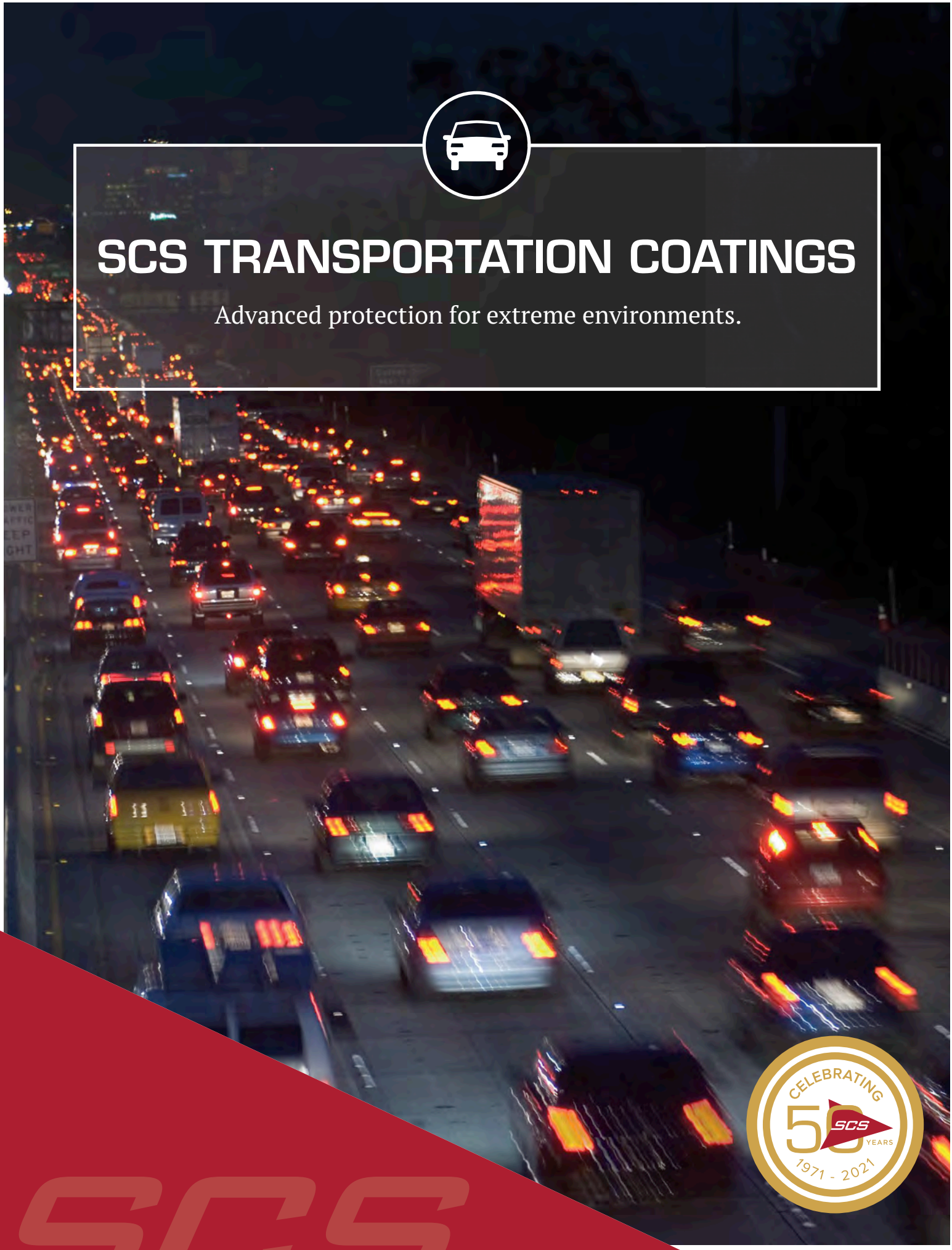


SCS TRANSPORTATION COATINGS

Advanced protection for extreme environments.

