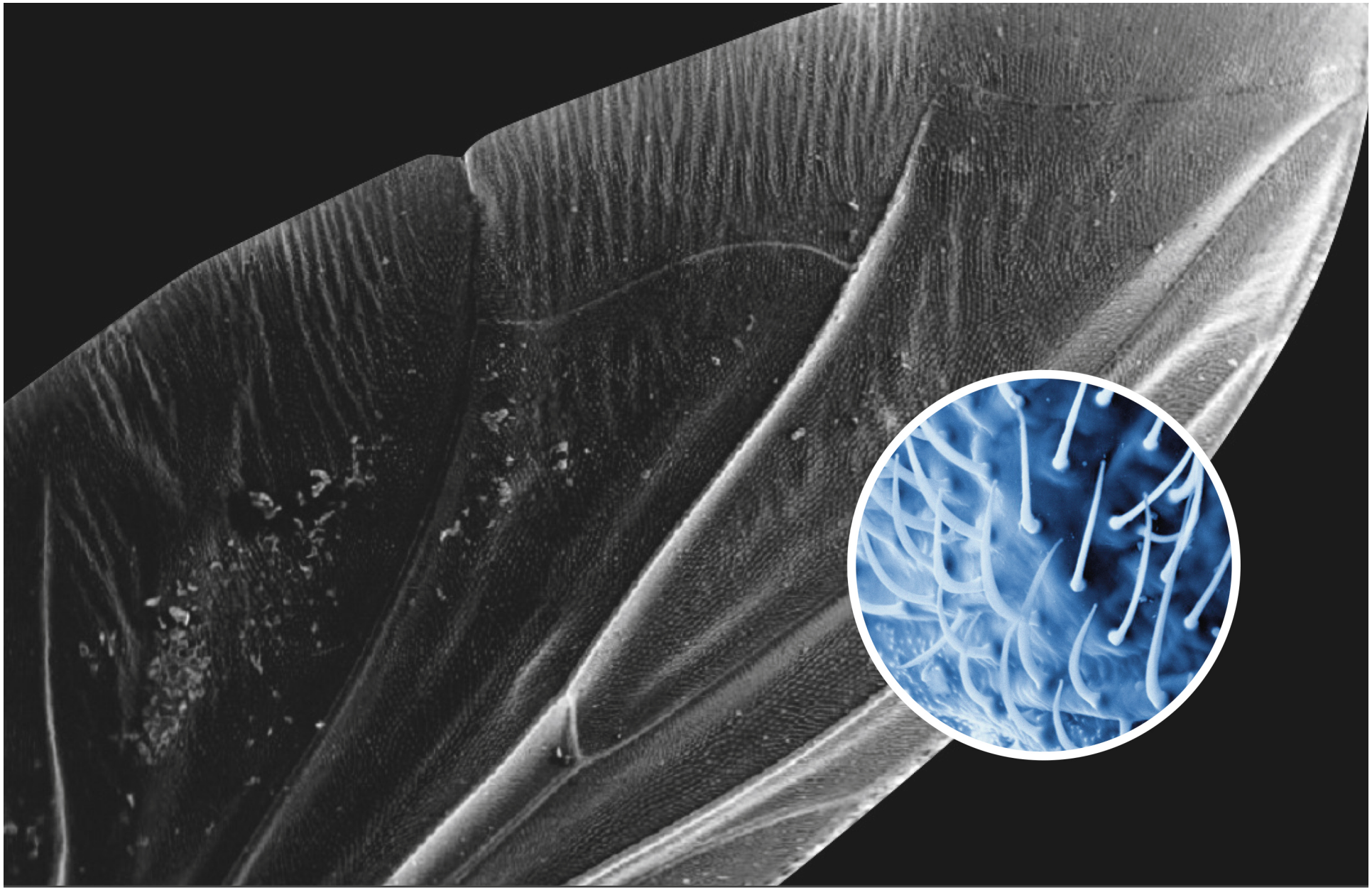

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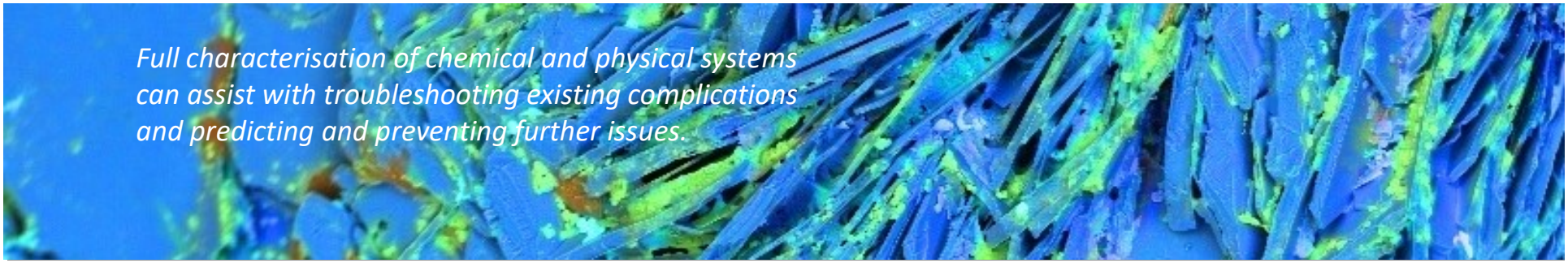
Microanalysis Australia

Microanalysis Australia is a small, specialised materials characterisation laboratory. With more than 50 years combined experience in physics, inorganic and organic chemistry and scientific consulting, our team of intelligent, educated and motivated scientists utilise an extensive range of high-tech analytical equipment to provide you with answers to complex questions quickly and efficiently.



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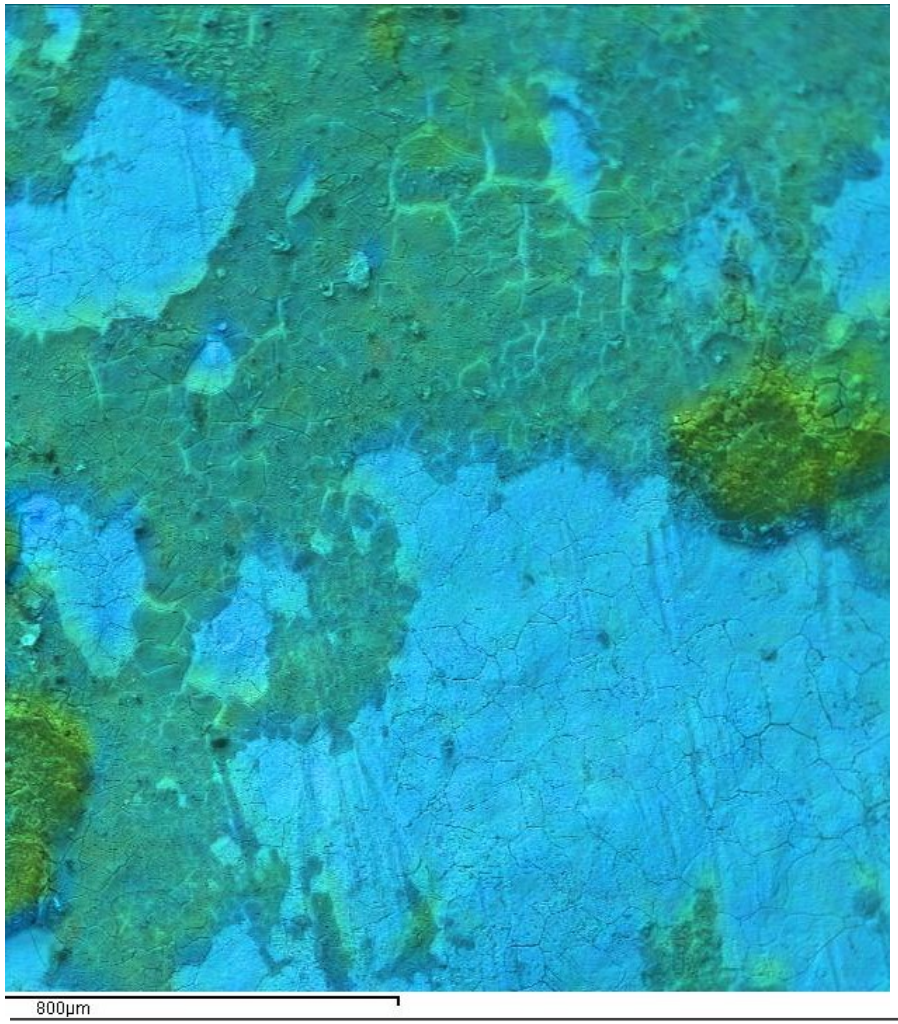

