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“Tune-able” Hybrid™ Coatings for Light Metal Components

Glen.Slater@cirrusmaterials.com

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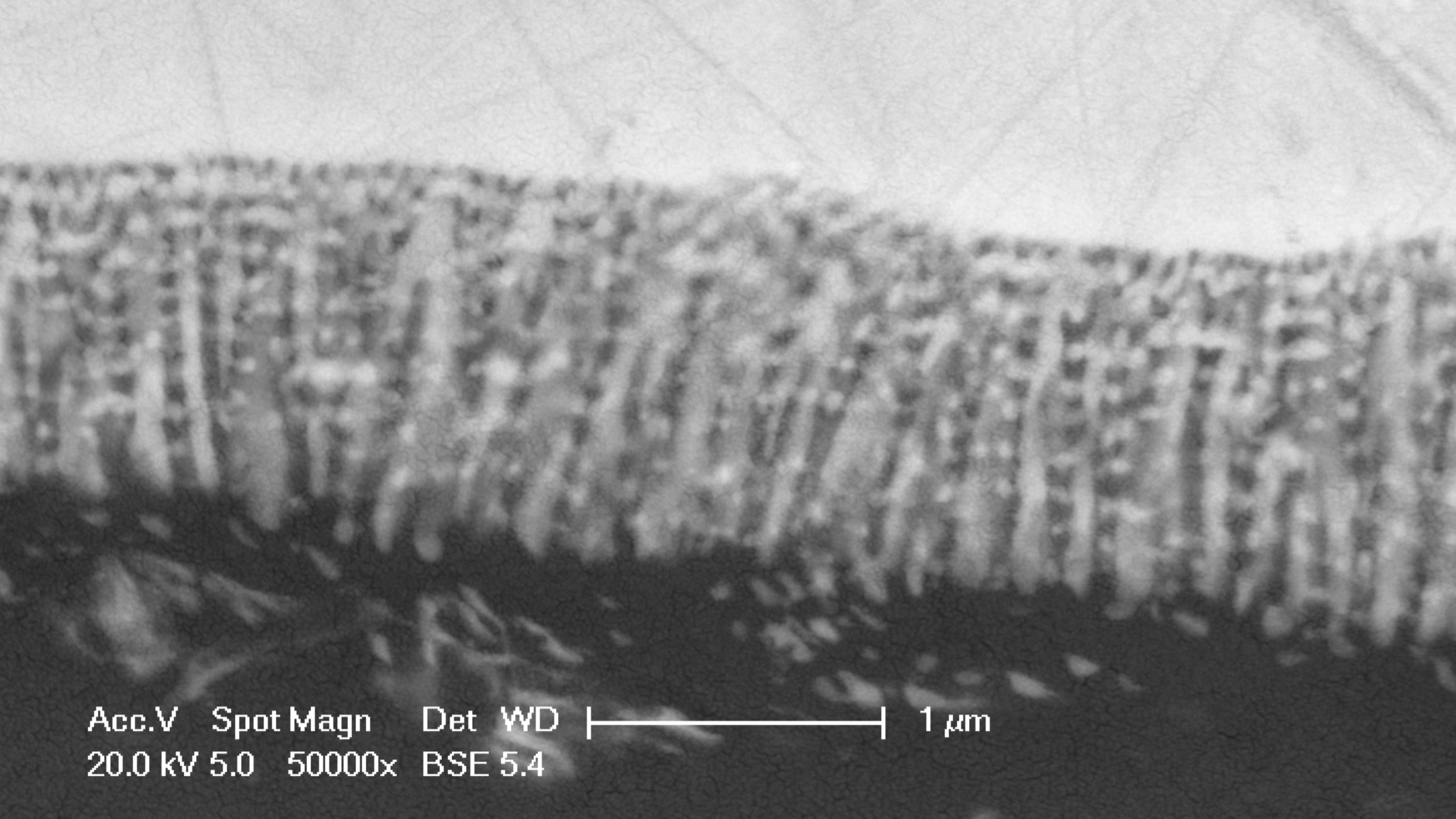
Hybrid™ Coating = combination of anodising and electro-deposition.


Acc.V Spot Magn Det WD
20.0 kV 5.0 50000x BSE 5.4
1 µm

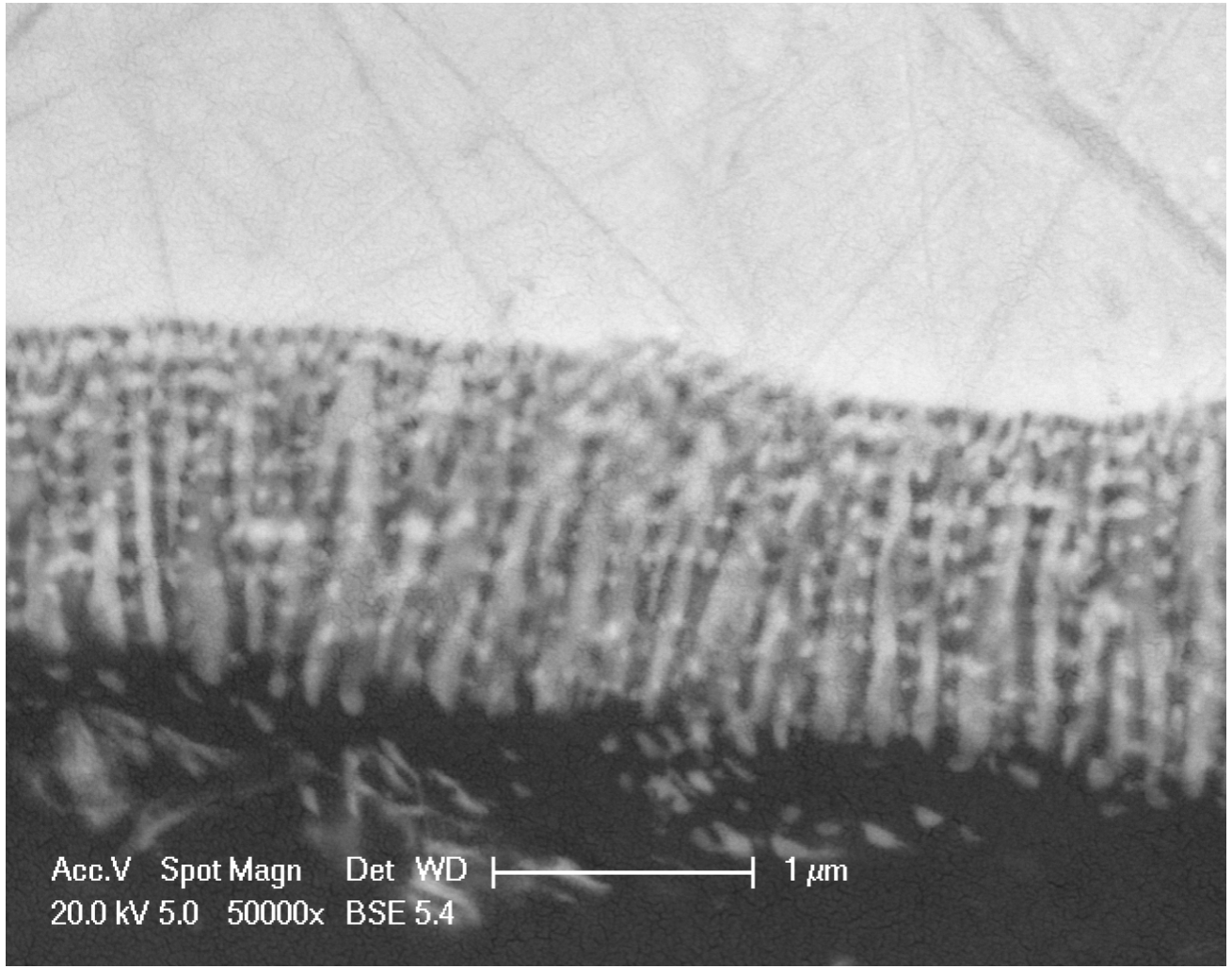
Why?

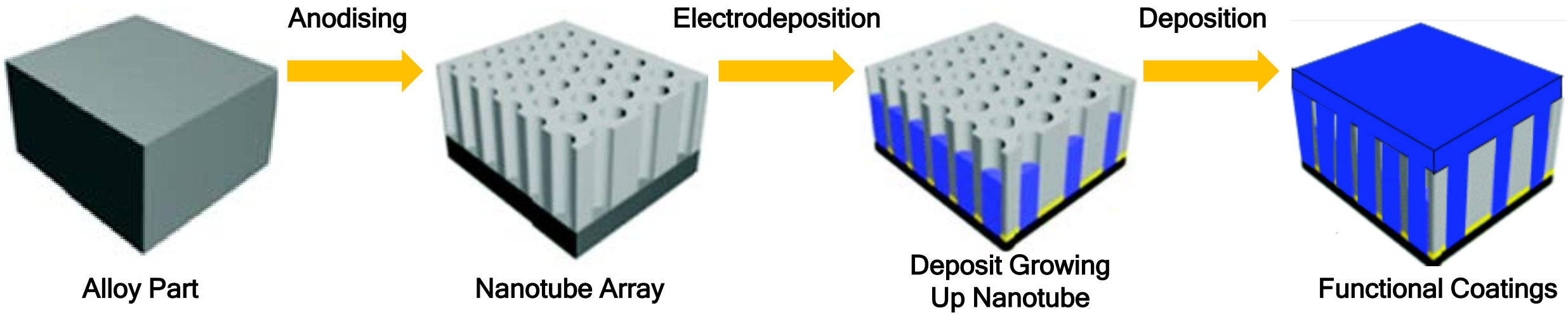
Alternative to sealants / pre-treatments for aluminium:

- Non-toxic
- Creates “functional” surface on anodised substrate

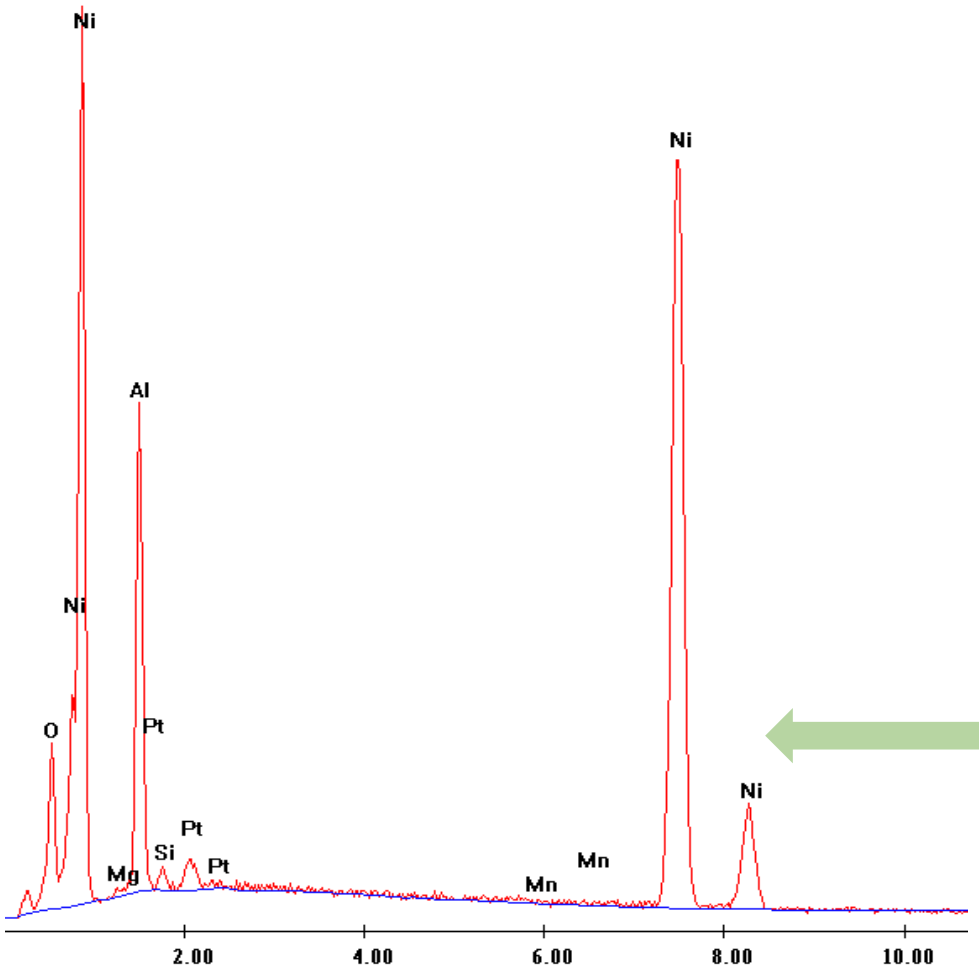
Alternative to electroless Ni:

- Thin, durable coating
- Functional – conductivity + corrosion resistance
- Quick to apply – low cost, low energy use

