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Europlasma Launches World’s First Halogen Free Plasma Nanocoating to Protect Wearable and Portable Electronic Devices

PlasmaGuard

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Outline

- Background
- Plasma Nanocoating
- Why Nanocoating?
- Coating Strategies
- Some References
- Key Messages

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Mission

- Europlasma’s mission is to supply innovative nanocoating (ultra-thin coating) solutions based on proprietary low pressure plasma technology
- Europlasma is helping its customers to achieve the highest performance and protection for their products, with a production process that has the lowest environmental footprint

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- **1993-2003**: Design and build low pressure plasma equipment under **Europlasma®** brand name.
- **2003-2010**: Develop plasma processing technology. Build patent portfolio.
- **2010**: Transition in business model to technology licensor. Launch of **Nanofics®**.
- **2013**: Commercial break-through of **Nanofics®** in consumer electronics with Logitech/Ultimate Ears. Proof of concept in sporting goods.
- **2015**: Launch of **Nanofics® SE** barrier coatings for electronics.
- **2016**: **PlasmaGuard®** ingredient brand for premium sporting brands with a real commitment to a better environment launched.
- **2017**: Andlinger & Company - holding of **CPI** and **Spoolex** - acquires Europlasma, and provides growth capital.
- **2018**
- **2019**: PlasmaGuard

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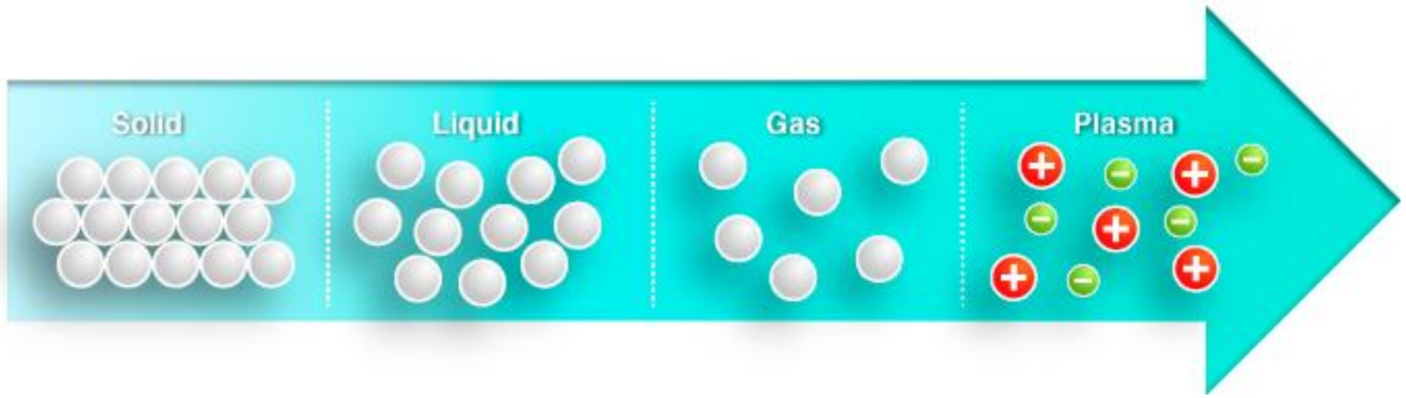
- Plasma is generated by an electromagnetical discharge
- In a gas at low or atmospheric pressure (and low temperature)
- Reaction takes place on the substrate surface



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CD1000
(chamber 1000 x 700 x 700 mm)

Loading with components, PCB’s, subassemblies or fully assembled devices

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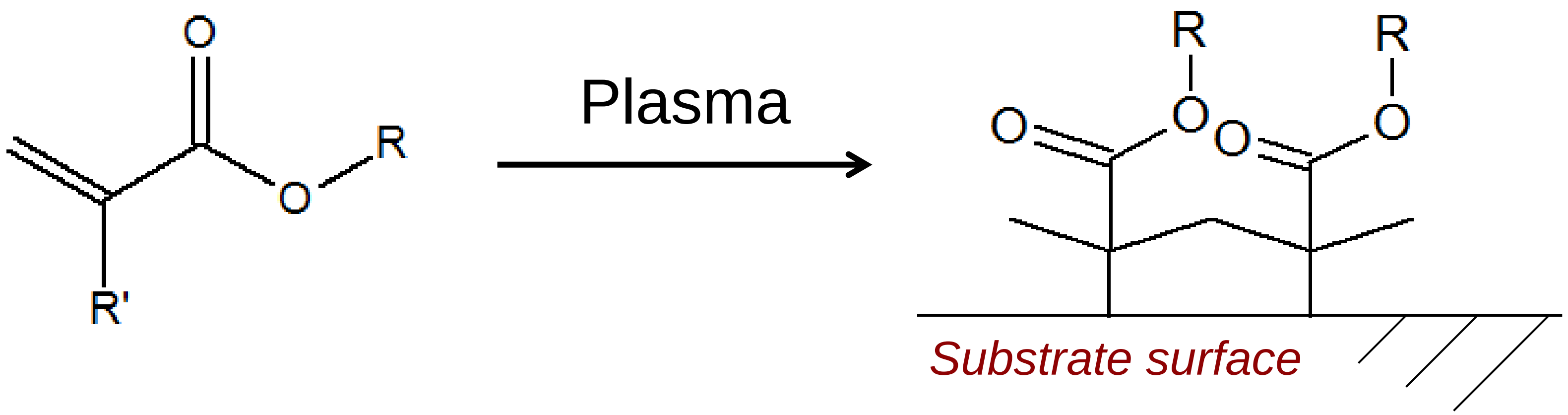
Plasma Nanocoating



Monomer precursor

Cross-linked coating
bound to the surface

R = functional group

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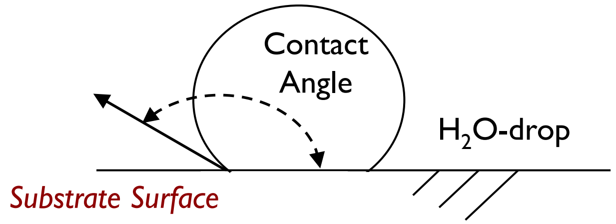
Coating Type	Markets	Functionality
Nanofics® 10	Electronics/Medical/Filtration	Hydrophilic Coating (WCA < 10)
Nanofics® 110	Electronics/Medical/Filtration	Hydrophobic and Oleophobic Coating (WCA > 110° Oil > 4)
Nanofics® 120	Electronics/Medical/Filtration	Hydrophobic and Oleophobic Coating (WCA > 120° Oil > 7)
Nanofics® SE	Electronics	Barrier Coating
PlasmaGuard®	Sporting + Outdoor	Durable Water Repellent (DWR)
PlasmaGuard® S	Electronics	Halogen Free Hydrophobic Coating (WCA > 120°)
PlasmaGuard® E	Electronics	Halogen Free Barrier Coating



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- The low pressure plasma process is performed in vacuum and starts from a molecular gaseous precursor
- It penetrates throughout a complex structure and conformally coats all surfaces including sharp edges
- All surfaces are covered, also those that are unreachable by liquid coatings, such as deep cavities and other hard to reach areas
- The ultra-thin coating does not damage fragile items being coated such as acoustic components

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- Wet chemical processes start from a liquid precursor
- Non-uniform coverage, hence they are not truly conformal as they tend to collect and pool in crevices and pull back from edges and sharp points (see illustration)
- Issues often encountered: bubbling, cracking, pinholes and orange peel, which are the typical spots where corrosion will start
- Difficult to reach the underside, between gaps and around critical components

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Environmental Benefits

- Case study for durable water repellent (DWR) coating of textiles
- By using only 1 kg of plasma precursor chemicals you save the world from:
  - *5 kg of wet chemical coating chemicals*
  - *more than 115 liters of waste water*
  - *almost 80 kg of CO_2*
  - *crosslinking agents, chlorides, formaldehyde and other toxic products used in wet chemical*
- Halogen free PlasmaGuard!

