Veranstaltungsreihe /

researchXchange: Parylene-based encapsulation technology for wearable or implantable electronic devices

09. Dezember 2022

www.coat-x.com

THE COMPANY

LEADER IN THIN FILM ENCAPSULATION

Solution provider

- Founded in 2016
- Headquarters @ Microcity La Chaux-de-Fonds, Switzerland

- Financed by two private investors, one strategic investor and 4 founders

- 15 (Switzerland) engineers and technicians
- 2 sales representatives for USA and Northern Europe

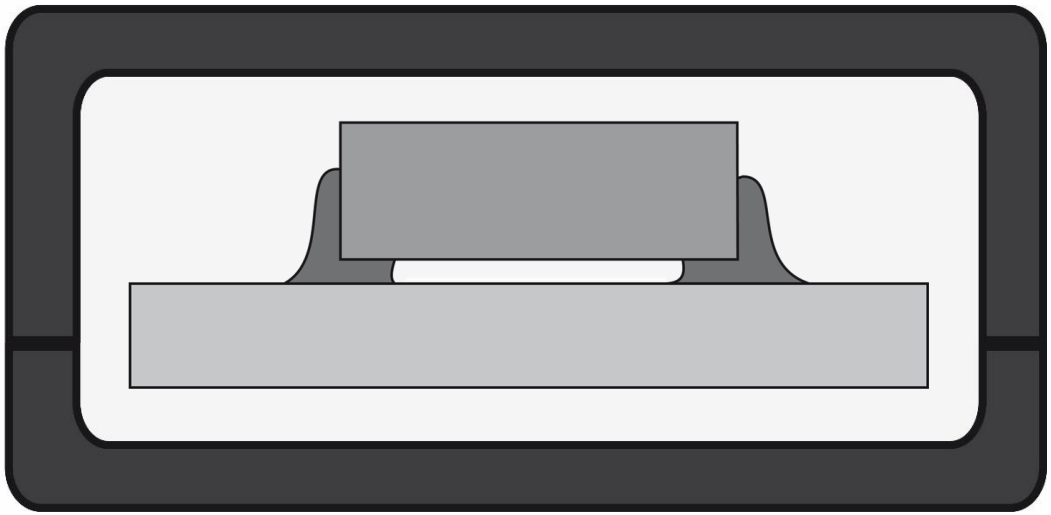
- COAT-X Japan has been founded in 2021
- Headquarters in Shinshiro
- 3 engineers and 2 sales persons

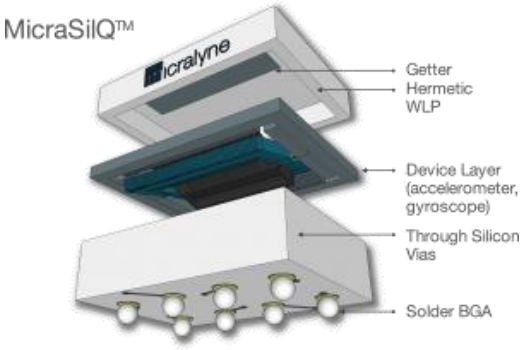
AN INTERNATIONAL FOOTPRINT

THE PROBLEM…

Packaging challenge for electronic or medical devices:

- Limitation in miniaturization
- Complex welding process
- Rigid and non-flexible
- Cost intensive