Unique Capabilities

- Characterisation and quantitation of homogeneous mixtures
- Particle size and morphology including aspect ratio and sphericity
- Surface properties of microfabricated and supported catalysts including porosity, texture, etc
- Characterisation of processes including
- Elemental and phase mapping to show reaction sites, compositional variation or contamination on surfaces
- Verification of specifications
- Identification of unknowns
- Solubility testing in a wide range of environments

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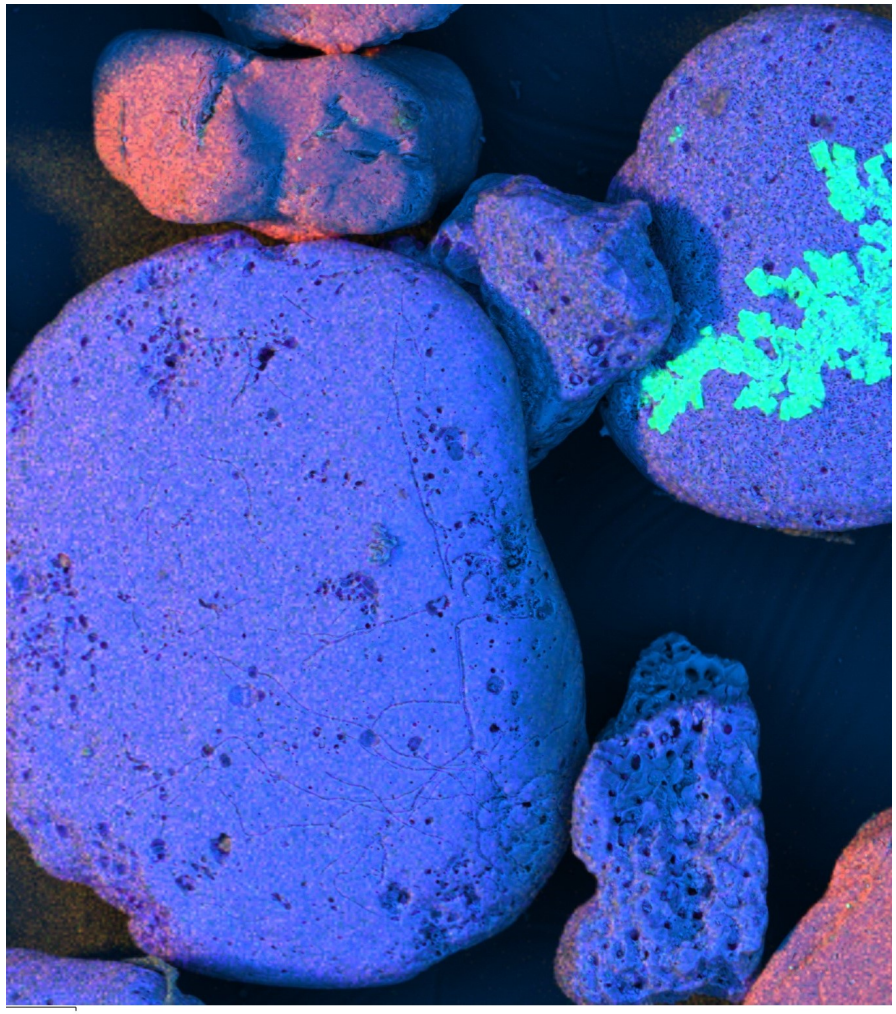
Innovative Solutions

Taking analytical results and interpreting them into useful information allows Microanalysis to provide innovative solutions to system and component failures, legal proceeding, process, fabrication, operating and condition monitoring system issues.



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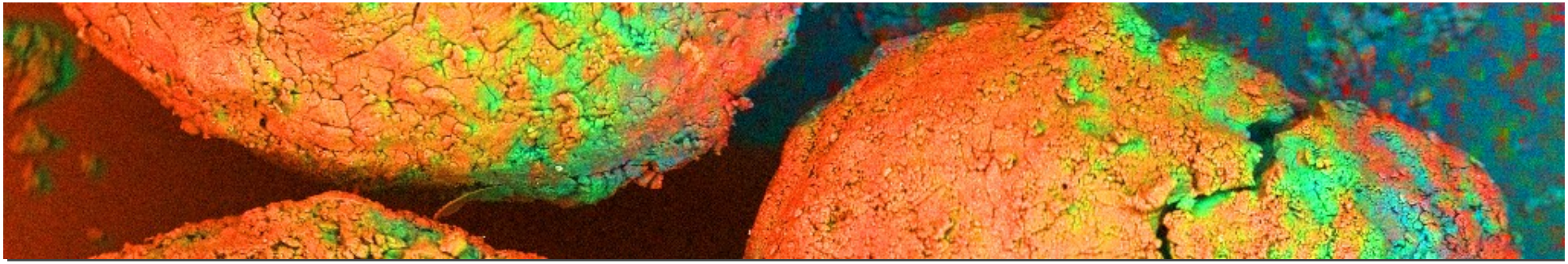
Scanning Electron Microscopy

One of our main tools for corrosion analysis, Scanning Electron Microscopy (SEM) with Energy Dispersive X-ray Spectroscopy (EDS) provides a high magnification look at the corrosion product, sites and associations and allows us to combine imagery with precise elemental composition to build a complete picture.



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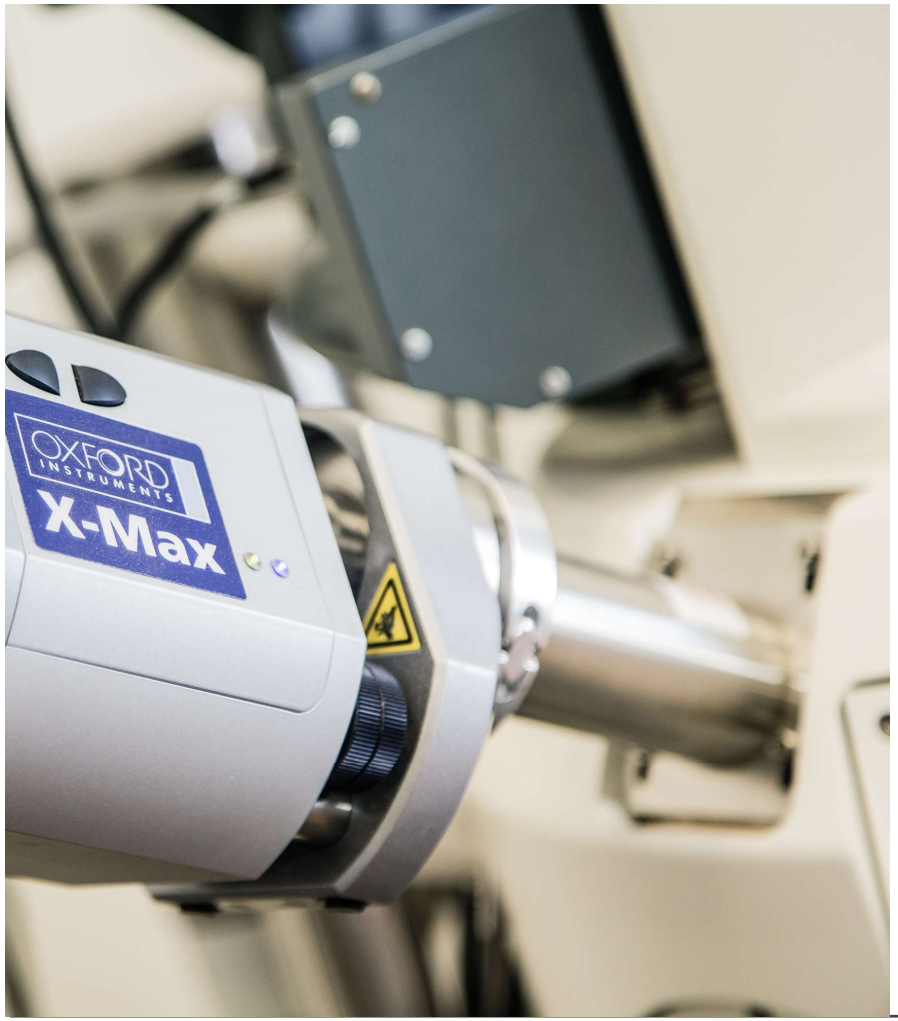

