EMS TRENDS

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Protection for Complicated SMD Assemblies

IN SUMMARY

Most common conformal coatings actually can hurt, not protect, delicate and dense PCB assemblies. Parylenes are deposited differently, and offer EMS providers another option for electrical/dielectric, chemical, and mechanical protection. Variant HT proves promising for miniaturized assemblies.

Size reduction and demand for increased capabilities in consumer electronic devices are major forces driving electronic assemblies today. We have entered an era where there is no such thing as a "single use" product anymore. Devices smaller than a playing card and virtually as thin now contain phone, computing, video streaming, music, Internet, GPS, and more functionalities. The list doubles almost daily.

This requires increased capabilities embedded into shrinking real estate for the internal electronic boards that give these devices life. Component sizes are down to the micron level, fine-pitch BGAs/CSPs and stacked packages (Figure 1) co-exist with newer versions of older technologies, such as flexible thru-hole packages and embedded vias. Protection from thermal shock, shorts, corrosion, dirt, and humidity is a real issue.

Various conformal-coating formulations long have been standard for electronic device protection. However, most common coating formulas actually can hurt rather than help, because they are too heavy, hard to apply in a uniform manner, weigh down delicate components, or are too viscous to wick into tiny openings and low standoffs to coat and protect completely without clogging.

This is a continual challenge to product designers and to the EMS providers who build the final assembled electronic modules. Protection is a must. Field failures (Figure 2) are the worst nightmare for both the shop building the devices and the manufacturer whose credibility rests on the performance of the end product.

Discovering Parylene

Parylene is the generic name for a series of polymeric organic coating materials that are polycrystalline and linear in nature. They possess useful dielectric and barrier properties per unit thickness, and are chemically inert. Parylenes are deposited differently than conventional conformal coatings and require no type of post curing or handling. The standard pros and cons of conformal coatings and how to apply them do not affect parylene users. Parylene coatings are thin, pinhole-free, and conform to components due to their molecular-level polymerization — basically growing on the deposition surface one molecule at a time.

PCB assemblies (PCBAs) to be coated are placed in a deposition chamber at the start of the parylene conformal coating process. A powdered raw material, known as dimer, is added in the vaporizer at the opposite end of the system. The dimer is heated, causing it to sublimate to a vapor, then heated again to break it into a monomeric vapor. This vapor is transferred into an ambient-temperature chamber, where it spontaneously polymerizes onto the parts, forming a thin, yet strong, parylene film (Figure 3). The parylene process is carried out in a closed system under controlled vacuum. The deposition chamber and parts to be coated remain at room temperature throughout. No solvents, catalysts, or plasticizers are used in the coating process.

Because there is no liquid phase in this deposition process, there are none of the subsequent meniscus, pooling, or bridging effects seen in the application of liquid coatings; dielectric properties never are compromised. The molecular growth of parylene coatings ensures an even conformal coating at the manufacturer's specified thickness and, because parylene is formed from a gas, it also penetrates into every crevice, regardless of how inaccessible standoffs may seem. This ensures complete encapsulation of the substrate without blocking small openings.

Parylene coatings are lightweight, offering barrier properties without adding dimension or significant mass to delicate components. Parylene coatings typically are applied in thickness ranging from 500 Å to 75 µm. A 25-µm coating, for example, will have a dielectric capability in excess of 5,000 V. One key benefit of parylene is that it actually strengthens delicate wire bonds by an estimated factor of 10.

Because parylene coatings are optically clear, they don't distort electronic signals or optical inspections. These optical characteristics, and the thin physical properties of parylene, make it a choice protective coating for fiber-optic applications.

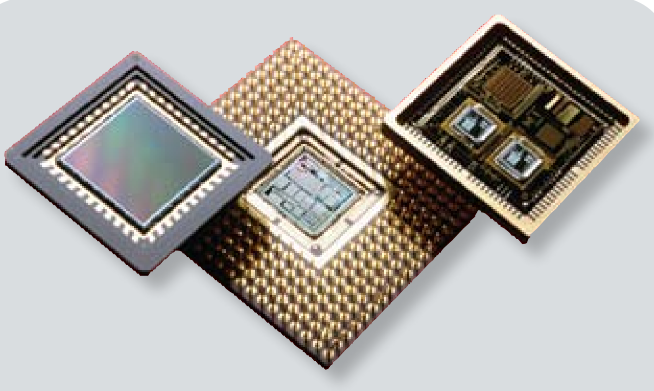

Figure 1. Modern components present a challenge for conformal coating, due to low standoffs and fine features.

