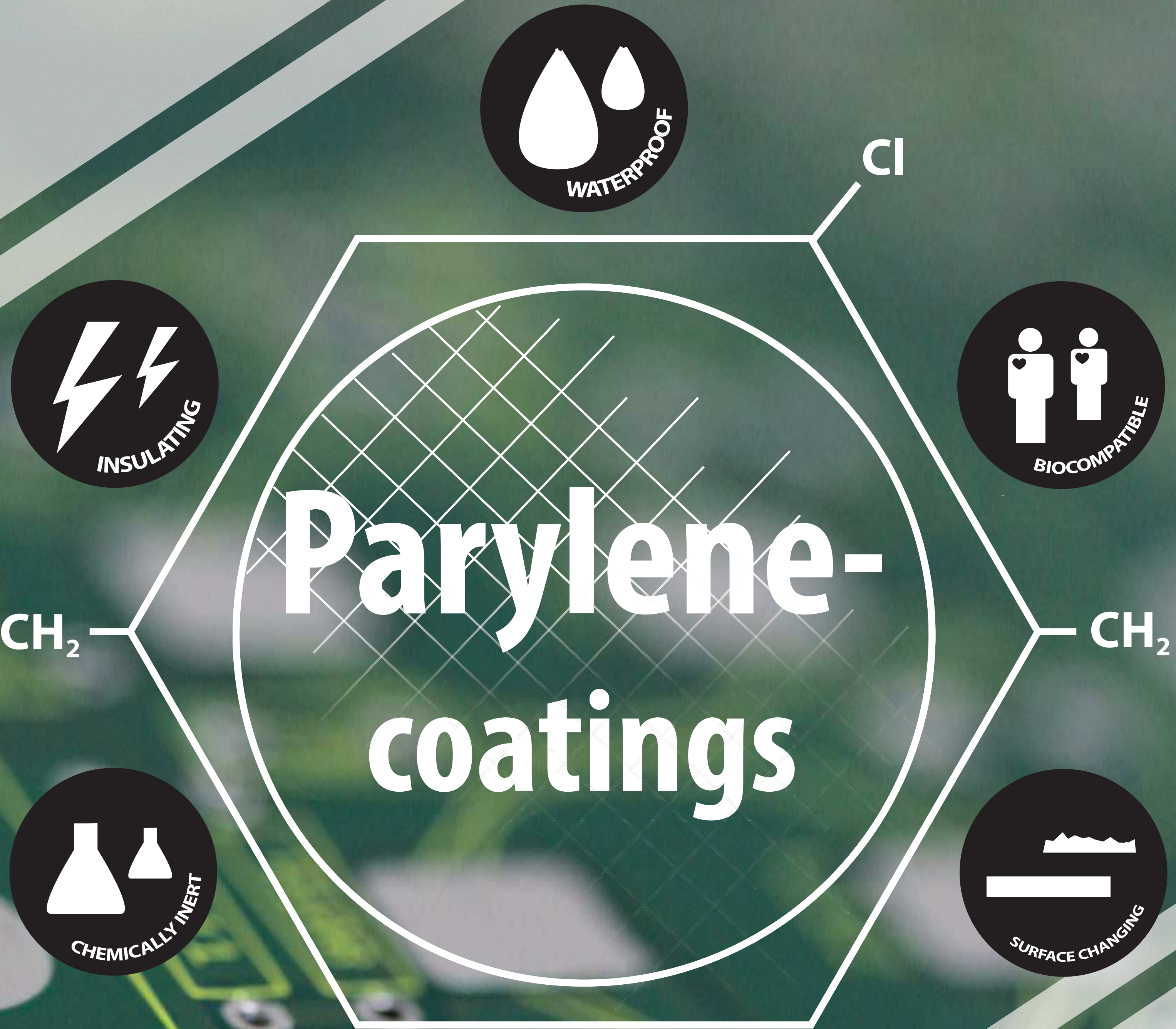
Parylene-coatings



electronic diener

Plasma-Surface-Technology

Raw material - Dimer powder

Parylene peeled-off from a mirror

What are parylene coatings:
Parylene is the abbreviation for the polymer group named poly (**par**a-xyl**ylene**). These polymers consist of differently substituted para-xylylenes. The initial state for the coating is given by the so-called **dimers.** A dimer is a molecule composite which consists of two identical subunits, namely the monomers.