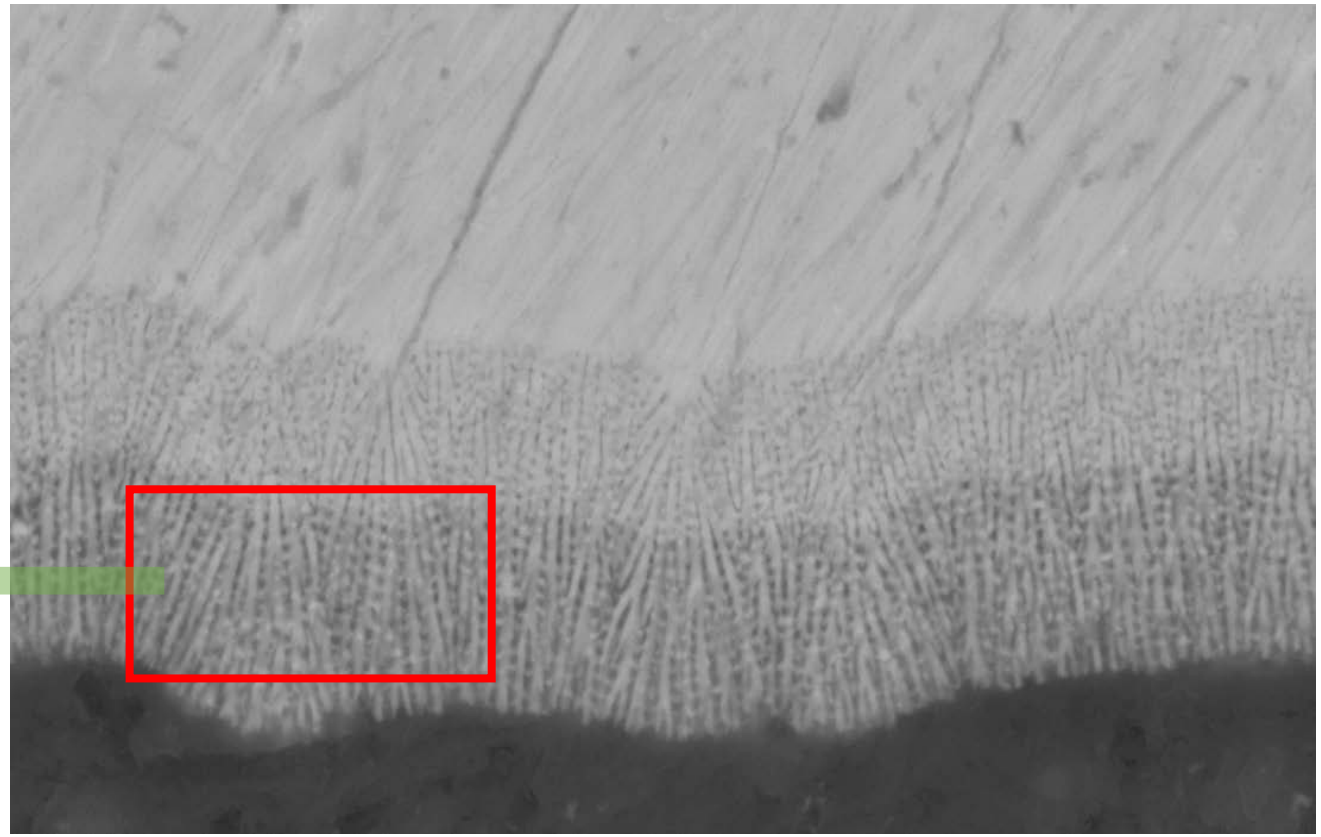


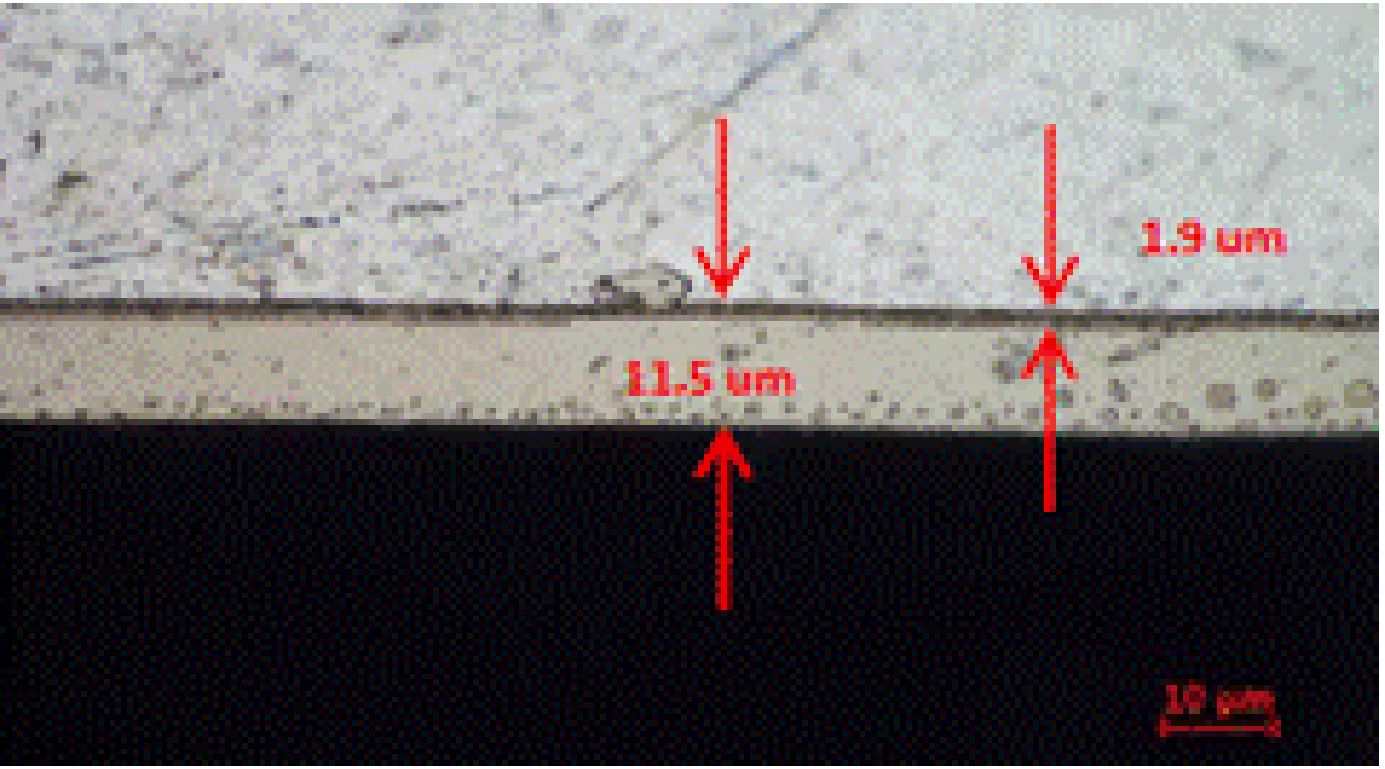


Hybrid™ = combination of anodising and electro-deposition.



The “interlock” layer ensures strong adhesion between the substrate, and the surface coating.

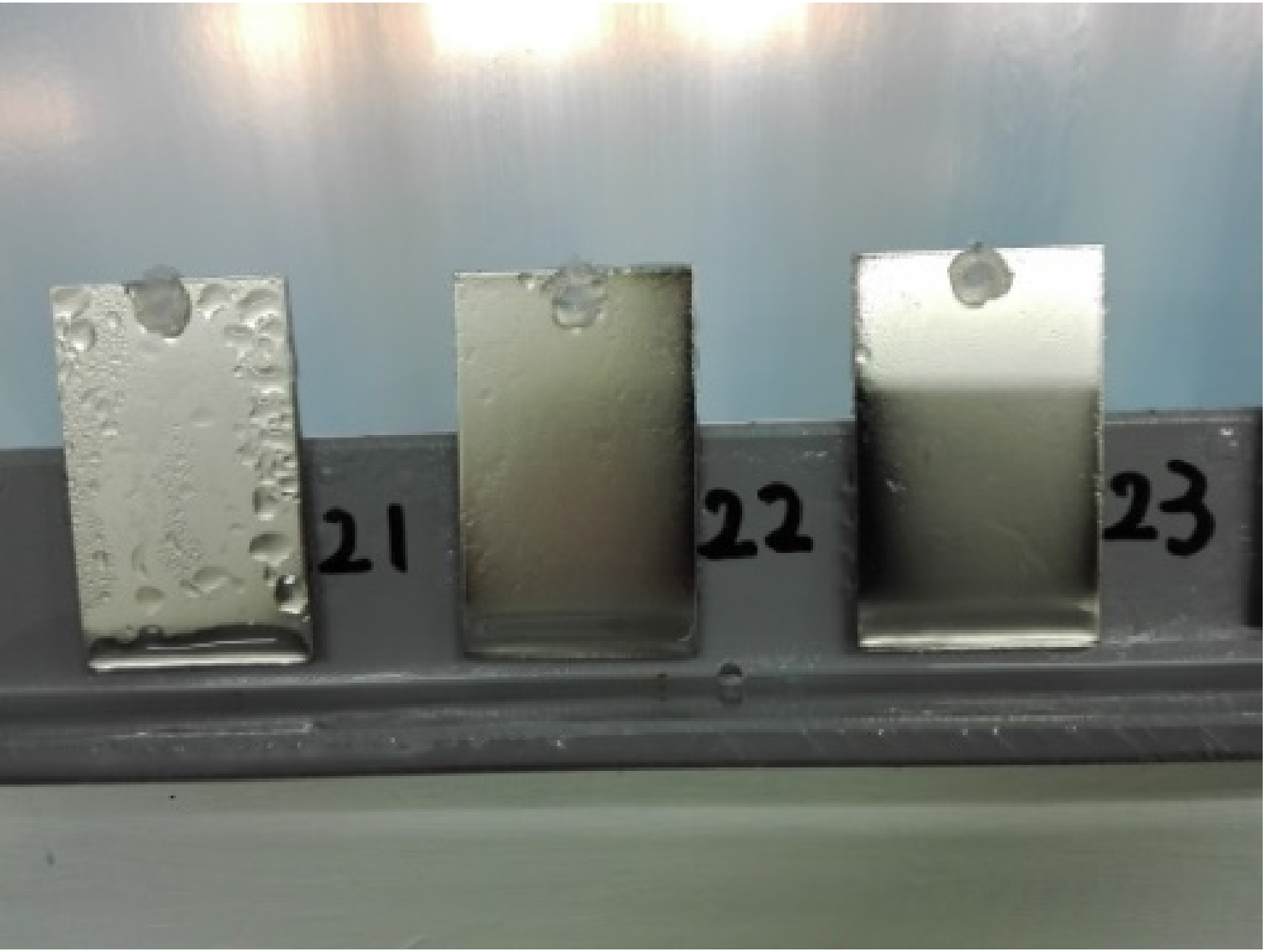




- New coating approach – TRL 2 – 4.
- Protects light metal substrates from corrosion and wear, without limiting the functionality of the component
- Low material costs, low energy use;
- High performance from a thin coating on light metals;
- Simple, controllable process, once you understand it;
- Uses existing production equipment – should be easy to adopt.

Conductivity Testing per MIL DTL 81706

Standard (flat) Hybrid Coating using duplex Nickel



Neutral Salt Spray - ASTM B117

6 micron duplex Hybrid Ni

- Anodising 2 microns
- Columnar nickel 4.5 microns
- Laminar nickel 1.5 microns

Time (hours)	Conductivity mΩ/in²	
	Pre	Post
> 120	0.3	0.9

10 micron duplex Hybrid Ni

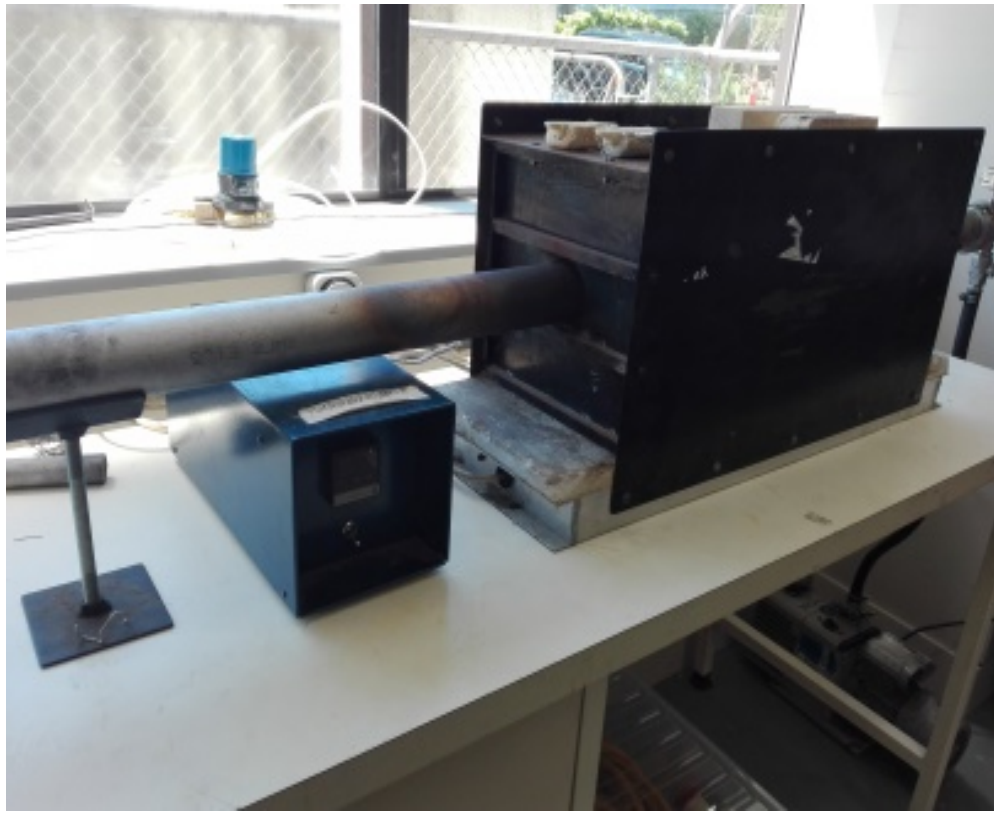
- Anodising 2-3 microns
- Columnar nickel 7 microns
- Laminar Nickel 3 microns

Time (hours)	Conductivity mΩ/in²	
	Pre	Post
> 500*	0.25	0.9

* > 75 hours CASS

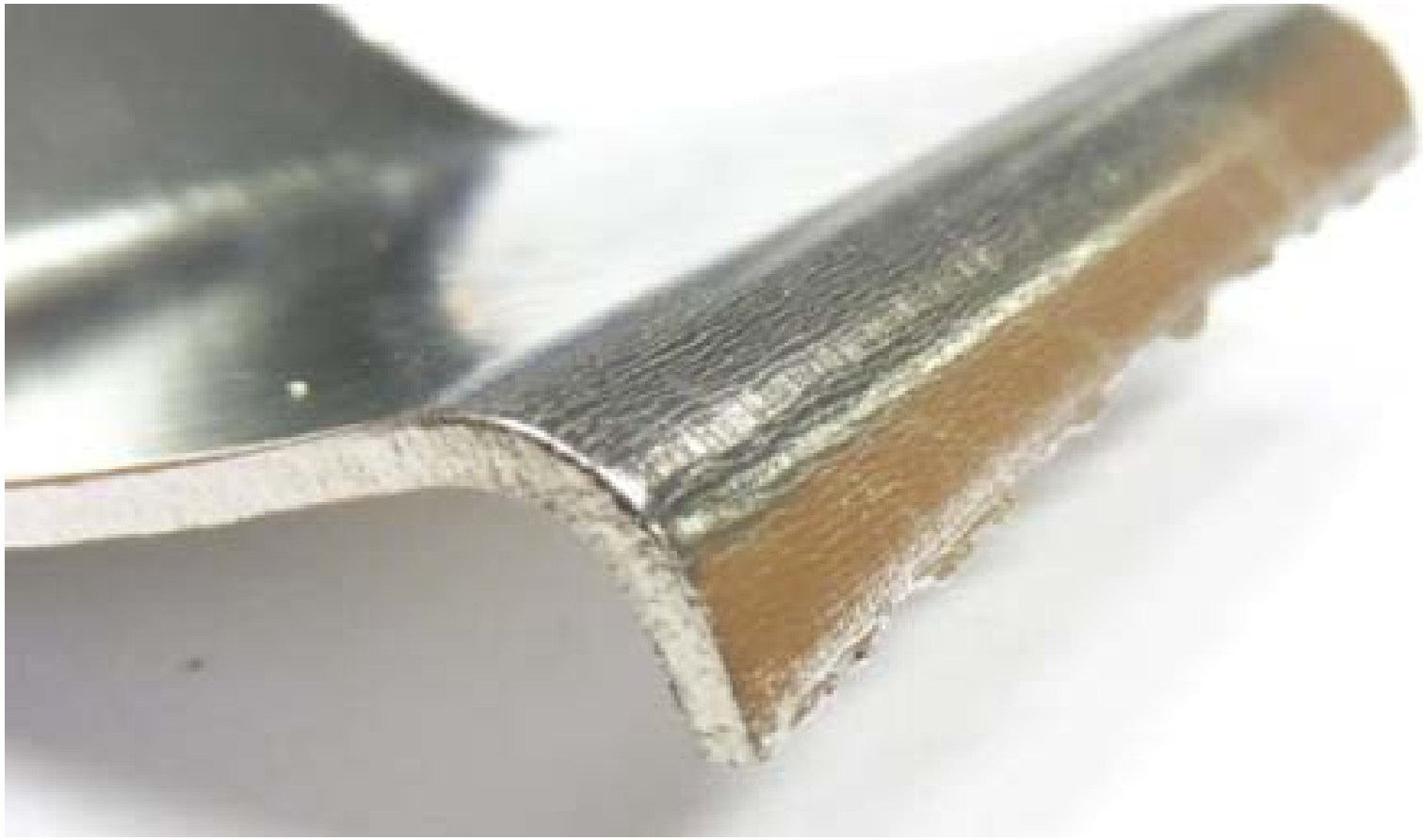
5 Cycles

-65°C	30 minutes
+25°C	2 minutes
+175°C	30 minutes
+25°C	2 minutes



Hybrid Coating Thickness	Conductivity		Crack or Peel
	Pre	Post	
6 micron	0.3 mΩ/in^2	1.2 mΩ/in^2	No
10 micron	0.3 mΩ/in^2	0.9 mΩ/in^2	No

