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A fresh approach to surface metrology for additive manufacture

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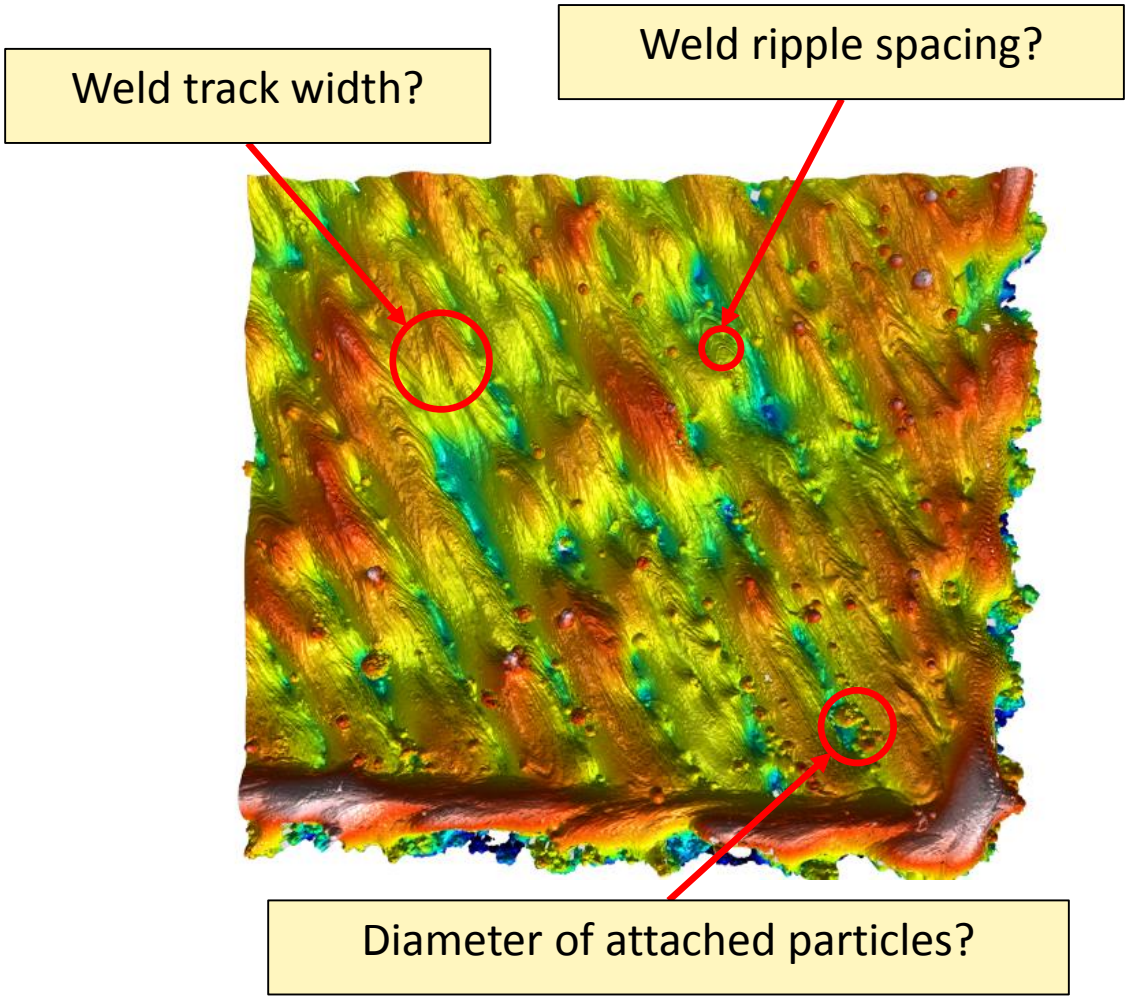
A paradigm shift
in surface metrology

Feature-based characterisation



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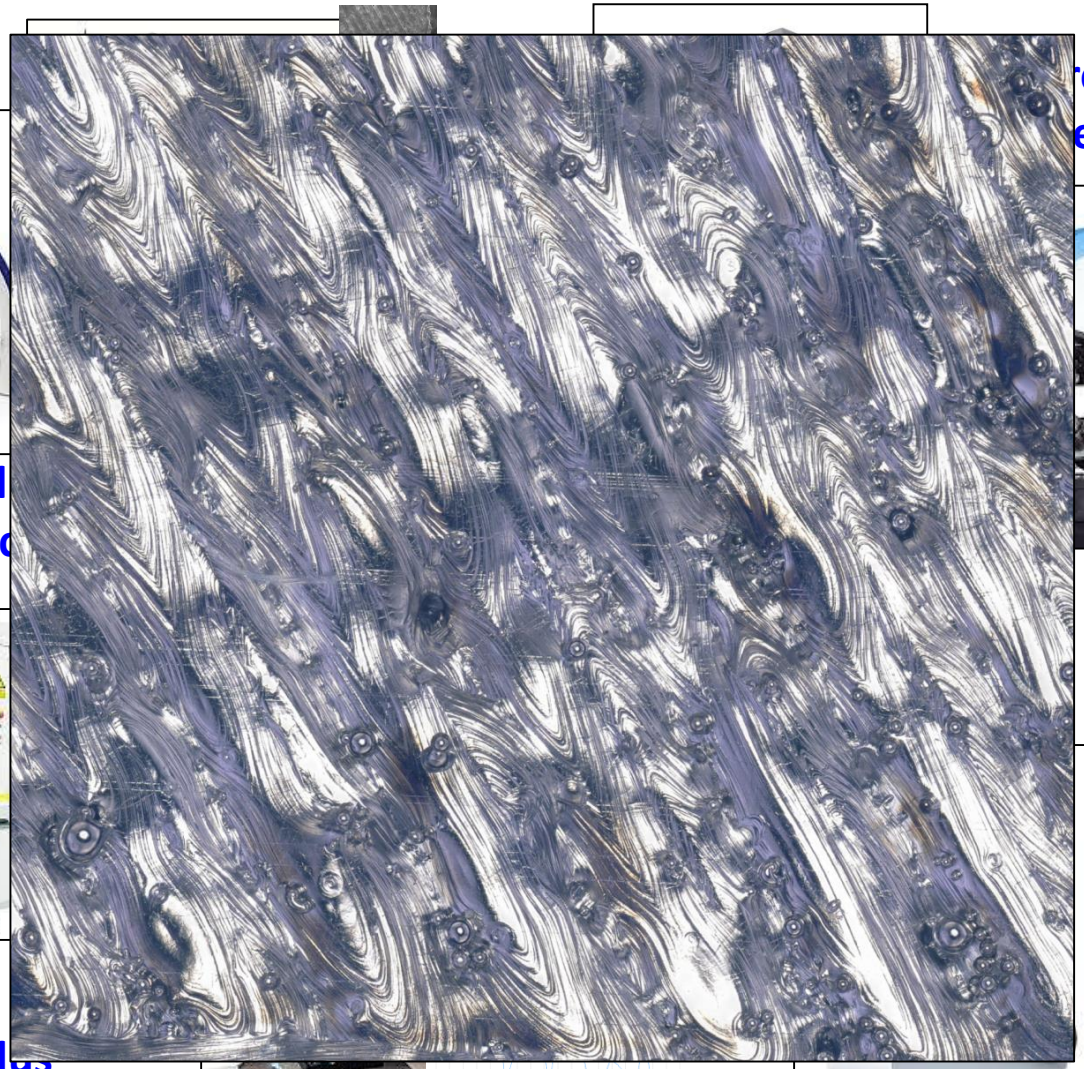
Measurement technologies