Advantages and properties:
Parylene coatings offer a wide range of benefits. Parylene coatings …

- are perfectly **conformal:** that means that the coating is adapting also on complex substrate contours such as sharp edges or holes.
- are **„pinhole-free“**, starting at layer thicknesses of about 0.5 microns.
- are **chemically insoluble** and **resistant** to a wide range of chemicals.
- exhibit **very good barrier properties** to moisture and chemicals.
- own a **high dielectric strength.**
- possess dry lubricating film properties (low friction coefficient).
- are **hydrophobic** - contact angle of H2O between 92 ° and 98 °.
- are **transparent** between 90 and 96 % in the range of the visible wavelength (depending on the type of parylene).
- are **biocompatible** - The parylene types C and N can be certified according to USP Class VI, ISO 10993 and FDA.

Parylene Types:
Parylene N

- Basic type - consisting only of atoms of hydrogen and carbon and is therefore halogen-free
- Very good crack penetration.
- Very good dielectric properties and dielectric strength (low dielectric constant)
- Lowest friction coefficient*, often used for equipment of minimal invasive surgery
- FDA approval
- Long-term temperature resistance**: 60 ° C

Parylene C:

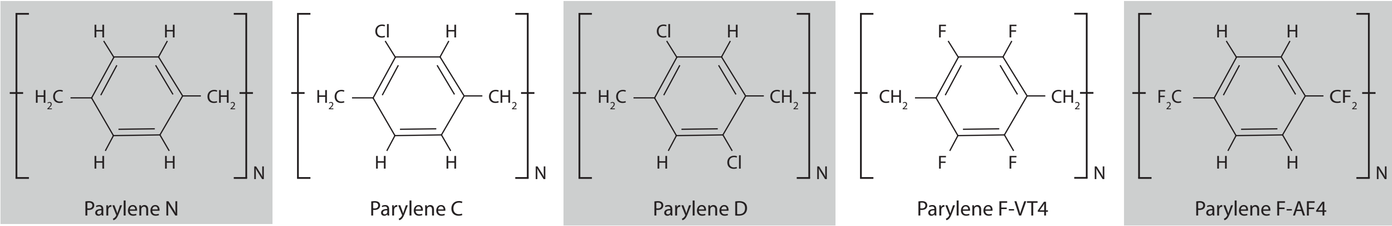
- One chlorine atom on the aromatic ring
- Most common parylene type.
- Lowest permeability of humidity (H2O) and other gases and thus excellent barrier properties and good corrosion protection.
- Relatively high deposition rate, thus the most economical deposition process.
- Good mechanical properties
- FDA approval
- Long-term temperature resistance**: 80 ° C

Parylene D

- Two chlorine atoms on the aromatic ring
- Good mechanical properties
- Low permeability of humidity (H2O) and other gases
- Highest temperature resistance of chlorinated types
- Long-term temperature resistance**: 100 ° C

Parylene F-VT4:

- Four fluorine atoms on the aromatic ring
- Since thermally even higher loads than Parylene D, it displaces this increasingly



Monomer units of the most common parylene types

- Good dielectric properties
- Good crack penetration
- Long-term temperature resistance**: 200 °C
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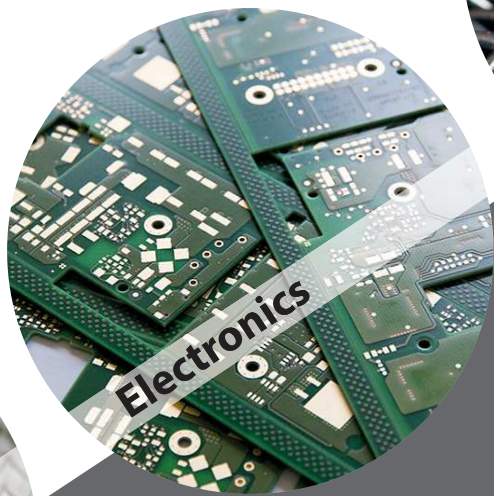
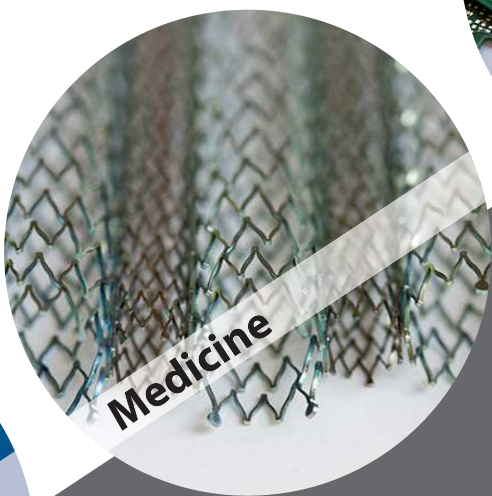
Parylene F-AF4:
- Four fluorine atoms on the aliphatic groups
- Best crack penetration.
- By far the highest temperature resistance of all Parylene types - up to 350 °C long-term temperature stable**.
- Resistant to UV radiation
- Very low coefficient of friction*
- FDA approval
- Excellent dielectric properties and dielectric strength (low dielectric constant)
- The most expensive version, therefore only used when these special properties are necessarily required.