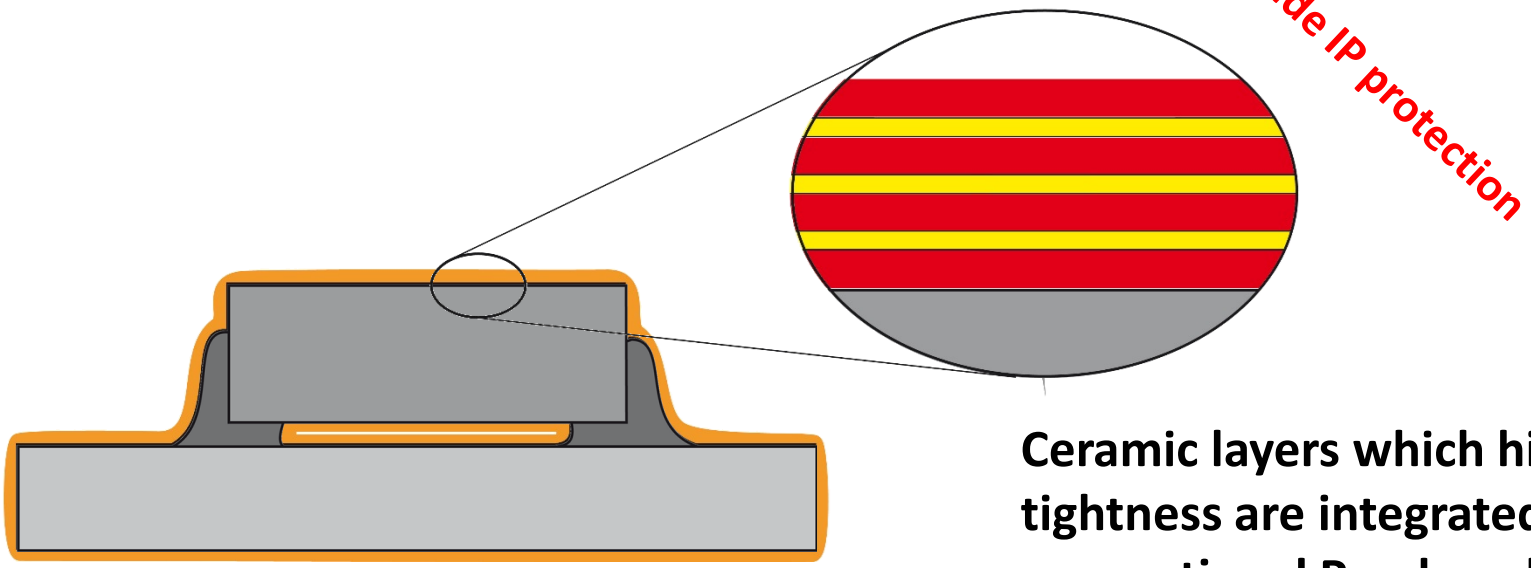


…THE SOLUTION

Conformal multilayer packaging:

- Allows significant miniaturization
- Controlled deposition at room temperature
- Transparent / flexible
- Reduced costs
- 2’000 times more waterproof than Parylene!

Worldwide IP protection



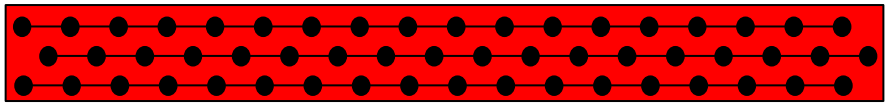
Ceramic layers which high tightness are integrated into conventional Parylene layers.

ULTRA TIGHT THIN FILM TECHNOLOGY

Parylene coatings

by CVD are defect-free and conformal.

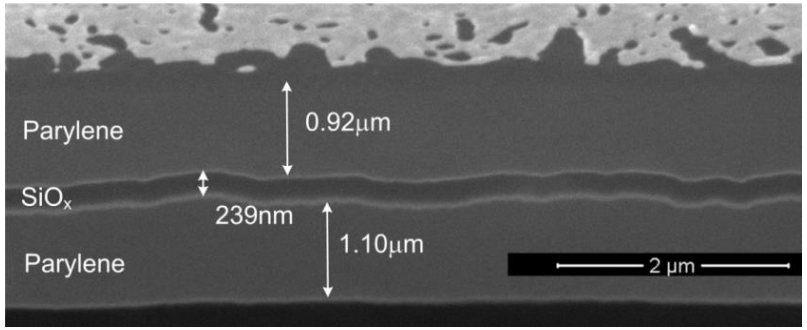
But, they are not absolutely tight at molecular level.