Optical microsc

Focus stacking

XCT

Stylus profilometer

rence Scanning erometry

Focus variation

Point autofocus

Confocal microscopy

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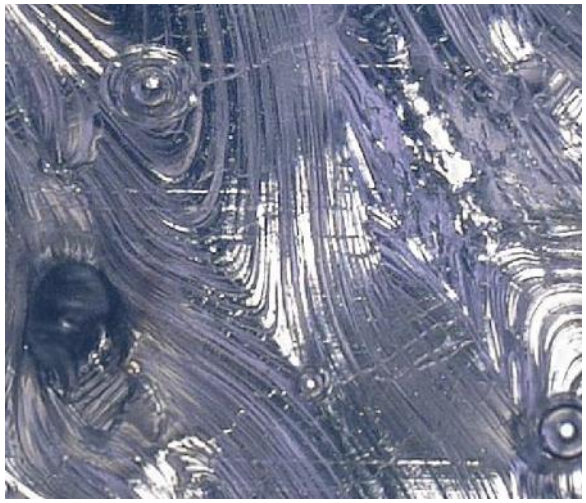
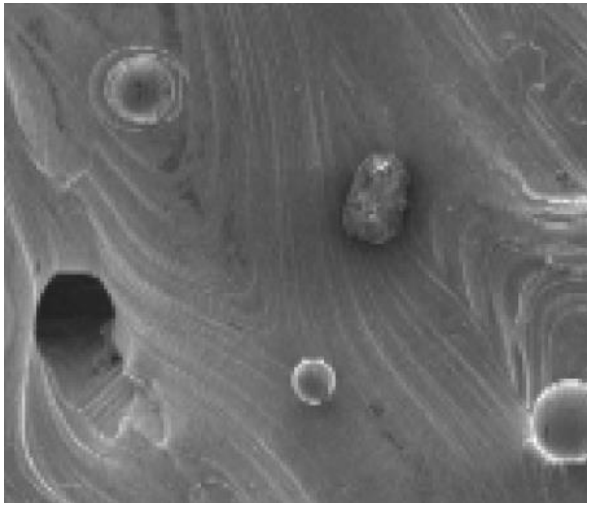
Direct feature comparison

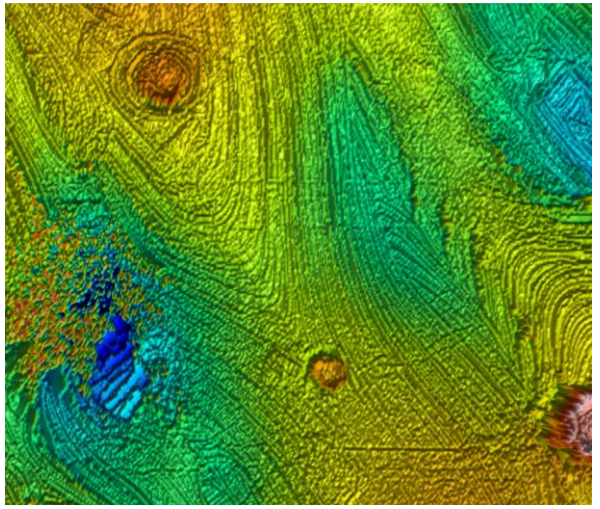
Optical microscopy



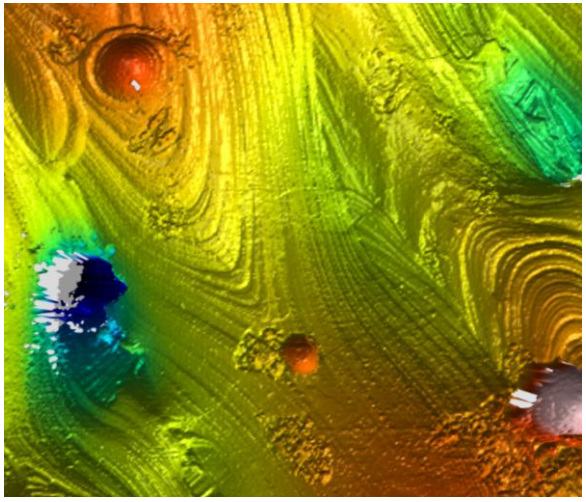
SEM



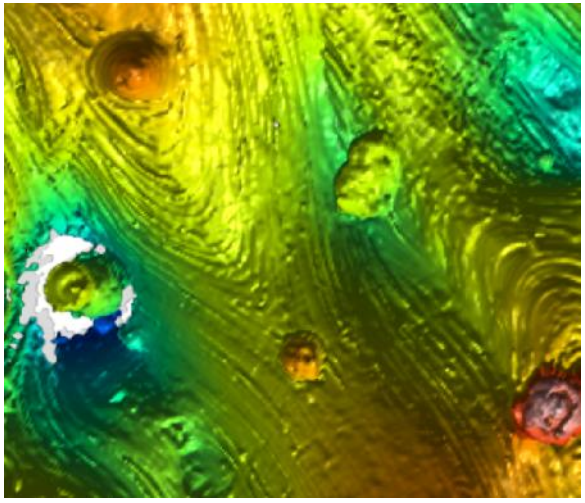
Confocal microscopy



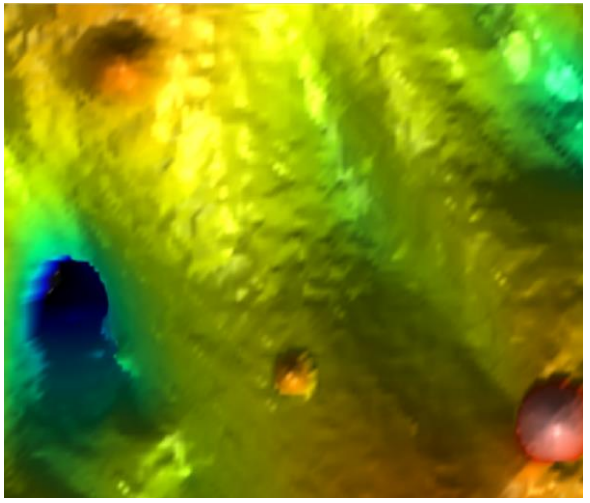
Coherence scanning interferometry



Focus variation



X-ray computed tomography



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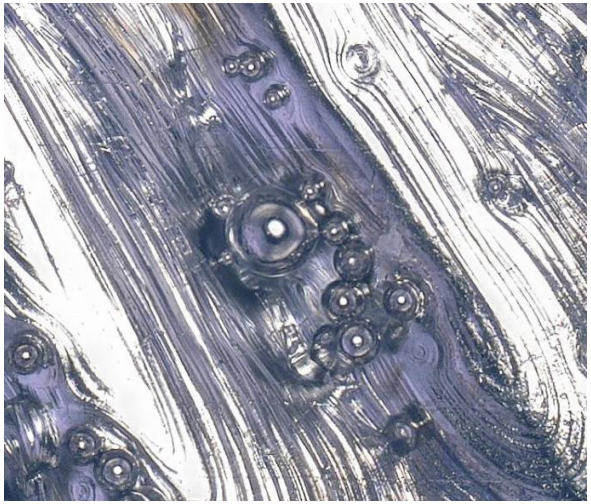
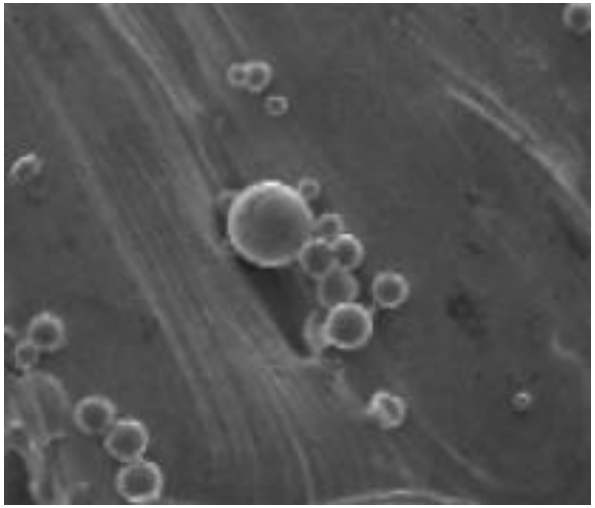
Direct feature comparison

