Technical Lecture

Parylene Coating
Permanent Sealing of electronic Components with extreme Requirements

Heicks Parylene Coating GmbH
Dipl.-Ing. Rudolf Heicks
Agenda

• What…
  happens through exposure to moisture?

• How…
  can you protect electronic assemblies?

• How…
  does the parylene process take place?

• What…
  characterizes parylene coating?

• What…
  is the field of parylene coating?

• What…
  are the charges for parylene coating?
Parylene coating

Assembly group coated with parylene
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Increase of climate endangering

• Past
  – Big components
  – Large distance between traces
  – Minor density of devices
  – Minor exposure to climate

• Present
  – Components are getting smaller
  – Very slight distance between traces
  – Density of devices is steadily increasing
  – Strong exposure to climate
Electronic migration

Process of electronic migration

Humidity & contamination (Fluxer/Salt/Fingerprints)

- Electronic migration
- Dissolution of metallization at the anode
- Dendritic crystallization at the diode

Source: EP&P/October 1999
Electronic migration

- Exposure to humidity is the most frequent reason for failure of PCBs due to electronic migration.

- This causes failures in performing or the total breakdown of the assembly group.

Electronic migration on an electronic assembly group

Source: AUCOTEAM GmbH
Whisker formation

- Antimony, cadmium, indium, zinc and tin have an increased tendency to whisker.
- Whisker arise in assemblies sometimes after years in operation.
- Whisker growth occurs increased on components or printed circuit boards, which are subject to mechanical stress.

(Weichlöten in der Elektronik. Eugen G. Leuze, Saulgau 1991)

Parylene prevents whisker formation

Dramatic whisker growth which can happen in certain circumstances
(Source: Raytheon Analysis Lab, McKinney Tx.)
Whisker formation

- whiskers forms especially easy in assemblies that have been processed with lead-free tin solder (<95% tin).

(Source: F169BBS News about e-biz, politics, crime, women and everything else.)
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# CVD Process

- Nearly everywhere the same layer thickness

## Advantages

**Varnishing**
- Painting, Dip coating, Selective Varnishing
- Low priced
- Quick process term

**Parylene**
- Vacuum process with 5 different powders
- Ultra thin transparent and pinhole free layer starting with 0.2 µm / 5 µm to 25 µm
- No degassing of solvent/plasticizer
- Absolute biocompatible and biostable
- Chemically steady
- Low weight
- High temperature stability
- Prevents whisker formation
- Process takes place on ambient temperature
- Texture conserving (real conformal Coating)
- Excellent electrical isolation, high voltage resistance
- Highest protection against corrosion

**Moulding**
- Potting with epoxy resin, polyurethane or silicone
- Strong protection against humidity due to very thick coating
- Stabilisation of components

## Detriments

**Varnishing**
- Protection limited
- Emission of solvent is possible
- Not free of pinholes
- Uneven layer thickness
- Edge alignment
- Nearly no wetting of components

**Parylene**
- Process under vacuum (components have to be vacuum proof)
- Long process term
- Not permanently UV-resistant

**Moulding**
- Long (setting) hardening period
- High weight
- Degassing is possible
- Limited thermo-mechanical reliability

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Protection of PCBs

SMD - Assembly

Usually assembly groups are protected against environmental influences by epoxy, urethane, silicone and acrylic paint systems. However, the protective effect often is not sufficient in case of strong load.

Component with varnishing

Component coated with parylene

Edge alignment

Defective stains

Nearly constant layer thickness

real conformal coating
Protection of PCBs

THT - Assembly

Reasons:

• Defective stains in varnish by pores or edge alignment
• Unsufficient density of permeability against water steam or hazardous gases

In this case a polymer layer (parylene) separated in the vacuum process can protect the necessary reliability of the assembly group.
Protection of PCBs

coating thickness on electronic devices

homogeneous layer thickness provides all-round protection

• In the edge region the desired layer thickness remains

• The parylene coating reaches thin and deep gaps and even covers tops

• The coating is virtually non-porous and structure preserving
Protection of PCBs

Resistence of different layers to 0,9% saline solvent

<table>
<thead>
<tr>
<th>Polymer</th>
<th>Coating method</th>
<th>Layer thickness [µm]</th>
<th>Time until total breakdown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poly-Parylen C</td>
<td>CVD</td>
<td>25</td>
<td>&gt; 30d</td>
</tr>
<tr>
<td>Epoxid</td>
<td>Dip coating</td>
<td>100 ± 25</td>
<td>6 h</td>
</tr>
<tr>
<td>PVC</td>
<td>Dip coating</td>
<td>100 ± 12,5</td>
<td>8 h</td>
</tr>
<tr>
<td>Polyurethan</td>
<td>Dip coating</td>
<td>100 ± 12,5</td>
<td>6 h</td>
</tr>
<tr>
<td>Silicon</td>
<td>Dip coating</td>
<td>75 ±12,5</td>
<td>58 h</td>
</tr>
<tr>
<td>Teflon</td>
<td>Spraying</td>
<td>75</td>
<td>6 h</td>
</tr>
</tbody>
</table>


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Parylene coating
Coating process

1. Evaporation
2. Pyrolysis
3. Condensation

Dipara-xylylen Dimer

Para-xylylen Monomer

Polypara-xylylen Polymer

Vacuum chamber

Source: PPPS: „Klimaschutz mit Dünnschichten“

How does the parylene process take place?

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How does the parylene process take place?