Thermal Cycling - Mil-Std-883 Method 1010 Condition F



Samples tested:

- As coated
- After Thermal Shock testing
- After NSS testing
- After Lightning Strike testing

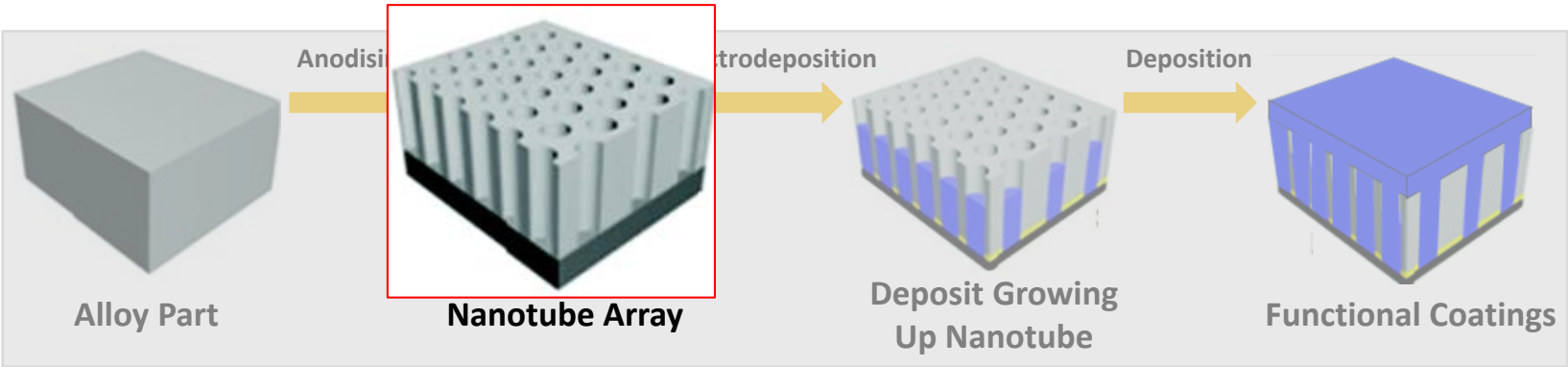
Tests Performed

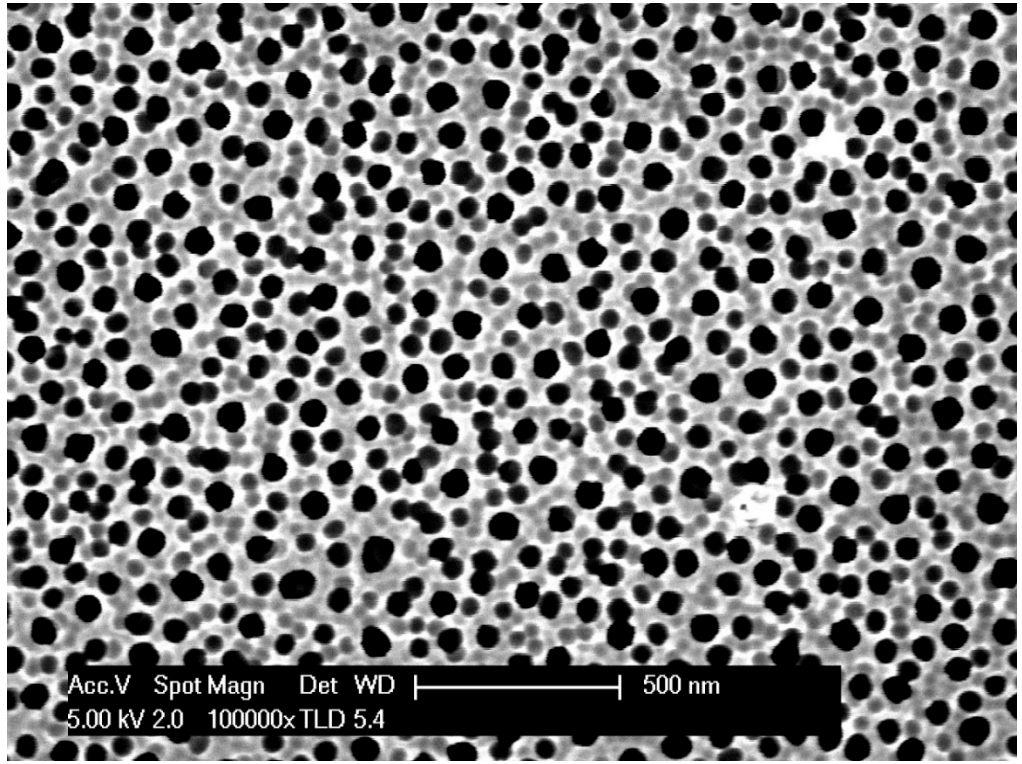
- Scribe grid test
- Mandrel bend test

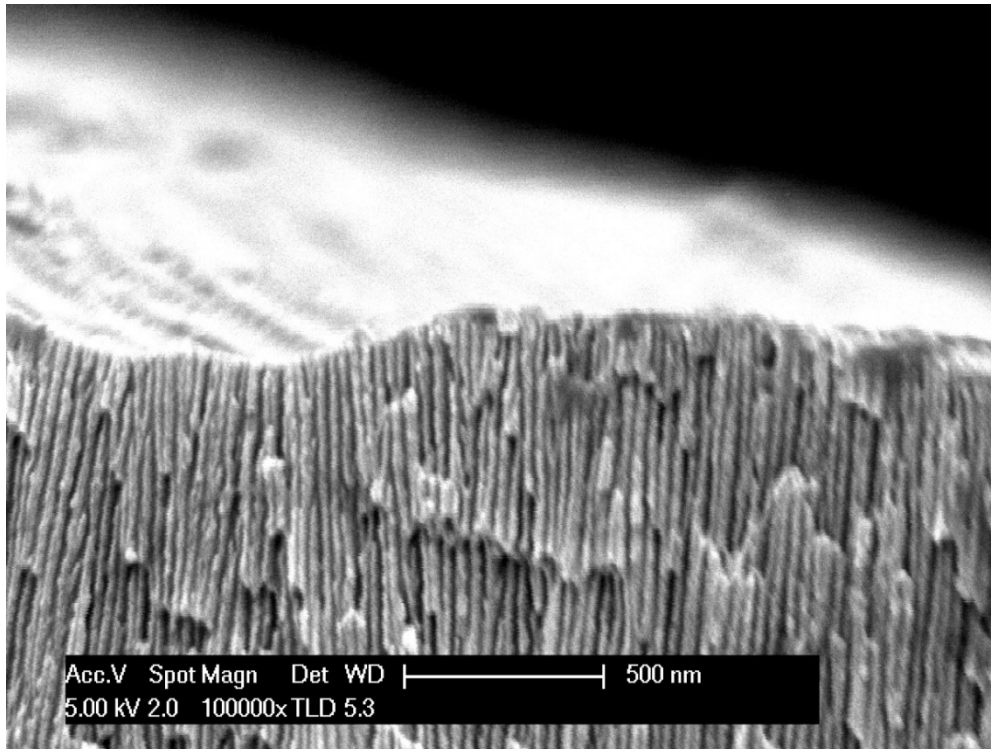
Adhesion - ASTM B571

Lightning Strike – EN2591-214

Tune-able?

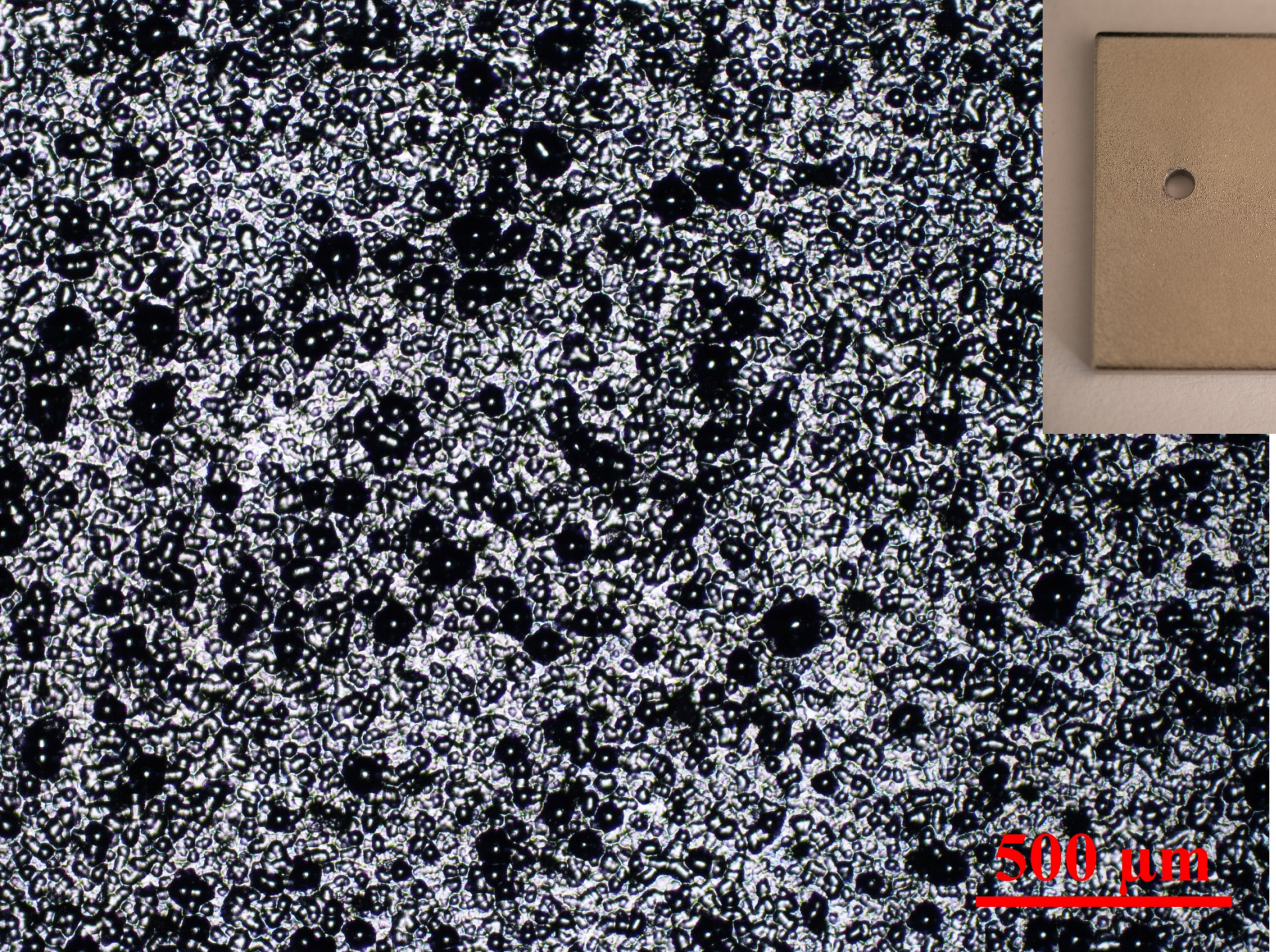

Anodisi
trodeposition
Deposition
Alloy Part
Nanotube Array
Deposit Growing
Up Nanotube
Functional Coatings