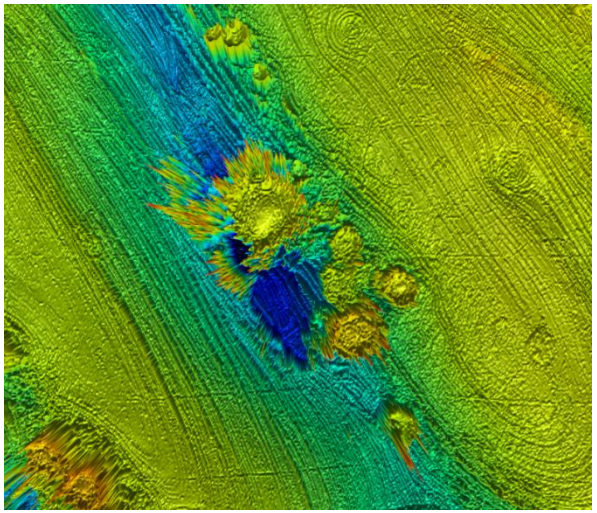
Optical microscopy



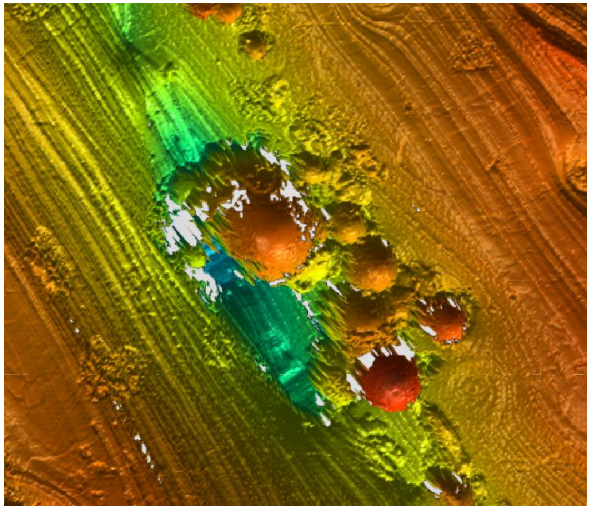
SEM



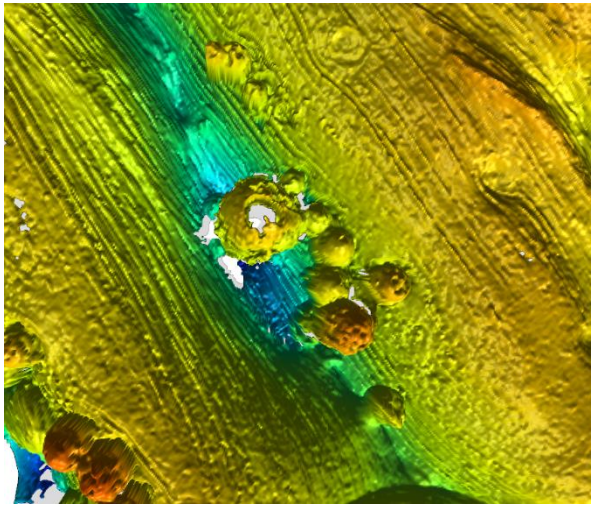
Confocal microscopy



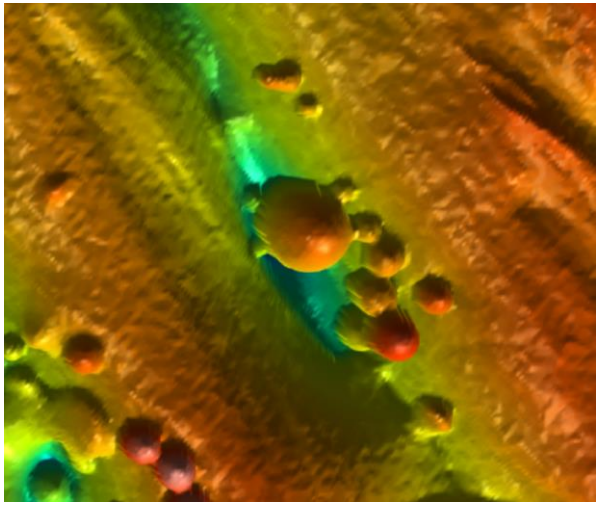
Coherence scanning interferometry



Focus variation

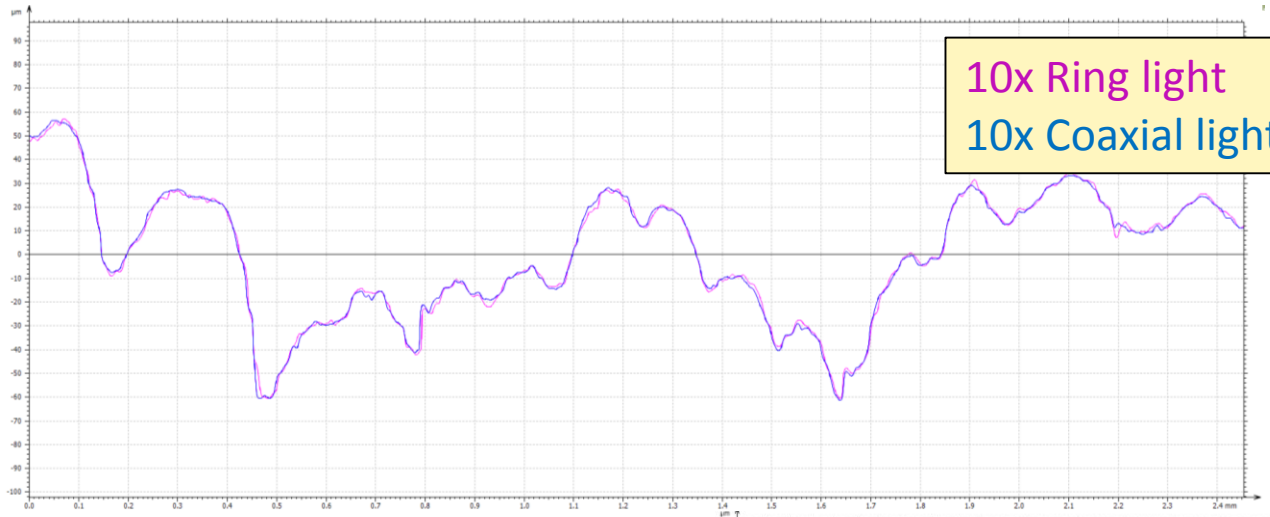


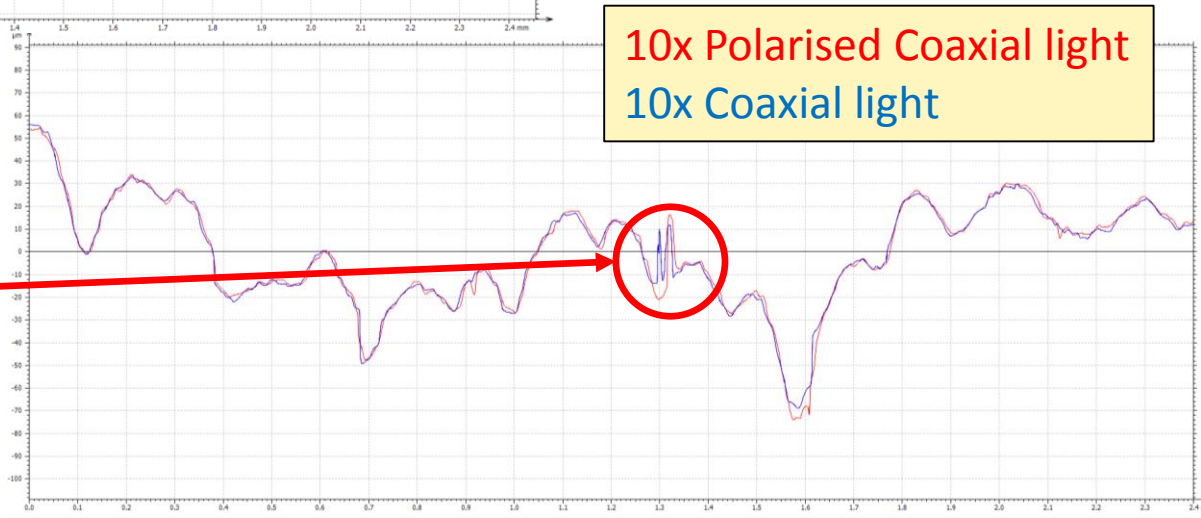