Parylene coating

Coating process

1. Cleaning of assembly group
2. Manually masking of patches to stay uncoated
3. Parylene process in vacuum chamber for a period of 12-20 hours
4. Manually demasking of uncoated patches
5. Demasking of coated patches with special laser
6. Optical inspection of parylene layer
7. Documentation of process parameter
Parylene coating
Removal of parylene

- Manually protection with special protective masks
- Manually removal of protective mask after parylene coating
- Demasking of coated patches with special laser
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Parylene coating
Characteristics

- Hydrophobe (water repellent) surface
- Chemically resistant with barrier impact against organic and in-organic substances (acids, solutions, gases, water steams)
- Electrically isolating, high proof voltage (5 kV at 25 µm Parylene „C“)
- Bio-compatible und bio-stable coating
- Prevents whisker formation
- Thin, transparent, pinhole-free layer starting from 0,2 µm
- Very good gap penetration and edge covering capability (up to 99% of layer thickness) for complex substrates
- Excellent protection against corrosion
- Homogene layer formation
- No gassing of solutions or plasticizers
- Friction proof 92 A Shore
- MIL specification MIL-I-46058C
- FDA approval (official food control through medical products agency of USA)
Parylene coating
Types of parylene

- **C** very good electrical and physical characteristics, high impact as barrier < 100°C
- **N** high dielectric and strongest coating penetration < 70°C, very good fissility (Spaltgängigkeit)
- **D** high barrier impact (swelling behaviour) and temperature protection < 150°C
- **F** good electric characteristics und temperature protection > 200°C, good gap penetration capability, minor coefficient of friction
- **AF** high UV-resistance, good electrical characteristics > 350°C, high barrier impact, very good fissility, minor coefficient of friction
- **HT** Brand name of Special Coating Systems

- USP CLASS VI ISO-10993-6
- FDA: MAF 1176
- MIL Specifications: MIL-I-46058C
What characterizes parylene coating?

The cross-cut test is a very rapid and simple method to assess the adhesion of coating systems.

- Using a 25mm wide semitransparent pressure sensitive tape with an adhesive strength of 43 ± 6 g/mm²
- The grating pattern consists of a 10x10 grid of squares of 1mm²
- The center of the strip is placed over the grid pattern and smoothed by a finger
- Within 90 seconds after application of the tape, this is stripped off with a smooth motion at an angle of 180°
- The evaluation of the examination is carried out visually with the naked eye, by comparing with Table 1

<table>
<thead>
<tr>
<th>Description</th>
<th>Surface</th>
<th>Grading ISO</th>
</tr>
</thead>
<tbody>
<tr>
<td>The edges of the cuts are completely smooth, none of the squares of the lattice is detached.</td>
<td></td>
<td>GT 0</td>
</tr>
<tr>
<td>At the intersections of the grid lines small fragments of the painting chipped off; chipped off surface about 5% of the sections.</td>
<td></td>
<td>GT 1</td>
</tr>
<tr>
<td>The painting chipped off along the edges of cut and/or at the intersections of the grid lines; chipped off surface about 15% of the sections.</td>
<td></td>
<td>GT 2</td>
</tr>
<tr>
<td>The painting chipped off along the edges of cut partly or in broad strips and/or the painting from individual sections totally or partly chipped off completely; chipped off surface about 35% of the sections.</td>
<td></td>
<td>GT 3</td>
</tr>
<tr>
<td>The painting chipped off along the edges of cut in broad strips and/or of individual sections totally or partly; chipped off surface about 65% of the sections.</td>
<td></td>
<td>GT 4</td>
</tr>
<tr>
<td>Each degree of flaking that cannot even be classified by classification 4.</td>
<td></td>
<td>GT 5</td>
</tr>
</tbody>
</table>
Qualifizierung der Parylene-Beschichtung
Schichtdickenmessung innerhalb der Vakuumb Kammer

Vakuumb Kammer
Messplättchen
Rondell
What characterizes parylene coating?

Qualification of the parylene coating certifications
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Parylene coating

Applications

- Electronic industry, especially printed circuit boards
- Aerospace industry
- Plastic and metal industry
- Medical engineering like cardiac catheter and stents
- Automotive
- Railway engineering
- Mining industry
- Protection of documents
- Dissection of insects

All vacuum apt materials are suited for coating

- rubber
- glass
- metal
- ceramic
- plastic
- silicone
What is the field of parylene coating?

Parylene coating
Example of application (1)

PCBs

HIMA Paul Hildebrandt GmbH + Co KG

HIMA Paul Hildebrandt GmbH + Co KG

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What is the field of parylene coating?

Parylene coating
Example of application (2)

Electronic manufacturing for UAVs (Unmanned air vehicle)
Parylene coating
Example of application (3)

Electronic manufacturing for UAVs (Unmanned air vehicle)
What is the field of parylene coating?

Parylene coating
Example of application (4)

3-D MID Demonstrators
(Molded Interconnect Device)

Forschungsvereinigung Räumliche Elektronische Baugruppen 3-D MID e.V.
FAPS – Lehrstuhl für Fertigungsausautomatisierung und Produktionssystematik
Parylene coating
Example of application(5)

3-D MID Demonstrator
(Molded Interconnect Device)

Metal surface in form of a „light bulb“ with traces out of powder coating
LPKF
Parylene coating
Example of application (6)

Butterflies and beetles
Parylene coating
Example of application (7)

test documents

uncoated

coated with Parylene F
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Parylene coating

Charges

• Parylene process takes place in dimensional limited vacuum chamber

• Number of patches to remain uncoated determines the price

• Price of parylene powder in use (N,C,D,F,AF) determines the price

• Parylene process usually is more expensive than varnishing

• Parylene process usually is cheaper than moulding
Thanks for your attention

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