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ITMA 2015
Best Innovation in Sportswear
and Outdoor Apparel

CES 2017
Innovation Awards Honoree
Tech For A Better World

CES INNOVATION AWARDS 2017 HONOREE

ISPO AWARD GOLD WINNER 2016/2017

ISPO 2016
Best Performance
Footwear Component

ORGANISED BY edana FILTREX INNOVATION AWARD 2017

Filtrex
Innovation Award
2017 Nominee

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Splashproof
Top Coating
Nanofics® 110/120

Waterproof
Barrier Coating
Nanofics® SE

Splashproof
Top Coating
PlasmaGuard® S

Waterproof
Barrier Coating
PlasmaGuard® E

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Top Coating

- Single layer top coating of 50-500 nm
- Nanofics® 110/120 and PlasmaGuard® S are applied on individual component, PCB, sub-assembly, whole device, or combination of previous
- Z-axis conductivity allows flexibility in the manufacturing process
- No influence on acoustic behaviour
- No colour change (patented diffuser)
- Biocompatible (ISO 10993-5) and not hypersensitive (ISO 10993-10)
- Typical cycle time 10-30 min

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Top Coating

- IPX 2-4
- Combination with good mechanical design allows to reach higher IPX levels:
  - *reduce water ingress*
  - *make sure water is easily drained from device*
  - *seal specific high voltage parts and/or connectors*

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Barrier Coating

- Multi-layer barrier coating of 1-3 µm with hydrophobic top layer
- Similar chemistries as Nanofics® 110/120 and PlasmaGuard® S respectively
- Protection against corrosion when powered device is submersed (low voltage)
- Different levels of protection:
  - *water*
  - *sweat*
  - *salt water*
- Same machine as single layer top coating with upgraded software and hardware
- Typical cycle time of 3-4 hours

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Barrier Coating

- IPX 5-8
- Impact of top layer depends on functional test protocol

Coating Type	Top Layer	Surface Functionality
Nanofics® SE	Nanofics® 110	WCA > 110° Oil > 4
Nanofics® SE	Nanofics® 120	WCA > 120° Oil > 7
PlasmaGuard® E	PlasmaGuard® S	WCA > 120°

Combination

- Coat PCB and/or key components with barrier coating PlasmaGuard® E or Nanofics® SE
- Mask fragile components such as microphones or speakers
- Requirement to mask contact points and/or connectors depends on application and design
- Z-axis conductivity depends on thickness of the coating
- Combine with ultra-thin PlasmaGuard® S or Nanofics® 110/120 top coating of full device for optimal protection:
  - *top coating to reduce water ingress*
  - *barrier coating to protect internal electronics against trapped water or sweat*

Comparison with Parylene

- PlasmaGuard® E has much lower wettability surface than Parylene
- In-situ plasma cleaning/activation guarantees good adhesion of PlasmaGuard® E to different substrates, making masking much more easy
- PlasmaGuard® E does not easily crack, because it is a flexible coating, which makes it very suitable for flexible substrates
- PlasmaGuard® E shows better barrier properties than Nanofics® SE and Parylene of same thickness in submersion test (see further)
- 1 µm of PlasmaGuard® E shows similar barrier properties as 5 µm of Nanofics® SE or Parylene, allowing more design freedom (see further)

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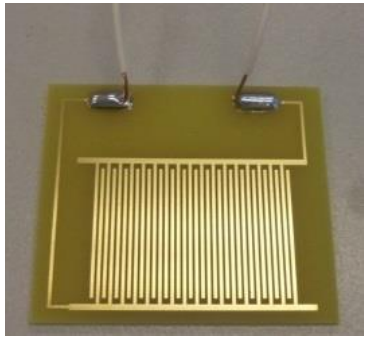
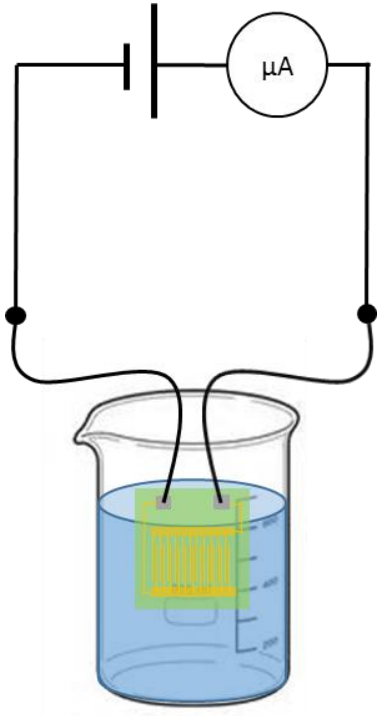
Test Protocol

- Shortcut test protocol to evaluate corrosion protection on a powered PCB while immersed in liquid
- Applied voltage: 5 V
- Liquids: water, salt water, artificial sweat
- Evaluation criteria:
    - *current < 0,1 mA*
    - *no visible signs of corrosion*