X-ray computed tomography



Extracted profiles

An example from focus variation (alignment by eye & software auto-registration)





Optical effect?

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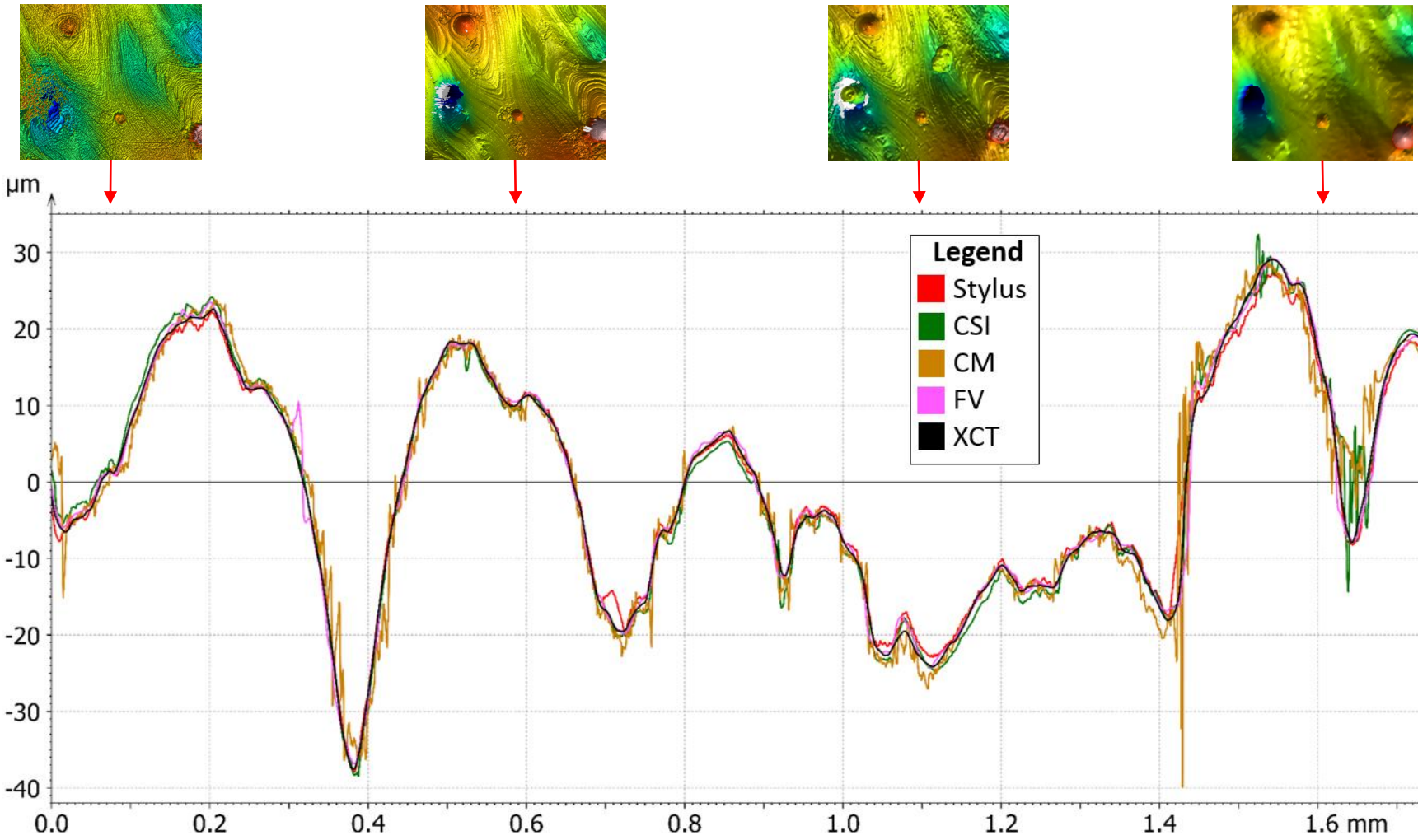
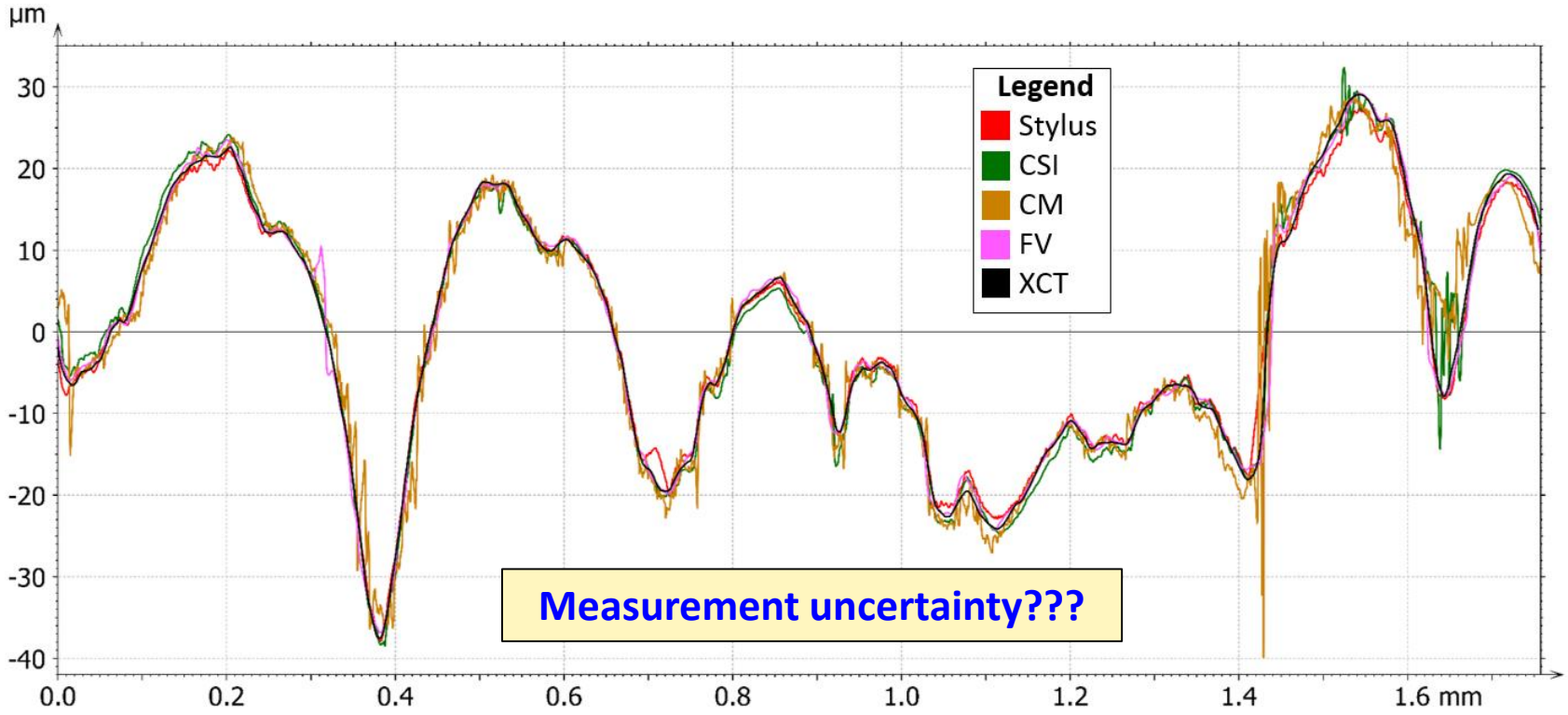
Direct topographical comparison