Technique

- High resolution imaging with easily visible contrast between different elemental compositions
- In suitable samples, we can use polished sections to identify whether corrosion initiation sites are at grain boundaries, material interfaces, near inclusions or intragranular
- Identify microbially induced corrosion
- Differentiate between natural oxides and corrosion products in contaminant materials
- Corrosion mechanisms in simulated circumstances (galvanic cells, corrosion product, pit shape)

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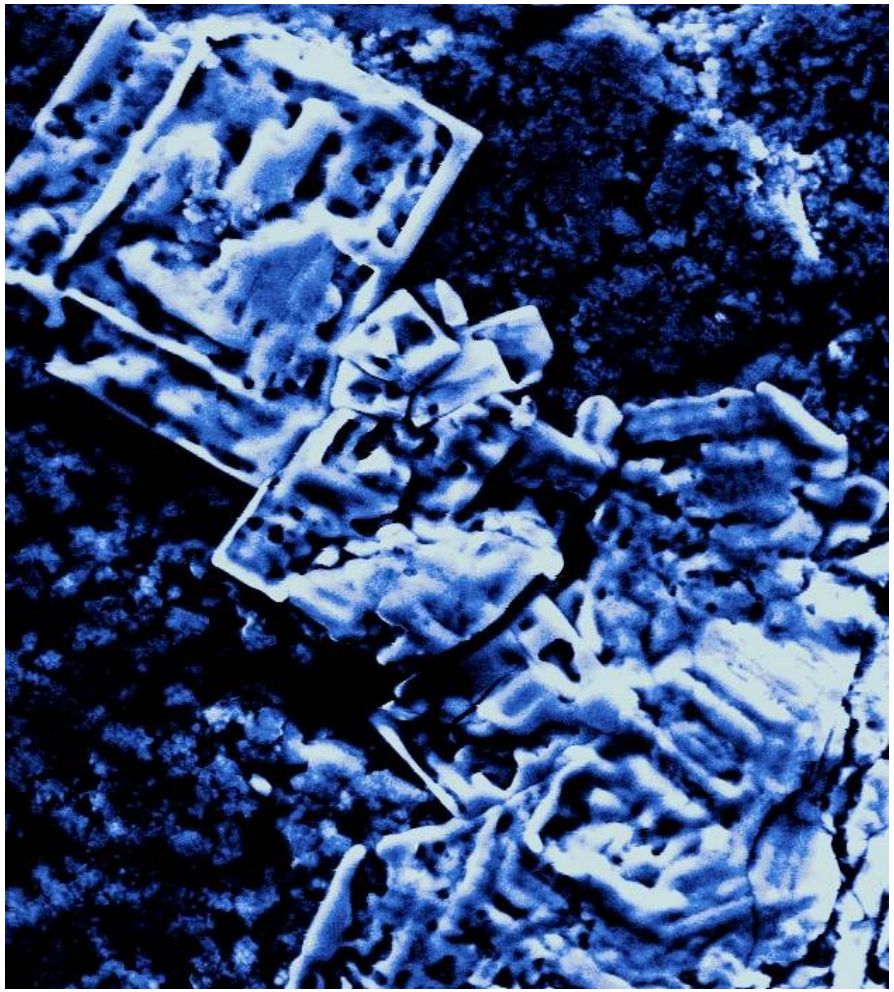


Root cause analysis

- Investigation – requires understanding of the relevant system
- Characterisation of initial materials
- Examination of environment
- Investigation into process
- Determination of actual or potential failure point
- Conclusion or resolution

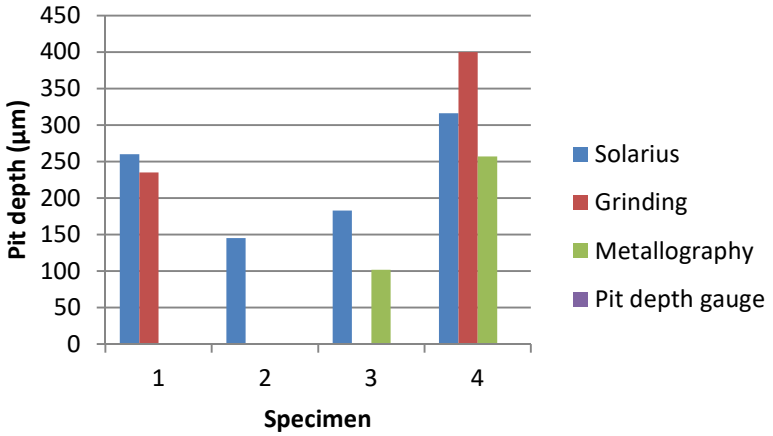
Pit depth analysis

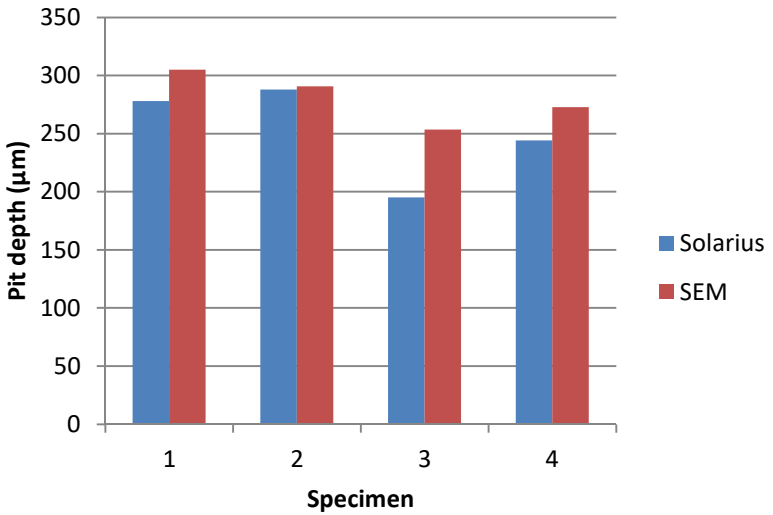
- Traditional techniques
  - Pit depth gauge
  - Grinding
  - Metallographical (sectioning and optical)

Insufficient resolution for narrow pits or destructive testing. Can bias results. Operator interpretation.

- Alternate techniques
  - SEM
  - Solarius

Less subjectivity, more consistent results. Non-destructive (for small samples).





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Complementary Analyses

- Particle counting
  - Condition monitoring
  - Failure prediction
  - Filtration and SEM
- XRD
  - Differentiate oxides and carbonates
  - Determine structure/compounds
- Laser profilometry
  - Determine topography
  - Pit depth analysis
  - Extent of pitting/corrosion on a surface
  - Wear patterns/cracking

