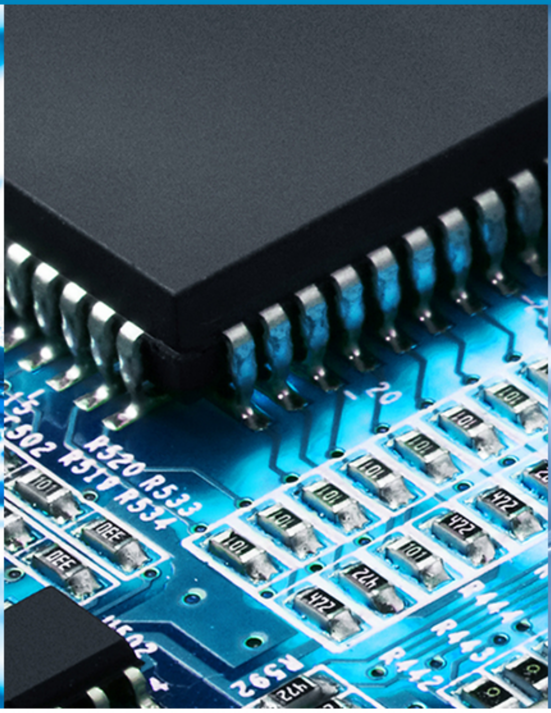
1-814-535-3505

PARYLENE 101 A COMPLETE GUIDE

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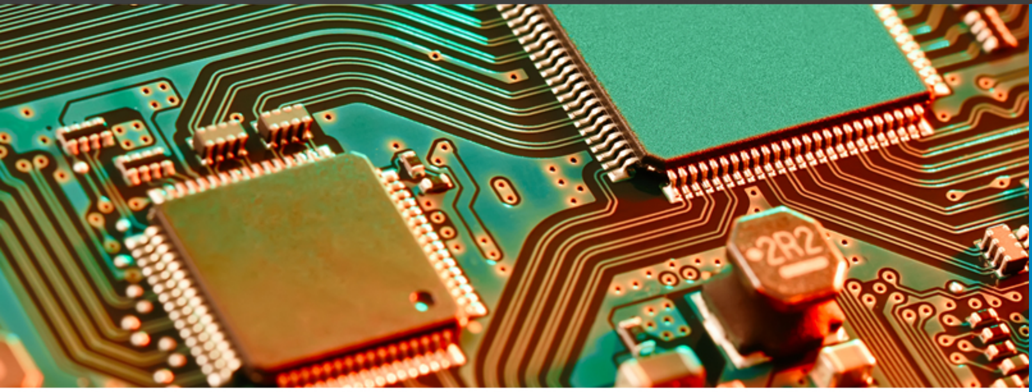
WHY PARYLENE? History & Advantages



Parylene Advantages

- There is no liquid phase involved. Coatings are truly conformal, of uniform controllable thickness, and are completely pinhole-free at thicknesses greater than 0.5μ.
- Parylene coating completely penetrates spaces as narrow 0.01mm.
- Room temperature formation means the coatings are effectively stress-free.
- Parylene is chemically and biologically inert and stable and make excellent barrier material.
- Parylene has excellent electrical properties: low dielectric constant and loss with good high-frequency properties; good dielectric strength; and high bulk and surface resistance.
- Parylene has good thermal endurance: Parylene C performs in air without significant loss of physical properties for 10 years at 80°C and in the absence of oxygen to temperatures in excess of 200°C.
- FDA approval of parylene-coated devices is well-documented. The coatings comply with USP Class VI Plastics requirements and are MIL-I-46058C / IPC-CC-830B listed.
- Parylene coating has excellent mechanical properties, including high tensile strength.
- Parylene is stable over a very wide temperature range (-200 ‘C to +200 ‘C), allowing the chamber items coated in Parylene to be put in an autoclave.
- Parylene coatings are completely conformal, have a uniform thickness and are pinhole free. This is achieved by a unique vapor deposition polymerization process in which the coating is formed from a gaseous monomer without and intermediate liquid stage. As a result, component configurations with sharp edges, points, flat surfaces, crevices or exposed internal surfaces are coated uniformly without voids.
- Parylene coating provides an excellent barrier that exhibits a very low permeability to moisture and gases.

