Packaging and fabrication opportunities enabled by the room temperature deposition of Parylene

Marco Haubold, Franz Selbmann, Dr. Mario Baum

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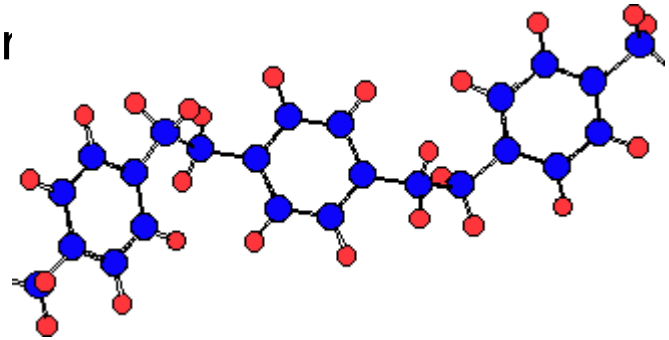
Packaging and fabrication opportunities enabled by the room temperature deposition of Parylene

- Information on Parylene
- The Parylene deposition process @ FhG ENAS
- Applications for micro- and macro syster

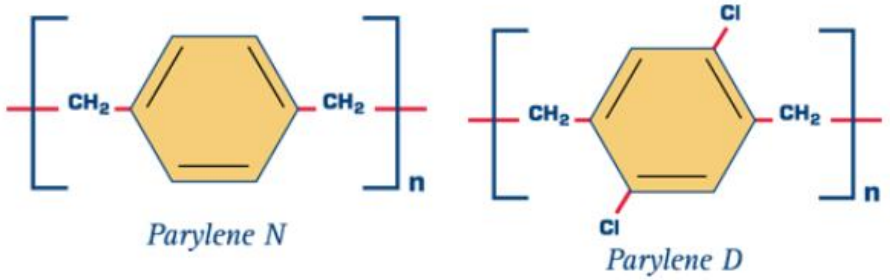


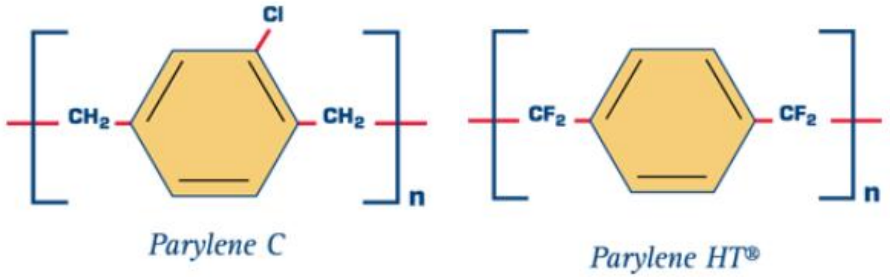
1. Parylene

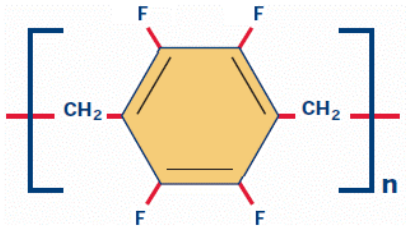
General Information

- Transparent polymer
- Electrical insulating (225 V/µm)
- Chemically stable
- Biologically compatible
  (FDA class VI, ISO 10993-1 cytotoxicity)
- Thermally stabile (400 °C)
- Environmentally safe – no by products

Poly(p-xylylene)







Parylene F

Source:
http://scscoatings.com/de/what_is_parylene/parylene_properties.aspx

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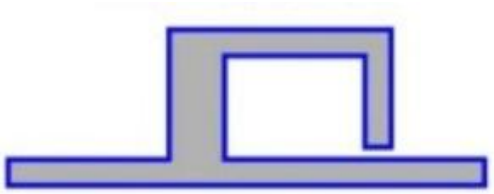
1. Parylene

General Information



Why is it attractive?