CELEBRATING 50 YEARS SCS 1971 - 2021

INNOVATIVE SOLUTIONS FROM THE LEADER IN PARYLENE

With 50 years of experience in Parylene engineering and applications, Specialty Coating Systems (SCS) is the world leader in Parylene conformal coating technologies. We're a direct descendant of the companies that originally developed Parylene, and we leverage that expertise on every project – from initial planning to process application.

SCS employs some of the world's foremost Parylene specialists, highly experienced sales engineers and expert manufacturing personnel, working in state-of-the-art coating facilities in 11 countries worldwide. Our extensive, proactive approach to production and quality requirements gives our customers peace of mind and minimizes the resources they need to meet even the most challenging requirements and specifications.

50 years

11 countries

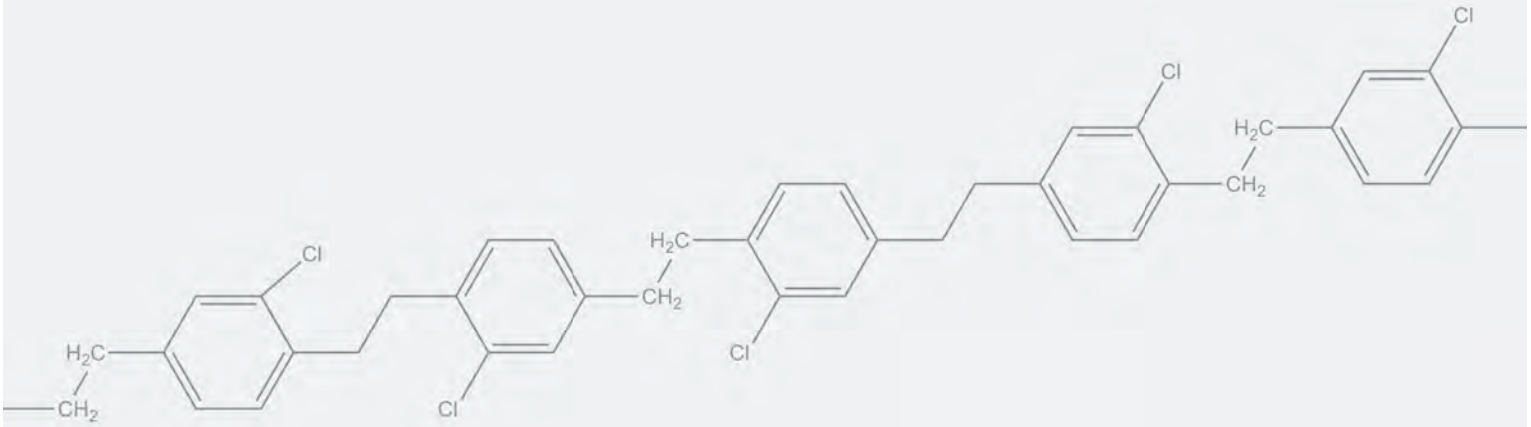
3 continents

>1,000 employees

SCS PARYLENE COATINGS

SCS combines the properties of Parylene with its years of experience, vast technologies and worldwide resources to provide the transportation industry with reliable coatings and services, including Parylene HT®, which is specifically engineered to withstand the most extreme conditions in the industry. Ultra-thin and pinhole-free, SCS Parylene coatings offer beneficial attributes, including:

- Thermal stability up to 450°C (short-term)
- Superior fluid, chemical, moisture and electrical barrier properties
- Excellent crevice and multi-layer penetration
- Unparalleled ultraviolet stability



PARYLENE COATING PROPERTIES THAT PROTECT

BARRIER PROPERTIES

SCS Parylene coatings are excellent moisture and chemical barriers for transportation components. Applied in the micron range — much thinner than industry standard coatings — Parylene provides a superior pinhole-free, uniform barrier to protect against corrosive liquids, fluids, gases and chemicals, even at elevated temperatures. Table 1 shows that Parylene HT films minimally swelled with exposure to automotive chemicals and fluids; however, the swelling completely reversed after the solvents were removed by vacuum drying. Additionally, there were no perceivable changes in the films' physical or chemical properties.