The History of Parylene

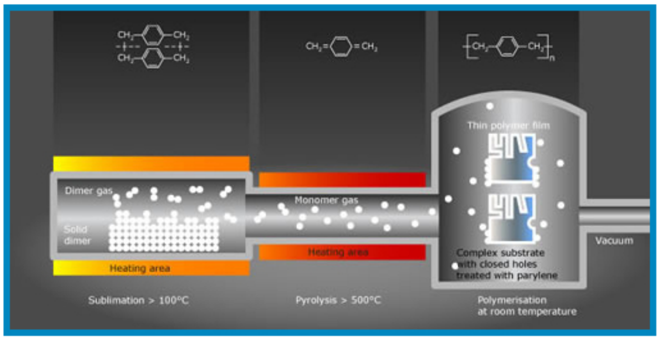
Parylene development started in 1947, when Michael Szwarc discovered the polymer as one of the thermal decomposition products of a common solvent p-xylene at temperatures exceeding 1000 °C. Szwarc first postulated the monomer to be para-xylylene which he confirmed by reacting the vapors with iodine and observing the para-xylylene di-iodide as the only product. The reaction yield was only a few percent, and a more efficient route was found later by William F. Gorham at Union Carbide.

Parylene is considered by many to be the ultimate conformal coating for protection of devices, components and surfaces in electronics, instrumentation, aerospace, medical and engineering industries. Parylene is unique in being created directly on the surface at room temperature. It is chemically stable and makes an excellent barrier material, has excellent thermal endurance, as well as excellent mechanical properties and high tensile strength.

DEPOSTION PROCESS How it Works

Parylene coating is applied through a vapor deposition process onto the substrate or material that is being coated. Depending on the coating type and required thickness, typical parylene deposition rates are about .2/mils per hour, so machine runs can vary from as little as 1 hour to over 24 hours. The process begins with raw dimer in solid state (these are: Parylene C, Parylene N, Parylene D, Parylene AF-4, or other variants) being placed into a loading boat, which is then inserted into the vaporizer. The raw dimer is heated between 100-150º C. At this time, the vapor is pulled, under vacuum into the furnace and heated to very high temperatures which allows for sublimation and the splitting of the molecule into a monomer. The monomer gas continues to be drawn by vacuum one molecule at a time onto the desired substrate at ambient temperatures in the coating chamber.

The final stage of the parylene deposition process is the cold trap. The cold trap is cooled to between -90º and -120º C and is responsible for removing all residual parylene materials pulled through the coating chamber. The process is visually described through figure 1 below:



The parylene deposition process is relatively simple to understand, but tough to master. A thorough understanding of the process is key to controlling thickness and ensuring a successful coating cycle.

Coating Requirements

An important consideration of appropriate parylene thickness is total required clearance. While an enclosure-PCB has few clearance issues, in many cases even an additional millimeter of parylene coating can be sufficient to generate dysfunctional mechanical abrasion, damaging the parylene surface and reducing its conformal qualities.

Regarding dielectric strength, items whose required levels of dielectricity are higher will need a thicker coat of parylene. Balancing dielectric strength with clearance generally requires quality testing to determine their correct ratio. The end-item customer may not always provide these specifications; learning how to determine dielectric/clearance ratios without this data is integral to mastering the parylene deposition process.

APPLICATIONS Where Parylene is Used

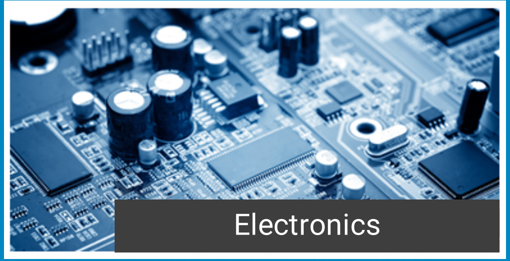
A question we often get is “Can X be parylene coated?” We are often amazed at the sheer number of items that can be and are coated with parylene. A quick look at the different items that we have parylene coated over the years reveals that more often than not, parylene coating is a value add to these and many more products:

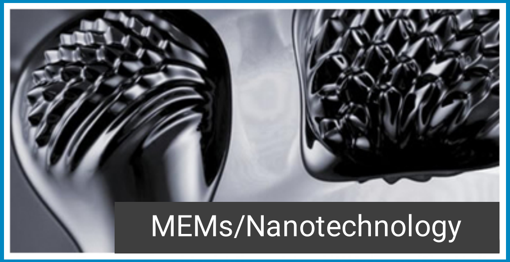
Printed circuit boards	Silicon Wafers
MEMs	Keypads
LEDs	Stoppers
Catheters	Seals
Stents	Mandrels
Magnets	Molds
Paper	Motor Assemblies
Needles	Power Supplies
Sensors	Backplanes
Ferrite Cores	Photoelectric Cells
Metallic Blocks	Forceps
Optical lenses	Test tubes
Implantable devices	Probes
Valves	Fiber Optic Components
O-rings	Pace-makers
Tubing	Bobbins

This is far from a comprehensive list of items that can be parylene coated, but it should give a good idea how many different applications that parylene can be used for.

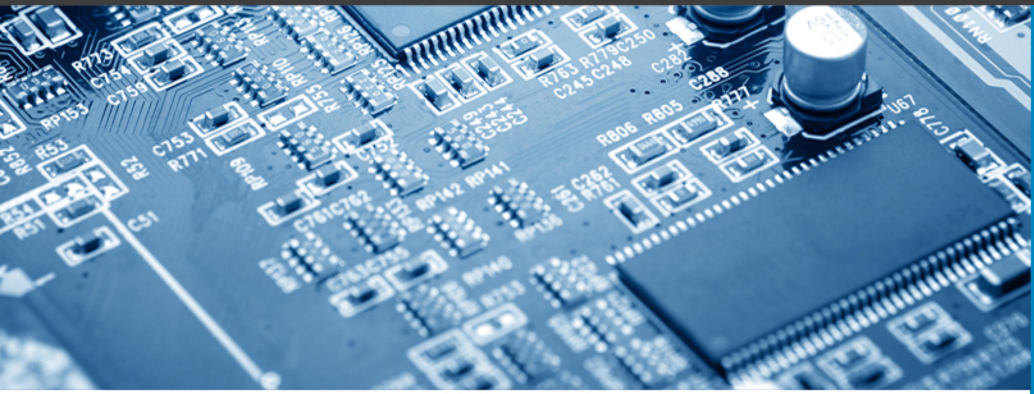
Industries

Parylene is used in various ways throughout many industries and products including:





ADHESION Methods for Improvement



Parylene, through its deposition process, does not adhere chemically, only mechanically, to any given substrate. In order to improve parylene adhesion to its best possible levels for a wide variety of substrates, different methods of surface modification via adhesion promoters must be used. Adhesion promotion methods are typically used prior to the actual coating process, however some can be integrated during the process itself.

The largest factor affecting parylene (or any conformal coating) adhesion is surface cleanliness. Contaminants on the substrate that have accumulated during all phases of manufacturing, as well as handling and transportation, can cause very poor adhesion and lend to poor overall coating quality. It is highly recommended that substrates be cleaned prior to coating (Contrary to popular belief, this INCLUDES No-Clean Fluxes). Cleaning can be done via manual methods, inline, batch, or ultrasonic means.

A-174 Silane

The most common surface modification method to improve parylene adhesion is the use of A-174 silane. A-174 silane is usually applied after the masking operation, either by a manual spray, soaking, or a vapor phase silane process, depending on each individual application. The A-174 silane molecule forms the chemical bond to the surface enabling parylene’s mechanical property to form improved adhesion characteristics.

When looking to improve parylene adhesion, a close review of all of the current processes, to include handling, is a necessity. Once best adhesion practices have been established, it is of utmost importance to enforce strict adherence to the processes. If adhesion becomes an issue, any deviation from a process can be a good troubleshooting start-point.

Using industry best practices, such as substrate cleaning and A-174 silane application, combined with standard, repeatable processes will ensure strong adhesion for parylene coating.

COST How it's Determined

Parylene is often priced out to be one of the more expensive conformal coating options. After a quick look at some of the cost factors, it will be easy to see why. Three of the main factors that influence parylene cost are raw materials, labor, and lot volume.