Track width: 0,5 mm
Pitch: 0,5 mm



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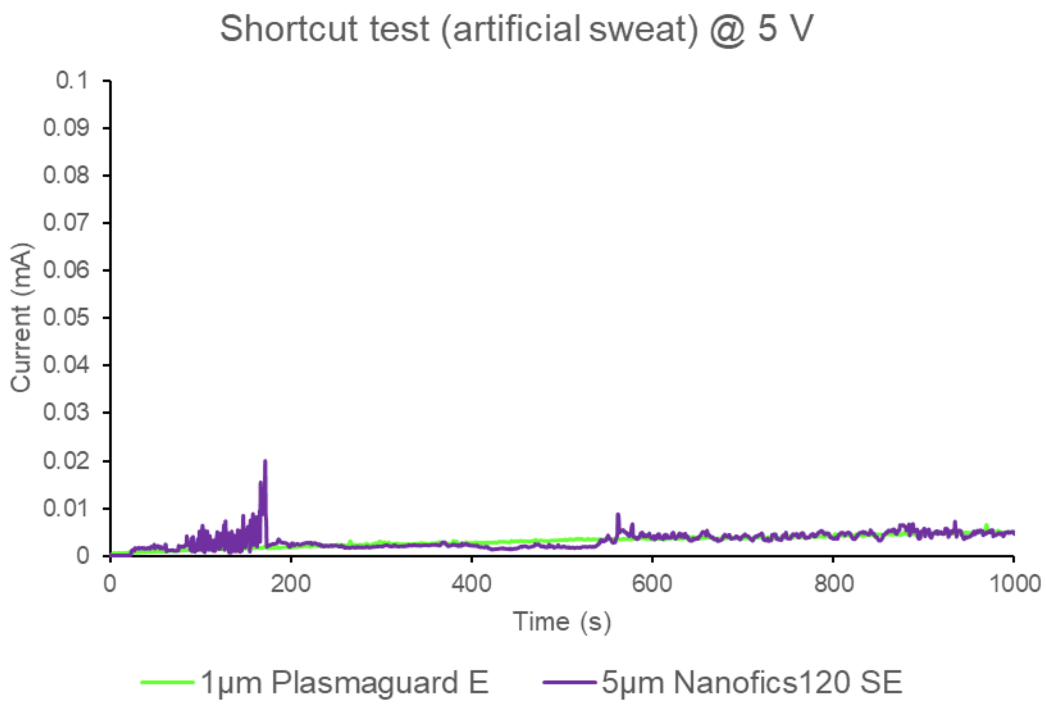
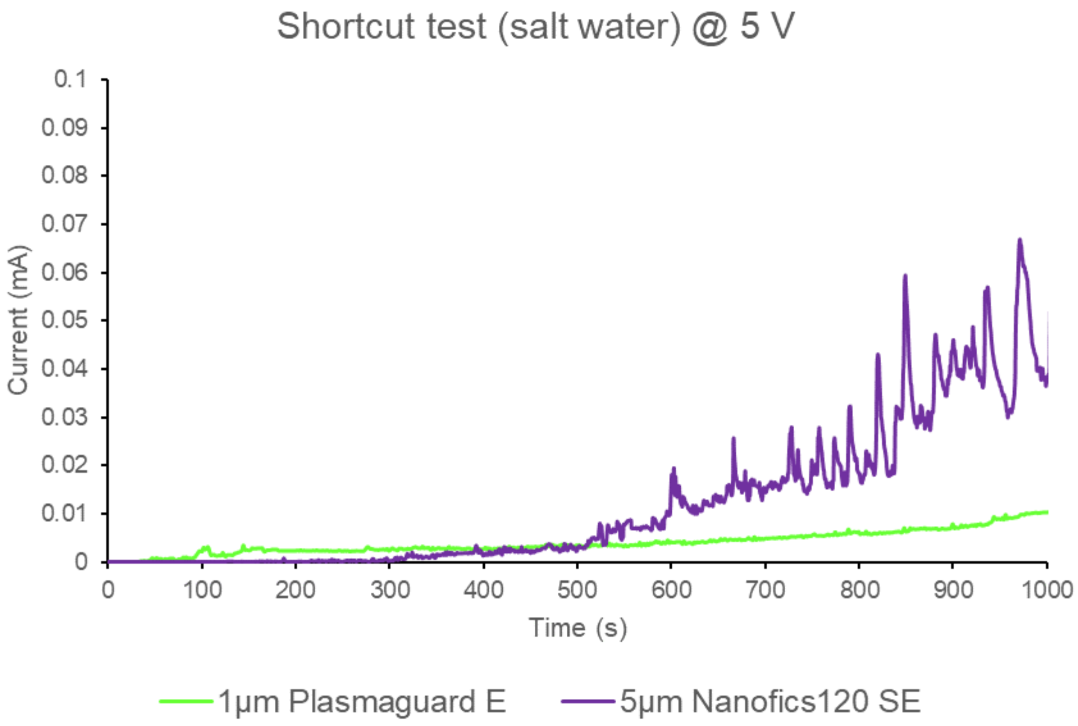
PlasmaGuard® E versus Nanofics® SE





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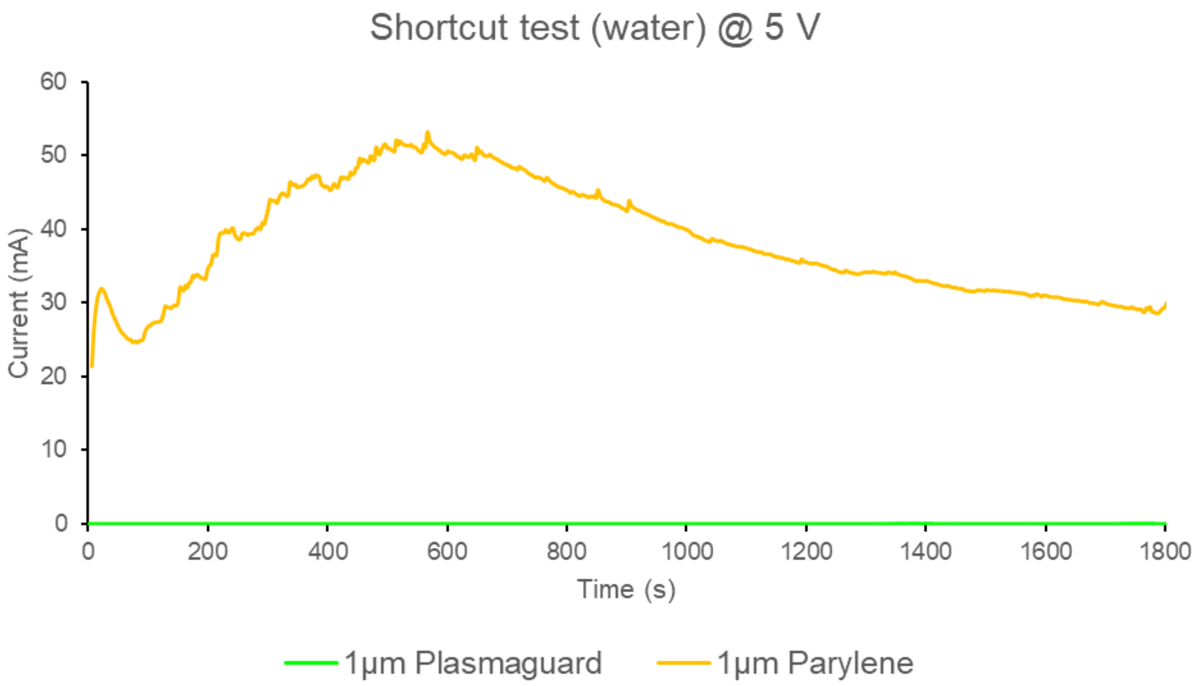
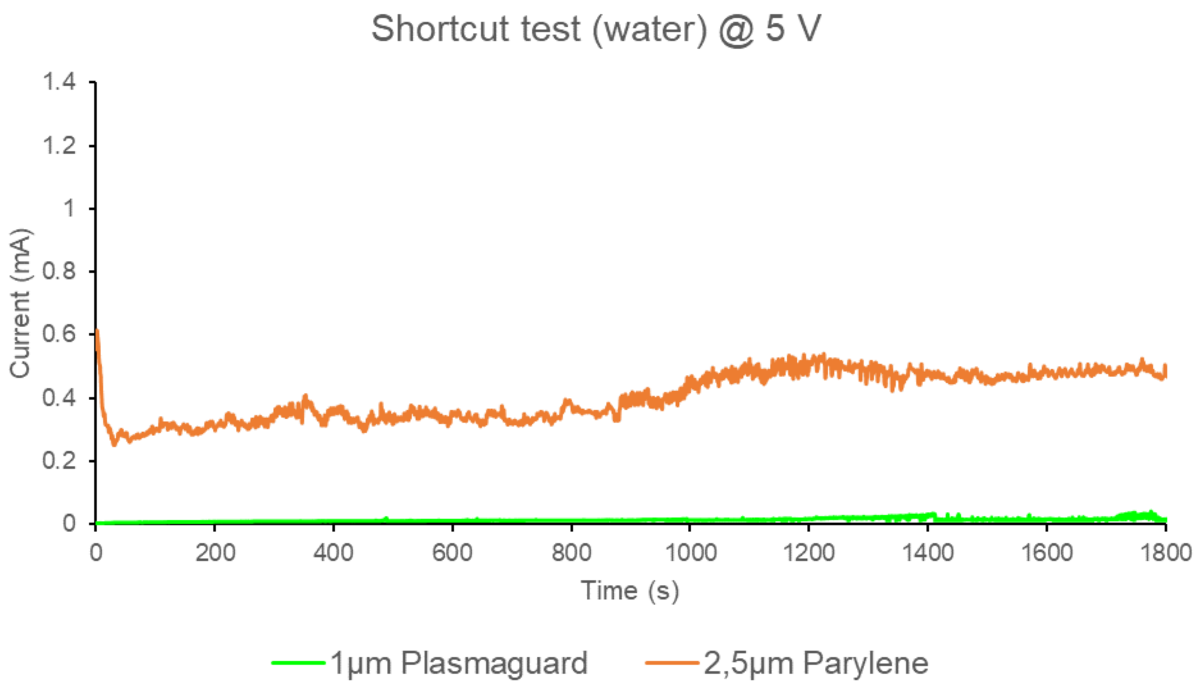
PlasmaGuard® E versus Parylene C