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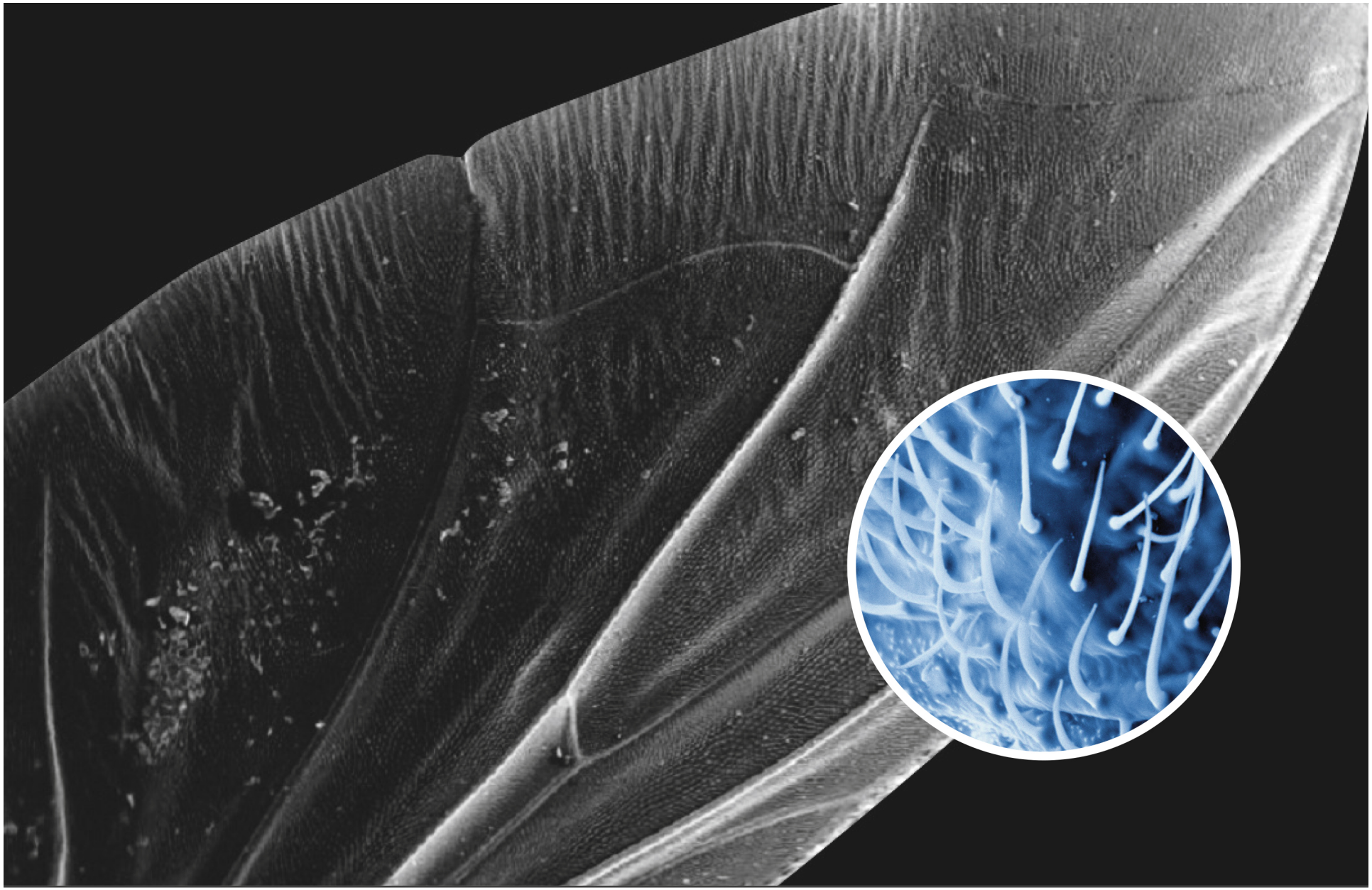

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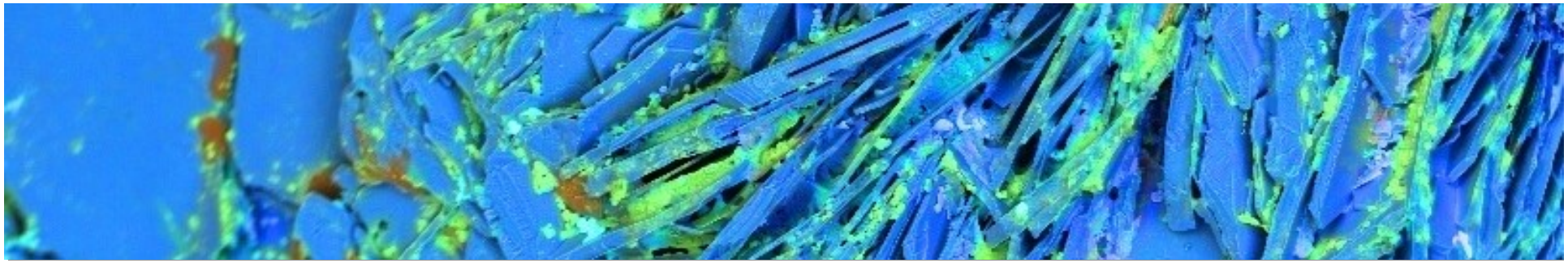
Corrosion Testing

We currently perform 3 corrosion tests:

- The C1 test
- The Modified C1 test
- The DIN test



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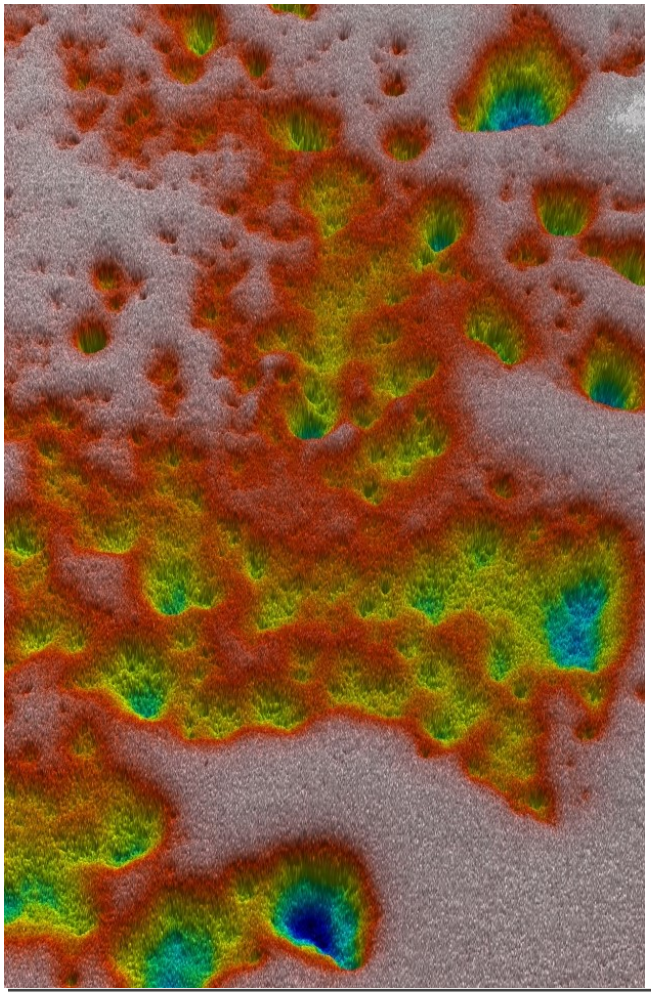
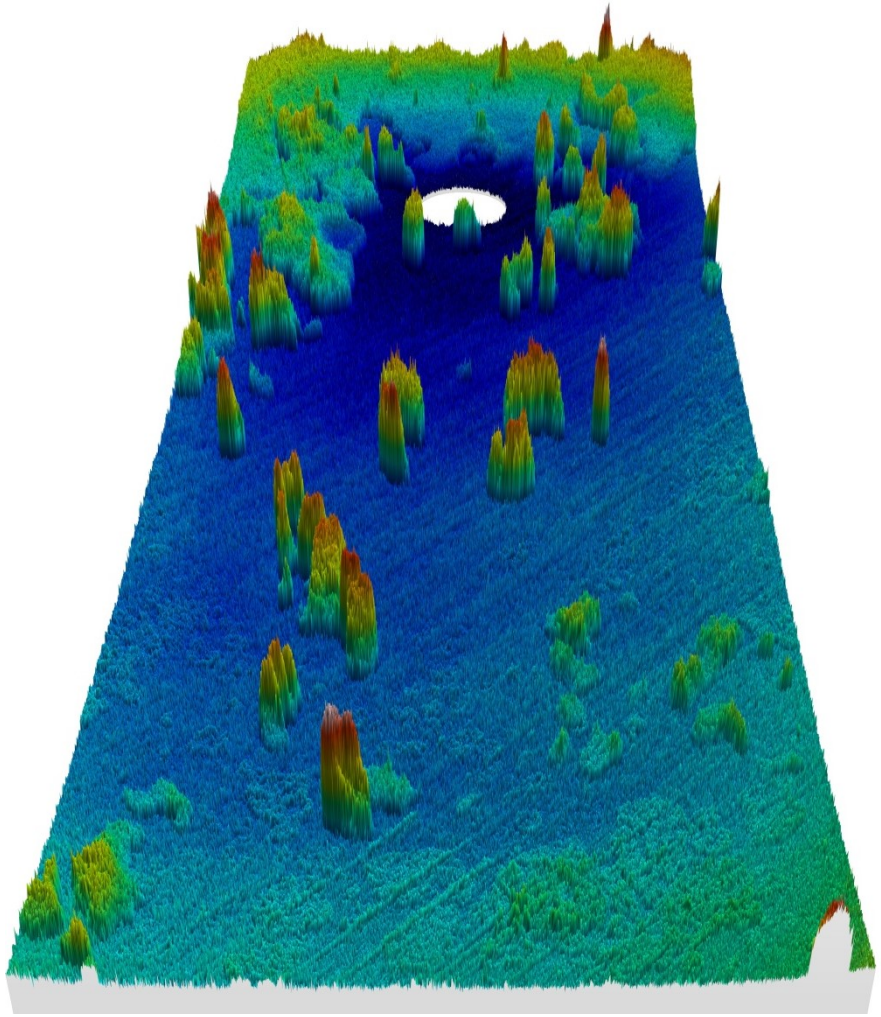