- Allows the fabrication of conformal coatings @ **Room Temperature**
- Low friction coefficient (0,14 .. 0,33)
- Excellent moisture barrier with dielectric properties

Table 3. Parylene Barrier Properties

Polymer	Gas Permeability at 25°C, (cc·mm)/(m²·day·atm)[a] N_2	O_2	CO_2	H_2	Water Vapor Transmission Rate (g·mm)/(m²·day)
Parylene N	3.0	15.4	84.3	212.6	0.59[b]
Parylene C	0.4	2.8	3.0	43.3	0.08[c]
Parylene D	1.8	12.6	5.1	94.5	0.09[b]
Parylene HT	4.8	23.5	95.4	–	0.22[d]
Acrylic (AR)	–	–	–	–	13.9[e]
Epoxy (ER)	1.6	2.0 – 3.9	3.1	43.3	0.94[e]
Polyurethane (UR)	31.5	78.7	1,181	–	0.93 – 3.4[e]
Silicone (SR)	–	19,685	118,110	17,717	1.7 – 47.5[e]

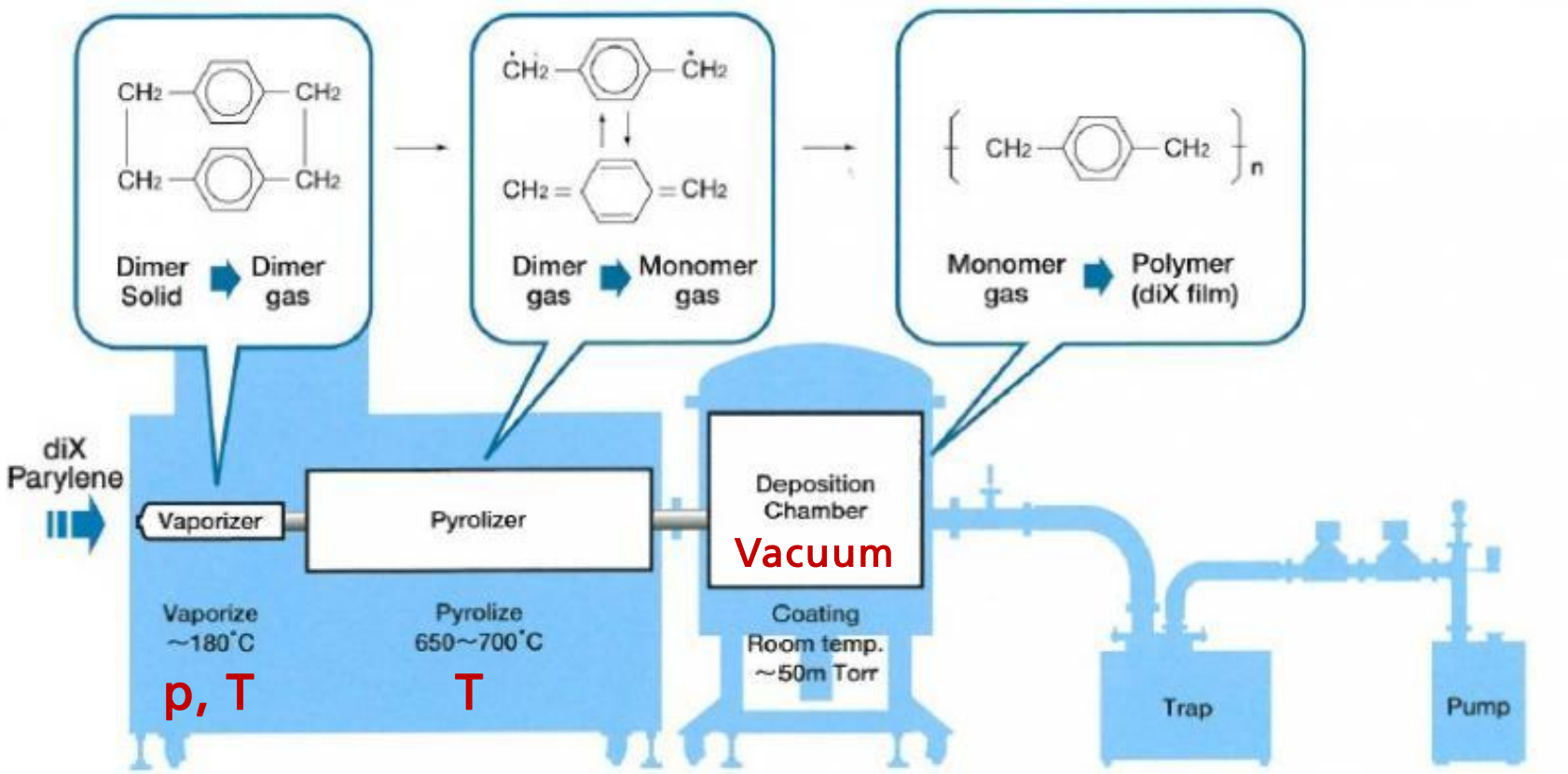
[a]ASTM D 1434
[b]ASTM E 96 (at 90% RH, 37°C)
[c]ASTM F 1249 (at 90% RH, 37°C)
[d]ASTM F 1249 (at 100% RH, 38°C)
[e]*Coating Materials for Electronic Applications*, Licari, J.J., Noyes Publications, New Jersey, 2003.