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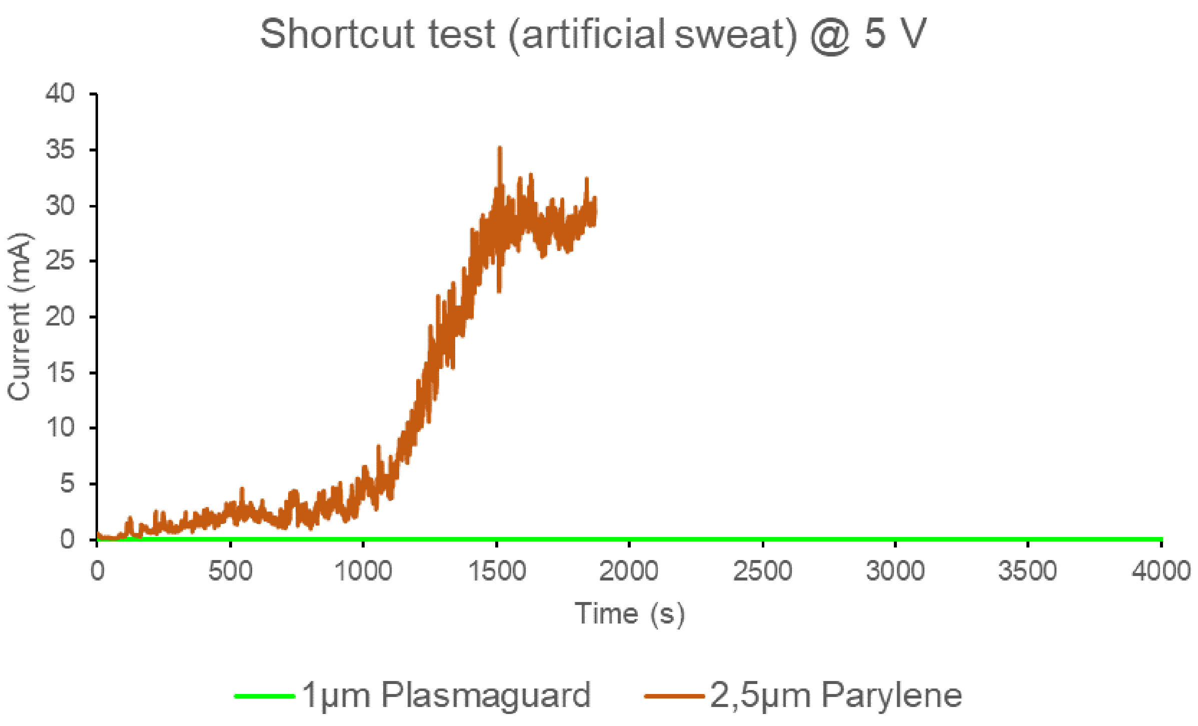
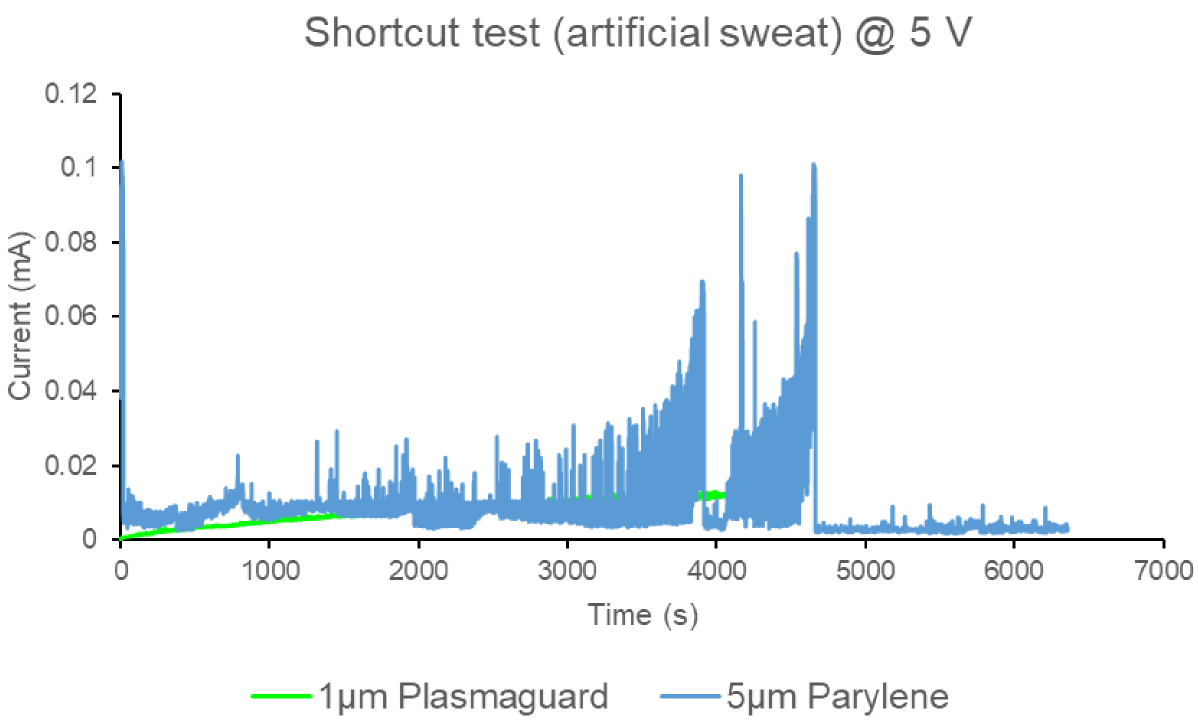
PlasmaGuard® E versus Parylene