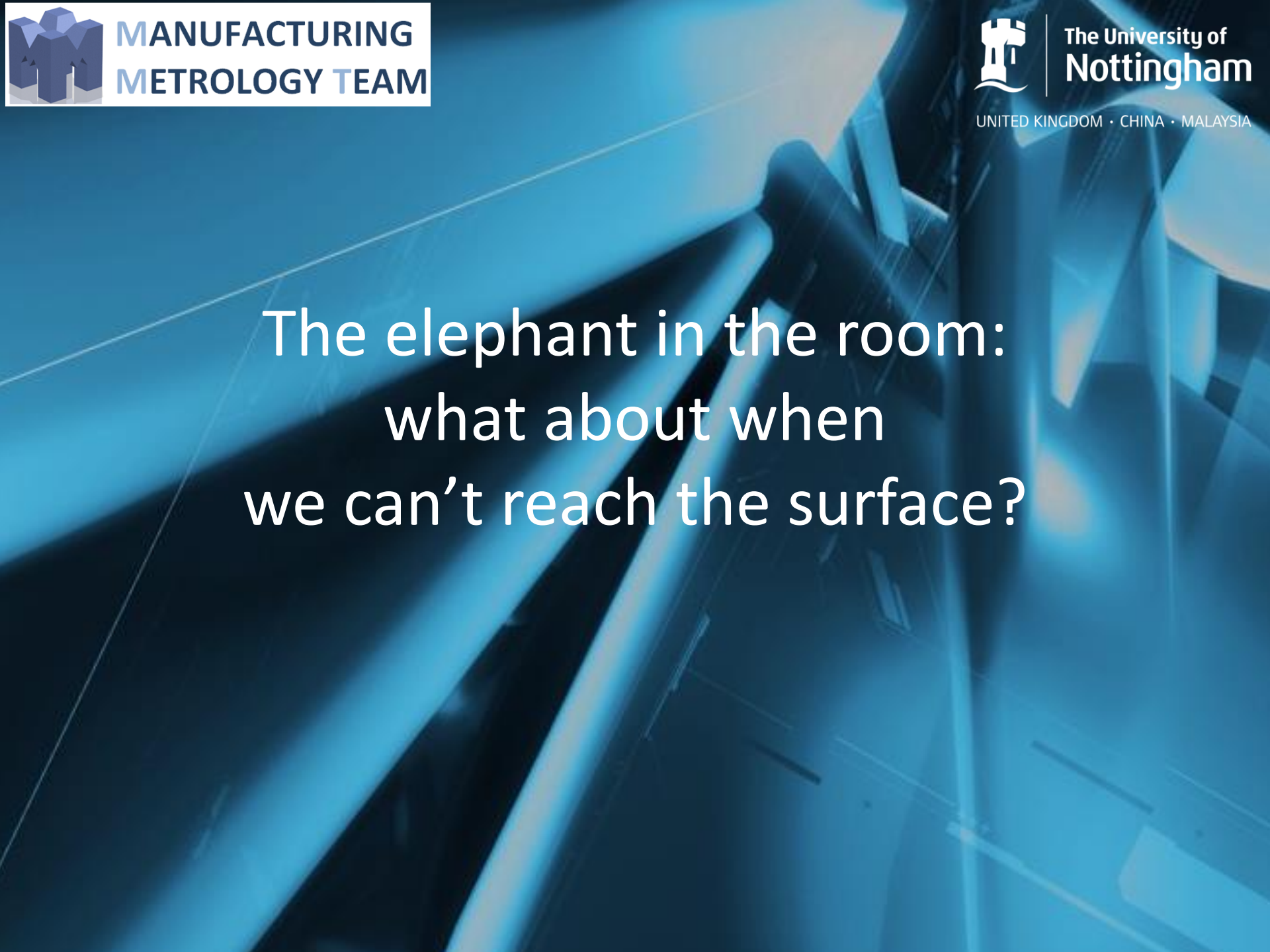


Direct topographical comparison

Our current work

Extending our method of surface assessment by comparison of topographies (previously **qualitative**) to a **statistically robust**, **quantitative** approach.

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The elephant in the room:
what about when
we can't reach the surface?

Surfaces of objects with complex form

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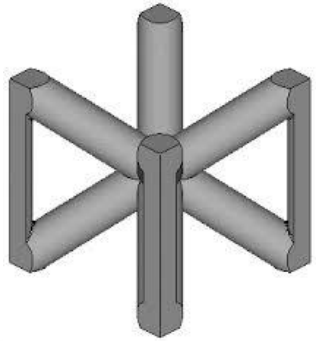
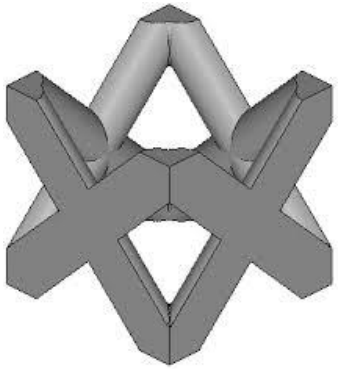
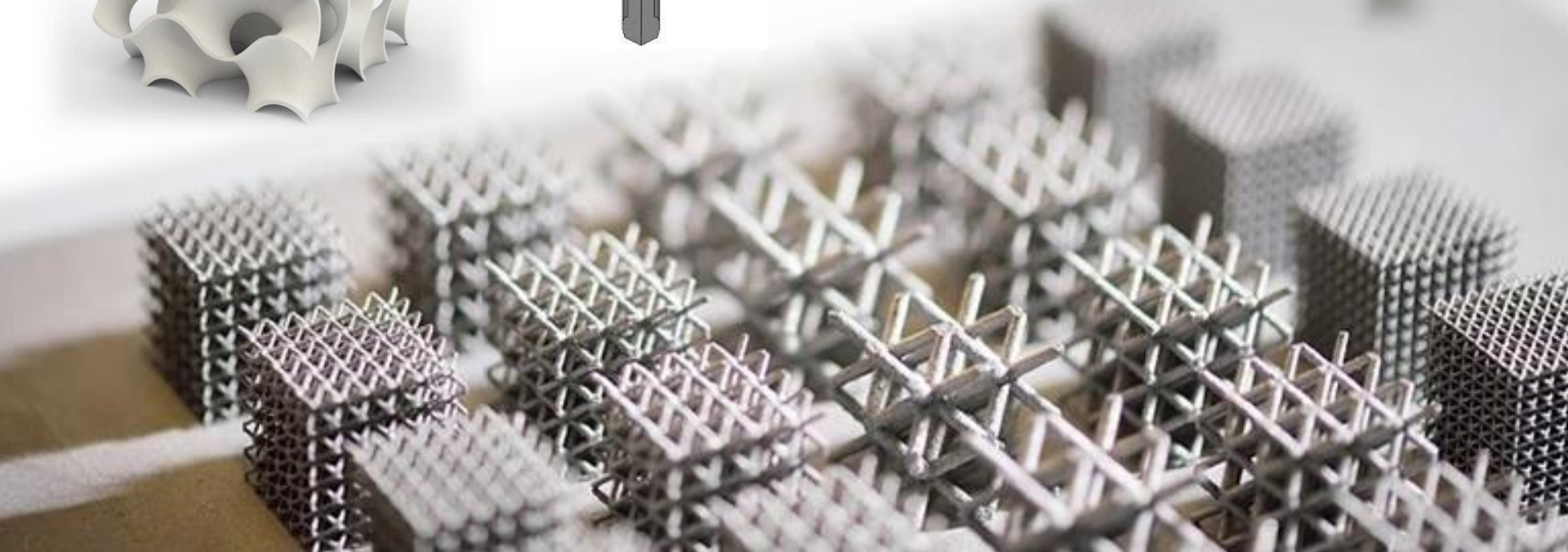
So how do we measure the surfaces of these beasts?