C1 Test

- Designed for liquid samples
- Subjects aluminium and steel coupons to sample material for periods of 7, 14, 21 or 28 days
- Sample is made up to 10 wt.% moisture or tested as received, whichever is greater
- Metal coupons are prepared for test by hand polishing
- Aluminium and steel coupons are tested in separate vessels with one coupon fully submerged in sample, one half submerged and one wholly in the air suspended above the sample
- Coupons are tested for mass loss (general corrosion) and intrusion depth (local corrosion)
- Sample is said to fail if either general or local corrosion threshold is exceeded

Modified C1 Test

- C1 test modified for bulk sample testing
- Specific guidelines for tamping of solid samples is provided
- Minimum air to sample volume ratio is specified
- Vessel is to be sealed completely to simulate oxygen deprivation of cargo holds
- Pass/fail criteria are as described by C1 method



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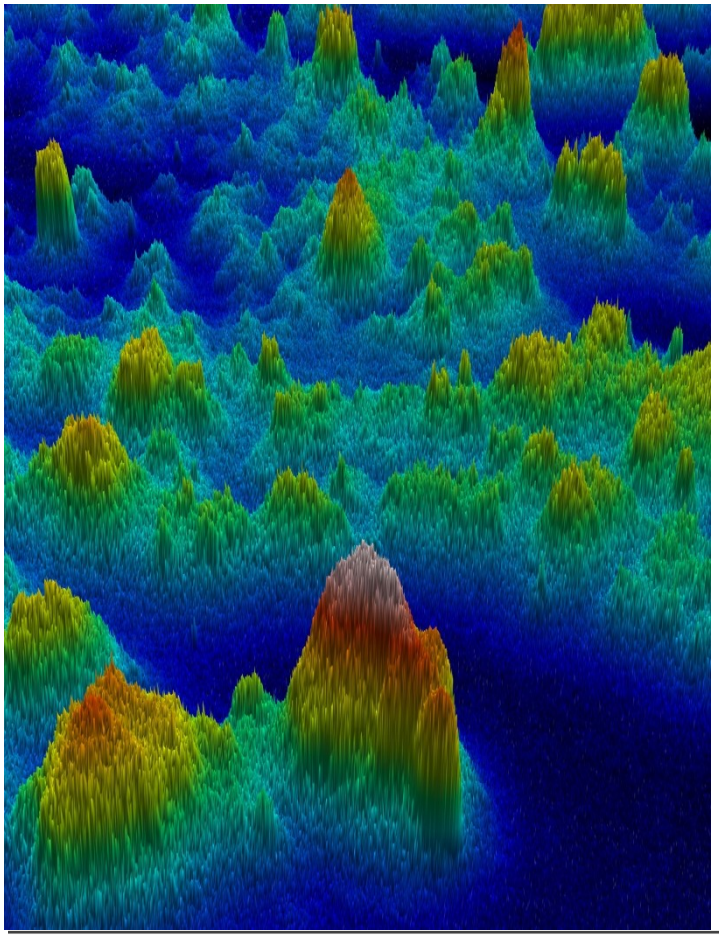
DIN Test – Class 8 Exemption



- Specific materials required to have testing by C1 may have local corrosion determined by DIN method
- The DIN method was developed to provide a probability to corrode rather than a pass/fail result
- Considers sample parameters of:
  - Particle size distribution;
  - Soil resistivity;
  - Moisture content;
  - pH value;
  - Buffer capacity;
  - Sulfide content;
  - Neutral salts content [c(Cl-), c($SO4^{2}$-)]; and
  - Sulfate content.
- The results of each parameter are assigned an indexed value. The sum of these values provides the probability of corrosion and corrosion category

Classification of soil aggressiveness according to DIN 50929-3			
Soil Category	**Soil Aggressiveness**	**Probability of wide or deep pitting corrosion**	**Probability of general corrosion**
Ia	Virtually not aggressive	Very low	Very low
Ib	Weakly aggressive	Low	Very low
II	Aggressive	Medium	Low
III	Strongly aggressive	High	Medium

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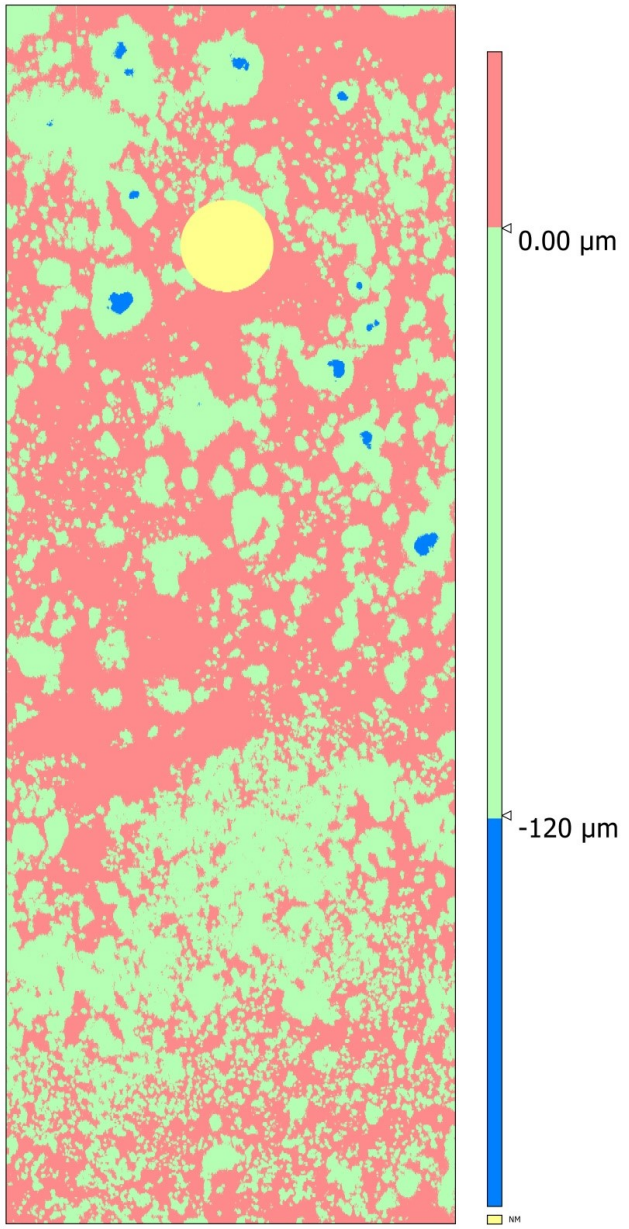
New Test Procedure…

Microanalysis Australia is involved in inter-laboratory method development to improve and clarify local corrosion intrusion depth measurement techniques.

This has included significant volumes of repeatability testing with very favourable results to date.

This work is hoped to form the foundation of a new test method for solid bulk cargoes in the near future.