Circuit boards coated with Parylene HT were salt-fog tested by an independent facility. The coated boards showed no corrosion or salt deposits after 144 hours of exposure in accordance to ASTM B117-(03) (See Figure 1). Boards coated with SCS Parylenes C and ParyFree®, a new halogen-free variant of Parylene, exhibited similar results.

THERMAL STABILITY

Harsh operating environments range from -40°C to more than 300°C, making coating stability critical to the trouble-free life of transportation electronics. SCS Parylene HT is specifically engineered to provide long-term thermal stability up to 350°C, with short-term stability up to 450°C.

UV STABILITY

SCS Parylene HT offers measurable UV stability after more than 2,000 hours of UV exposure (ASTM G154). Its chemical structure provides protection from degradation and discoloration as a result of such exposure.

DIELECTRIC PROPERTIES

SCS Parylenes also have excellent dielectric properties. Their high dielectric strength is attributable to the fact that they can be formed as thin, continuous films, free from the defects and fillers commonly found in conventional coatings that tend to reduce dielectric strength.

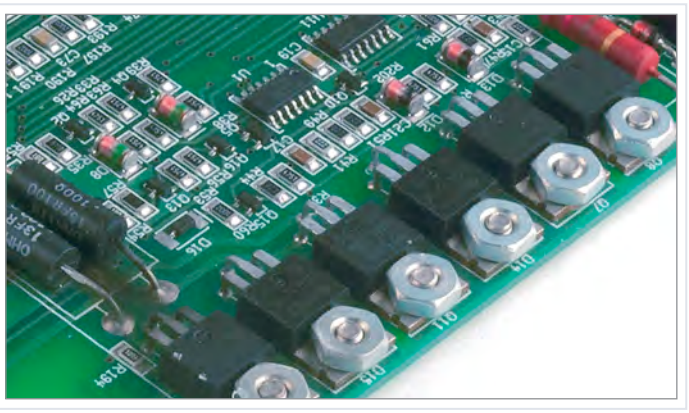
SCS Parylenes have low dielectric constants and dissipation factors among industry standard coatings, enabling them to transfer electrical signals without absorption or loss.

TABLE 1: Automotive Chemical and Fluid Resistance of SCS Parylene HT

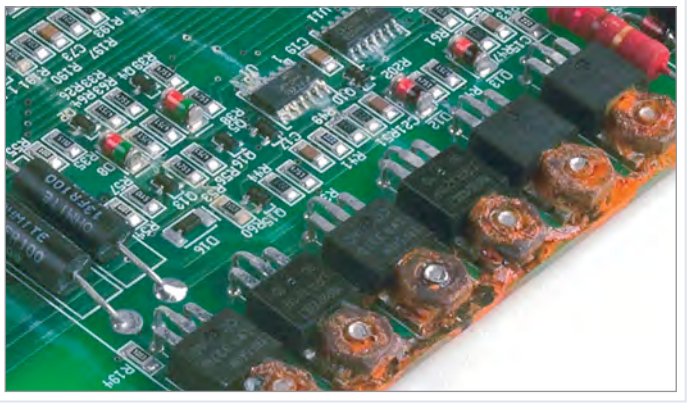
Chemical	Parylene HT Film Swelling
Automotive Fluids Heated to 90°C Antifreeze — 50% solution Engine Oil — 10W30 Transmission Fluid — Dexron Ill Mercon	<2.5%
Automotive Chemicals Heated to 75°C Nitric Acid — 10% and 70% solutions Sulfuric Acid — 10% solution Sulfuric Acid — 95% – 98% solution	<1%
Automotive Fluids at Room Temperature Brake Fluid — DOT 3 Power Steering Fluid Windshield Washer Fluid Unleaded Gasoline — 87 Octane Diesel Fuel	<1.5%