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PlasmaGuard® E versus Parylene

Submersion in:	Time to failure:			
	Parylene C 1µm	PlasmaGuard E 1µm	Parylene C 5µm	PlasmaGuard E 5µm
Water	1 s	> 4100 s	> 85 h	> 85 h
Artificial Sweat	1 s	> 4100 s	1.25 h	> 85 h
Salt Water	1 s	2200 s	18 h	38 h

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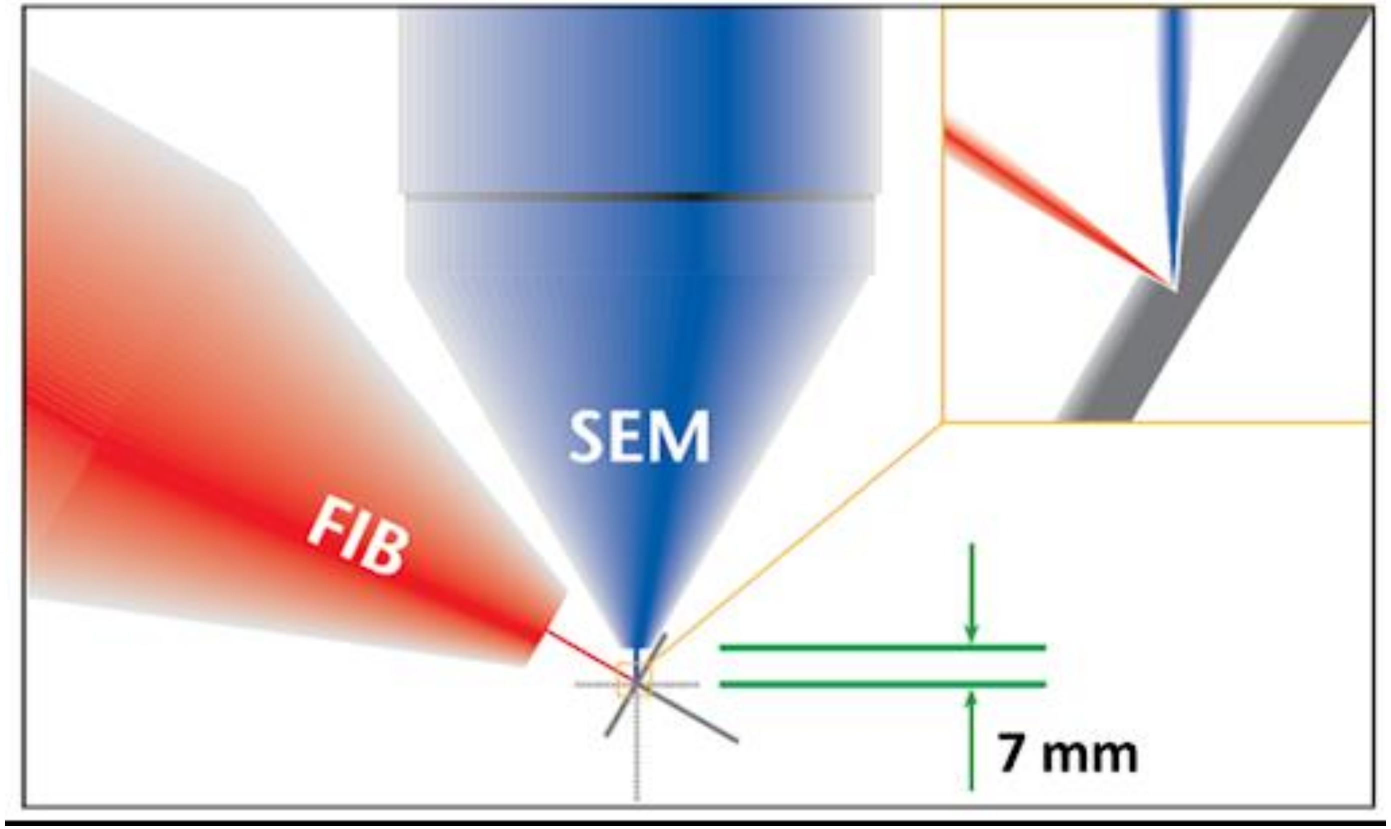
FIB-SEM

- Focused Ion Beam
  - *Allows a clean cut (removal of material)*
- Scanning Electron Microscopy
  - *Imaging of the coating*
- FIB-SEM
  - *Imaging of the interface between coating and substrate*



http://emc.missouri.edu/fib-sem/

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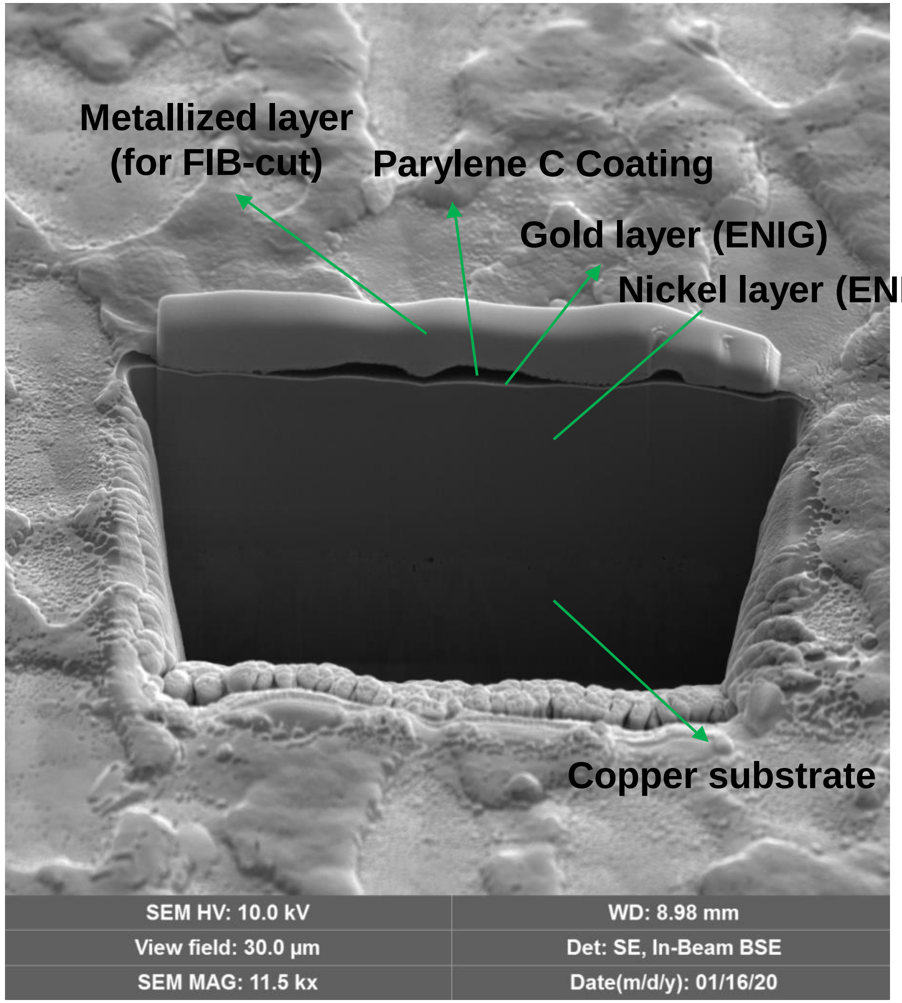
PlasmaGuard® E versus Parylene