Source:
http://scscoatings.com

2. The Parylene deposition process

The Gorham process

Published by William F. Gorham in 1966



Source: http://www.kiscoparylene.com/news/2012/06/14/static-and-dynamic-conformal-coating

2. The Parylene deposition process

Vertical integrated tool in clean room environment

- Clean room class ISO 4
- Chamber dimensions:
  - Ø 350 mm
  - Height 350 mm
  - Rotary table
- Deposition rate:
  - 5 nm / min .. 300 nm / min
- Plasma conditioning
  - 850 W; 2,45 GHz
  - Ar; N_2/H_2; CF_4
- Additional treatment - Silanization
  - Silane A-174

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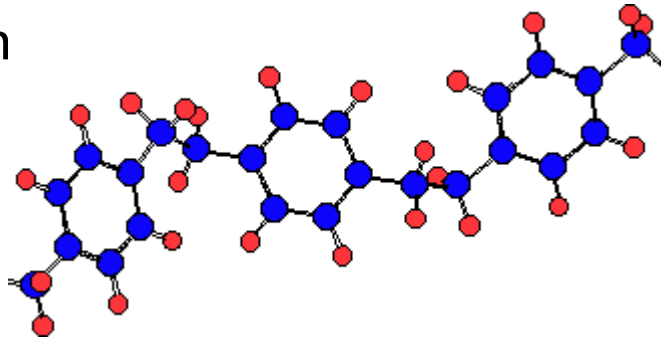
- Applications for micro- and macro system



3. Applications for micro- and macro systems

In general

- **Electronics** (dielectric coatings, inductors, magnets, encapsulation of organic electronics, passivation of µ-bumps, bond wires)
- **Medical** (biocompatible encapsulation, protection during sterilization)
- **Automotive** (protective coatings for electronics)
- **MEMS** (functional material with desired properties)
- **Barrier layers** (e.g. filter, membranes, valves)
- **Friction minimization & corrosion**
- **Bonding** (on wafer level < 230 °C)