Surfaces of objects with complex form

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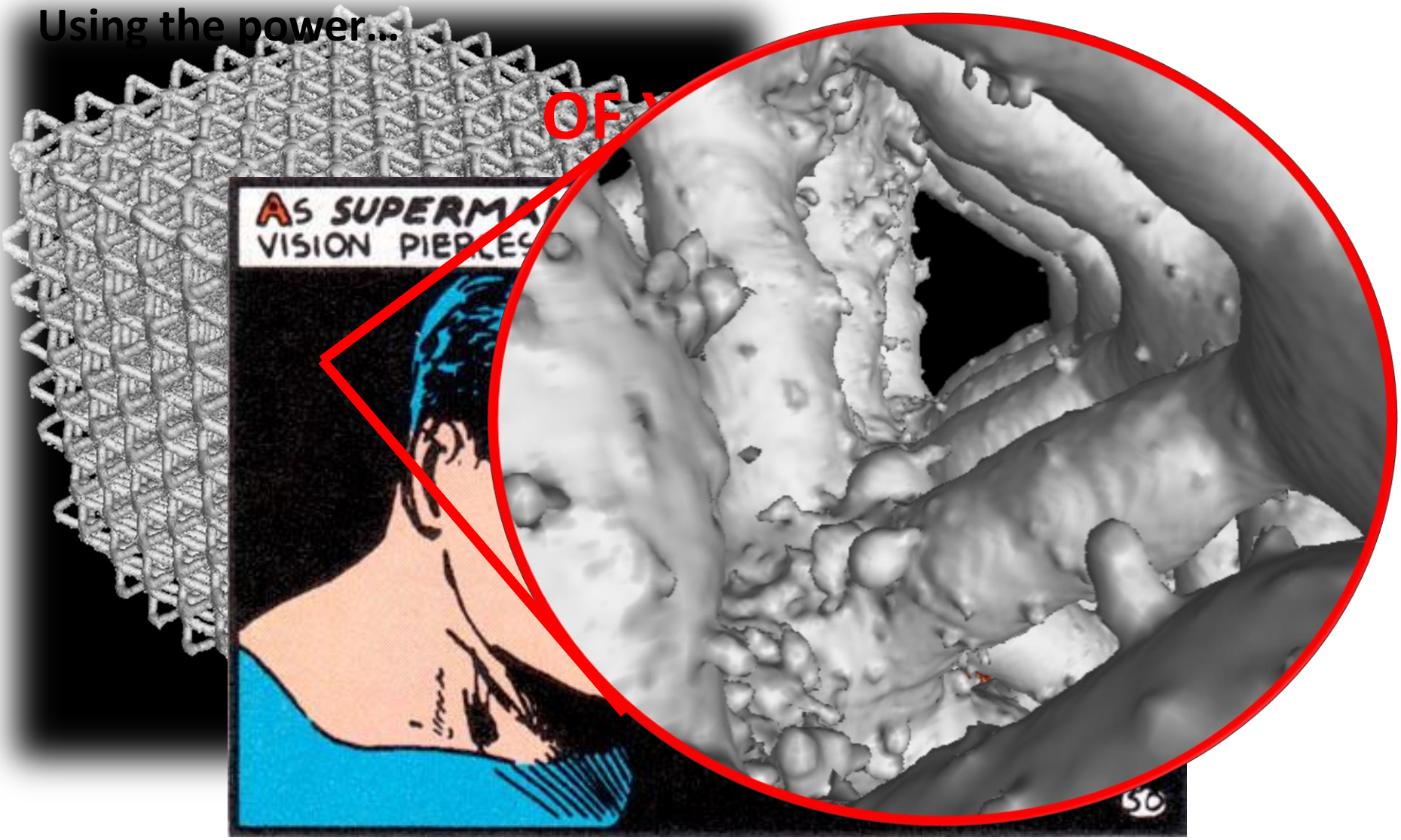
Using the power…



XCT Pipeline

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Additive manufacturing process