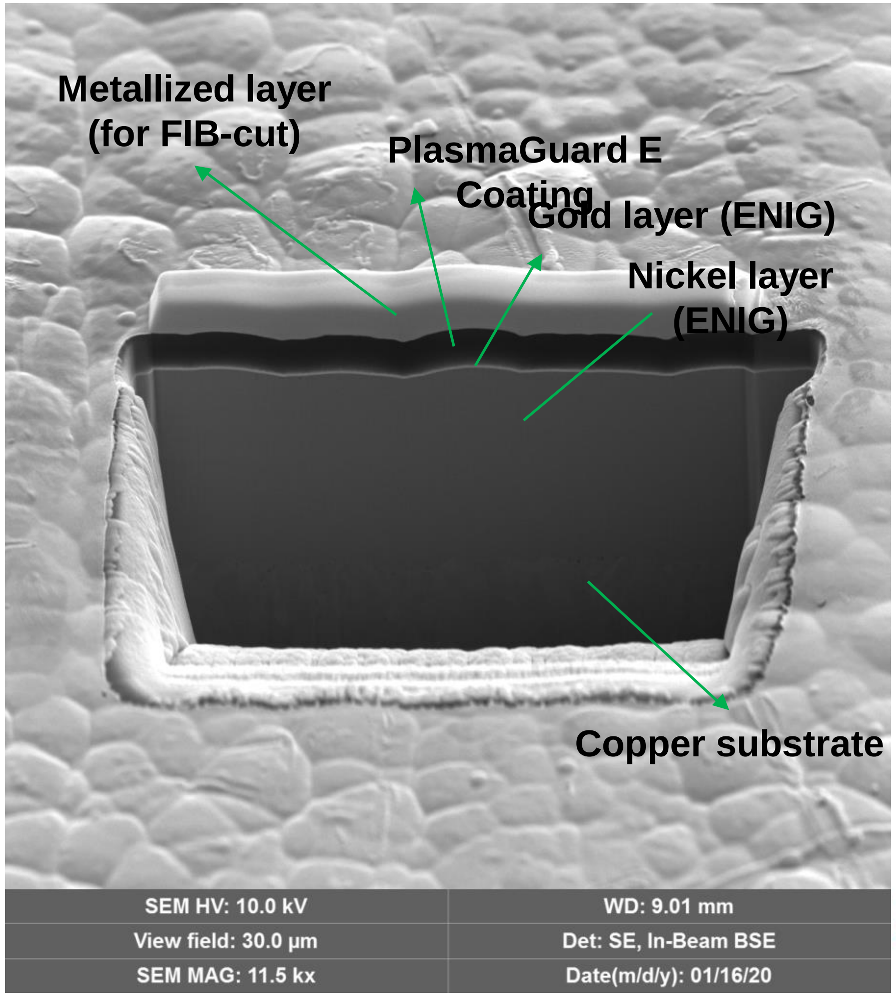
1 µm Parylene C



Results

- **1µm Parylene is not conformal**
- **Parylene coating 0-500 nm**

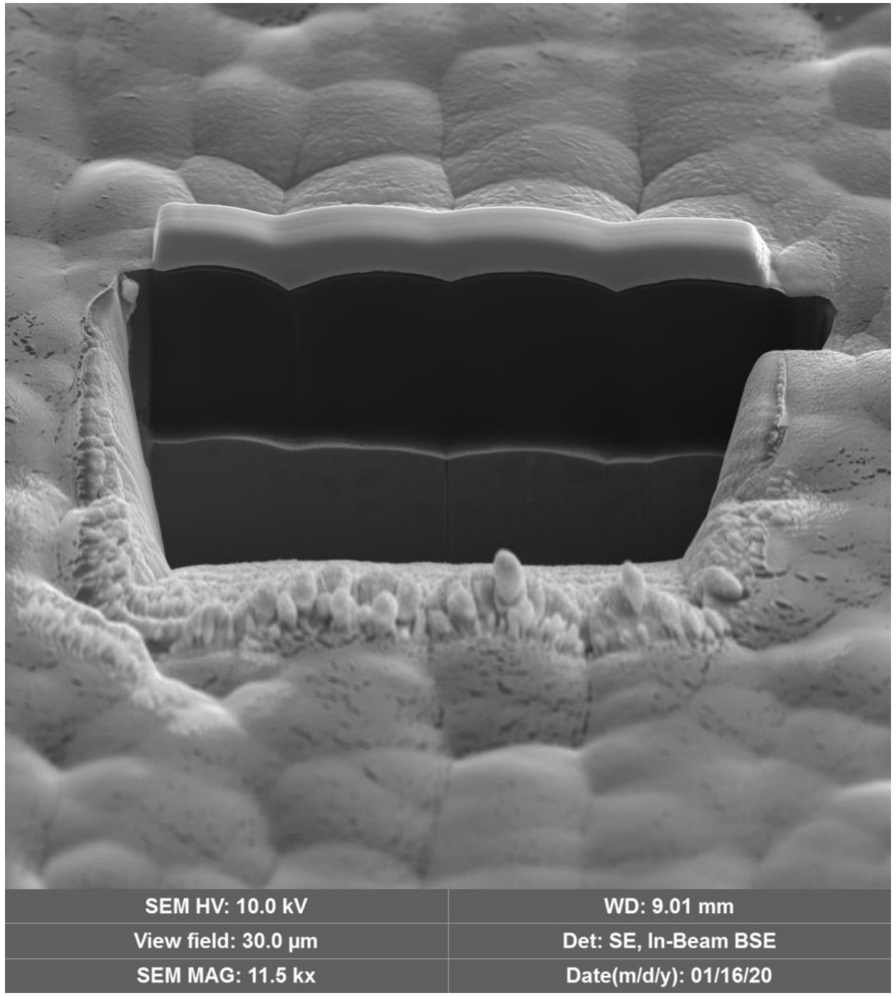
1 µm PlasmaGuard E



ard

PlasmaGuard® E versus Parylene

