board regions where it is acceptable to apply conformal coating, though it may not be required. Sometimes a designer or quality department may want to see coating applied on all non-keep-out areas. In many cases there is a trade-off between the desired coated area and aesthetics, with a number of customers seeking a visually appealing process.

Coating Thickness

Conformal coating thickness is tested on bare, flat board surfaces or test coupons. Preferred, cured, conformal coating thickness does vary by chemistry. The IPC (Association Connecting Electronics Industries) standard deems cured films to be between 25-75 µm (0.98-2.95 mil) for acrylic, urethane, and epoxy resins. Silicones are applied roughly twice as thick. Coating thickness per chemistry as recommended by IPC-CC-830 is noted in Figure 1.

Thickness is often also addressed in establishing baseline performance criteria on a formulator's technical data sheet. These performance characteristics often reflect values determined within the thickness range noted in Figure 1. Lastly, thickness may also be addressed in the most pertinent place of all, the circuit assembly's engineering drawing.

Increasing the coating thickness in your application does not correlate to an increase in protection of your assembly. Nevertheless, it is not unusual for end users to push the limits on coating thickness. End users can favor thicker films of coating for various reasons. The assembly could be installed in a harsh environment or you could simply be providing the process engineer additional peace of mind. That being said, requiring a thicker than recommended film should not be pursued blindly. A formulator may not guarantee product performance outside of their recommended thickness range. Further, the product itself may have characteristics that are counter to the protection process at high film thickness. Hard coatings, such as acrylics and urethanes, can often crack as cured film builds increase.

In short, there are published standards for appropriate film thickness for your process. Outside of this independent research, end-users often set their own standards that may fall outside of the recommended target range. These instances should always be qualified prior to production and in conference with the formulator. You must also be mindful of what these coverage requirements do to your resulting application method. Sufficient coverage on packages, particularly on corners, sides, or under leads (if required) can be challenging in thin film applications, whereas thick film processes can increase the flow characteristics of a coating application and be more difficult to manage around keep-out areas. The coating type, thickness, and application method require a delicate balance in building a defect-free process.

Application Methods

Manufacturers have a myriad of application methods to choose from in building their coating process. Factors such as budget, board volume, and product mix are typically obvious factors in making this decision. However, quality and taking into account the established coverage area required as dictated by the engineering requirements must be a major factor in this decision-making process.

Dipping

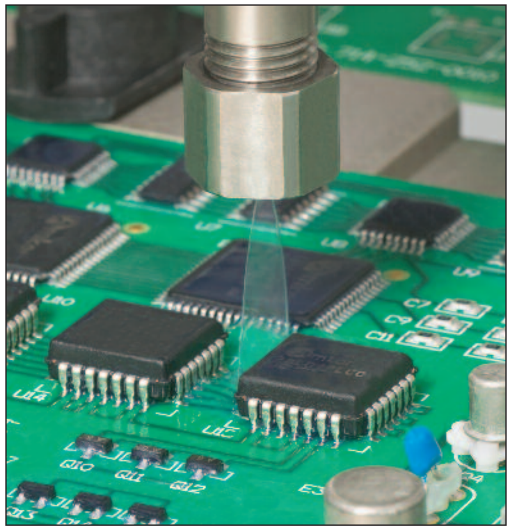
A good low-cost method for low volume coating operations starts with a dipping process. Here the assembly is immersed in a bath of coating so exposure to the chemistry is complete. Dipping does offer benefits in covering complex topography since the entire board is immersed. Thickness is controlled by the withdrawal rate of the assembly from the bath. Dipping is a process conducted vertically so coating can be uneven as the material flows to the bottom of the board during the withdrawal process.

Since the chemistry sits in an open vat, any chemistry that is reactive to the ambient environment must be closely monitored as the viscosity of the coating can change with exposure to elevated temperatures or humidity. Also, since the entire board is immersed, any keep-out areas must be meticulously masked to prevent impingement into these zones.

Manual Spray

A more common application approach is manual spray via an aerosol can or handheld nozzle. This process is also very easy to implement with minimal equipment costs. There is certainly a level of variability in this process as thickness is difficult to control and operator dependent. As the operator moves the nozzle over the board surface, shadowing can occur as coating is applied in each direction. It is suggested that after each cycle that the board is rotated 90 degrees to assure an even film build and counteract shadowing in any one direction.

Manual spray is a fast process, though the nature of mass coverage



does require masking of keep out areas which can be a laborious process. You will also see a significant loss of coating in the process as the vast majority of the chemistry is wasted. This puts a strong emphasis on operator safety and ventilation of vapors or solvents lost in the spray process.

Selective Coating

Selective coating provides an automated approach to eliminate process variability, increase throughput in high volume applications, and greatly reduce or eliminate masking due to its inherent robotic control. These programmable units greatly reduce material waste in the application with transfer efficiencies of 99% (vs. 25%-40% for dipping or manual spray) so coating cost per board is much less.

The selective process can entail numerous application methods depending on the desired application and conformal coating type. Solvent-based coatings contain a low percentage of resin and subsequently are very low in viscosity (sub 100 cps). As the solvent evaporation for these coatings can be as high as 80%-90%, the coating is put on the assembly much thicker wet, to obtain your target dry film thickness. For instance, it would not be unusual to have to apply a 200 µm wet film to achieve a 25 µm dry film after solvent evaporation. As a result, solvent-based coatings are often applied via an airless film coating process at robot speeds up to 500 mm/sec. Film coating provides superb edge definition over larger coated areas.

Thinner films of coating can be achieved with the introduction of air to create an atomized process. Low volume (0.5 psi – 5 psi), pattern shaping air can be used to break down a coating into small particles or droplets to result in a much thinner wet film. This process can be used for solvent-based, low viscosity fluids when a user is looking for a very low dry film thickness.

Atomization is also the preferred method for higher viscosity coatings (often silicones) or UV chemistries. There are very few limits on what you can atomize. Very thick materials can be sprayed by altering the atomizing air pressure, though selectivity can be compromised in high pressure applications. Conformal coating films are often created with pressures below 5 psi. A series of spray caps can result in pattern shapes varying from conical to fans in pattern widths down to 3 mm. For added control, most selective coating applications integrate a detailing tool to jet, or needle dispense in and around small keep-out areas.

Selective coating has a higher initial cost than dipping or manual spray operations, but can often be justified by the higher throughput, material savings, and reduction in masking labor. All of these factors must be taken into consideration when evaluating the best process for your production environment.

Conclusion

Implementing a conformal coating process is a delicate balance of material selection, understanding the engineering requirements for coverage, keep-out area, and thickness, and choosing an appropriate application method. Every variable in the process has its own pros and cons that you must weigh against your internal resources and production volume. Changing one variable may also impact other decisions you make in the process so it is always important to qualify your process prior to implementation.

This article was written by Frank Hart, Global Sales and Marketing Manager, PVA (Cohoes, NY). For more information, visit ***http://info.hotims.com/65858-507.***