XCT Measurement

CAD model

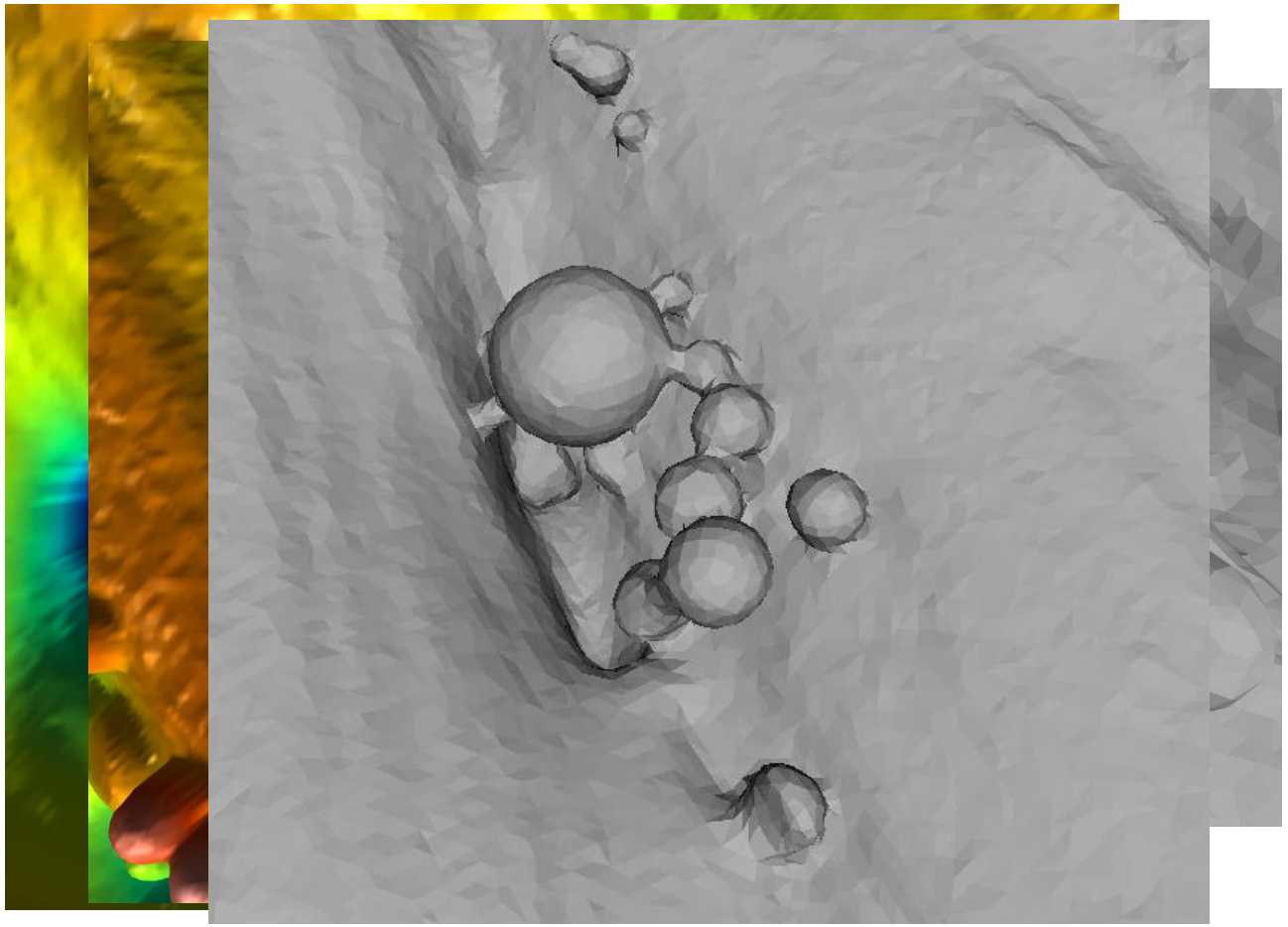
Manufactured geometry

Reconstruction

Surface extraction

Extracted Surf. model

The lost information



The big problem: surface determination

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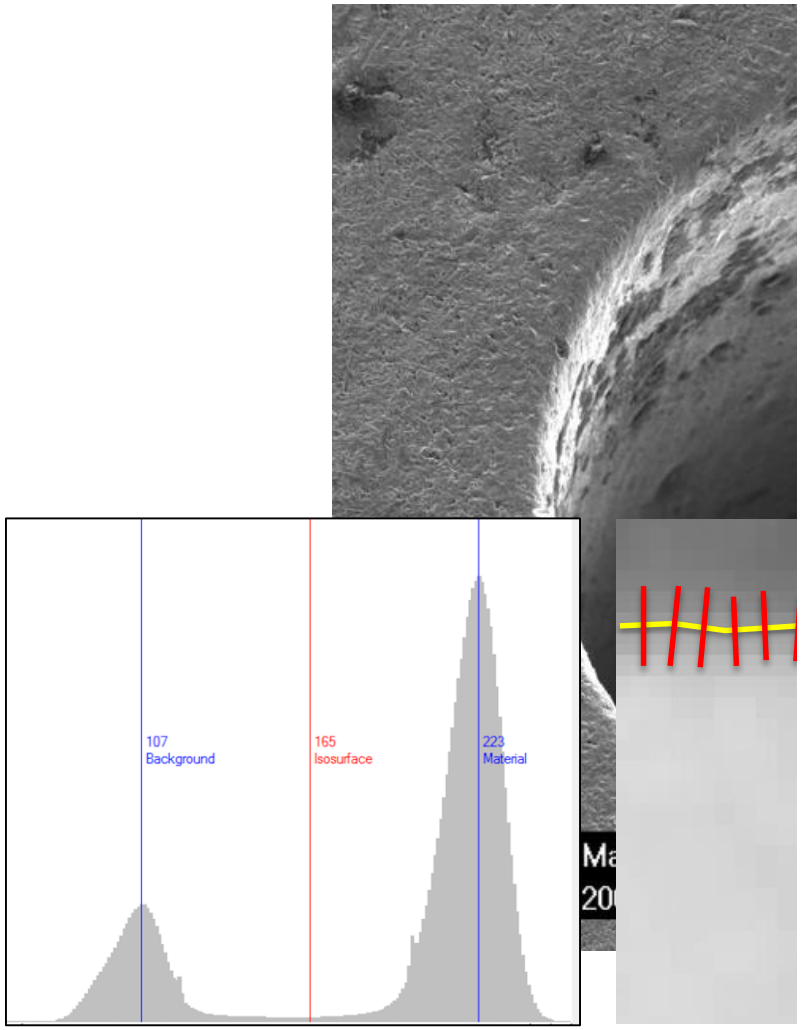
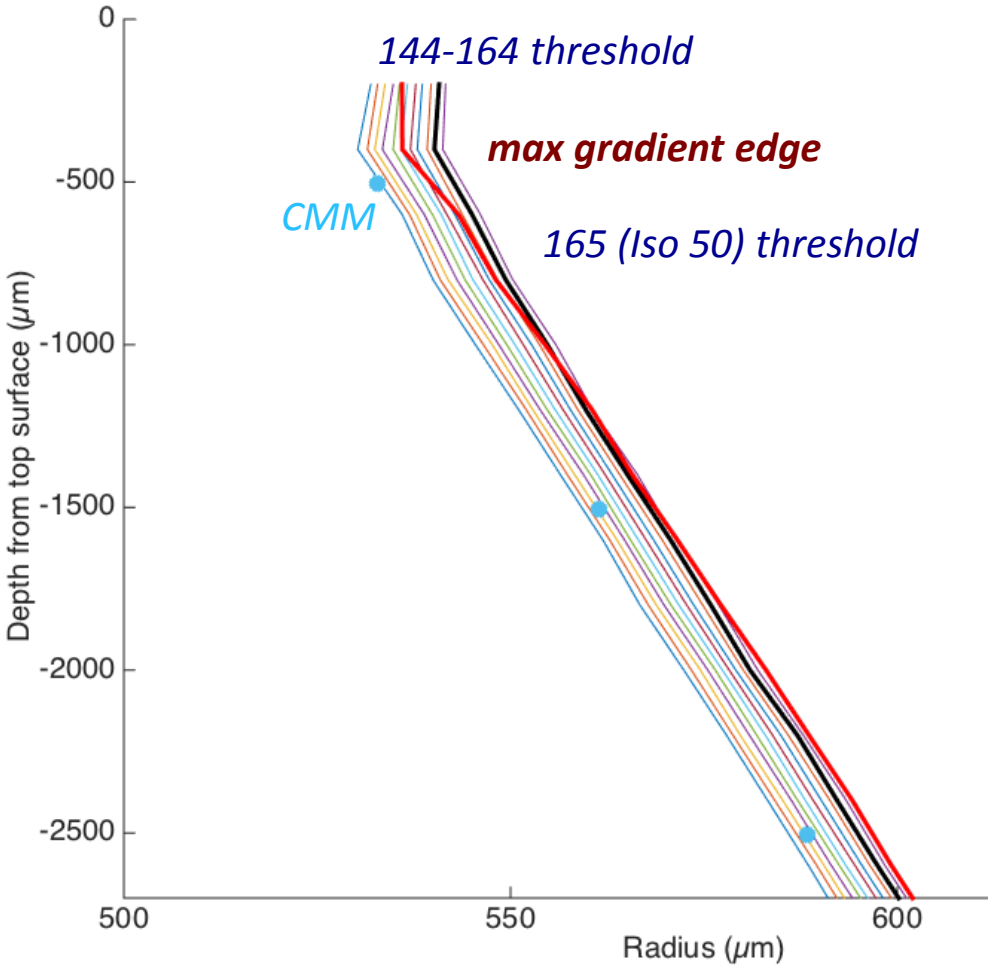
Rabani, Senin, Hemli, Butler-Smith & Leach, 2016, euspen's 16th International Conference & Exhibition, (Nottingham, UK)