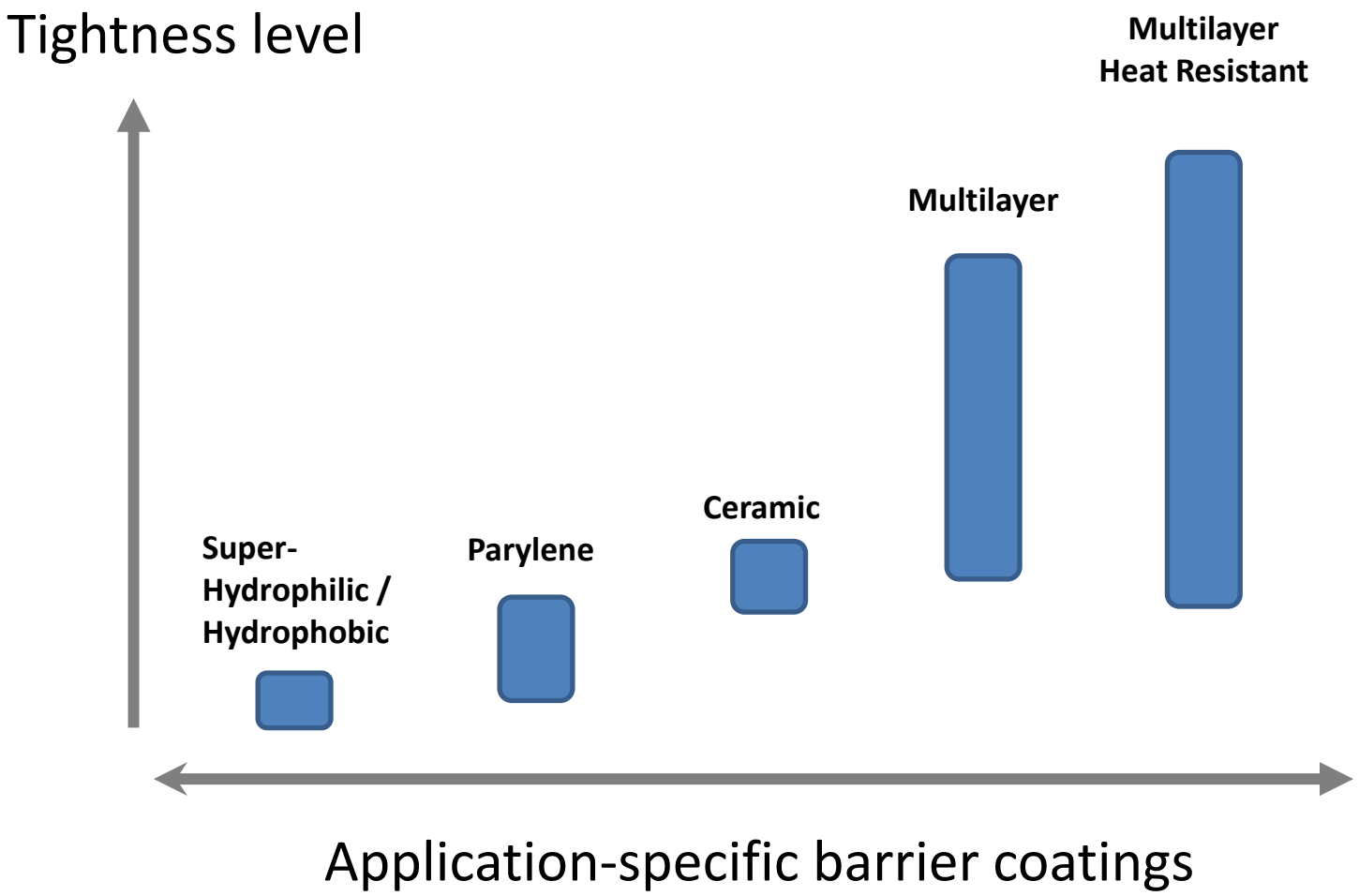
Ceramic coating

by CVD have pinholes and cracks due to high internal stress.

But, they are tight at molecular level.



OUR COATING PORTFOLIO



COAT-X SERVICES AND PRODUCTS

1 Coating Services
(PE-CVD, CVD, ALD)

- Parylene-C, Parylene-F, Parylene-N
- Ceramic coatings (SiO_2, SiC, SiO_xN_y, Al_2O_3, TiO_2)
- Multilayered combinations
- Masking/demasking
- ISO 13485, ROHS, REACH compliance

2 Solution Development Verification

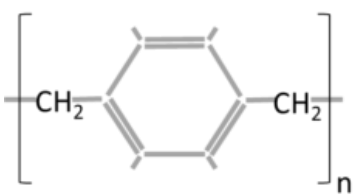
- Hermeticity measurements
- Adhesion tests
- Corrosion tests
- Accelerated aging tests
- Network of experts for test outsourcing*

3 Technology Transfer

- Tailored reactor design
- Tech licensing
- Reactor renting & servicing
- Co-development and research partnership

(* MEB, XPS, WVTR, aging, …)

PARYLENE GRADES



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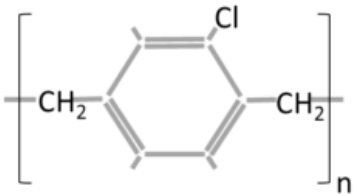
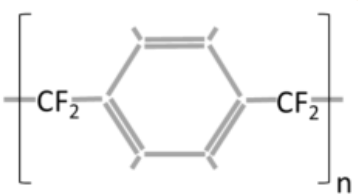


C

VT-4



AF-4

	Parylene XPC	Parylene XPN	Parylene XPD	Parylene XPF1	Parylene XPF2	SiO2 XCR	Multilayer ML3	Method ASTM
Density (g/cm^3)	1,29	1,10-1,12	1,42	1,3-1,5	1,65	2,17-2,65	-	D1505
Index of refraction (n_D^{23})	1,64	1,66	1,67	1,56	1,57	1,40-1,50	-	Abbe refractometry
Transmission visible range (%) (380-750nm)	>90	-	-	-	-	>85	>85	UV-Vis Spectrophotoscopy
Friction Coefficient Static	0,29	0,25	0,35	0,15	0,39	-	-	D1894
Friction Coefficient Dynamic	0,29	0,25	0,31	0,13	0,35	-	-	D1894
Temporary peak temp. (°C) (100.000 h)	80-100	60-80	100-120	350	140-200	1050	-	-
Durable heat Resistance (°C) (1.000 h)	115	95	130-135	450	250-350	-	-	-
Melting point (°C)	290	420	380	>500	435	-	-	DSC
Dielectric Constant (1 MHz)	2,95	2,66	2,8	2,17	2,35	-	-	D150
Breakdown voltage DC (V) 1um 10um 25um	 1100 3500 5800	 500 4000 7000	-	 - - -	 - - 5500	 - - -	 - - -	-
Hardness Rockwell (HR)	80	85	80	122	-	-	-	-
WVTR (g.mm)/(m2.day)	0,1	0,75	0,12	0,28	0,32	-	6,00E-04	F1249-06

TRANSPARENT CERAMIC COATING

Thin and transparent ceramic coating by PE-CVD to protect noble metals, stainless steel and alloys.