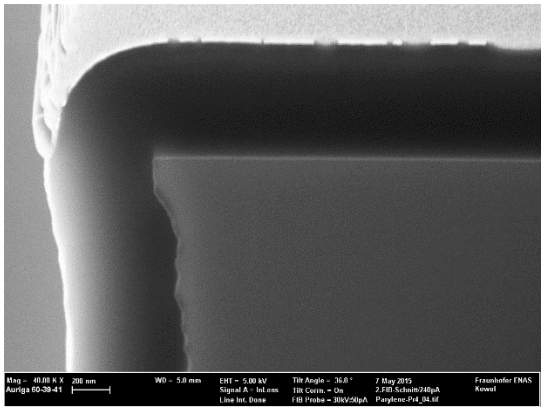


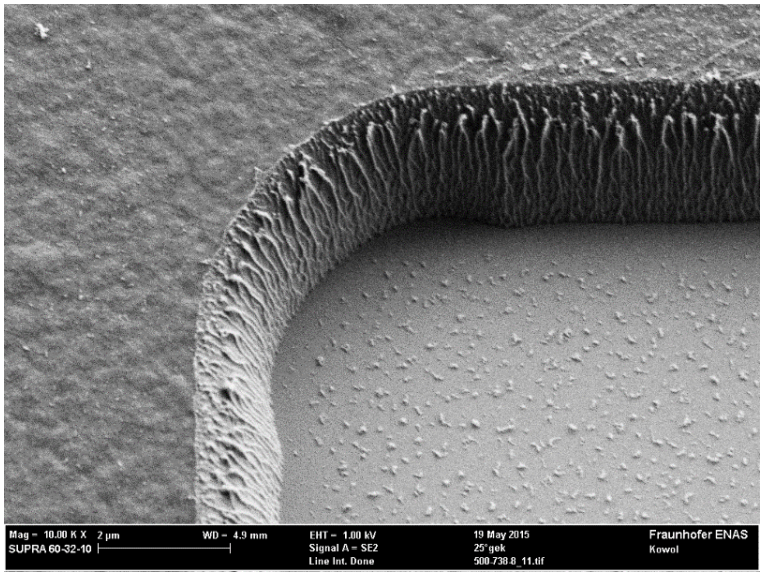


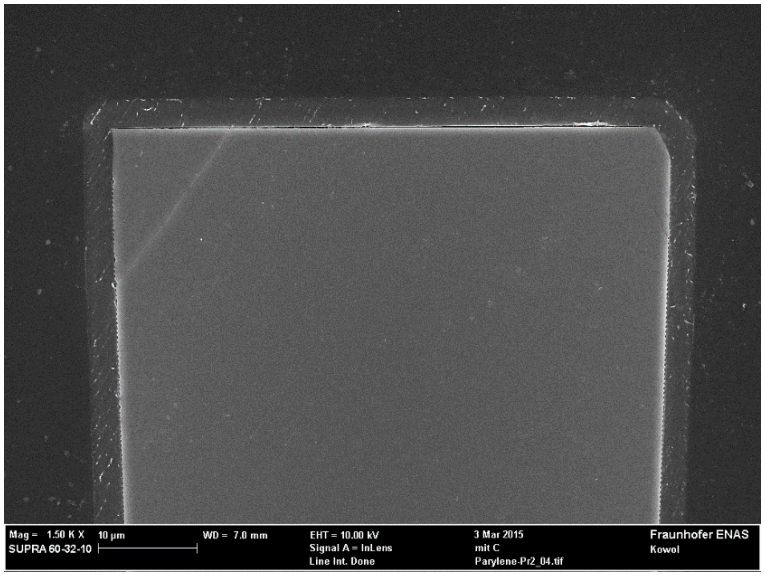

3. Applications for micro- and macro systems

Wafer level

- Fabrication of form elements on wafer level
  - Patterning by O_2 plasma
- Conformal coating of silicon features