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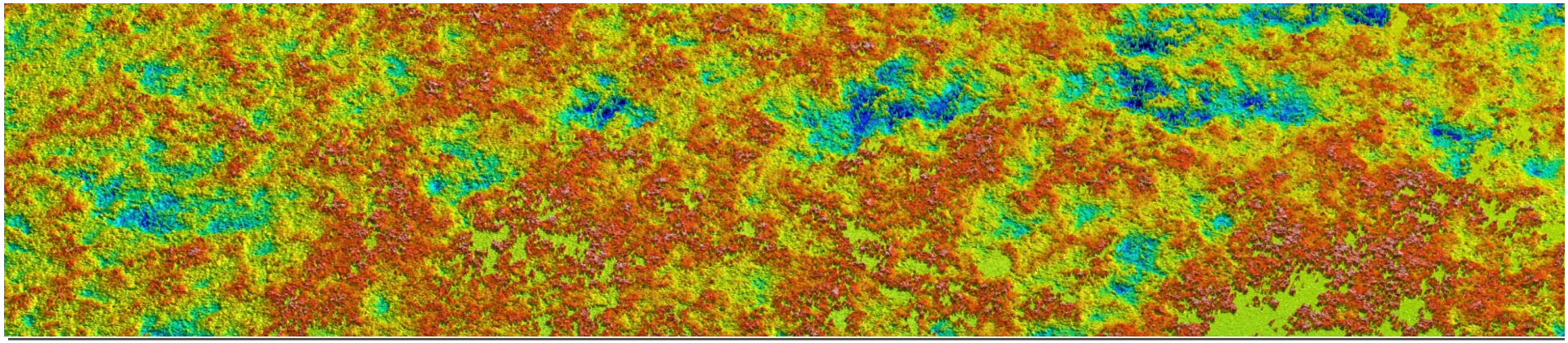
Solarius – Laser Surface Profilometer

Microanalysis Australia introduced surface profile scanning for corrosion testing to our clients in 2014. Since then, surface profile scanning has become the preferred method for repeatable depth assessments for its ability to remove operator subjectivity by analysing all intrusions, every time.



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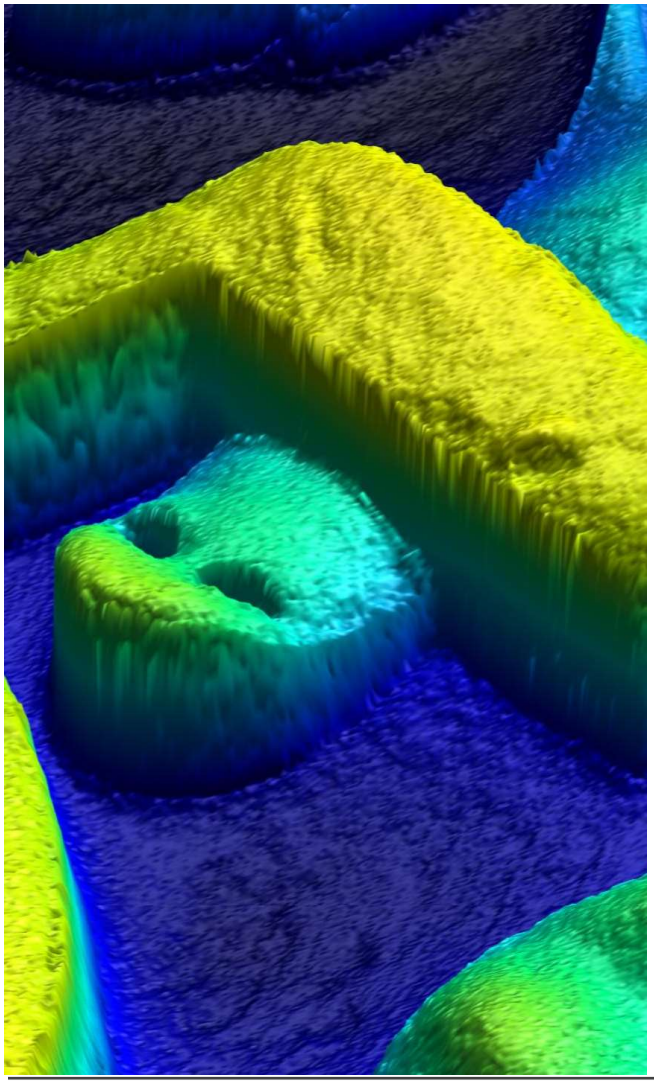

Capabilities

Optical Pen	CL1	CL4
Working Distance (mm)	3.3	16.4
Measuring Range (µm)	110	2500
Spot Size (µm)	1.9	8
Axial Resolution (nm)	8 / 35	130 / 400

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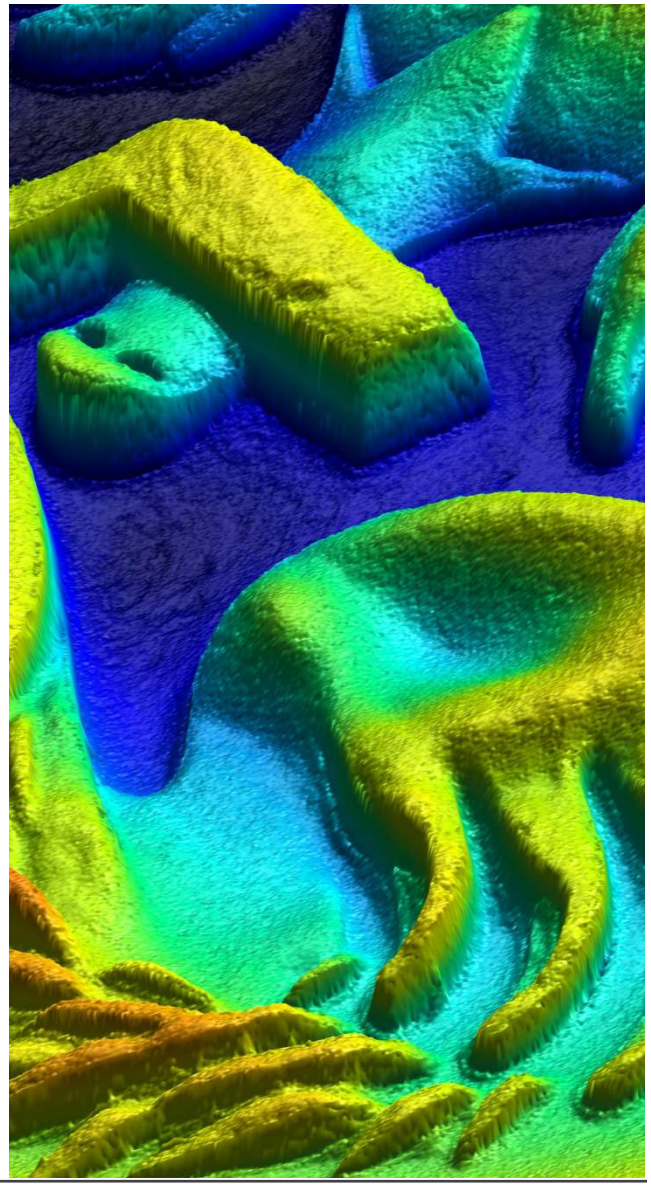
Local Corrosion Depth

Scans are run using the CL4 pen to accommodate significant intrusion depths.

Resolution optimisation testing was conducted to minimise surface scan times while maintaining repeatable depth measurements within an acceptable uncertainty.

This optimum resolution was found to be 5 µm x 50 µm and has a scan time of ~1 hour allowing for high sample throughput with high precision.