Multilayer vs. Single layer

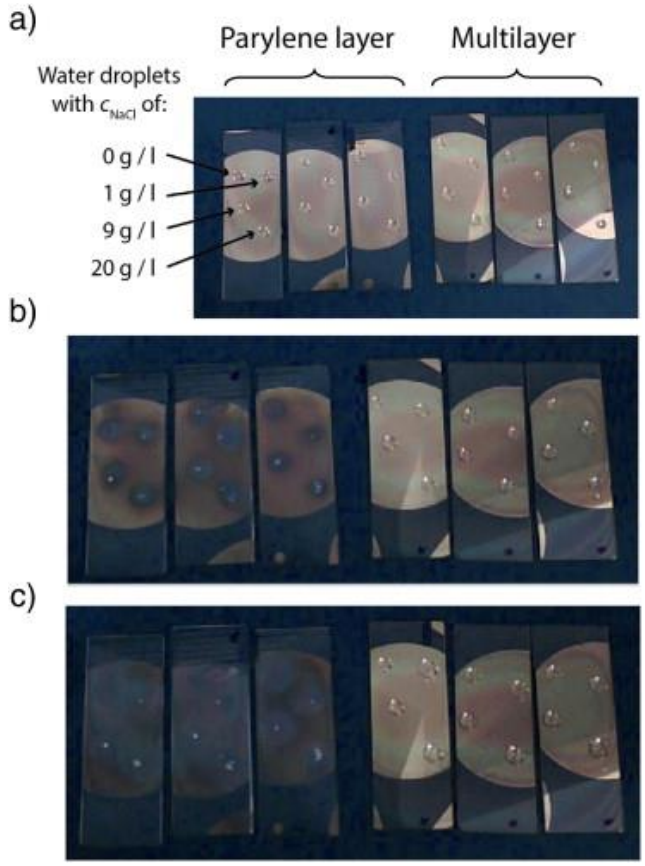
Water permeation measurements (WVTR) according ASTM F 1249

Materials	**WVTR** [g um m^{-2} day^{-1}]
Silicone	25000
Acrylic	14000
Polyurethane	1500
Epoxy	950
Parylene N	590
PET	500
Parylene C	80
SiO_2 (PE-CVD)	15
Al_2O_3/TiO_2 (ALD)	8
Multilayer (PE-CVD)	0.04
Multilayer (ALD)	**0.003**

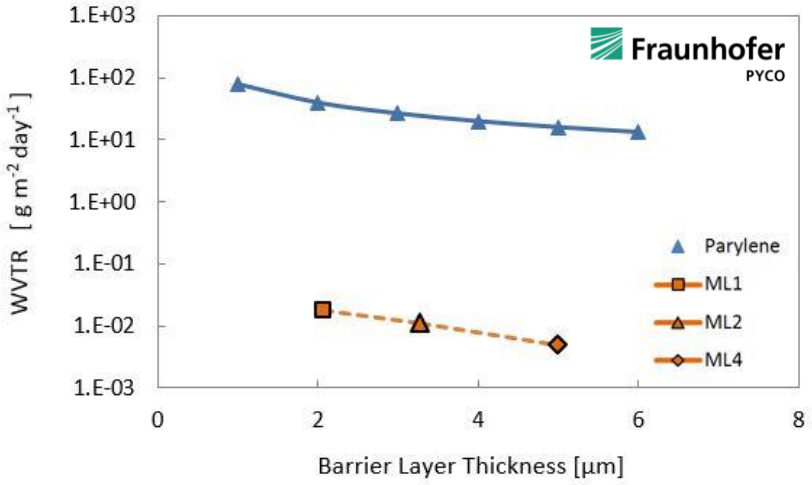
→ **A 2 µm Multilayer has the same protection performance than an epoxy layer of 10 cm and a silicone layer of 300 cm.**

Multilayer vs. Single layer

Water permeation measurements according ASTM F 1249



WVTR at 38°C and 90% RH



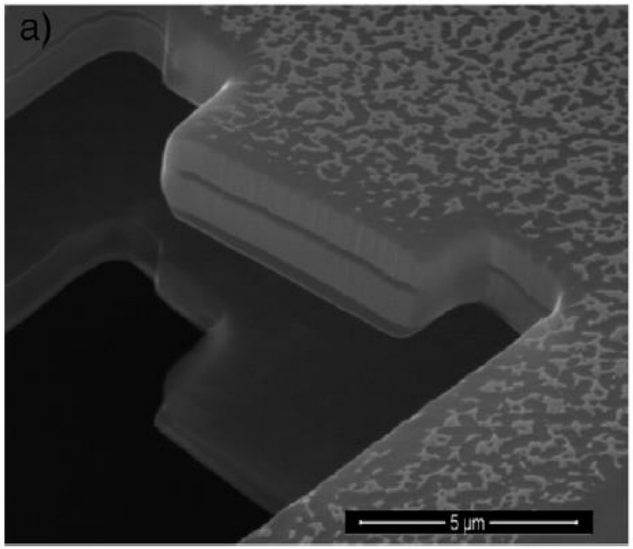
The Calcium mirror test shows a WVTR of $4 \cdot 10^{-3}$ g/m^2/day for a 5 µm multilayer at 38°C and 90% RH (ASTM F 1249).