* On steel without lubrication

** 11,4 years





Applications:

Electronics
- PCBs
- All kinds of sensors
- Semiconductor devices
- Ferrite cores
- Permanent magnets - rare earth magnets

Medical Devices
- Cannulas, catheters
- Biopsy needles
- Probes and endoscopes
- Ampoules / bags
- Hearing Aids
- Implants, corona stents

Aerospace
- Navigation Electronics / flight control systems
- Cockpit instrumentation
- Communication Technology
- Satellite Electronics / imaging equipment
- Radar / detectors

Automotive
- Pressure Sensors / Flow Sensors / Emission Sensors
- Engine electronics / control unit
- Rotors / stators / motors
- Monitoring and control systems
- Battery / Cell Systems
- Radar / detectors

LEDs
- Electronic billboards
- Aviation / Automotive Lighting
- Outdoor lighting
- Traffic lights

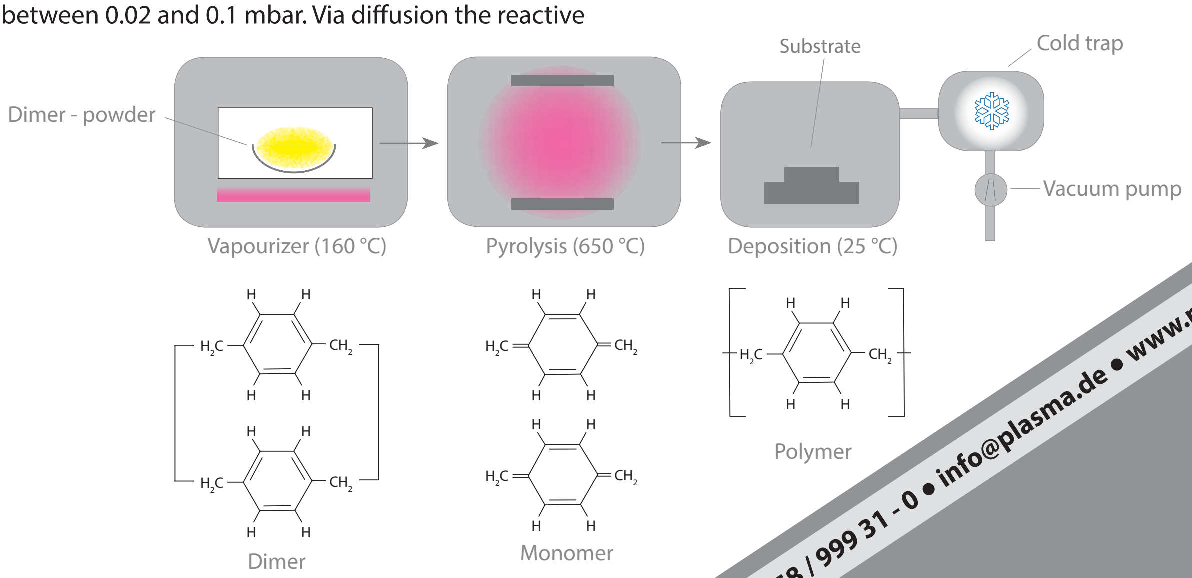
Industrie
- Seals
- O-rings
- Pipes
- Bottles / containers