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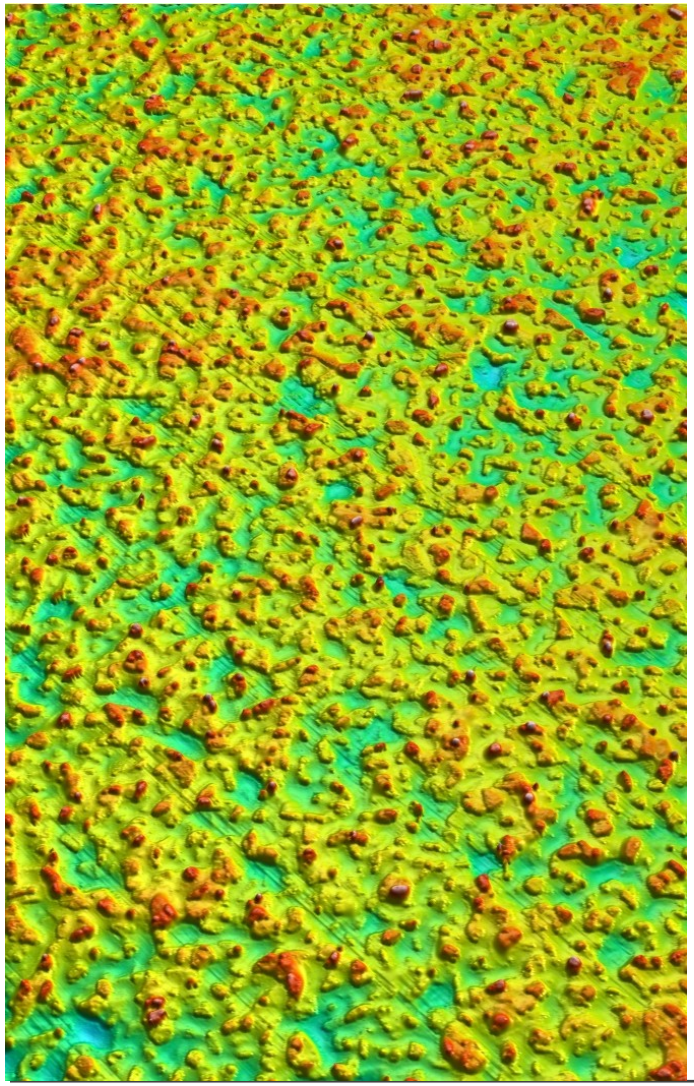
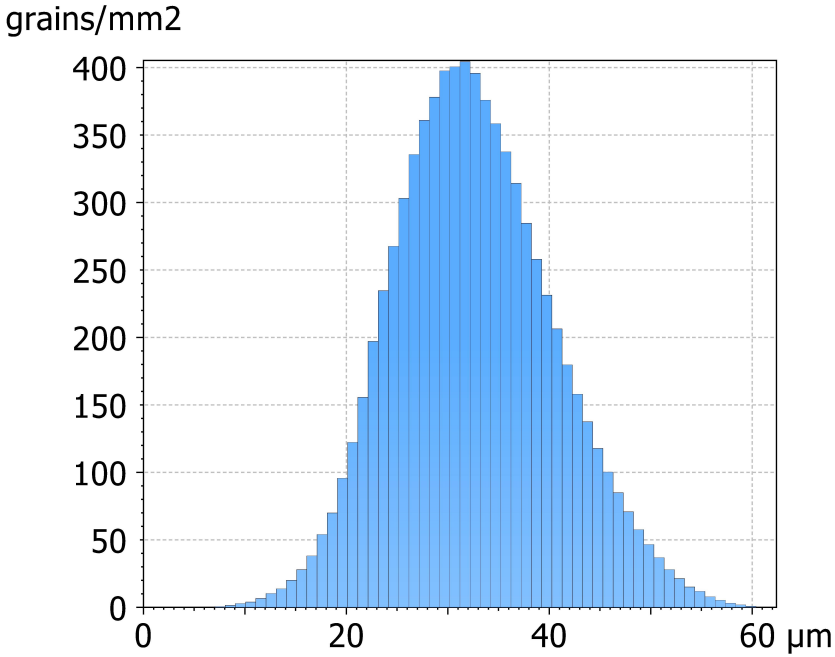


Surface Roughness

In addition to determination of depths, the Solarius is capable of surface roughness measurements for quality control or tolerance assessments.



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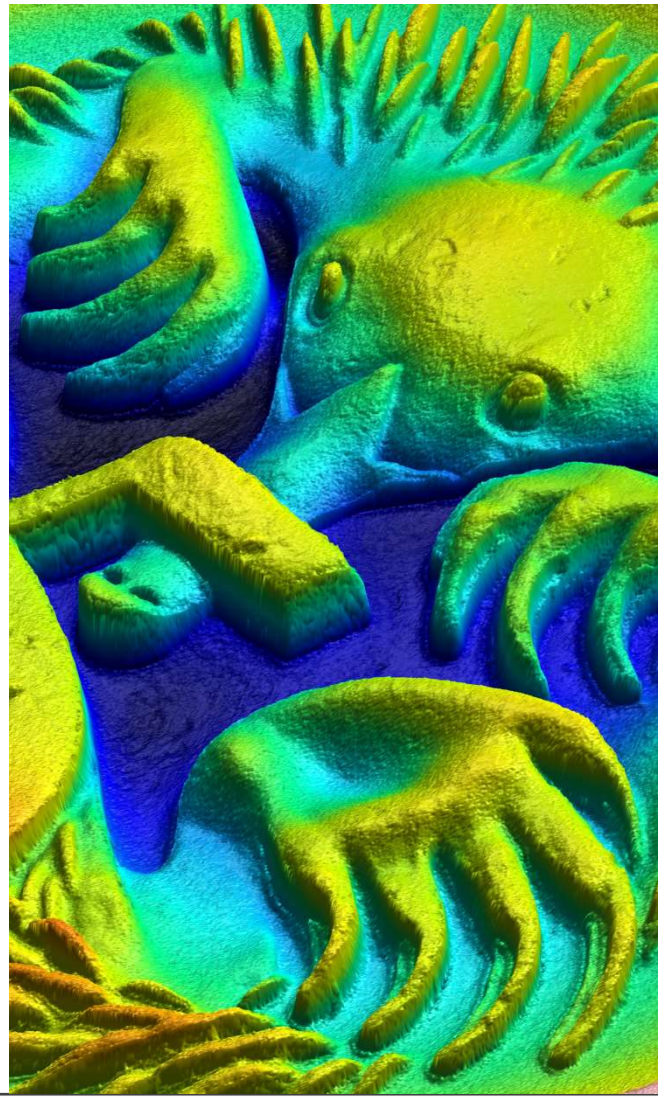
Additional Measurements

- Line scans
- Step height measurements
- Slope/inclination
- Distance (point to point)
- Volume measurements
- Skewness/Kurtosis
- Surface form removal
- … and more



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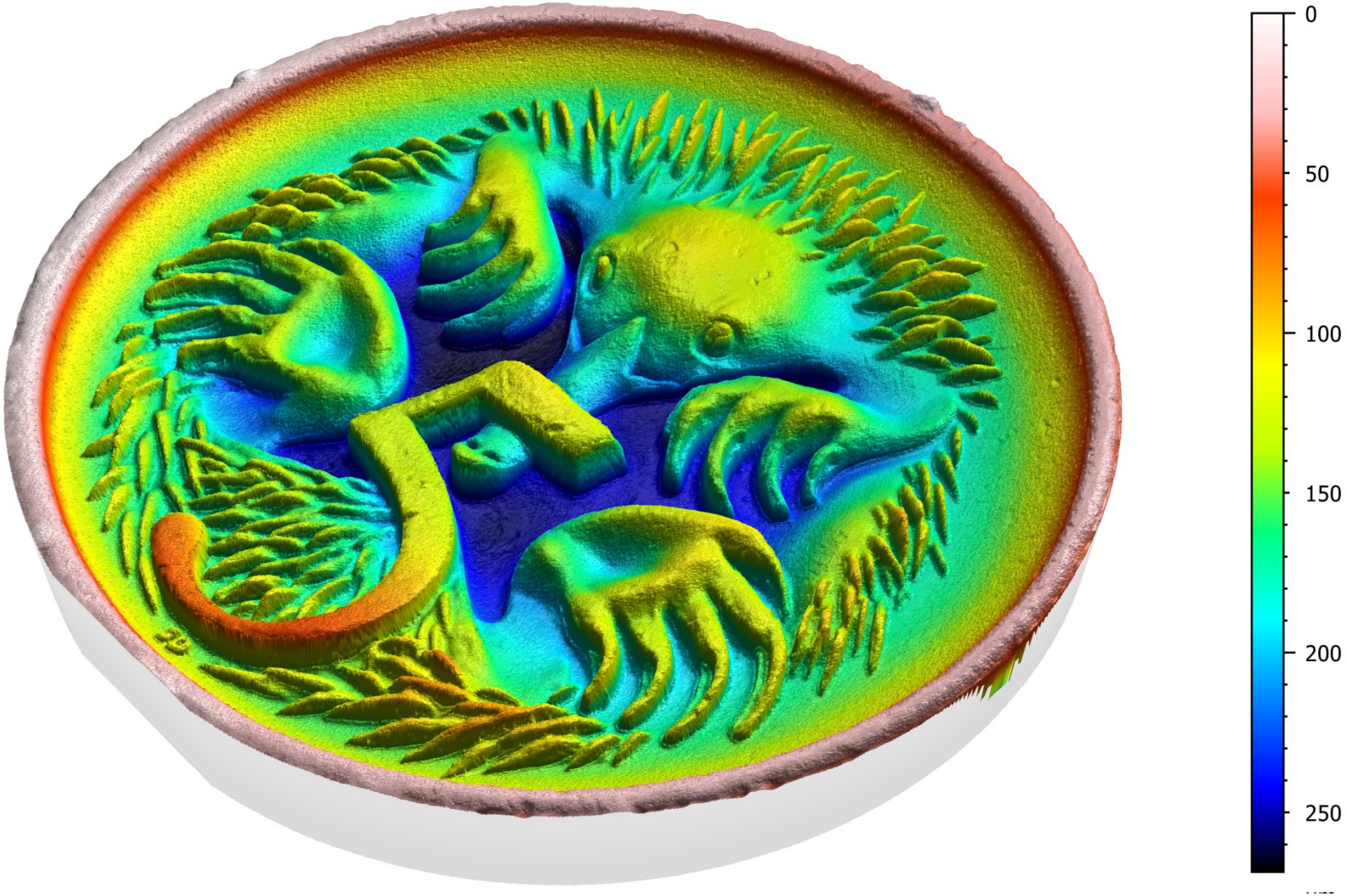