Testing Parameters:
Film thickness: 16-20 micron
Exposure time: 120 minutes

FIGURE 1: Circuit boards after 144 hours of salt-fog exposure



Coated with SCS Parylene HT



Uncoated

SCS PARYLENE PROPERTIES

		Method	Parylene N	ParyFree	Parylene C	Parylene HT	Acrylic (AR)[a,b]	Epoxy (ER)[a,b]	Polyurethane (UR)[a,b]	Silicone (SR)[a,b]
Water Vapor Transmission Rate (g•mm)/(m^2•day)		1,2,3,4	0.59	0.09	0.08	0.22	13.9[c]	0.94[c]	0.93 – 3.4[c]	1.7 – 47.5[c]
Water Absorption (% after 24 hours)		5	<0.1	<0.1	<0.1	<0.01	0.3	0.05 – 0.10	0.6 – 0.8	0.1
Gas Permeability @ 25°C $\frac{cc \cdot mm}{m^2 \cdot day \cdot atm}$	**N_2** **O_2** **CO_2**	6,7,8,9	3.0 15.4 84.3	<0.2 3.4 7.8	0.4 2.8 3.0	4.8 23.5 95.4	– – –	– – –	31.5 78.7 1,181	– 19,685 118,110
Dielectric Strength V/mil		10	7,000	6,900	5,600	5,400	3,500	2,200	3,500	2,000
Dielectric Constant	**60 Hz** **1 KHz** **1 MHz**	11	2.65 2.65 2.65	2.38 2.37 2.35	3.15 3.10 2.95	2.21 2.20 2.17	– – 2.7 – 3.2	3.3 – 4.6 – 3.1 – 4.2	4.1 – 3.8 – 4.4	3.1 – 4.2 – 3.1 – 4.0
Dissipation Factor	**60 Hz** **1 KHz** **1 MHz**	11	0.0002 0.0002 0.0006	0.00001 0.0009 0.0007	0.020 0.019 0.013	<0.0002 0.0020 0.0010	0.04 – 0.06 – 0.02 – 0.03	0.008 – 0.011 – 0.004 – 0.006	0.038 – 0.039 – 0.068 – 0.074	0.011 – 0.02 – 0.003 – 0.006
Service Temperature	**Continuous** **Short-Term**	12	60°C 80°C	60°C 80°C	80°C 100°C	350°C 450°C	82°C –	177°C –	121°C –	260°C –
UV Stability		13	≤100 hrs	≤100 hrs	≤100 hrs	≥2,000 hrs	–	–	–	–
Coefficient of Friction	**Static** **Dynamic**	14	0.25 0.25	0.23 0.23	0.29 0.29	0.15 0.13	– –	– –	– –	– –
Tensile Strength (psi)		15	7,000	9,600	10,000	7,500	7,000 – 11,000	4,000 – 13,000	175 – 10,000	350 – 1,000
Penetration Ability[d]			40 x dia.	10 x dia.	5 x dia.	50 x dia.	Spray or Brush	Spray or Brush	Spray or Brush	Spray or Brush
Rockwell Hardness		16	R85	R136	R80	R122	M68 – M105	M80 – M110	68A – 80D (Shore)	40A – 45A (Shore)

a. *Handbook of Plastics, Elastomers, and Composites*, Chapter 6, "Plastics in Coatings and Finishes," 4th Edition, McGraw Hill, Inc., New York, 2002.

b. *Conformal Coating Handbook*, Humiseal Division, Chase Corporation, Pennsylvania, 2004.

c. *Coating Materials for Electronic Applications*, Licari, J.J., Noyes Publications, New Jersey, 2003.

d. Depth into tubing and crevices.

Test Methods:

1. ASTM E96 (at 90% RH, 37°C) (Parylene N only)
2. ASTM F1249 (at 100% RH, 37°C) (ParyFree only)
3. ASTM F1249 (at 90% RH, 37°C) (Parylene C only)
4. ASTM F1249 (at 100% RH, 38°C) (Parylene HT only)
5. ASTM D570
6. ASTM D1434 (Parylenes N, C)
7. MOCON MULTI-TRAN 400 (ParyFree-N_2, Parylene HT)
8. ASTM D3985 (ParyFree-O_2)
9. ASTM F2476 (ParyFree-CO_2)
10. ASTM D149
11. ASTM D150
12. TGA/FTIR, DSC and thermal endurance testing
13. ASTM G154
14. ASTM D1894
15. ASTM D882
16. ASTM D785