Acc.V Spot Magn Det WD 500 nm
5.00 kV 2.0 100000x TLD 5.4


Acc.V Spot Magn Det WD 500 nm
5.00 kV 2.0 100000x TLD 5.3

Hemispherical
Hybrid™ Coating

Matte Black
Hybrid™ Coating



Hemispherical
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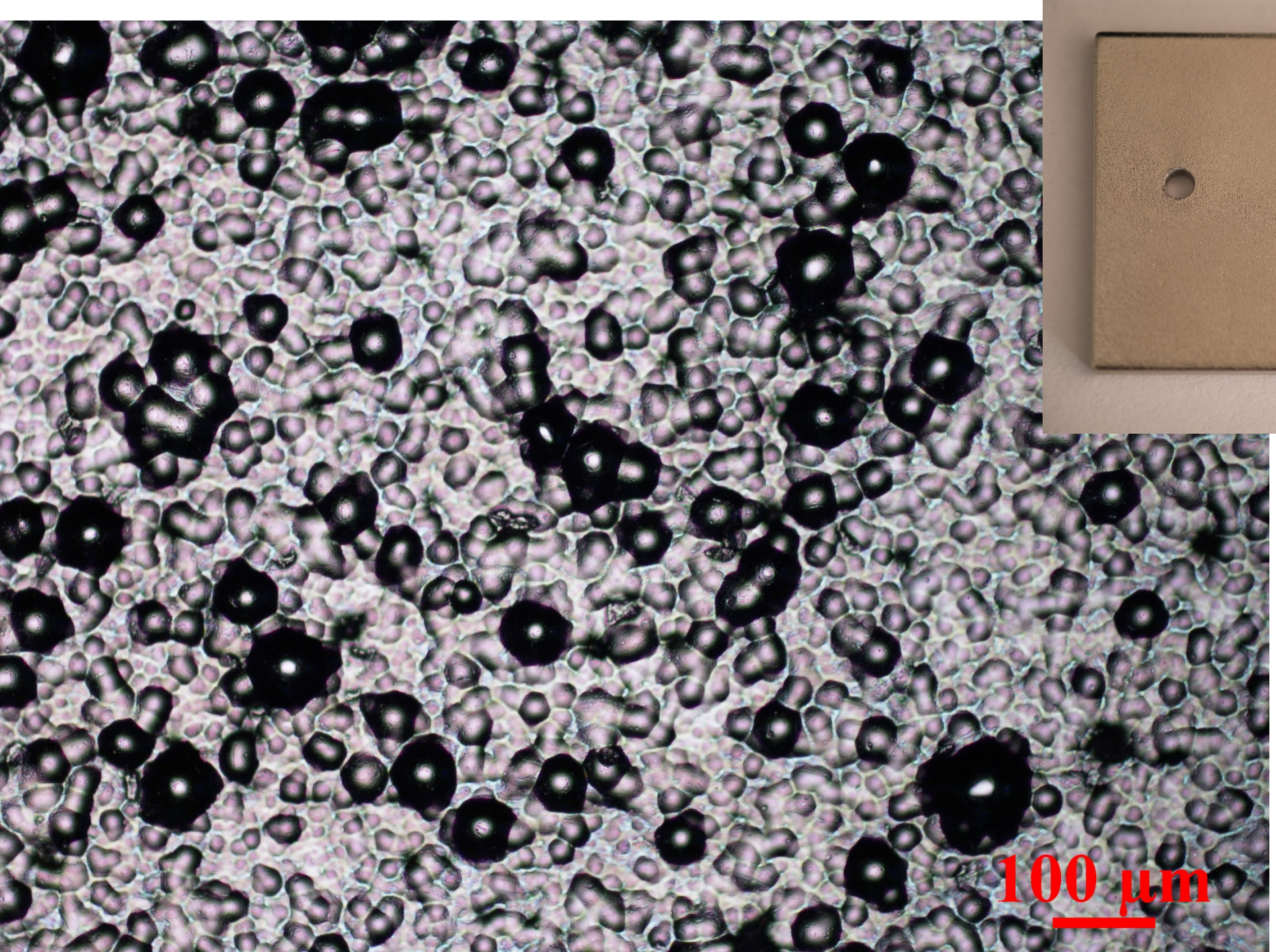

Hemispherical
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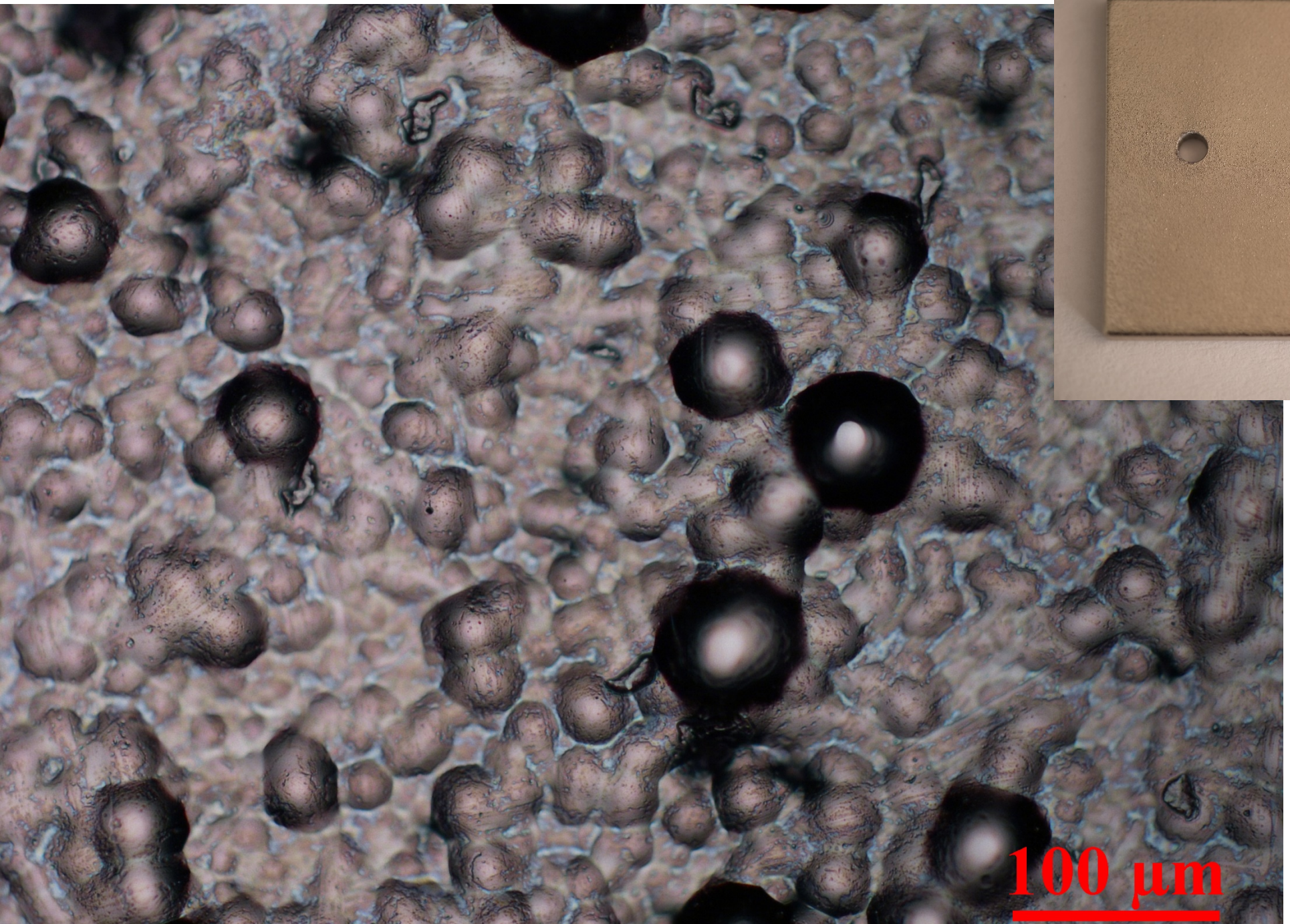

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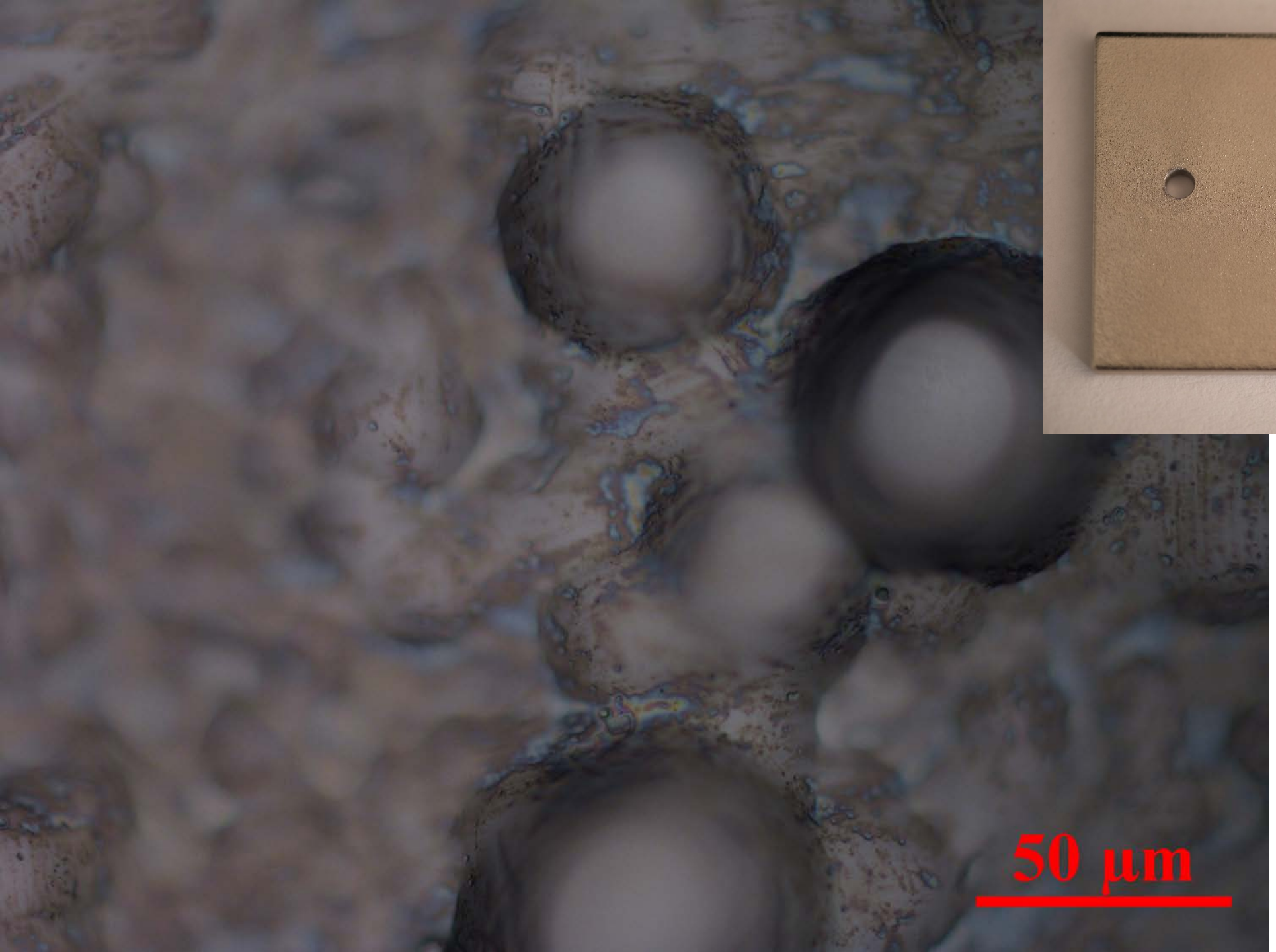

Hemispherical
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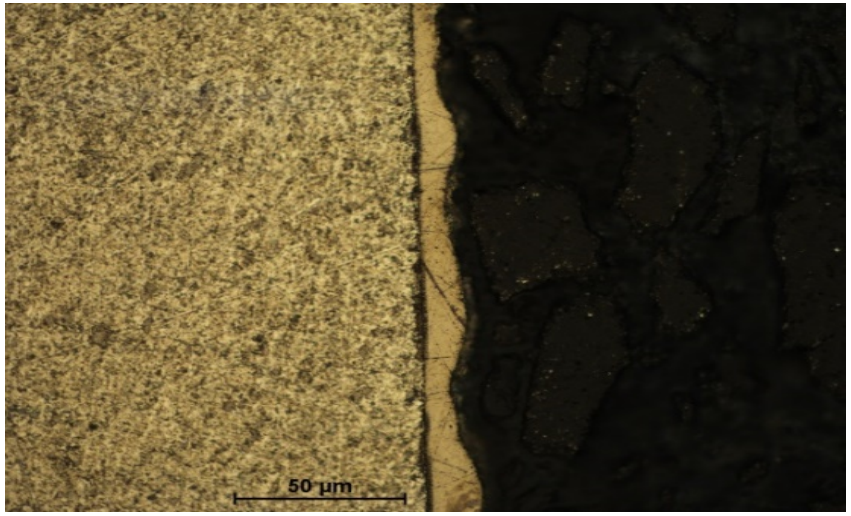
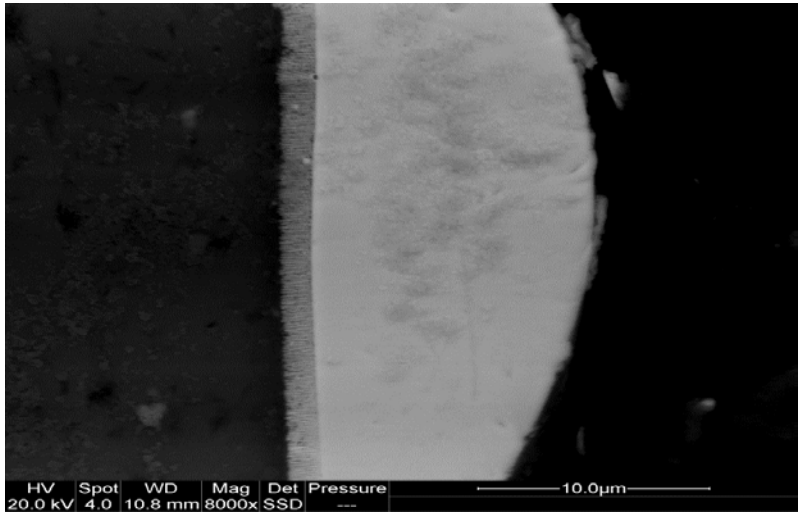
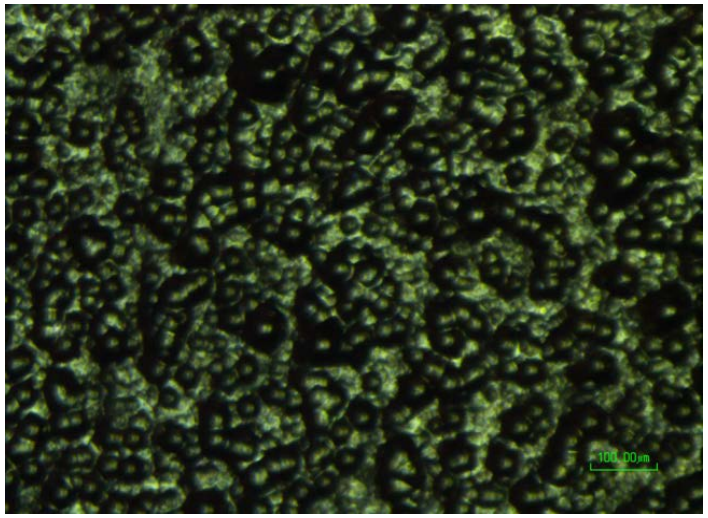
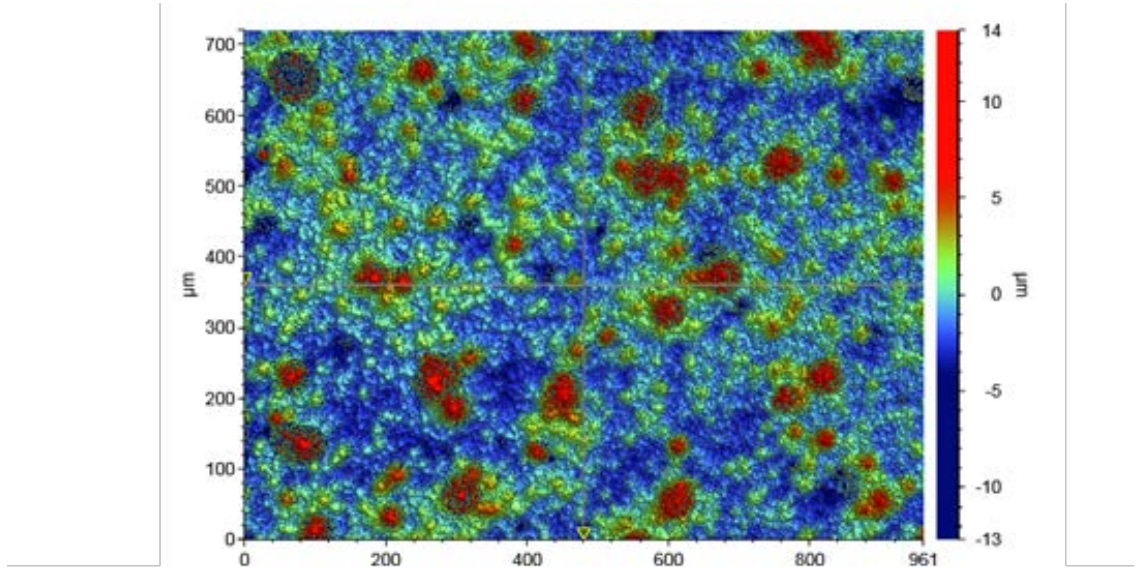
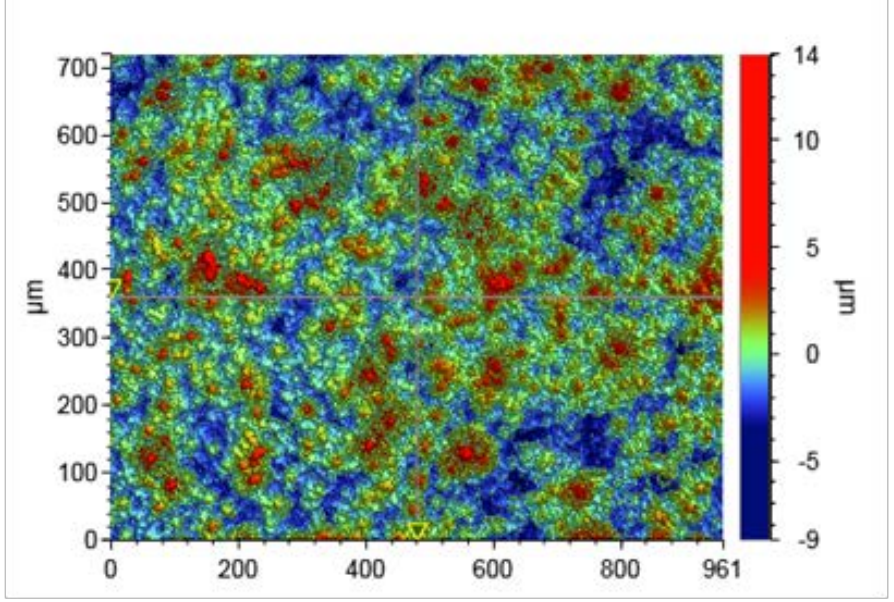


