Fraunhofer IISB

Fraunhofer Institute for Integrated Systems and Device Technology IISB

Electrical Insulation and Corrosion Protection

Parylene Coatings

AMB circuit carrier plus IGB, partially coated with parylene F-AF4, after exposure to hydrochloric acid

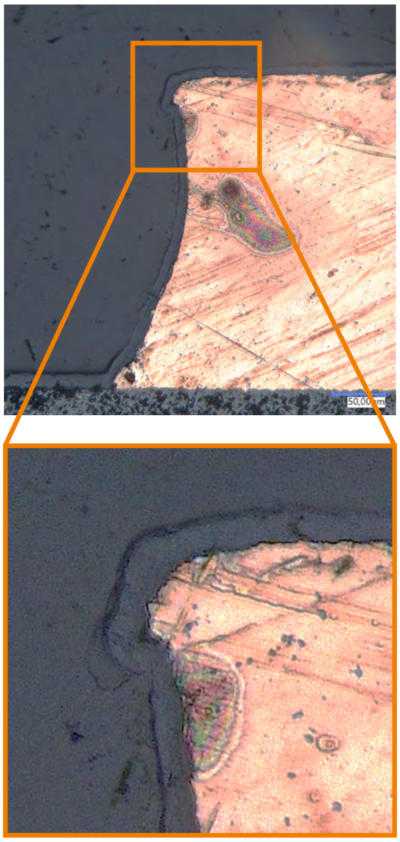
Insulation and corrosion protection for power electronic modules

Homogeneous potting without gas enclosures is crucial for the reliable function of power electronic modules. Especially when it comes to complex module designs with gaps, undercuts, and sharp edges, conventional potting methods reach their limits. A drawback of the widely used silicone gels as potting material is the permeability for humidity and gases, which can lead to corrosion attack under harsh environmental conditions as they are given for many applications (e.g., traction, aerospace, off-shore).

Parylene coatings for power electronic modules

Parylene are a class of thin film forming materials that belong to the thermoplastics. They include a variety of chemical vapor deposited poly(-p-xylylene) polymers. The basic molecule, called parylene N, is a carbohydrate (phenyl ring and aliphatic carbon bonds). By halogenation of different H-atoms, other parylene types are created.

Due to properties like high temperature resistance, high dielectric strength, good gap filling, and corrosion resistance, parylene coatings are a highly promising approach for the insulation and protection of power electronic modules. As parylene coatings are, with a maximum of about 50 µm, comparably thin, they can be seen as lightweight insulation that is especially interesting for aerospace applications.



Microscopic images of a parylene coated metallization edge: homogeneous parylene coating with good edge covering

Parylene

- Group of film forming thermoplastics
- Established material in medical engineering or aerospace
- Material properties
  - Inert
  - Hydrophobic
  - Transparent
  - High dielectric strength: Electrical insulation
  - Good gap filling capability: Suitable for complex module designs incl. undercuts
  - Resistance against environmental influences (temperature, humidity, acids): corrosion protection of electronic devices
- Void free coating via Chemical Vapor Deposition (CVD) in vacuum: Layers in the range of nm to µm
- No outgassing of solvents or other additives

Coating procedure

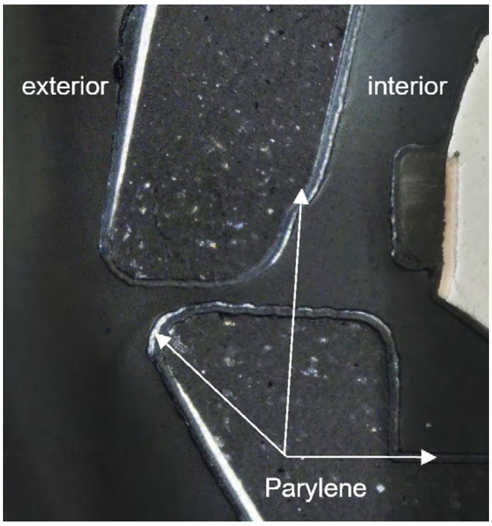
- Chemical Vapor Deposition (CVD)
  - Sublimation: parylene dimer powder is heated from solid to gaseous state (T > 100 °C)
  - Pyrolysis: Splitting of gaseous dimers to reactive monomers (T > 500 °C)
  - Deposition on the samples via condensation reaction and film forming by polymerization at RT

Pre-treatment

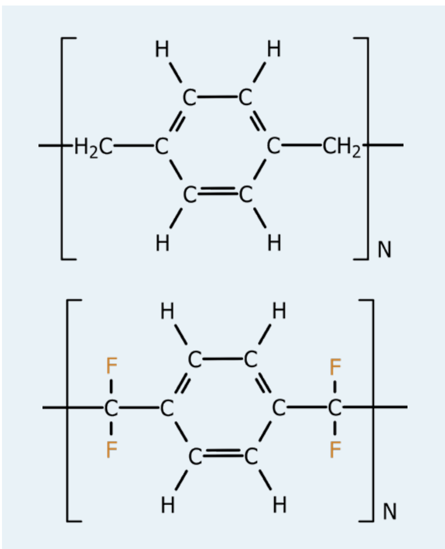
- Treatment to enhance adhesion of parylene coatings
  - Plasma activation
  - Primer coating as bonding agent
  - Customized cleaning

Selected material properties of different Parylene types

Parylene types	N	C	F-VT4	F-AF4
Temporary peak temperature in °C	120	200	300	450
Continuous temperature in °C	90	125	190	350
Tensile strength in MPa	45	69	52	52
Dielectric strength, short time in V/mil at 1 mil	7000	5800	5500	5500
Permeability for humiditiy (cm^{3}xµm)/(m^{2}x24h) at 37 °C, 90 % RH	0.59	0.06	0.23	0.22



Cross-section of parylene coated device: parylene covers the interior surfaces of the device homogeneously via a 50 to 100 µm gap © Adem Erboga / Fraunhofer IISB



Molecular structure of the parylene monomers C (top) and F-VT4 (bottom) © Victoria Zimmermann / Fraunhofer IISB

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