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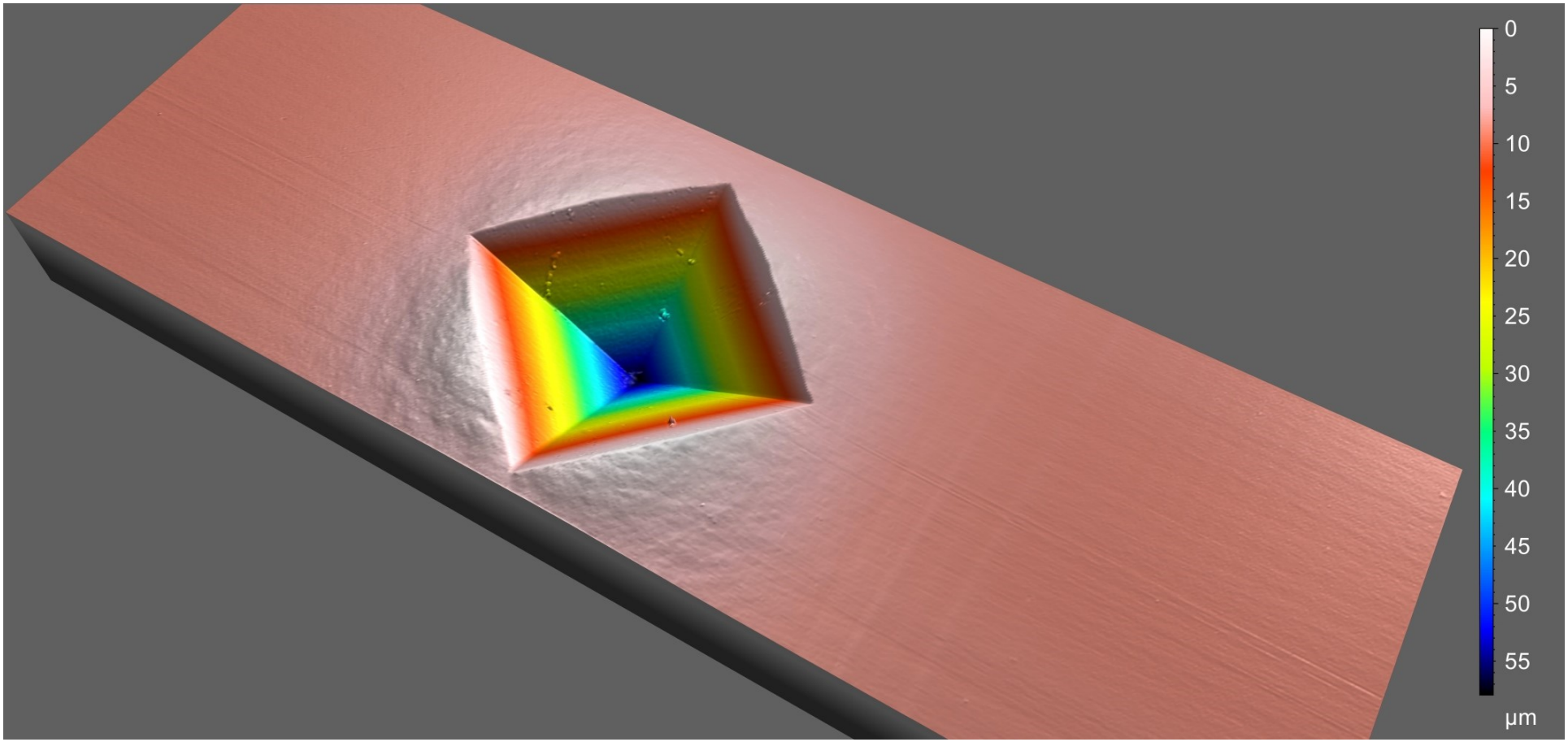

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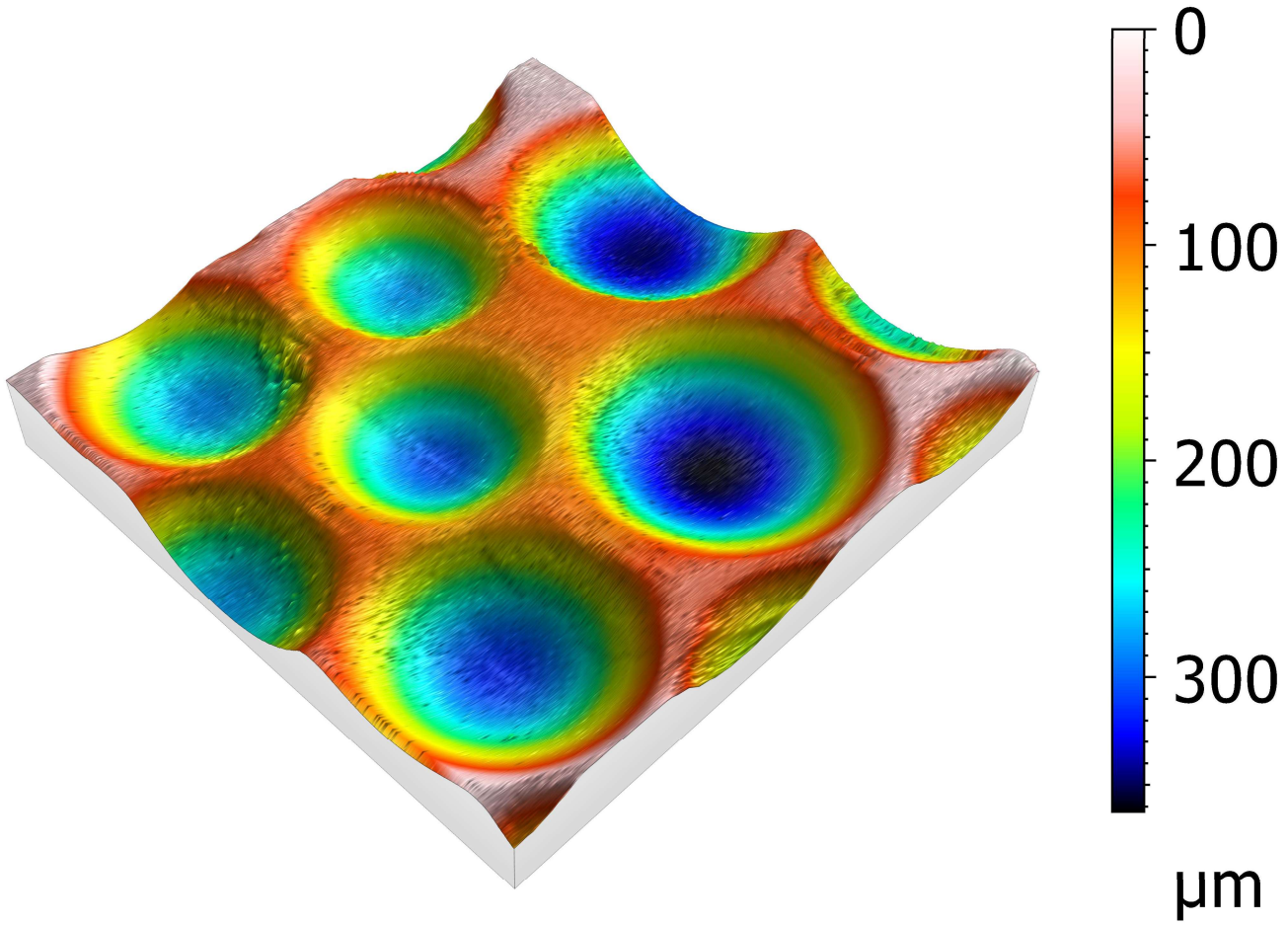

Thank you for your attention! Any questions?

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