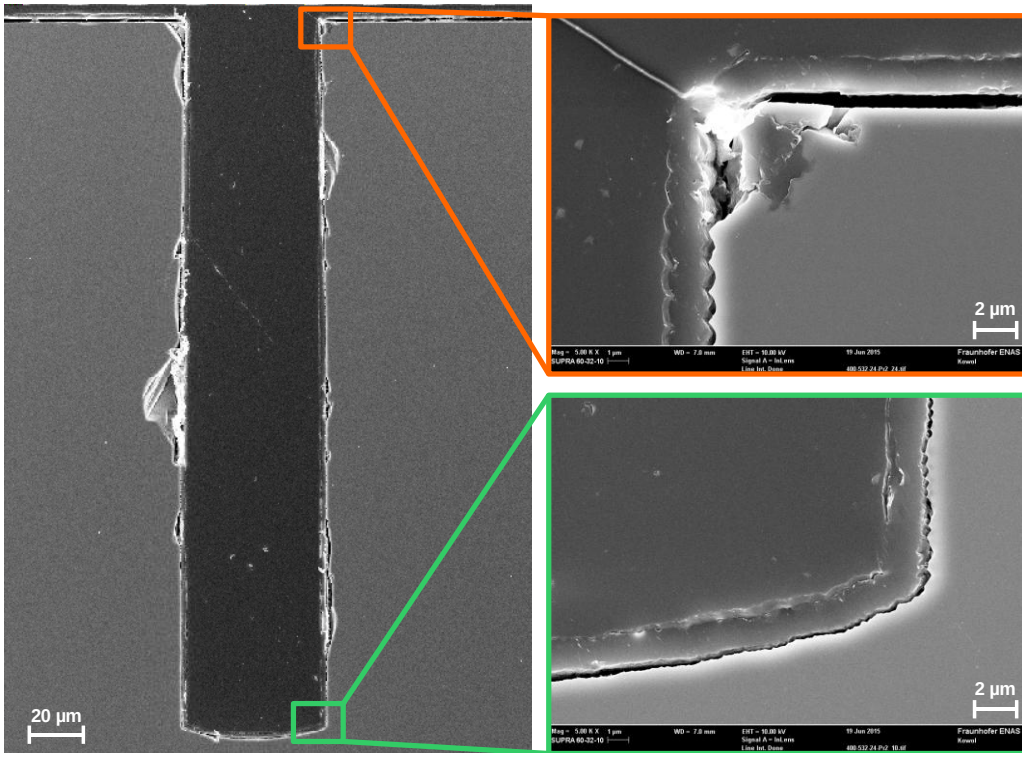






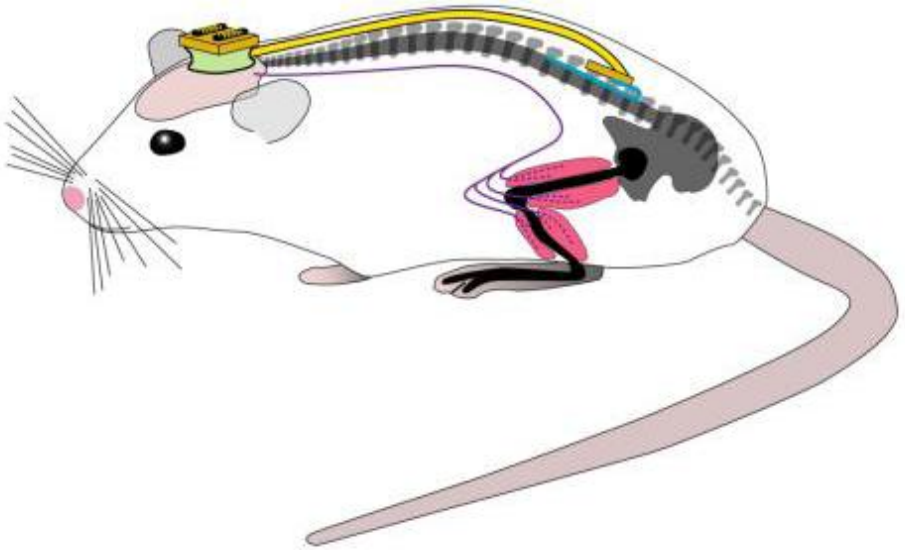
3. Applications for micro- and macro systems
Wafer level

- Through Silicon Vias for vertical integration – formation of LT insulation
  - Ø 50 µm; depth 230 µm (ongoing work)



3. Applications for micro- and macro systems

Parylene based micro arrays



"Microelectrode Implants for Spinal Cord Stimulation in Rats"

Mandheerej Singh Nandra, 2014

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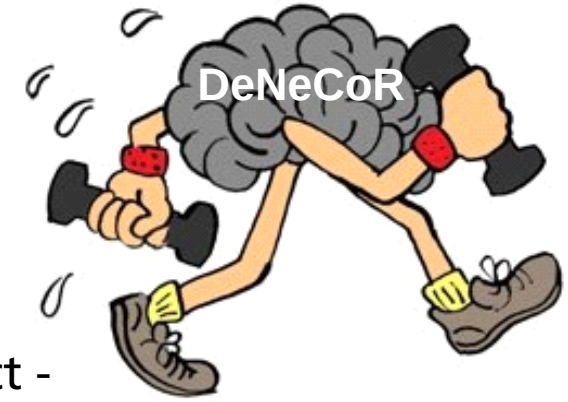
3. Applications for micro- and macro systems