Raw Materials – Parylene Dimer and Adhesion Promotion

Parylene dimer is the raw form of parylene. It is the solid inserted into the machine that is broken down through the deposition process. Cost for parylene dimer can be anywhere from $200 to $5,000 per pound depending on the different type of dimer. A typical coating run is around a pound of dimer.

Different adhesion promotion methods require different raw materials.From various board cleaning solutions to A-174 silane, these raw material costs need to be added to the price per assembly. There is not much that can be done with these costs, as adhesion is the name of the game in parylene.

Parylene Lot Volumes

Items to be parylene coated are placed into a vacuum chamber. There is finite space available in the chamber and everything inside gets coated. In order to get the lowest cost, we have to maximize the products in the chamber. If we are able to divide the material costs among a greater number of boards, the cost per board drastically drops.

Parylene Labor Costs

Like all conformal coatings, masking is usually the most labor intensive part of the process. However, parylene is different from other conformal coatings in that it is applied in a gaseous state through a vapor deposition process. The parylene molecules will penetrate anywhere that air can. As a result, great care needs to be taken during the masking process to ensure that every connector is adequately sealed and all tape is firmly pressed against the coating keep-out areas.

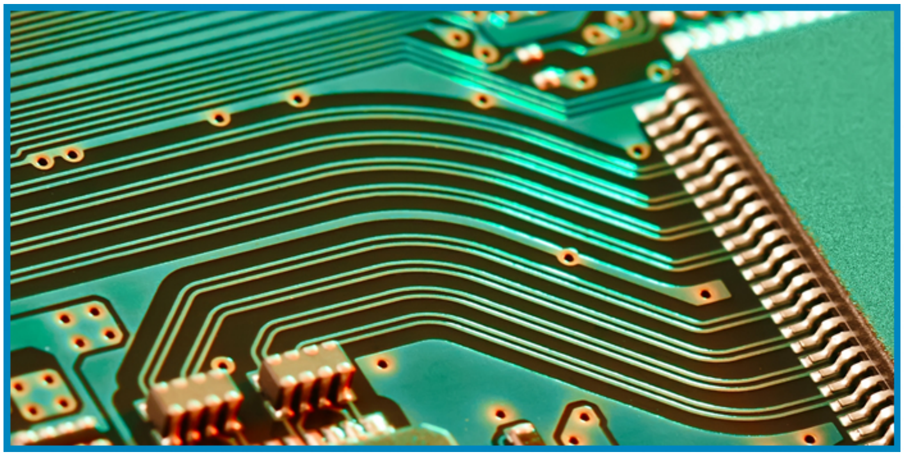
Another factor that will result in increased labor costs is the increased time spent per board to increase parylene adhesion. Spending extra time cleaning products and applying different adhesion promotion mediums will result in increased labor times.

THICKNESS Factors & Considerations

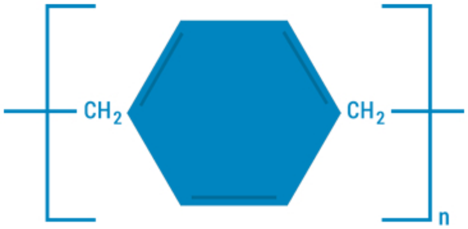
A question that is often brought up by customers who are new to conformal coating is what thickness to apply parylene.

One of the different factors to take into account when trying to determine the proper parylene thickness is the amount of clearance needed. If it is a printed circuit board that is an enclosure, there usually will not be too many clearance issues. However, in some cases, even an extra mil of coating can cause extra mechanical abrasion to the parylene which can result in damaged parylene.

Another factor to consider is the dielectric strength required. For applications that require higher dielectric strength, a thicker coat of parylene has higher dielectric properties than a thinner coat. Trying to balance the dielectric strength issue with the clearance issue is a tight rope to walk and will usually require some testing to determine the proper balance. In the easiest of cases, an end item customer has specified the coating thickness to be applied and put this into writing on a drawing. After we review the drawing and compare the drawing with the assembly, we will be able to determine if any potential issues with the parylene thickness are present.