USEFUL IN MANY TRANSPORTATION APPLICATIONS

Due to the continued and rapid growth of advanced electronic systems, the transportation industry has evolved greatly over recent years. The industry, which used to rely heavily on mechanical systems, not only has increased in its use of electronic systems, but now includes new interpretations of autonomous vehicles and propulsion systems (e.g., electric, hybrid and fuel cell technologies). These advances are present not only in consumer vehicles, but also in construction equipment, buses, heavy-duty trucks, ships and agriculture machinery. Today, electronic systems no longer work as independent components, but as fully integrated systems that use sensors, MEMS and radar to control autonomous vehicles on the road.

SENSORS

Today's engine systems rely on sensors to monitor the accuracy and operation of moving parts, fluid levels,

temperatures and various pressures. Further, autonomous vehicles depend on sensors to control and monitor the exact placement of a vehicle on the roadway. Parylene's excellent barrier properties protect critical sensors from harsh chemicals, fluids and gases, even in high temperature environments. Additionally, Parylene HT has built-in stability to UV light for electronics used on the exterior of the vehicles.

ELECTRIC, HYBRID AND FUEL CELL TECHNOLOGIES

Many major transportation companies have developed electric and hybrid vehicles that utilize and generate electricity to reduce the world's reliance on oil for fuel. Parylene HT offers some of the best dielectric properties of protective coatings on the market, ensuring that the high level of power required for operating these electric and hybrid electronic systems will not be weakened or distorted.

Fuel cells operate in the midst of corrosive compounds at elevated temperatures, a very harsh environment for electronics. Parylene HT is chemically structured to provide superior protection for these components.

MEMS

Micro-Electro-Mechanical Systems (MEMS) continue to represent the cutting-edge of vehicle innovation, often replacing previous generation single-sensors. Today's multi-capacity MEMS packages can be found controlling critical systems, including engine management, safety and security, tire pressure monitoring (TPMS), electronic stability, fluid pressure, fuel injection, pedestrian protection and radar systems. Since Parylene is deposited as a gas, it is an ideal coating to protect complex MEMS wafers.

CIRCUIT BOARDS

The conformal and uniform nature of Parylene coatings ensures complete coverage of circuit boards to protect against corrosion and contaminants with no meniscus, flowing or edge-effects. The lightweight coatings add very little mass to even the smallest of circuit boards used in engine management systems, chip packaging, turbochargers and emission systems.

ENVIRONMENT-FRIENDLY COATINGS AND PROCESSES

SCS COMPLIES

As worldwide industry requirements and directives continue to evolve, SCS is at the forefront, ensuring our products and services comply with relevant regulatory, environmental and biological standards.

SCS coating centers maintain AS9100 and ISO 9001 certifications and are experienced in the Production Parts Approval Process (PPAP). Additionally, SCS Parylenes comply with the European Union's RoHS (Restriction of Hazardous Substances) Directive and REACH regulations. For more information about SCS certifications and standards, visit SCScomplies.com.

METAL WHISKER MITIGATION

As a result of industry directives, pure metal plating is replacing lead in the solders used throughout the worldwide electronics industry. While safer for the environment, metal plating is known to form whiskers, which cause reliability problems for electronic systems. Parylene coatings suppress the formation of metallic whiskers, OSEs (odd shape eruptions) and dendrites.

THE PARYLENE PROCESS

SCS Parylene coatings are applied in a room temperature vacuum chamber via a vapor deposition polymerization (VDP) process. Components to be coated are only required to have a reasonable vacuum tolerance. There are no solvents, catalysts or plasticizers involved in the coating process; since Parylene coatings require no elevated temperature cure cycle, there are no associated cure stresses. Unlike Parylene coatings, conventional dipped, sprayed or brushed coatings may require catalysts, cross-linking, elevated temperatures or UV cure cycles to improve coating properties.

Room Temperature | Molecular-level Deposition | No Solvents, Catalysts or Plasticizers

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