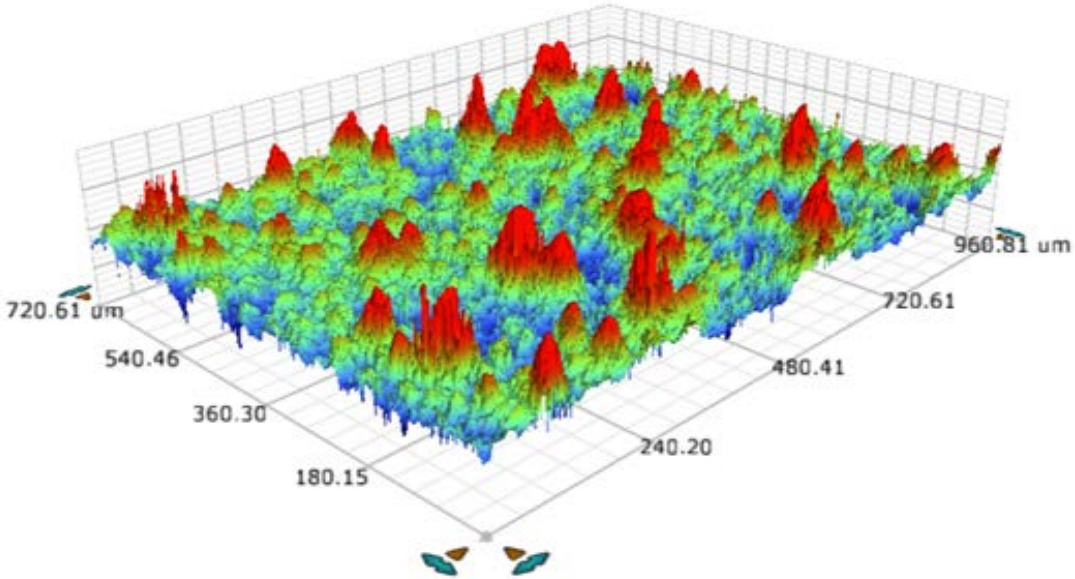


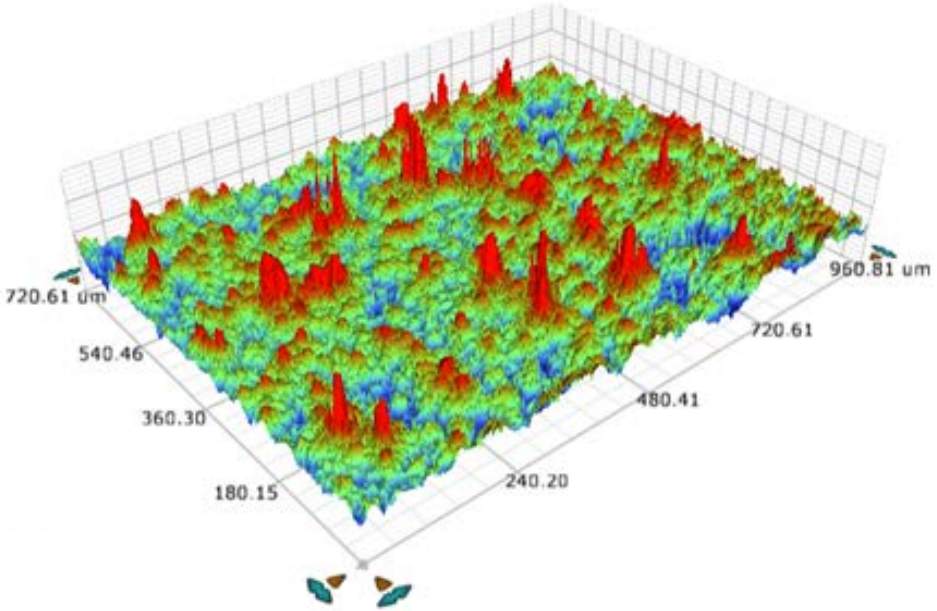


Tune-able surface morphology allows control of hydro/ice/oleo phobic properties, control UV – IR absorption, or surface aesthetics. Hemispherical Hybrid™ coatings can be made feel soft to touch.



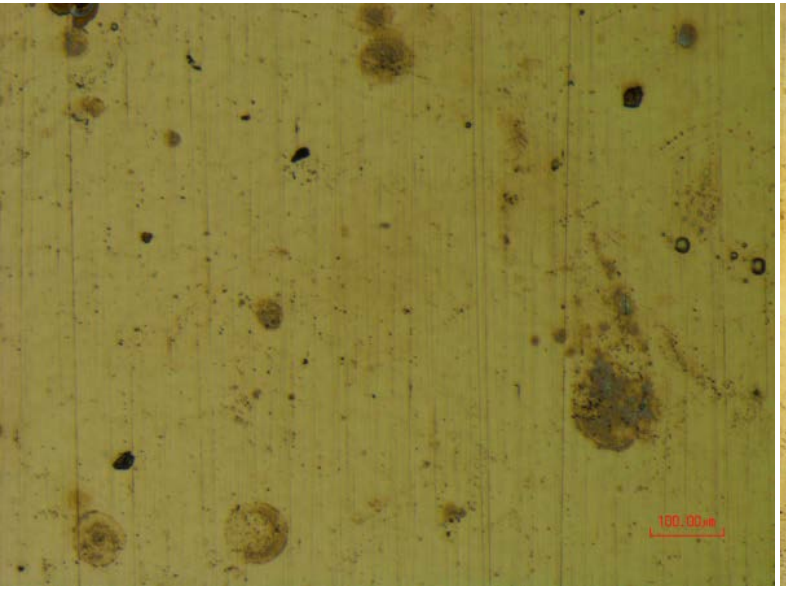


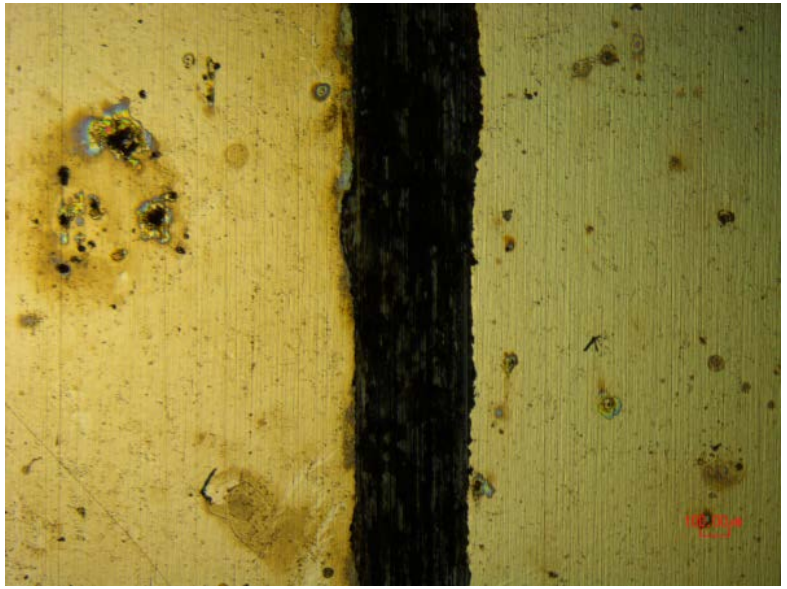


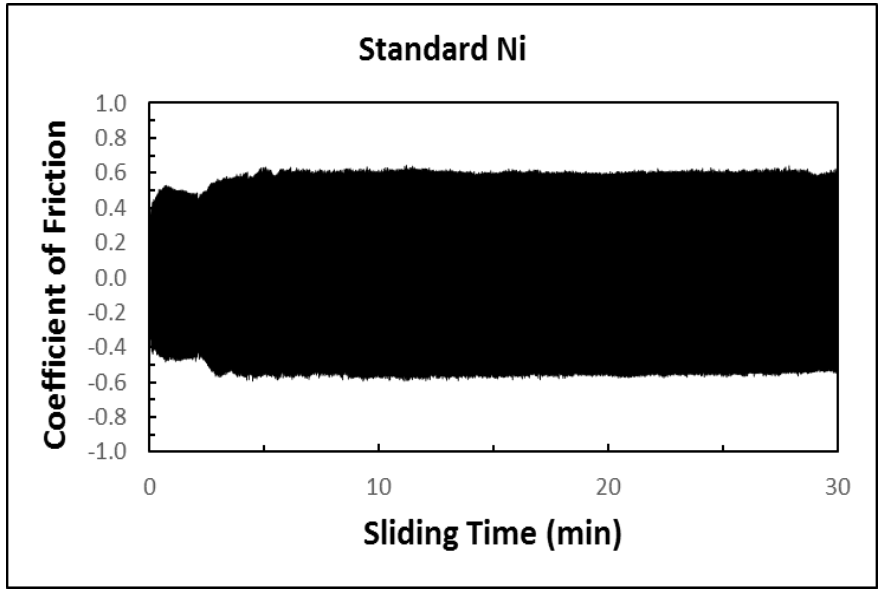


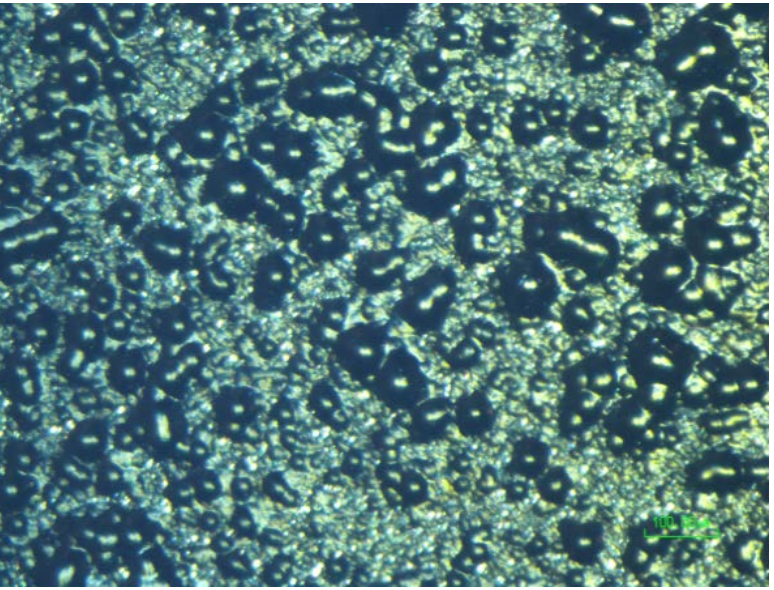
Tune-ability – 3d laser profile of surfaces prepared using different tuning parameters

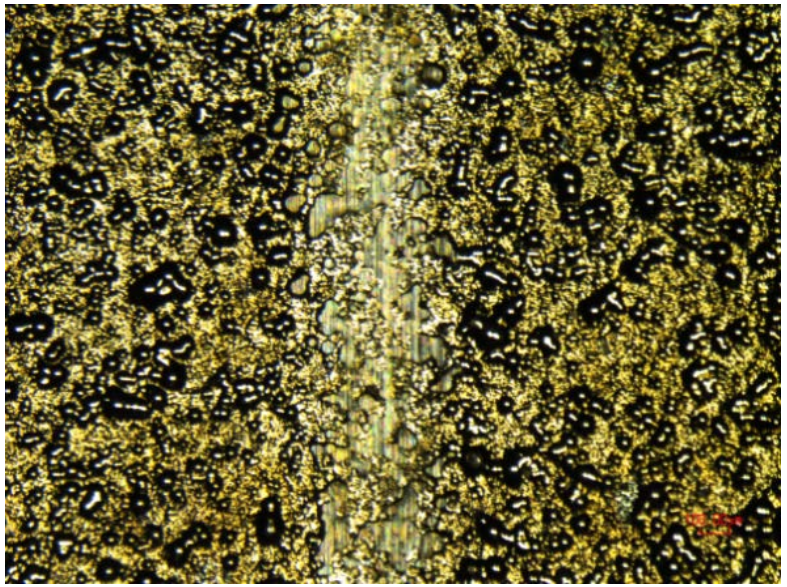
Typical Bright Nickel Coating on Aluminium