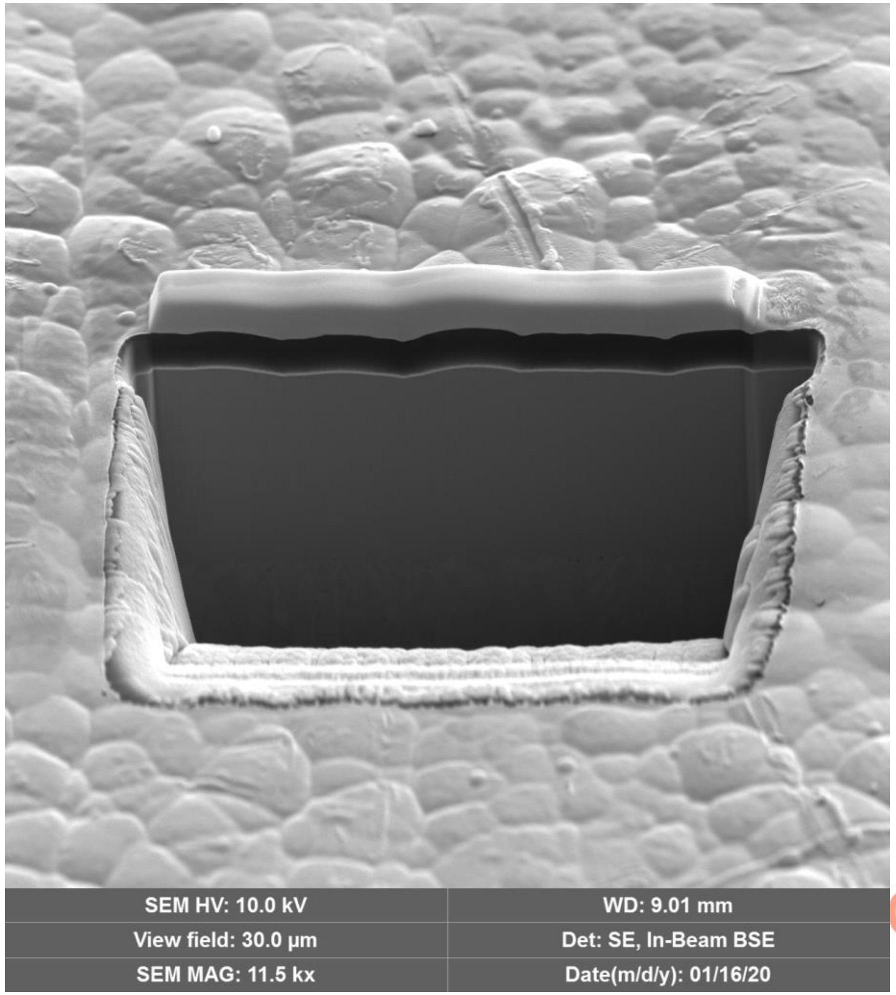
5 µm Parylene C



Results

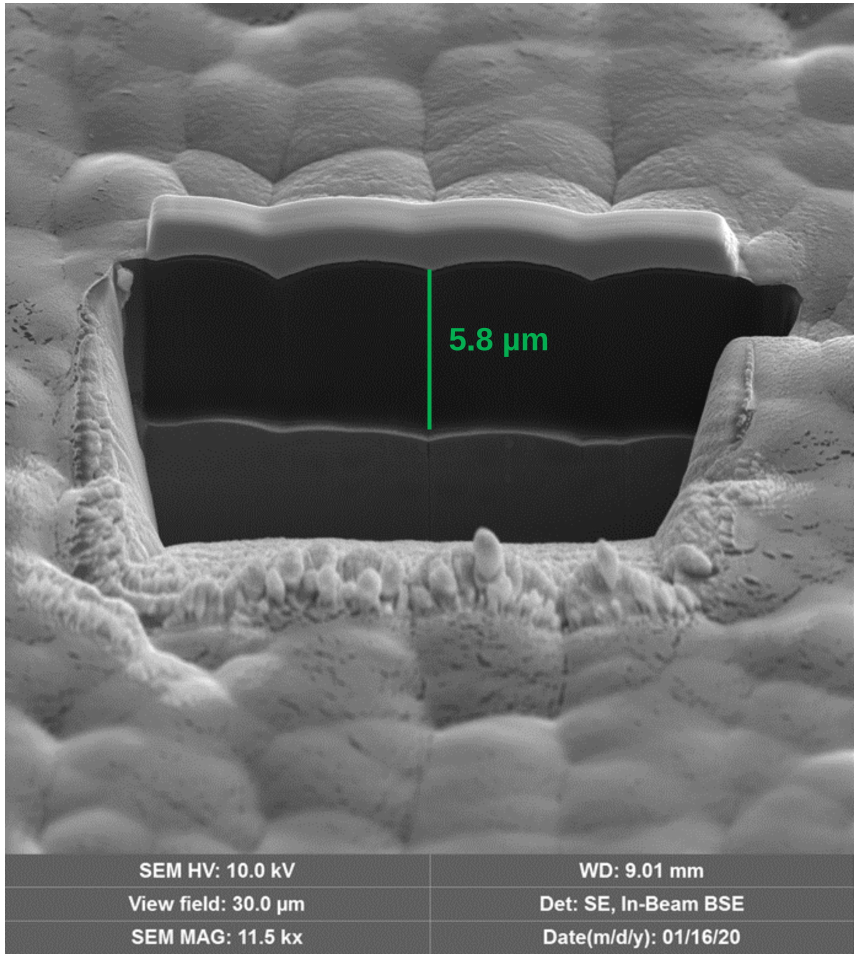
- **5µm Parylene is more conformal compared to 1µm Parylene coating**
- **1µm PlasmaGuard as similar conformity as 5µm Parylene**