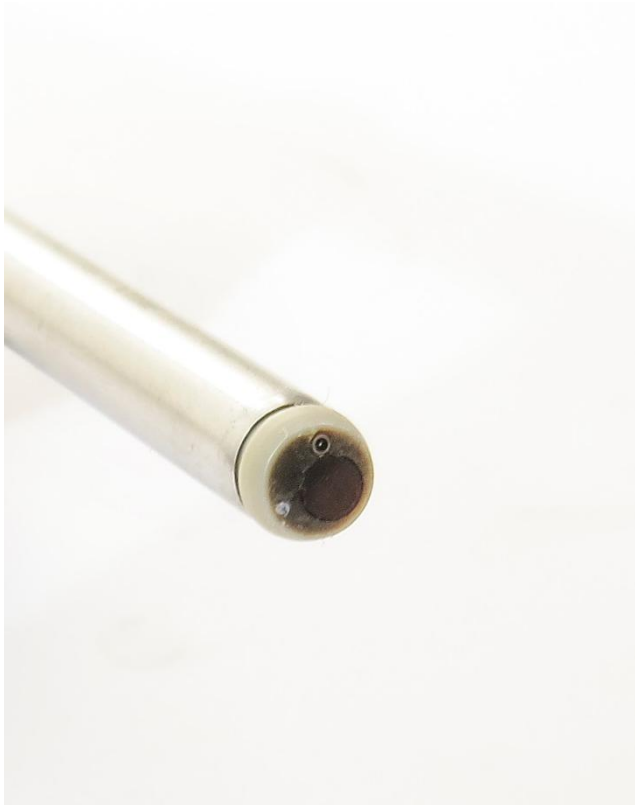
Parylene as encapsulation of medical devices

- Final coating of components
- Coating of optical and acoustical components
- Protective layer during sterilization



- EU project -
- DeNeCor -
- 3 years -

eniac JOINT UNDERTAKING



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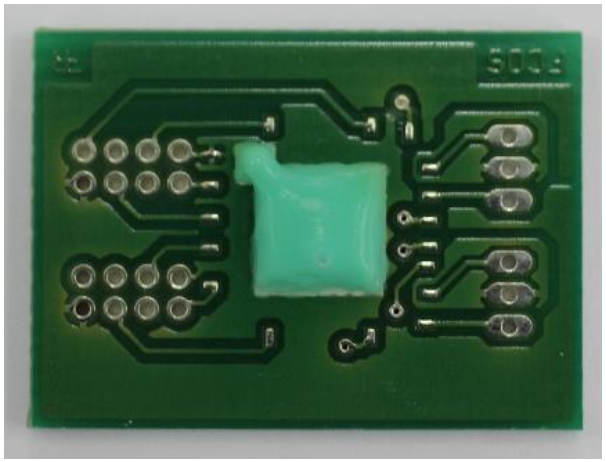
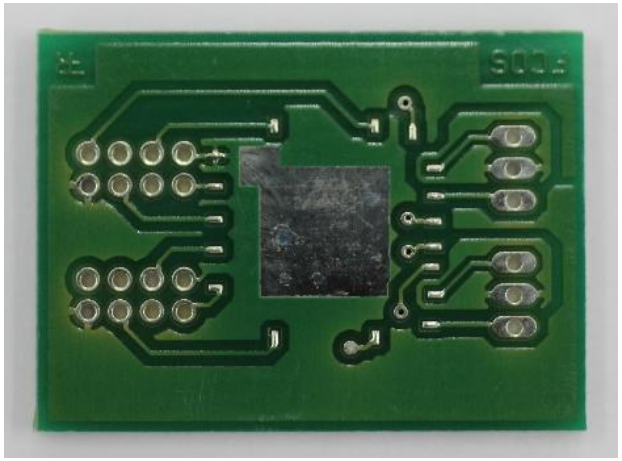
3. Applications for micro- and macro systems

Board level

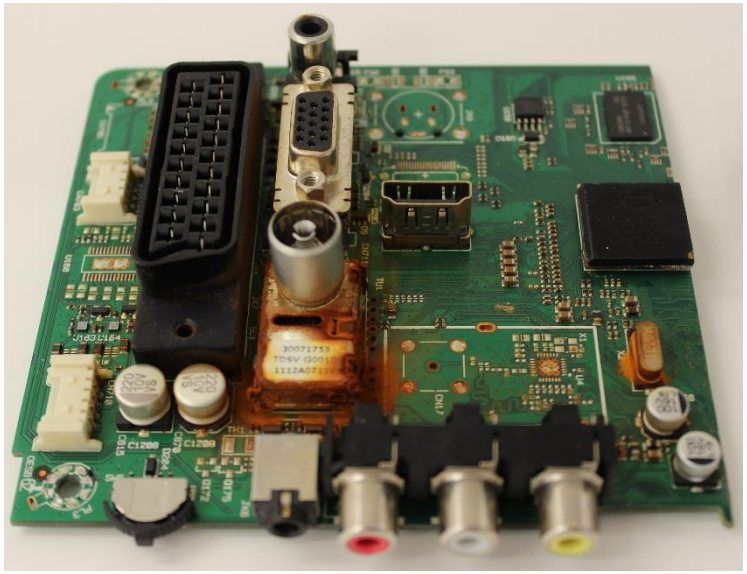
- Double isolation – very well defined
- Corrosion resistance