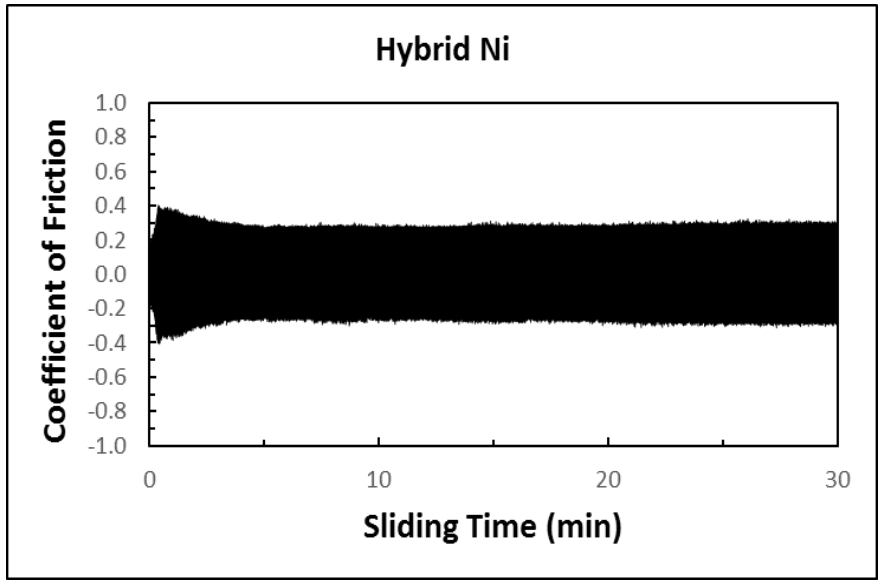




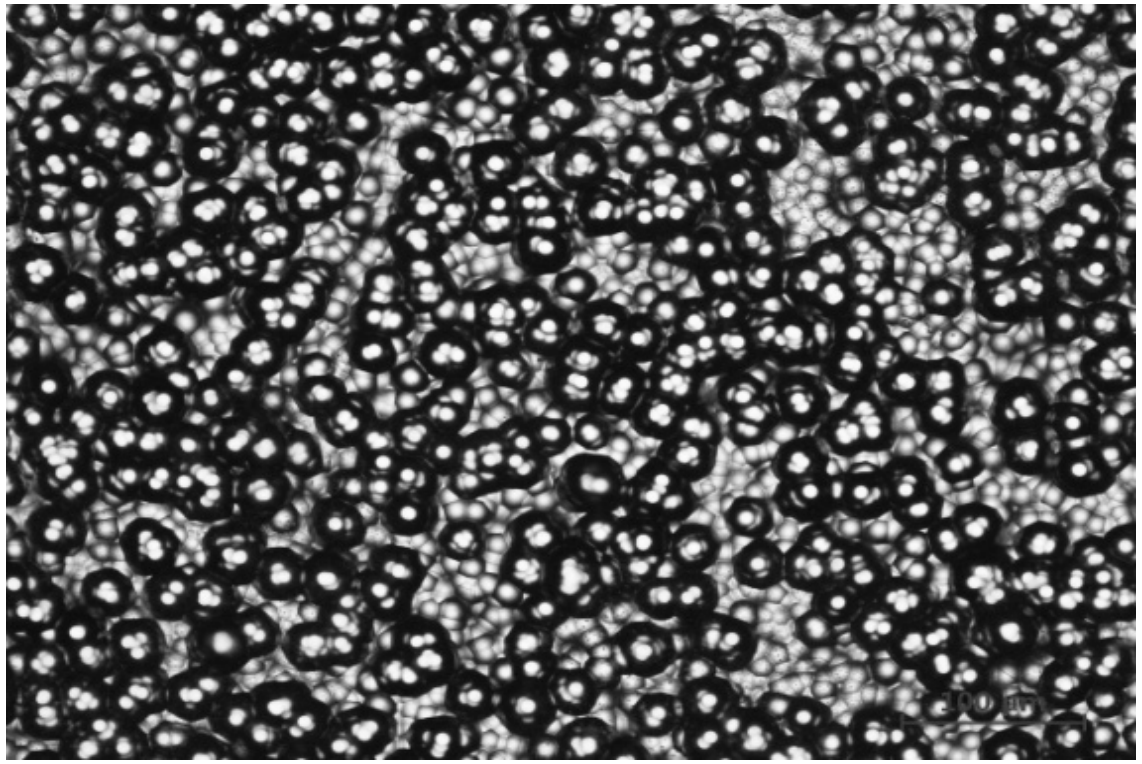






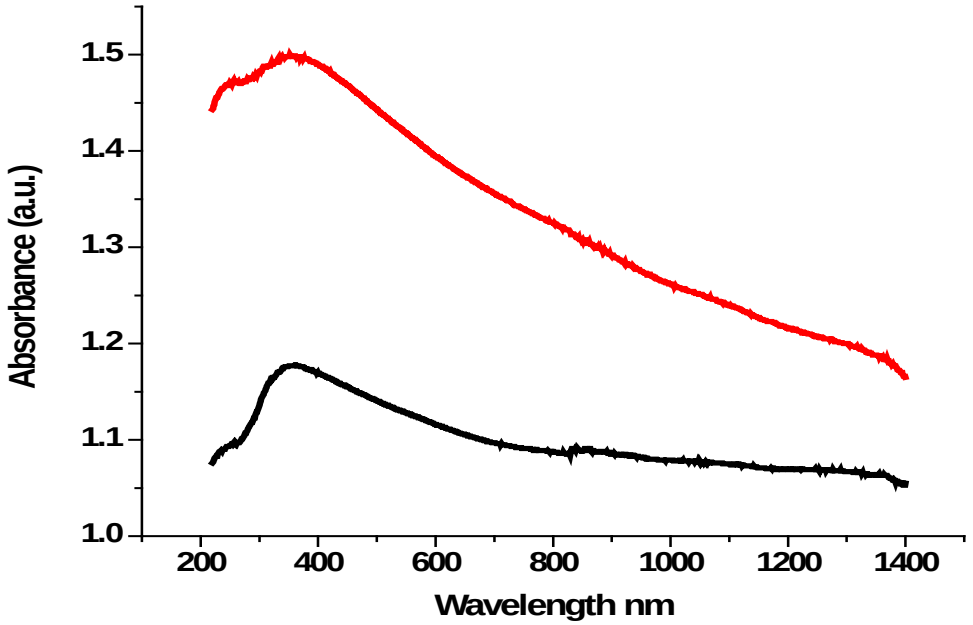


Hybrid™ Hemispherical Bright Nickel

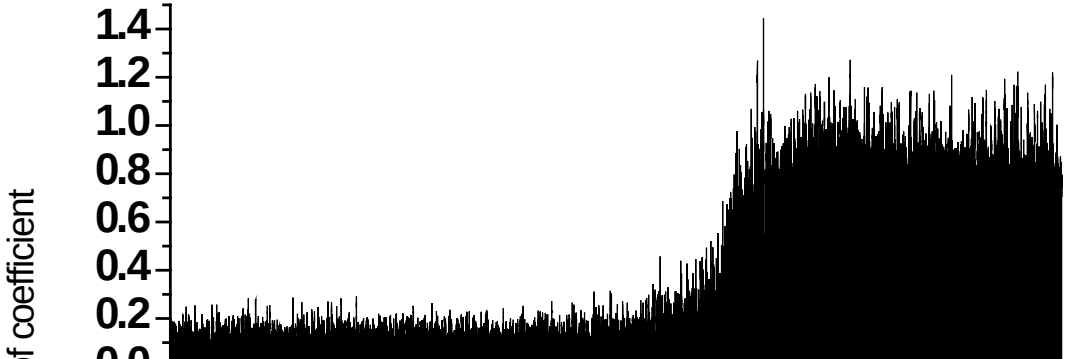


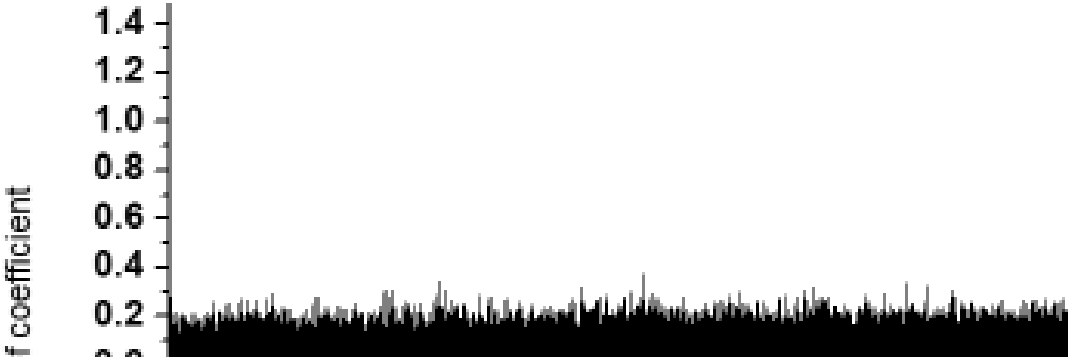
Hemispherical Hybrid™ Black Nickel Coating

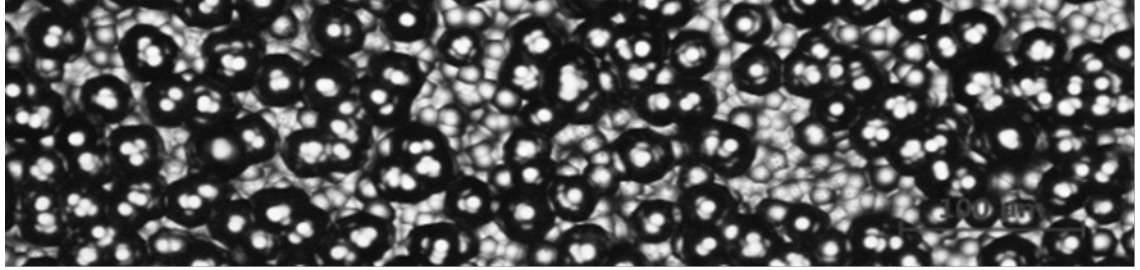
UV-Vis-infrared light absorption properties

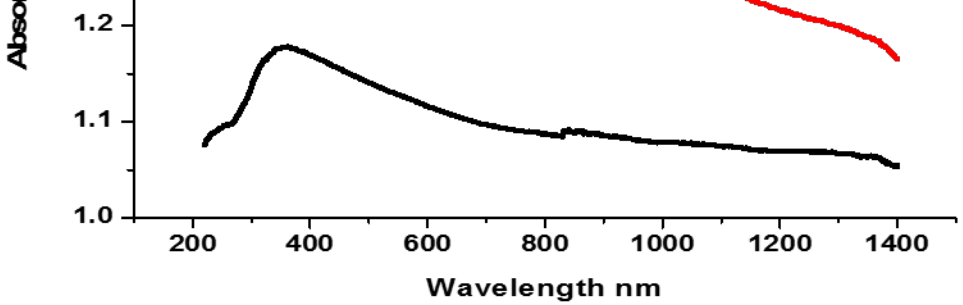


Hybrid™ Black Ni (red) versus standard Black Ni.