1 µm PlasmaGuard E



PlasmaGuard® E versus Parylene

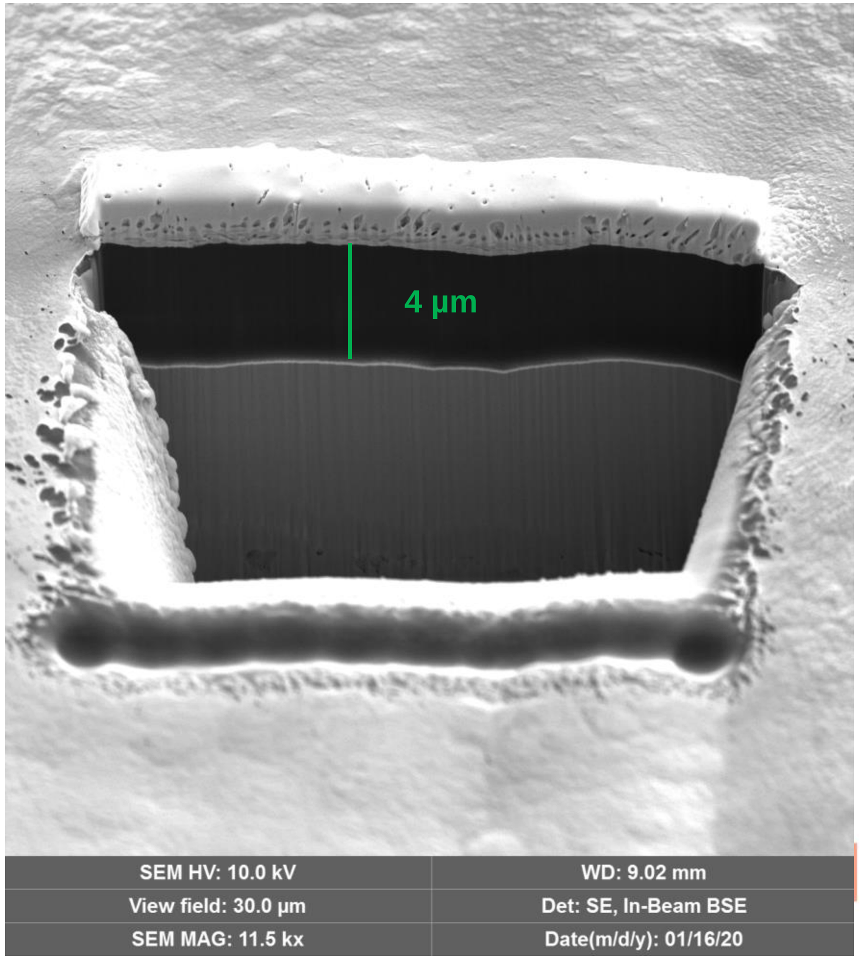
5 µm Parylene C Pos. 1



Results

- **Thickness variations on PCB of 50x50 mm for 5µm Parylene C coating**

5 µm Parylene C Pos. 2



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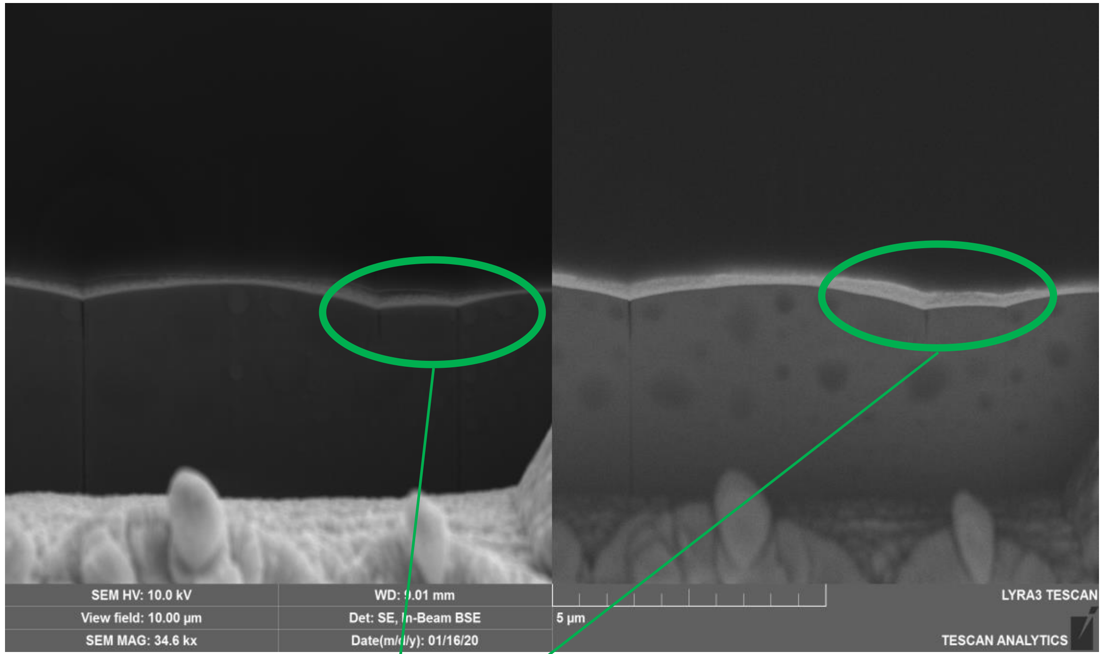
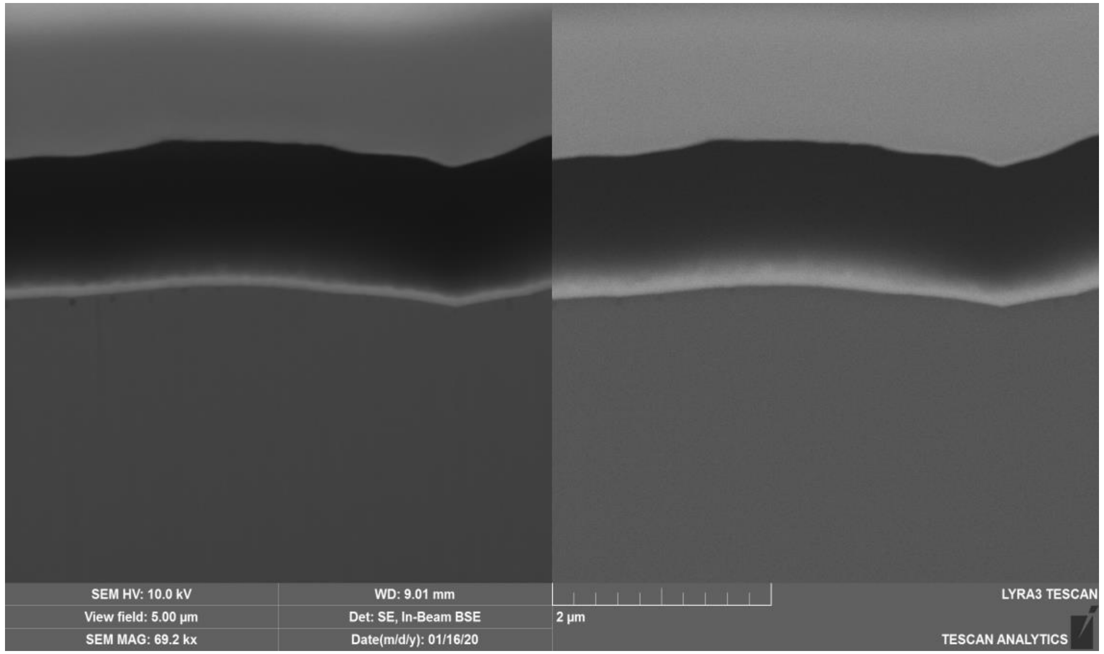
PlasmaGuard® E versus Parylene

5 µm Parylene C



1 µm PlasmaGuard E



Delamination between Parylene and gold layer

Results

- **Delamination is observed between the gold layer and the 5µm Parylene C coating**
- **1µm PlasmaGuard E exhibits excellent adhesion to the gold layer**

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PlasmaGuard® E versus Parylene

1µm Parylene C	5µm Parylene C	1µm PlasmaGuard E
• Poor conformity • Heterogenous thickness 0 - 0.5µm • No delamination	• Good conformity • Heterogenous thickness 4 - 5.8µm • Delamination	• Good conformity • Homogenous thickness • Excellent adhesion

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PlasmaGuard® E versus Parylene

	FIB-SEM		
Coating	Parylene C 1µm	PlasmaGuard E 1µm	Parylene C 5µm
Conformal	No	Yes	Yes
Thickness distribution	Heterogenous	Homogenous	Heterogenous
Delamination	Cannot be evaluated	No	Yes

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JBL® by HARMAN

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ASUS

Skullcandy

William Demant

SMS AUDIO

jaybird

microson

DENON

yurbuds | POWERED BY JBL

B&O PLAY

fitbit

plantronics

PlasmaGuard

Europlasma

MOTOROLA

BRAGI

TOMTOM
GPS SPORT WATCHES

SHURE®

Whole You™

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GIONEE
Make Smiles

MEIZU

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Key Messages

- Growing penetration in consumer electronics
- Two distinct types of coatings: top coating and barrier coating
- Two distinct chemistries: halogen versus halogen free
- Machine is coating platform
- Work with customer to find optimal coating strategy for his/her wearable or portable product
- Environmental friendly
- Award winning technology

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Key Messages

- **With PlasmaGuard® Europlasma launches the world's first halogen free plasma nanocoating solution to protect wearable and portable electronic devices at IDTechEx!**
- **1 µm of PlasmaGuard® E outperforms 5 µm of Parylene!**

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