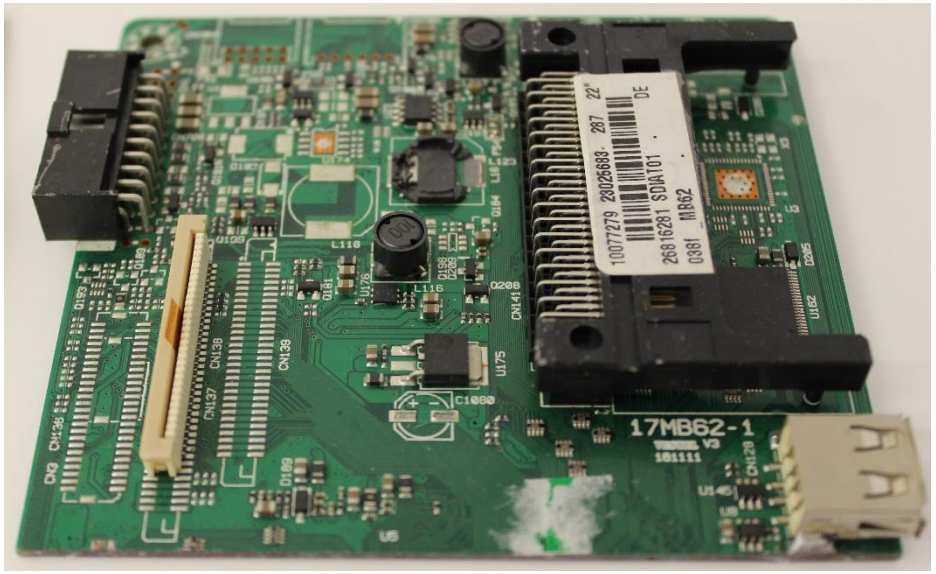


3. Applications for micro- and macro systems
Board level

- Storage in salt solution 50 g / l for 1 week



Without Parylene coating



With Parylene coating - 5 µm

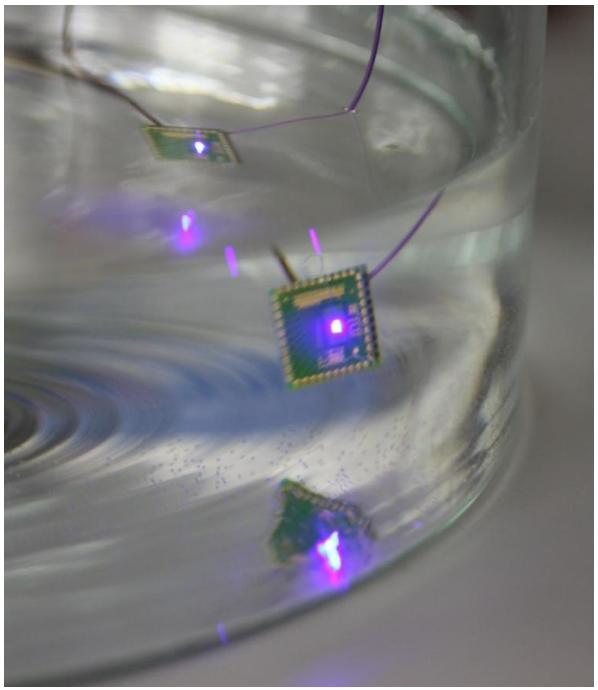
Conclusion

- Parylene is a very versatile material with unique properties that can specifically be designed by choice of dimer and process conditions

- Applicable to micro and macro structures on various substrates

- Infinite opportunities by deposition @ RT

- Challenge us! ☺



Thank you!

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