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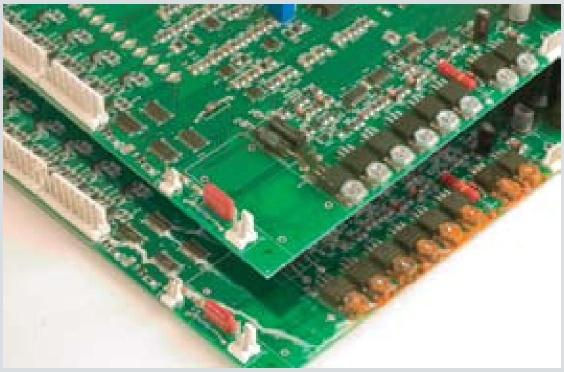

Figure 2. A populated PCB (bottom) shows corrosion due to insufficient protection from chemical, thermal, and electrical wear-and-tear.

Adding Capabilities

While existing parylene variants, such as C and D, meet most coating challenges, emerging variant formulae add protection tailored to miniaturized packages and devices. The HT variant was developed by replacing the alpha hydrogen atom of the parylene N dimer with fluorine. It has a lower coefficient of friction, low dielectric constant, and — because of its small molecular size — higher penetrating capability for micro-gaps and low-standoff components.

This formula provides protection in high-temperature environments up to 350°C, and in short-term exposures up to 450°C. When circuits run continually, operating temperature can be an issue. Also, miniaturized stacked components require protection from thermal shock. For devices like miniature plastic ball grid arrays (PBGAs), high temperatures can stimulate moisture ingress, which can induce failures. Traditional parylene formulations offered some level of protection, but the HT variant is shown to add thermal stability and strengthen the package integrity.

The HT variant also offers long-term ultraviolet (UV) stability. With visual displays and touchscreen controls comes the need for protection from continual UV exposure. This applies with many vehicle/aerospace display electronics, as well as medical/surgical instruments. Previous formulations of parylene have lacked resistance to extended UV exposure, degrading over time. Parylene HT provides a suitable barrier against light.

For many delicate packages and complex BGAs, moisture sensitivity is a real problem. Because the packages are miniature and their undersides are practically impossible to reach, failure to protect these packages can lead to delamination and catastrophic device failure. Compared to parylene N and C formulations, parylene HT is able to penetrate 25% further into crevices, allowing it to ingress deeper through open areas on the top or bottom of any package, regardless of the size or complexity of integrated devices.

Another issue is mixed technology, where some components on flexible circuitry require thru-hole mounting alongside surface mount devices (SMDs) on the assembly. All of these components require protection without clogging, while still having unhampered flexibility.

Many chip-scale packages (CSPs) used in complex assemblies are not only miniature, but also susceptible to random electrostatic discharge (ESD) damage. Parylene HT has a lower dielectric constant and dissipation factor than other parylenes, enabling it to provide small, tight packages with dielectric insulation via a thin coating. Voltage breakdown per unit thickness increases with decreasing parylene film thickness.

Vapor Deposition

The application of parylene coatings is a technical blend of art and science and, as such, has created a niche for contract shops that specialize in offering this specific service. Batch vapor deposition requires specialized equipment and skilled operators.

This service allows EMS providers who want to add parylene to their customers' products to avoid investment in capital equipment and employee training. Major EMS providers outsource millions of parts per year to parylene service providers globally; this is continually growing, driven by more complex electronic board designs.

Parylene service facilities provide the resources to help resolve coating challenges and should accommodate large-scale productions, like those run for consumer goods.

EMS providers must evaluate coating service providers by what best suits their needs, based around metrics like global locations for logistics management, facility capacity, engineering support, cleanroom capabilities, quality systems, and other factors.

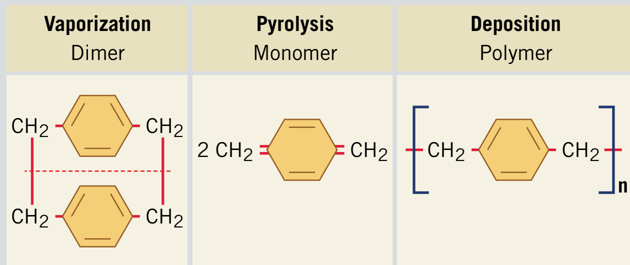

Figure 3. Parylene coating involves vaporizing dimer, heating the vapor to a monomer form, then depositing it as a polymer on a PCBA's surface.

Conclusion

Parylene HT is not intended to replace parylene N, C, or D, but joins the parylene family by bringing additional capabilities to a line of polymer coating materials that already offers device designers expanded capabilities.

Protection issues faced today are not going to diminish. They will become more complex with each new design iteration. Parylene HT enables custom and full-service EMS providers to add a level of strong, lightweight protection to assemblies, shielding them from higher operating temperatures and prolonged UV exposure. Conformal coating protection enables longer life and reliable performance in complex consumer products. SMT

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