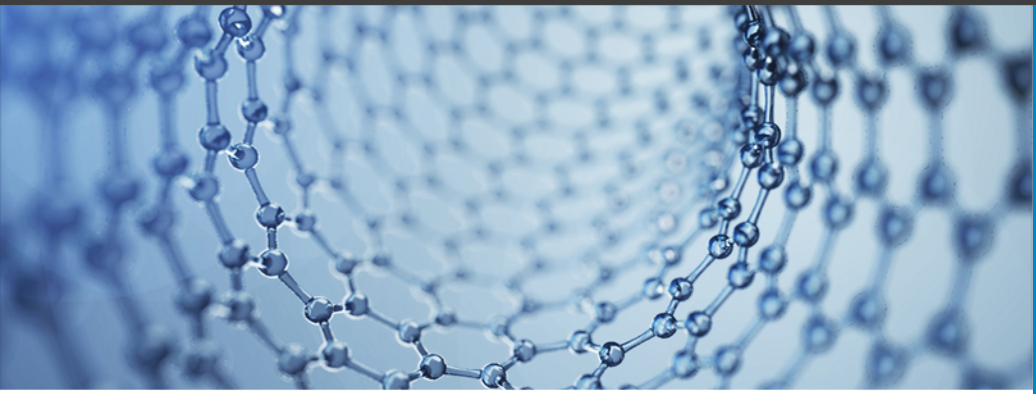


Each conformal coating material exhibits a range of unique performance properties that determine its product uses. Relevant factors include the required coating-thickness necessary to assure reliable performance. Like other coating types, parylene (XY) layer thickness is largely a function of several factors: (1) substrate material, (2) the kind of assembly being covered, and (3) its operational purpose. Chemically inert parylene is effective at far-thinner application thickness than liquid-applied materials for coating printed circuit boards (PCBs) and related electro assemblies:



Parylene	0.013 – 0.051 mm (0.0005 to 0.002 in.)
Silicone	0.051 – 0.203 mm (0.002 to 0.008 in)
Acrylic Urethane Epoxy	0.025 – 0.127 millimeter (mm. -- 0.001 to 0.005 inches)

COATING PROCESS Start to Finish



Phase 1 – Prior to Parts Arrival

Once we receive a purchase order from a customer, all of the pertinent information such as drawings, specifications, and special instructions are given to the quality department from our marketing team to create custom work instructions for that particular part.

Phase 2 – Coating Processes

After the work instructions and other administrative tasks have been completed, the parylene coating production process truly begins in our shipping department. Once all of the items have been unpacked, they are then routed to incoming inspection. Here, parts are counted to verify quantity against the customer purchase order and packing slip, as well as inspected to verify that no damage occurred to the assemblies prior to arrival at Diamond-MT. After incoming inspection, assemblies are then ready for individual processes.

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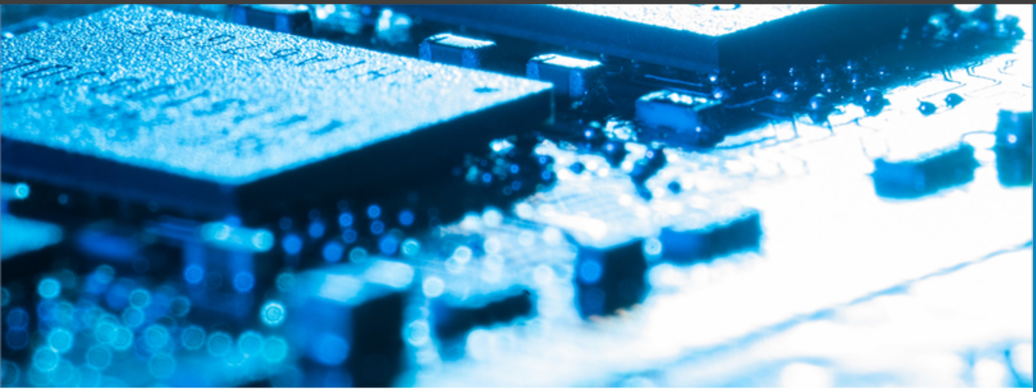
For example, if cleaning or cleanliness testing were required, it would be performed at this time. Once any unique processes have been completed, the products are then routed to masking. Masking is done in accordance with the customer's drawings and requests for coating keep-out areas. Once completed, the parts go into masking inspection to verify compliance with the customer's masking drawing. After parts pass masking inspection, adhesion promotion is administered. At last, the parylene coating is applied through a deposition process.