Hogg et al., Surface and Coatings Technology, Volume 255, 2014, pp. 124 – 129, http://dx.doi.org/10.1016/j.surfcoat.2014.02.070

→ 2000 times better than conventional Parylene-C

Multilayer vs. Single layer

Multilayers of Parylene and ceramic provide much tighter encapsulation than single Parylene layer or allow thickness reduction and faster deposition to ensure similar thightness



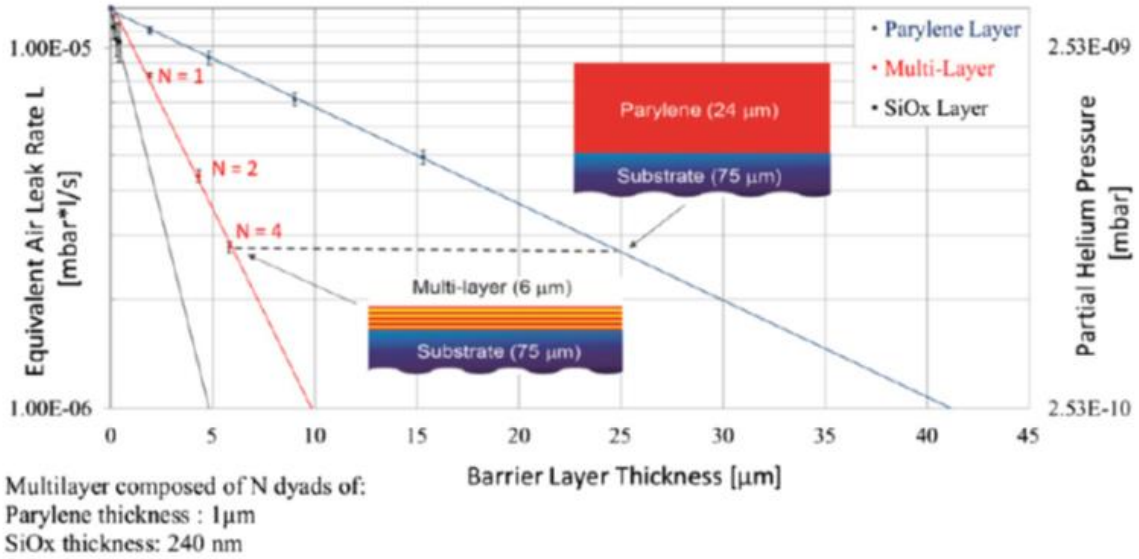
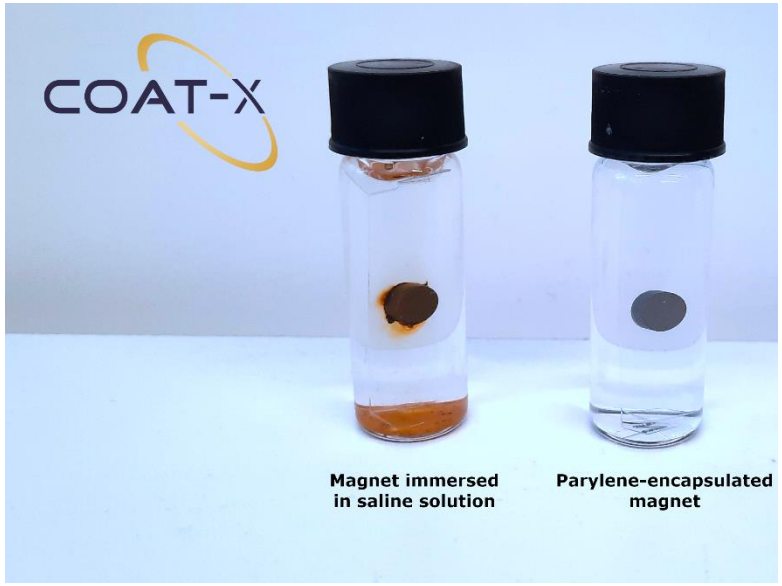


Figure 11. He-permeation results of SiO_x and Parylene thin films compared to multilayers composed of up to 5 Parylene (1 μm) and 4 SiO_x layers (240 nm). The multilayer of 6 μm thickness shows the same hermeticity for He-gas as a 24 μm Parylene thin film. A multilayer of 10 μm thickness would be able to fulfil the MIL-STD-883 standard acceptance criterion of the equivalent air leak rate $L = 1 \times 10^{-6}$ atm cm^2 s^{-1}.