		Parylene N	Parylene C	Parylene D	Parylene F-VT4	Parylene F-AF4
Property	Unit	Poly(para-xylylene)	Poly(monochloro-para-xylylene)	Poly(dichloro-para-xylylene)	Poly(tetrafluoro-para-xylylene) F-VT4: Substitution of 4 H atoms by 4 F atoms on the benzoe ring	Poly(tetrafluoro-para-xylylene) F-AF4: Substitution of 4 H atoms by 4 F atoms on the aliphatic groups
Density	[g/cm³]	1,11	1,29	1,42	~1,6	~1,51
Refractive index	[ ]	1,66	1,64	1,67	1,57	1,56
Tensile Modulus	[GPa]	2,4	3,2	2,8	3,0	2,6
Yield Strength	[MPa]	42	55	60	52	35
Tensile Strength	[MPa]	45	70	75	55	52
Hardness, Rockwell R	[GPa]	85	80	80	-	122
Yield Elongation	[%]	2,5	2,9	3,0	2,5	2,0
Elongation to break	[%]	30	200	10	10-50	10
Static coefficient of friction	[ ]	0,25	0,29	0,35	0,39	0,15
Dynamic coefficient of friction	[ ]	0,25	0,29	0,31	0,35	0,13
Durable Heat Resistance	[°C]	60	80	100	200	350
Temporary peak temperature	[°C]	95	115	135	250	450
Melting point	[°C]	420	290	380	-	≤ 500
Dielectric constant (1 MHz)	[ ]	2,66	2,95	2,80	2,35	2,17
Dissipation Factor (1 MHz)	[ ]	0,001	0,013	0,002	0,008	0.002
Dielctric strength	[MV/cm]	300	185-220	215	-	225
Volume resistivity	[23 °C, 50 %RH, Ω·cm]	1,4E+17	8,8E+16	2,0E+16	1,1E+17	2,0E+17
Surface resistivity	[23 °C, 50 %RH, Ω]	1,0E+13	1,0E+14	5,0E+16	4,7E+17	5,0E+15
Linear coeffcient of expansion	[µm/m·°C]	69	35	38	-	36
Heat cpacity	[25 °C, J/(g·K)]	1,3	1,0	0,8	-	1,0
Thermal conductivity	[W/m-K]	0,13	0,08	-	-	0,10

[1] W.Beach, C. Lee, and D. Bassett, Encyclopedia of Polymer Science and Engineering (Wiley, New York, 1985), 17, 990
[2] J.B. Fortin, Poly-para-xylylene Thin Films: A Study of the Deposition Chemistry, Kinetics, Film Properties, and Film Stability, Ph.D. Thesis, rensselaer Polytechnic Institute, 2001
[3] F.E. Cariou, D.J. Vally, and W.E. Loeb, IEEE Transactions on Biomedical Engineering 33(2), 202 (1992).
[4] Structural and dielectric properties of parylene-VT4 thin films Article (PDF Available) in Materials Chemistry and Physics 143(3):908–914 · February 2014 with 71 Reads
[5] Angaben aus www.matweb.com Material Property Data

Process description:

The deposition takes place by **polymerization** through a vacuum assisted coating process, the so-called **chemical vapor deposition – CVD.** The **"dimer"** (solid [2,2]-p-cyclophane), which is present in a powder-like shape, will be **sublimated** within the the **vapourizer.** The **thermal decomposition** of the relatively inert „dimer-gas" is carried out using a **pyrolysis tube** with temperatures of about 650 °C, resulting in the formation of highly reactive monomers. The process pressure is dependent on the used dimer-type and the dimensions/construction of the deposition system - common values are between 0.02 and 0.1 mbar. Via diffusion the reactive monomers enter into the vacuum chamber in which the coating material is placed on a rotating frame. The **reactive monomers** preferably **polymerize** on cold surfaces, and form a thin layer of poly(para-xylylene) or rather **Parylene.** Since not all of the monomers polymerize inside the chamber, it is necessary to work with a **cold trap** which is installed behind the chamber to avoid a coating/damage of the vacuum pump. During the process, the trap can be easily filled with **liquid nitrogen,** so that the residual monomers will polymerize in the cold trap.



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