Project Checklist

What to consider for your Parylene Coating project:

- Type of substrate (Material) to coat.
- Dimension of the part? Length, Width and max thickness?
- What is the objective of parylene coating?
- What needs to be coating free/masked?
- What contact points are allowed (for fixture holding purpose)? Contact area would not be coated by parylene.
- Type of parylene required, if known?
- Thickness of coat required, if known? IPC standard is .5-2 mils.
- Any cleaning method required after you send us the part for coating?
- Is Part IPA compatibility - This is alcohol base solvent which is mainly to remove any handling oil or grease contamination.
- What is the working temperature of the device / product?
- What are the tests, if any, to be carried out after parylene coating? Please provide test details if any.
- What is the End Product Application?
- What qty per run/shipment?
- Mass production startup schedule?
- Monthly volume for the project?

COATING PROCESS Start to Finish



Once coating has been deposited, the coated materials have the masking material removed using great care not to damage the thin layer of parylene applied. The parts are nearing completion, but before they can be packaged up and sent back to the customer, they need to go through a final inspection. The final inspection ensures that all previous steps were successfully completed and that the final product completely complies with the customer's drawing and specifications. Final inspections cover 100% of the product. Once the parts pass the final inspection, they are returned to the shipping department to be packed back into the boxes they came in and be returned to the customer. This is usually a ten business day evolution, but can be completed quicker on a negotiated basis.

Phase 3 – Post Coating Follow-up

Our sales and marketing team is in very close contact with our customers after the coating process to make sure the coating is exactly as the customer requires. If any changes are necessary to our process, our quality department will work hand in hand with the customer to make sure that the end product is exactly what is needed.

Parylene Equipment

The parylene coating process is controlled via a programmable logic controller. Each deposition system features an operator's control panel that displays critical, factory pre-programmed process parameters. Process settings are accessible and can be changed by qualified personnel when necessary. All machines feature closed loop monomer pressure control, ensuring deposition of the polymer film at a precise rate. All operating temperatures and pressures are continuously monitored and any deviation from the acceptable limits results in audible and visual alarms. Automatic process shutdown is initiated following process fault conditions of sufficient duration.

DIAMOND-MT About Us

Diamond MT was founded in 2001 as a firm specializing in contract applications of Conformal Coatings for Department of Defense and Commercial Electronic Systems. Since our beginning, Diamond MT has established a reputation for providing the highest quality services in the industry.

For years, our commitment to quality, integrity and customer satisfaction combined with an unmatched expertise in applications and processes has provided every one of our customers with superior results.

Diamond MT has been operating out of Johnstown, Pa since 2006. It is a ISO9001:2015, AS9100D certified facility that specializes in the application of liquid conformal coatings (AR, UR, SR, ER), parylene conformal coatings, equipment, dimer, masking boots, and consultation services.

Diamond MT opened a second facility in 2019 in Melbourne, Florida to offer world class liquid conformal coatings (AR, UR, SR, ER), parylene conformal coatings, equipment, dimer, masking boots, and consultation services to the Florida market.

Contact Us

Whether you are looking for a conformal coating solution, looking for a quote or want to learn more about which conformal coating solution would be best for your product, we are here to help.

Phone: 1-814-535-3505
www.diamond-mt.com

Quality Assured

Diamond MT is an ITAR registered facility. Our technicians are trained to adhere to the standards of AS9100D, ISO:9001:2015, IPC-A-160, IPC Class 3, IPC-J-STD-001, IPC-CC-830 and NASA-STD-8739.1. Our repair and rework are held to IPC-7711 and IPC 7721 standards. Many of our clients do not require our work to be held to such high standards, but we strive to offer the best quaity coating solutions.

Rapid Turnaround

Diamond MT's turnaround is the fastest in the business. We understand that critical projects need to be completed as quickly as possible. We work with you to determine what your needs are and create a production schedule that allows you to meet your goals in as little as 24 hours.