CORROSION PREVENTION WITH MULTILAYER COATING

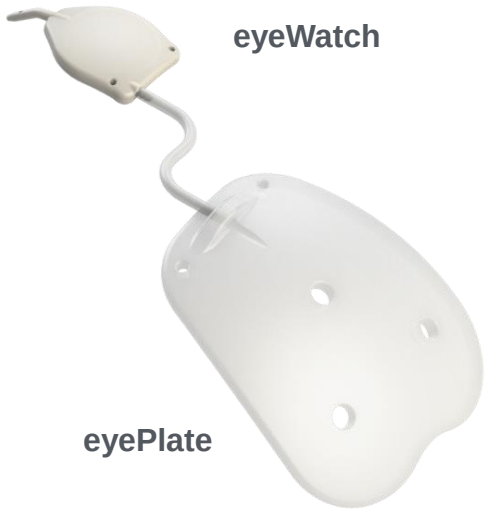
- Corrosion-sensitive permanent magnets are protected with the thin-film encapsulation technology of Coat-X
- Electrochemical dissolution of the metallic alloy is prevented
- Applied to surgical electro-motors, this allows resistance to hundreds of sterilization cycles



MEDICAL APPLICATION

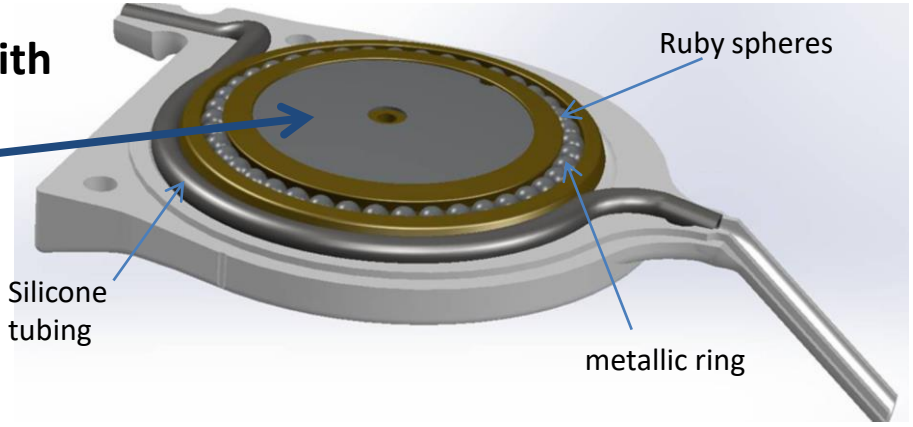
Protection of rare earth metals (for magnets)

The eyeWatch system



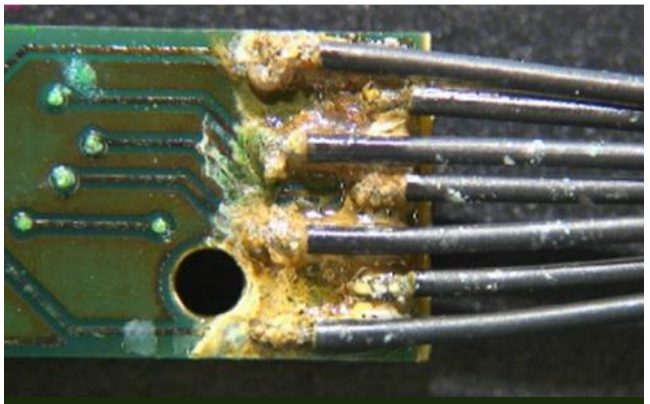
Central magnet coated with

Coat-X Multilayers

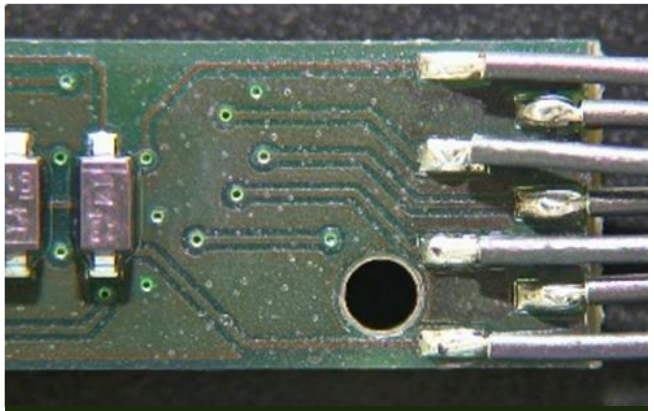


CORROSION PROTECTION WITH MULTILAYER

- Superior performance barrier coating (liquid & gas)
- 3D conformal protection of complex microstructures
- Single reactor, room temperature, batch process
- Transparent, flexible and biocompatible



Without Thin Film Encapsulation

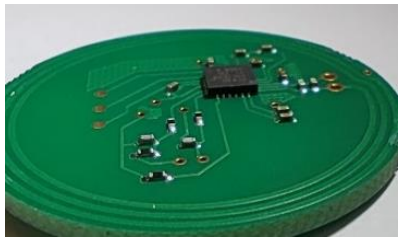


With Multilayer Parylene Coating

Protection of implantable electronic with multilayer parylene coating

- RF tags including sensing capabilities have been **encapsulated with a 10-micron multilayer coating** from COAT-X. It combines alternating Parylene and ceramics layers. No other packaging material nor casing was used.
- The multilayer coating was prepared using COAT-X **proprietary PE-CVD technology**.
- An **accelerated aging test** protocol was developed to demonstrate the long-term performance of the technology in the human body. The devices have been immersed at 87°C in Phosphate Buffered Solution (PBS) for several months to **simulate years of implantation.**
- Contactless interrogation of the RF tag was performed on a regular basis to verify proper function of the device.