An example from elsewhere: microholes

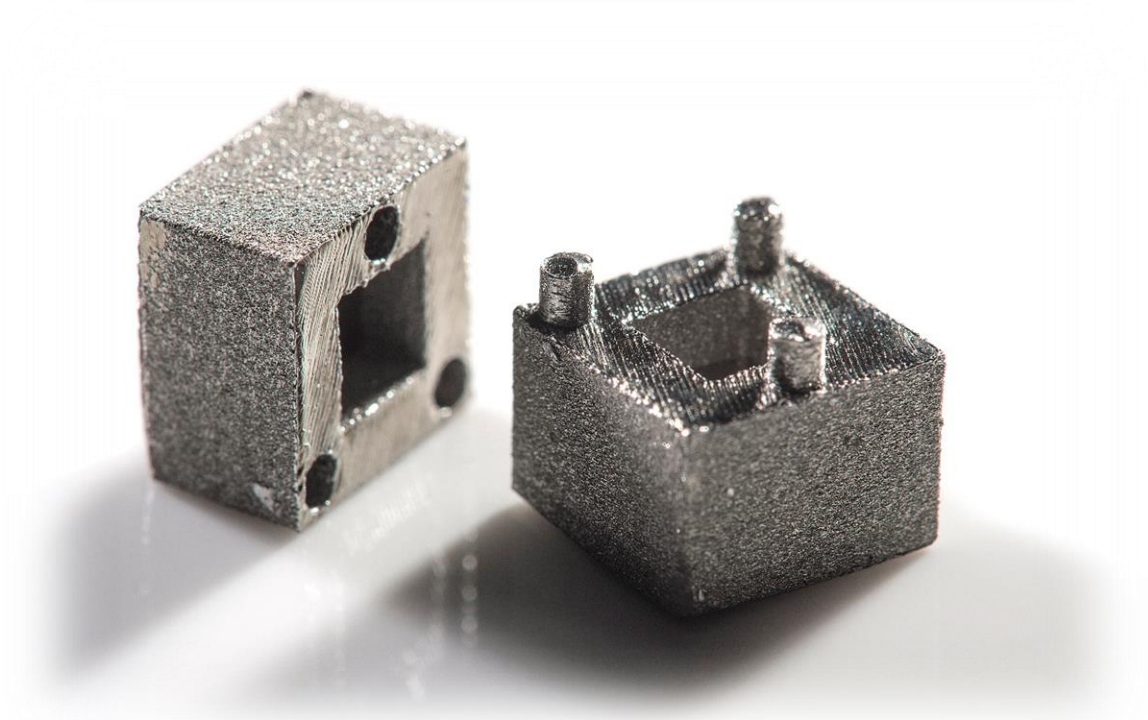




Internal surfaces: a test case

Selective laser melting of metals

- Hollow Ti6Al4V cube of (10 × 10 × 10) mm from an EOSINT M 280, separable to allow measurement of internal surfaces
- Top surface: comparable to previous work and representative of SLM surfaces
- Sides of recessed section used for relocation



So how does XCT compare?

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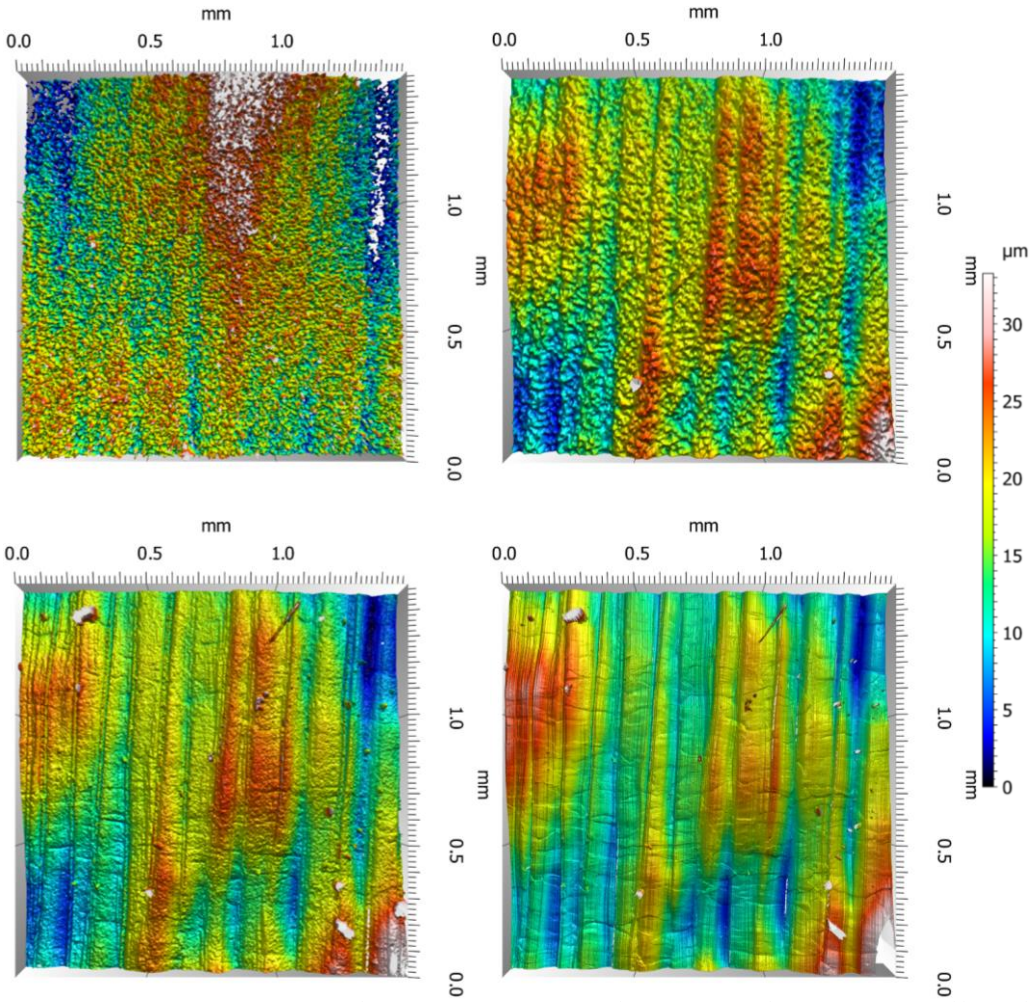
Qualitative similarity, and many parameters in a similar ballpark…

XCT 1
Sa = 2.63 µm



XCT 2
Sa = 1.90 µm

Focus variation
Sa = 1.86 µm

Coherence scanning interferometry
Sa = 1.93 µm

Shown: unfiltered raw data, while parameters were calculated for scale-limited surfaces using following cutoffs: S-filter of 11 µm based on grid of 4 × 4 pixels in lowest resolution data, L-filter of 0.5 mm to separate roughness and waviness based on visual assessment of surfaces.

Current work

Development of a **rigorous statistical model** for direct comparison of topographies

Investigation into the specific requirements of using **XCT** for investigation of **surface texture** to develop a **good practice model**, in terms of measurement setup, reconstruction and analysis

Participation in the **CT-STARR** (CT-Surface Texture for Additive Round Robin) co-ordinated by the University of Huddersfield

Investigation into the specific requirements of using **optical instruments** for measurement of **complex AM surfaces** to develop a **good practice model** in terms of measurement setup and analysis

Development of new technology for **in-line**, layer-by-layer surface measurement

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A fresh approach to surface metrology for additive manufacture

Thanks for your attention

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Manufacturing Metrology Team, Faculty of Engineering