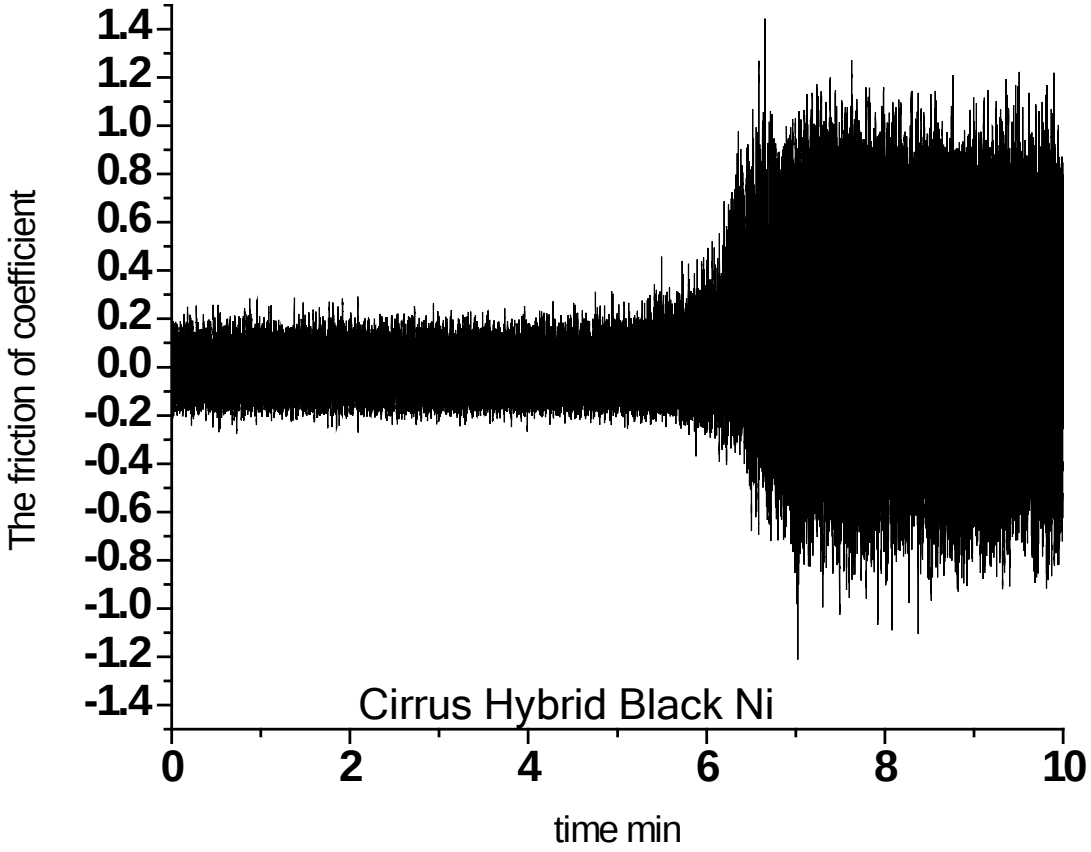


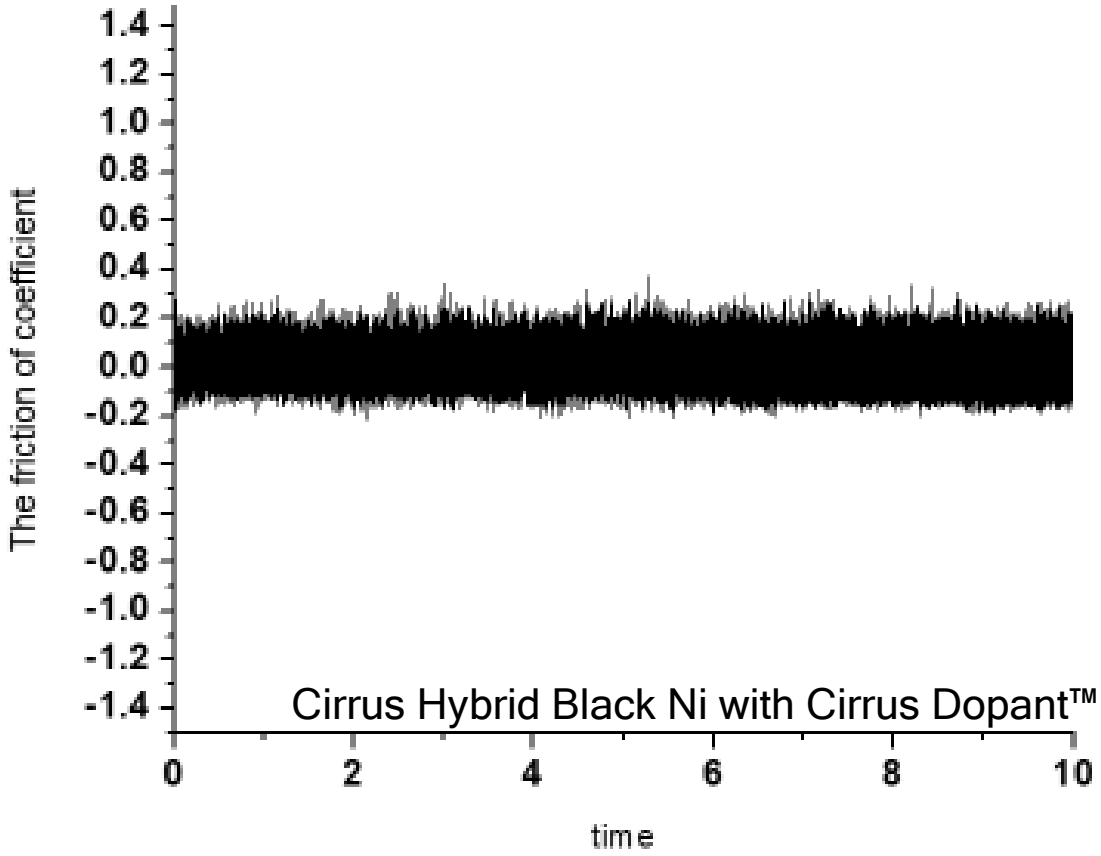




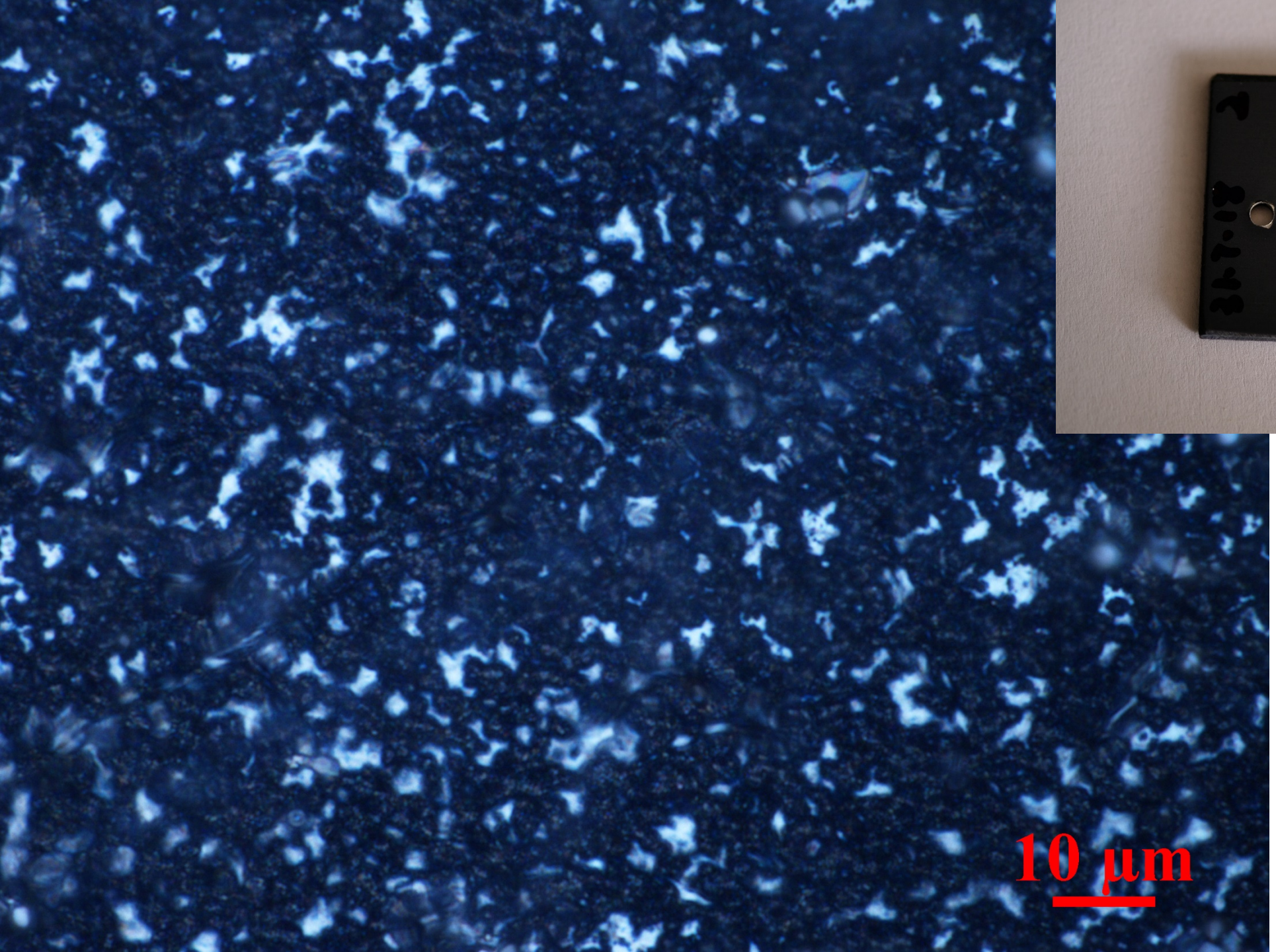


Co-efficient of Friction





Matte Black
Hybrid™ Coating



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Hybrid™ Coating

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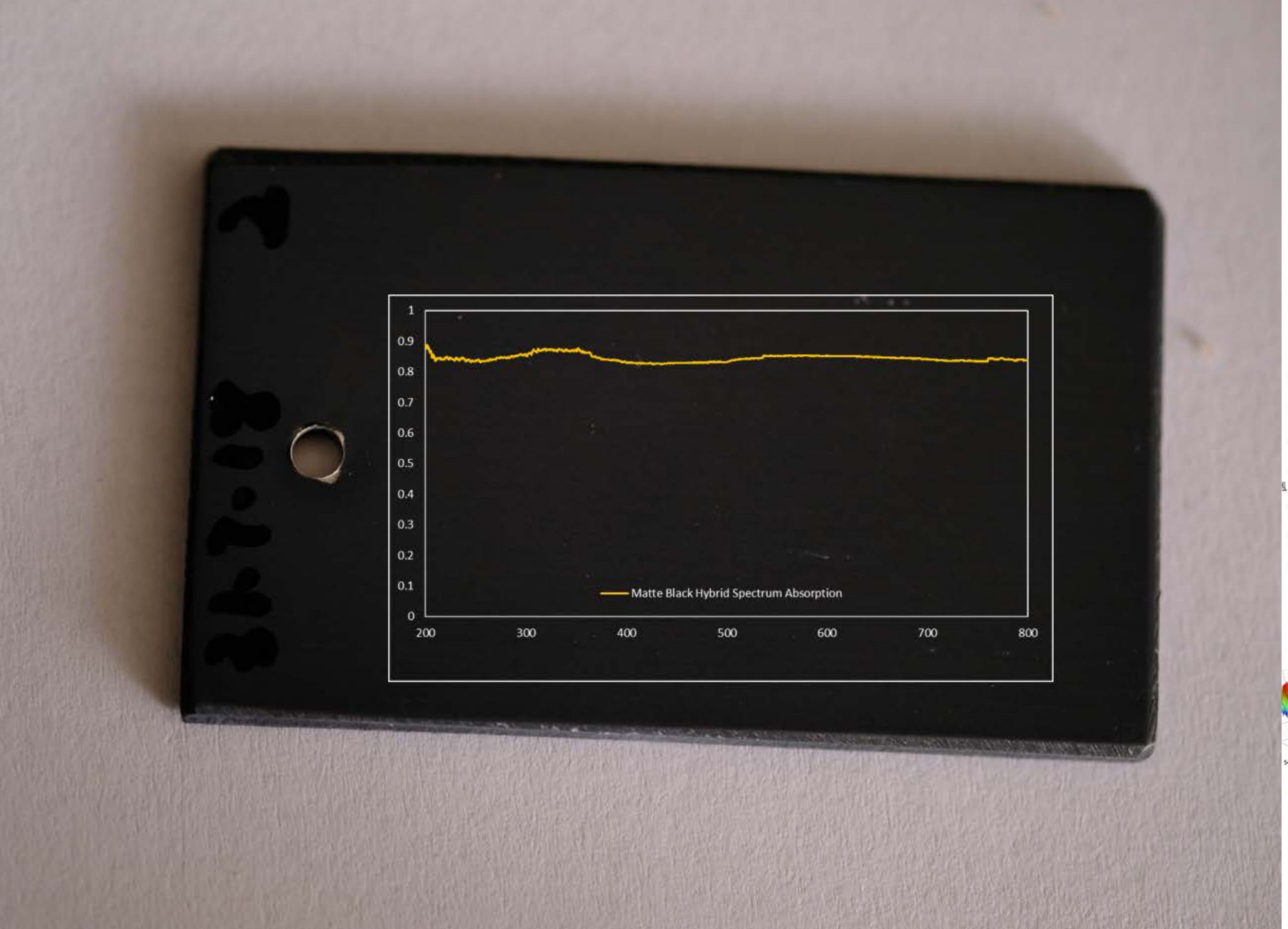
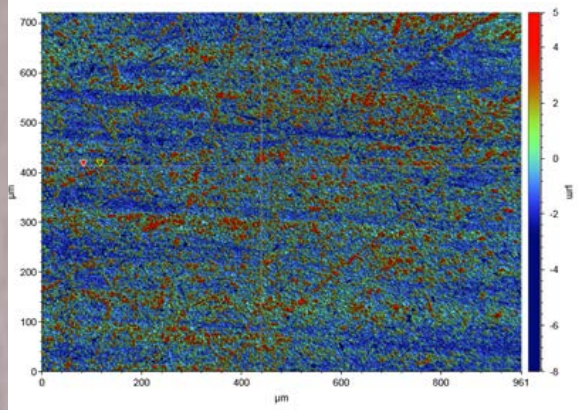
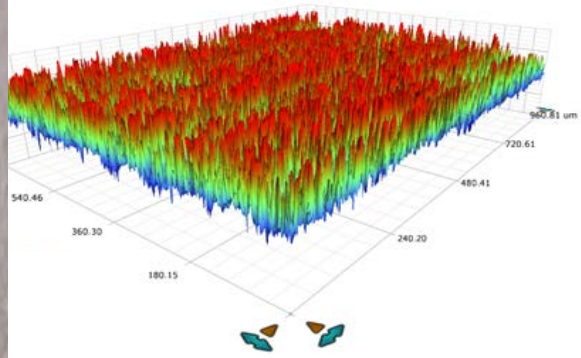