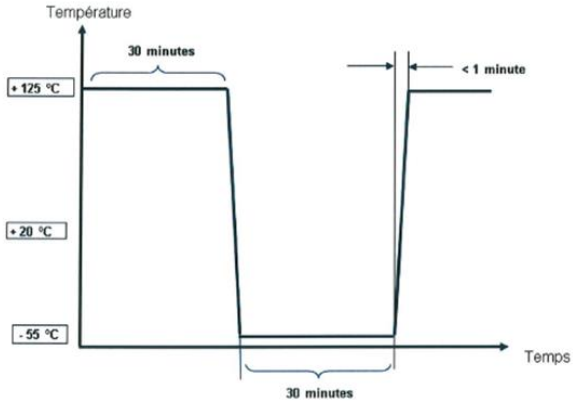
Test PCB platform comprising an RF communication block with antenna and temperature sensor

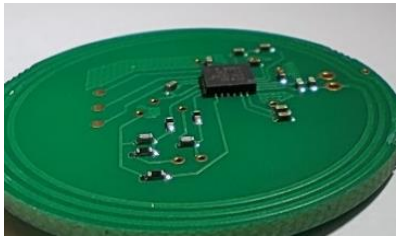


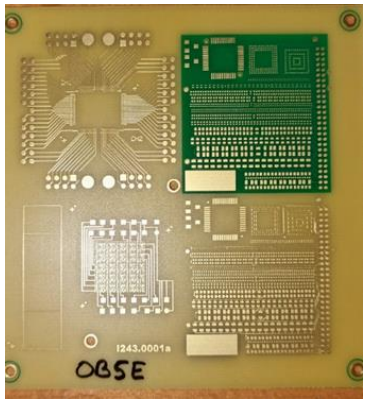
After more than 14 years of simulated implantation all tags are still fully functional. The test is extended to reach 20 years of implantation.

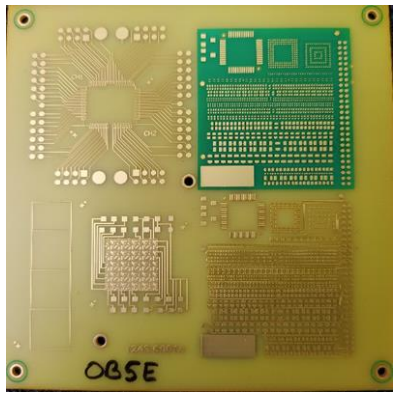
Thermal cycling of various PCB's with multilayer parylene coating

- Various types of PCB have been encapsulated with COAT-X multilayer parylene coating and submitted to thermal cycling.
- Up to 1000 cycles have been performed and the surfaces inspected.
- The coating is very robust on all PCBs, including on solder masks
- It demonstrate the high tolerance of the technology towards large temperature cycles, without delamination or cracks









Electronics still functional up 1000 cycles

No damages to the protecting multilayer film and could be observed

Surface functionalization

SUPER HYDROPHOBIC COATING

- Hydrophobic very thin ceramic films make any surface water repellent.
- Fluorene free
- Biocompatible
- OEKO-TEX validated
- Compatible with organic materials