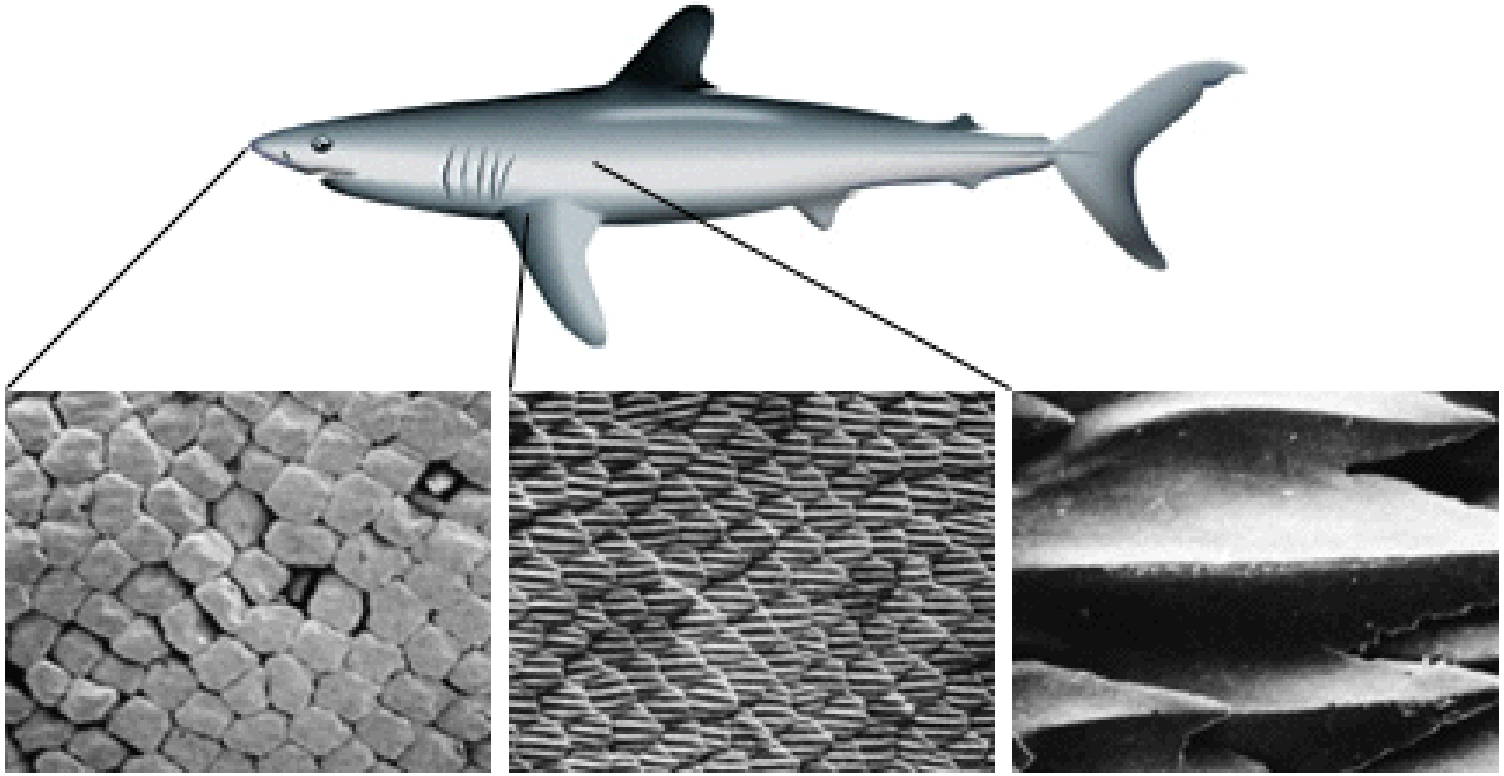




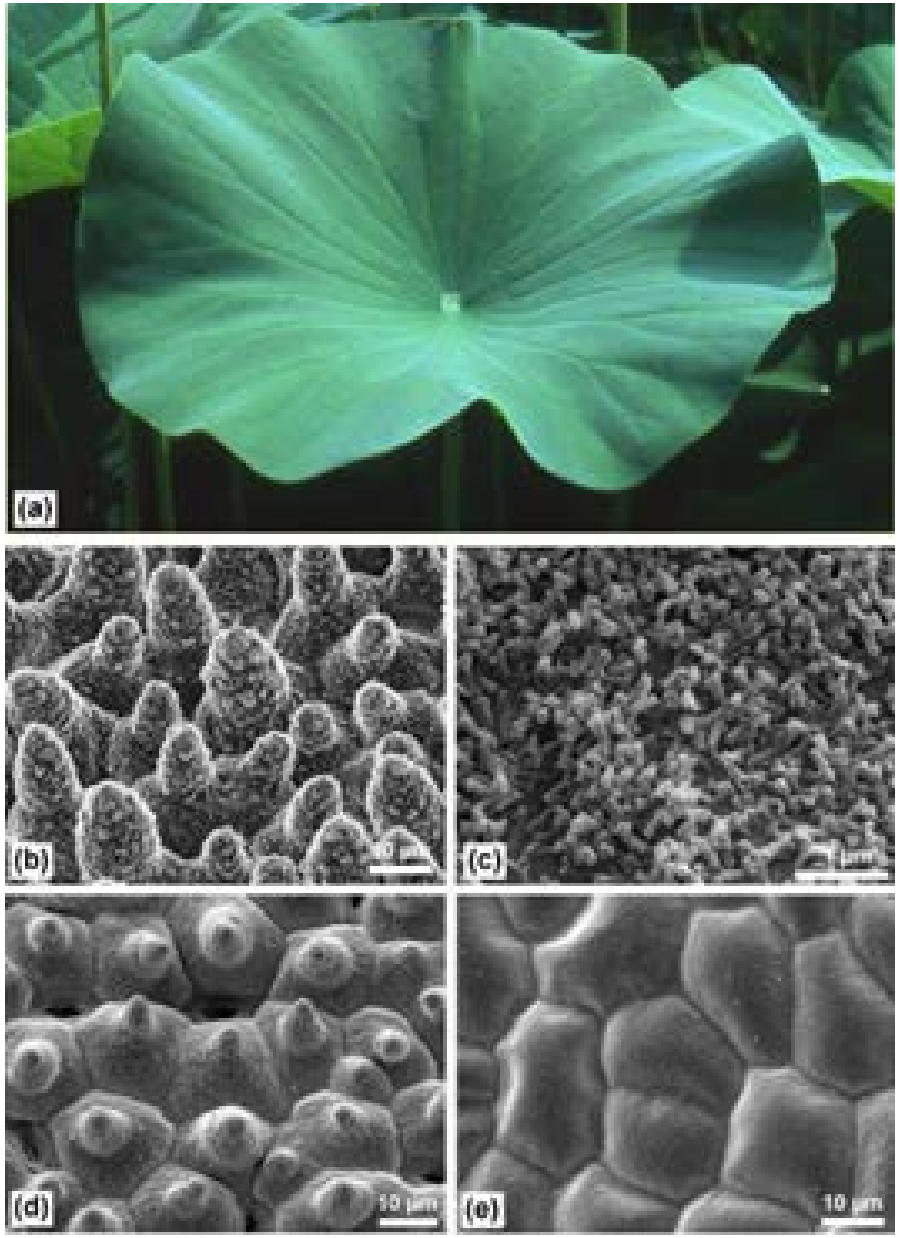
Latest Hybrid

Hybrid™ electro-deposited “Riblets” for drag reduction in air and water.

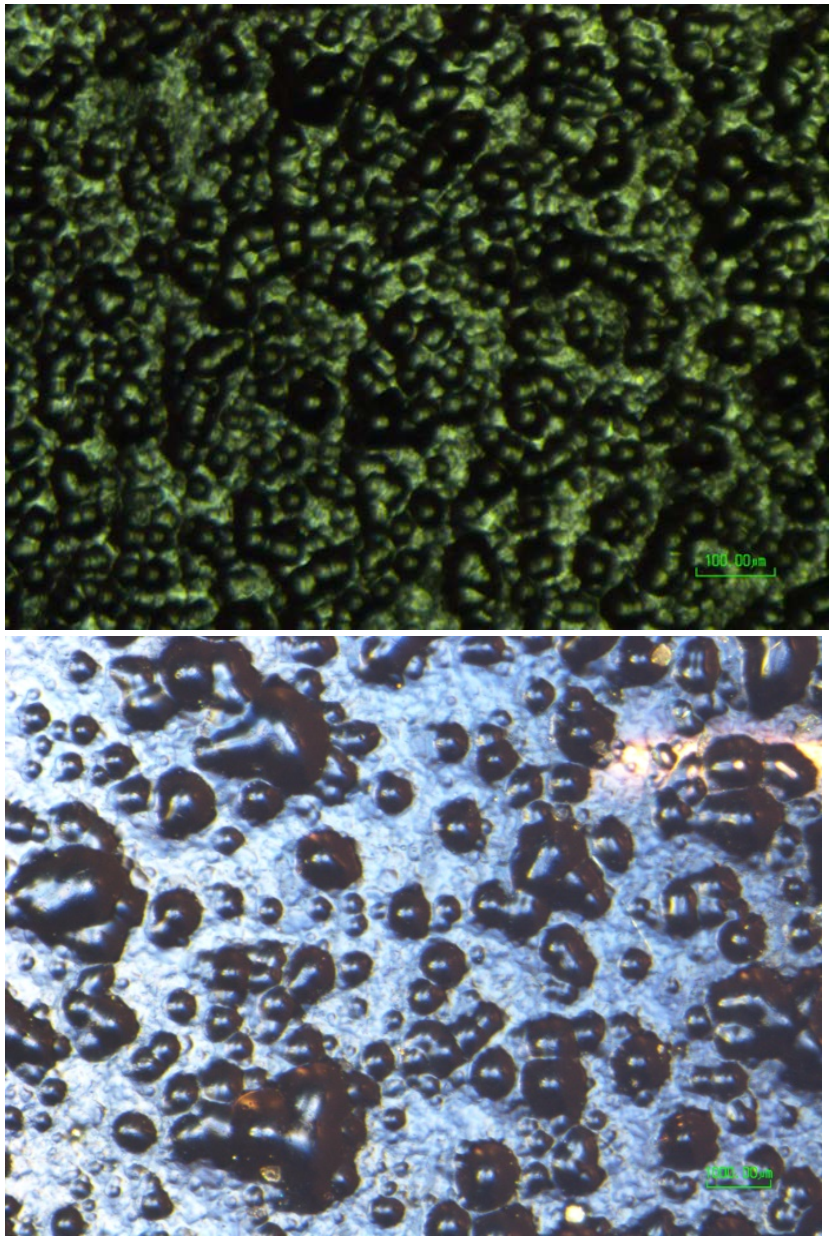
Riblet = micro-scale structures that reduce drag force across the surface.



Hydrophobic / Superhydrophobic surface drag reduction:



Similar structure and size



Riblet surfaces drag reduction:

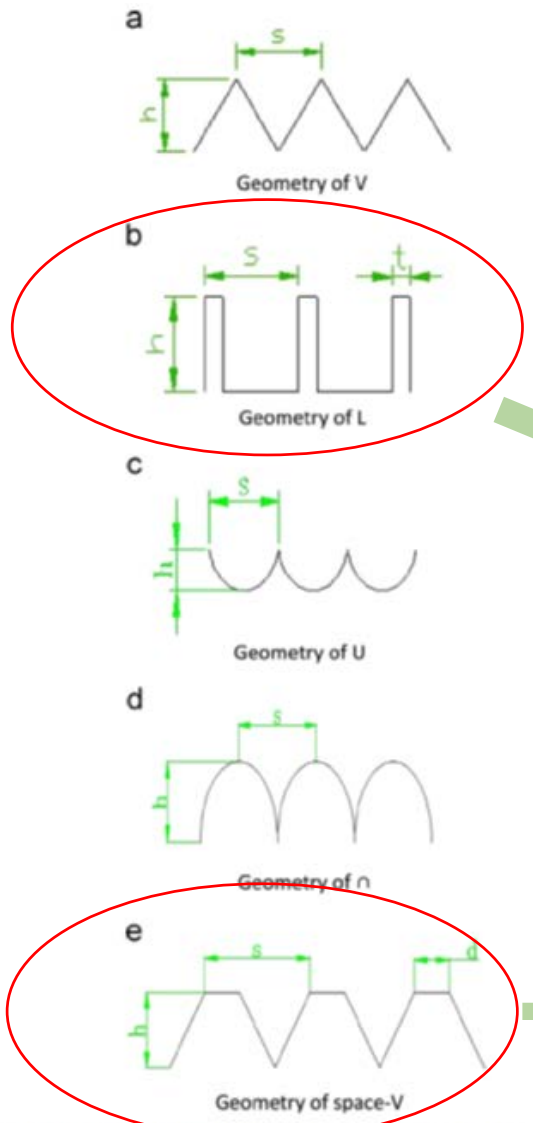


Fig. 3. Typical shark skin inspired riblet geometries that have been computational evaluated.

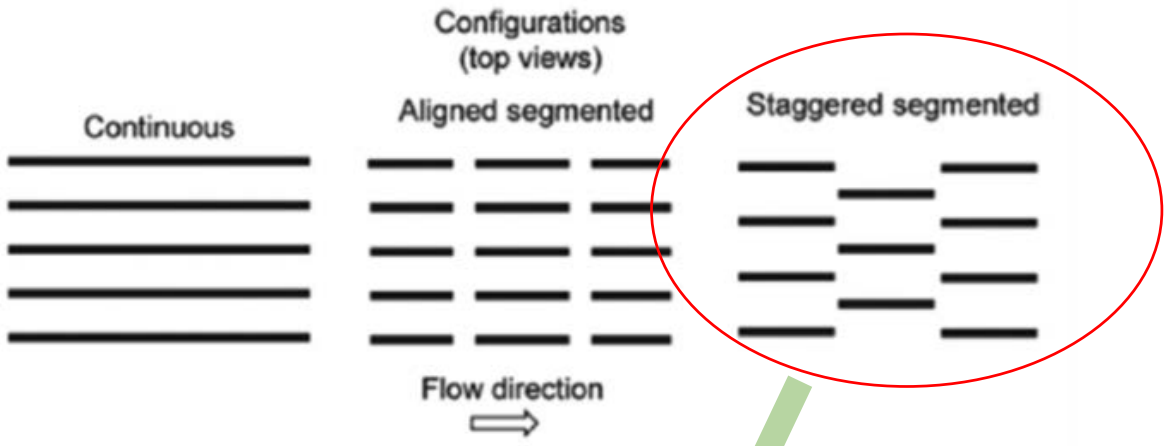
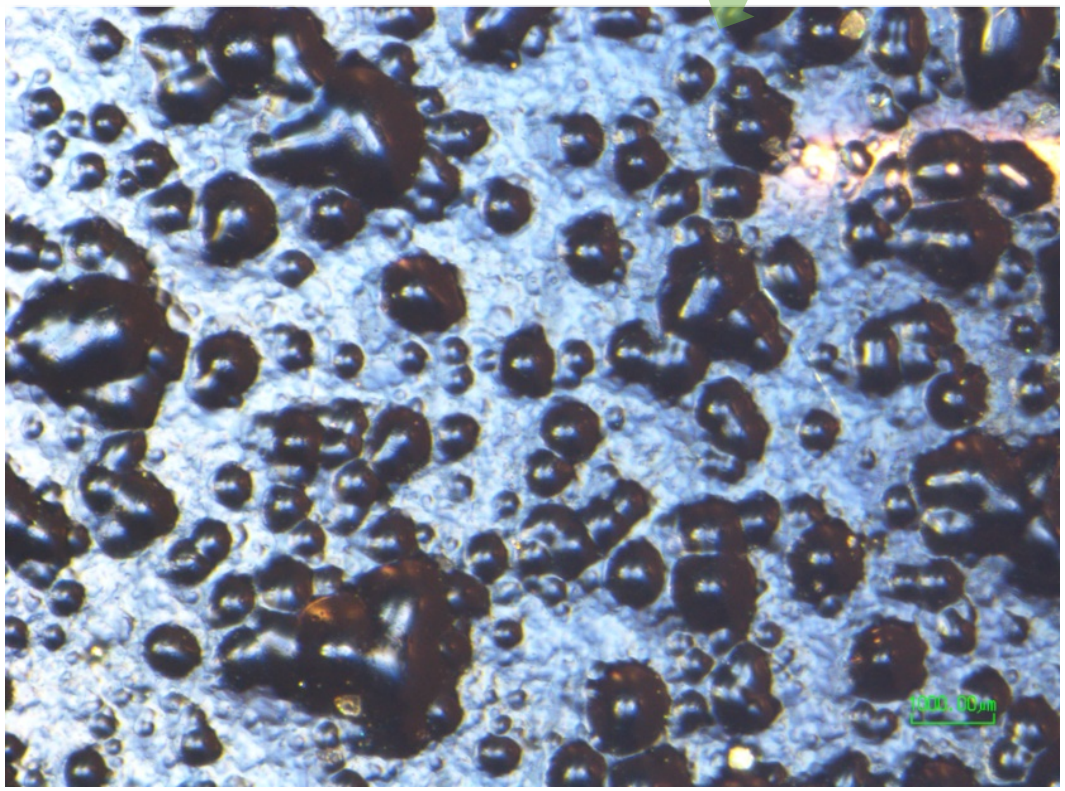
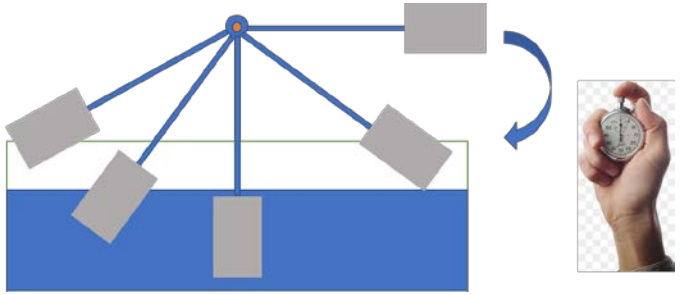


Fig. 4. Contious, aligned segmented, and staggered segmented configurations.



Initial Evaluation

- Contact Angle
- Drag Force



Hemispherical Hybrid™ Coating

Untuned Hemispherical = 5% - 7% drag force reduction (compared to flat sample).
Hybrid surface tuning is expected to improve this substantially.

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