SUPER HYDROPHOBIC COATING

Aerosol Filtration Testing of Fabrics for Development of Reusable Face Masks

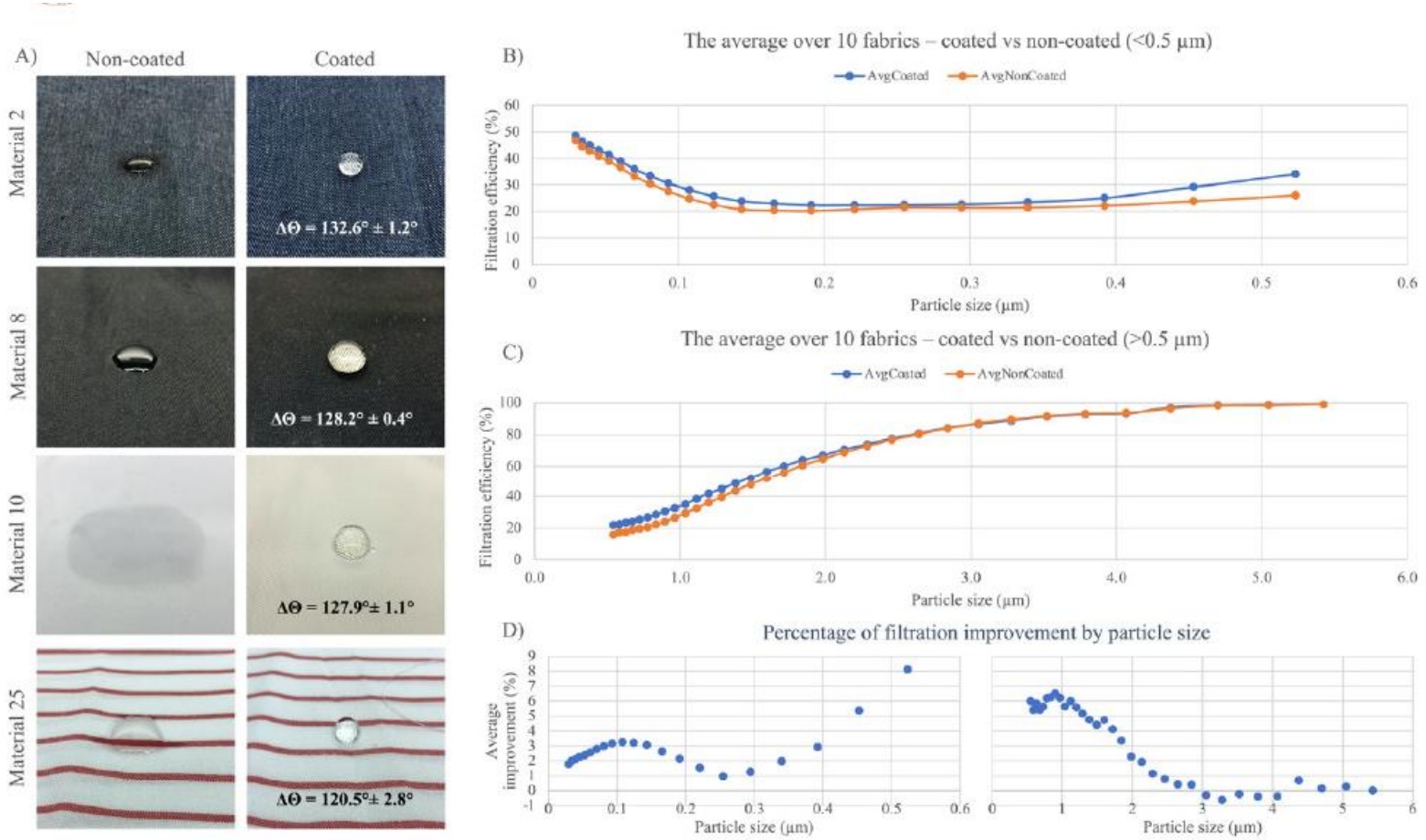
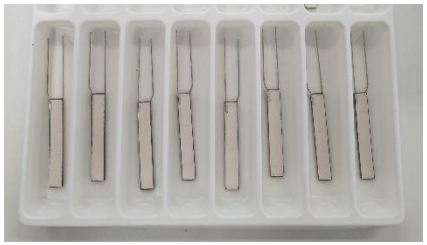


Fig. 10. Influence of coating on aerosol particle size-selective filtration performance. (A) Four materials before and after coating, with the increase in contact angle in overlay. (B, C) Average filtration efficiency over 10 coated and non-coated fabrics for particles smaller and larger than 0.5 µm. (D) Percentage of filtration improvement per particle size.

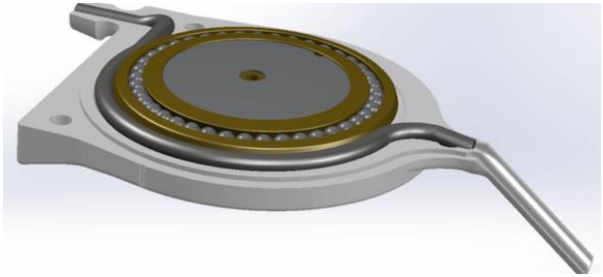
Stan, A., Aerosol Air Qual. Res. 21, 210052. https://doi.org/10.4209/aaqr.210052

ESTABLISHED CUSTOMER BASE - PROVEN TECHNOLOGY

Minimally invasive surgical instruments



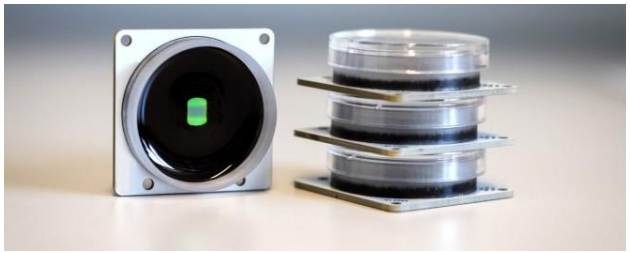
Rheon Medical – implant for glaucoma treatment



Implant for lymphedema treatment

Probe for water analysis

Microelectrodes array for bioassay



Boucheron – high jewelry

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COAT-X IS A CVD EQUIPMENT PROVIDER

COAT-X develops and manufactures CVD and PE-CVD production equipment

- Tailored-made to meet specific customer requirements
- Large chamber for better productivity
- Fully automated an integrated processes (activation, Parylene and ceramics deposition)
- Development and verification of application-specific recipes

Production Line

Installation of lean production line into clean room (ISO 5)

- ✓ **Single chamber process** **Ambient temperature**
- ✓ **Cleanroom performance** **ESD compatible**
- ✓ **Certification for Medical Devices ISO 13485:2016**

Thank you for your attention

PCBs

Watchmaking

Jewelry