Incorporating tracer particles for DVC of fibre-reinforced composites

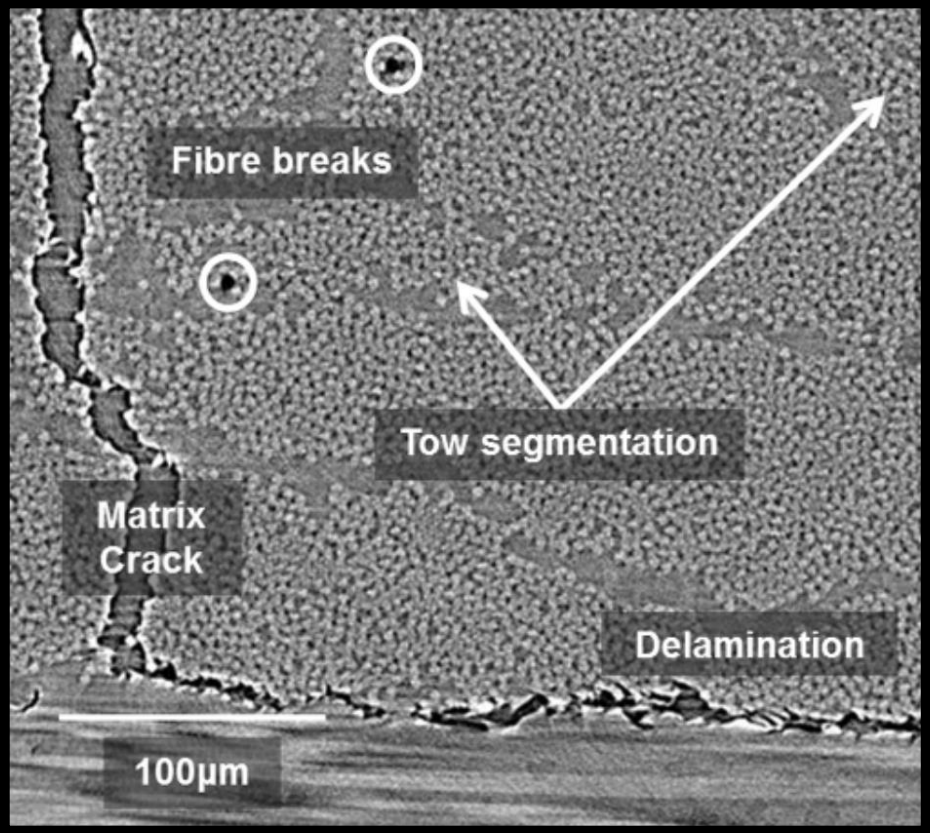
T. Chatziathanasiou[a], O. Demir[a,b], M. Diehl[a,c], C. Breite[a], M. Mehdikhani[a], Y. Swolfs[a]

[a] Department of Materials Engineering, KU Leuven
[b] Department of Mechanical Engineering, Konya Technical University
[c] Department of Computer Science, KU Leuven

Composites: Multiscale, hierarchical materials

Macroscale
Structure

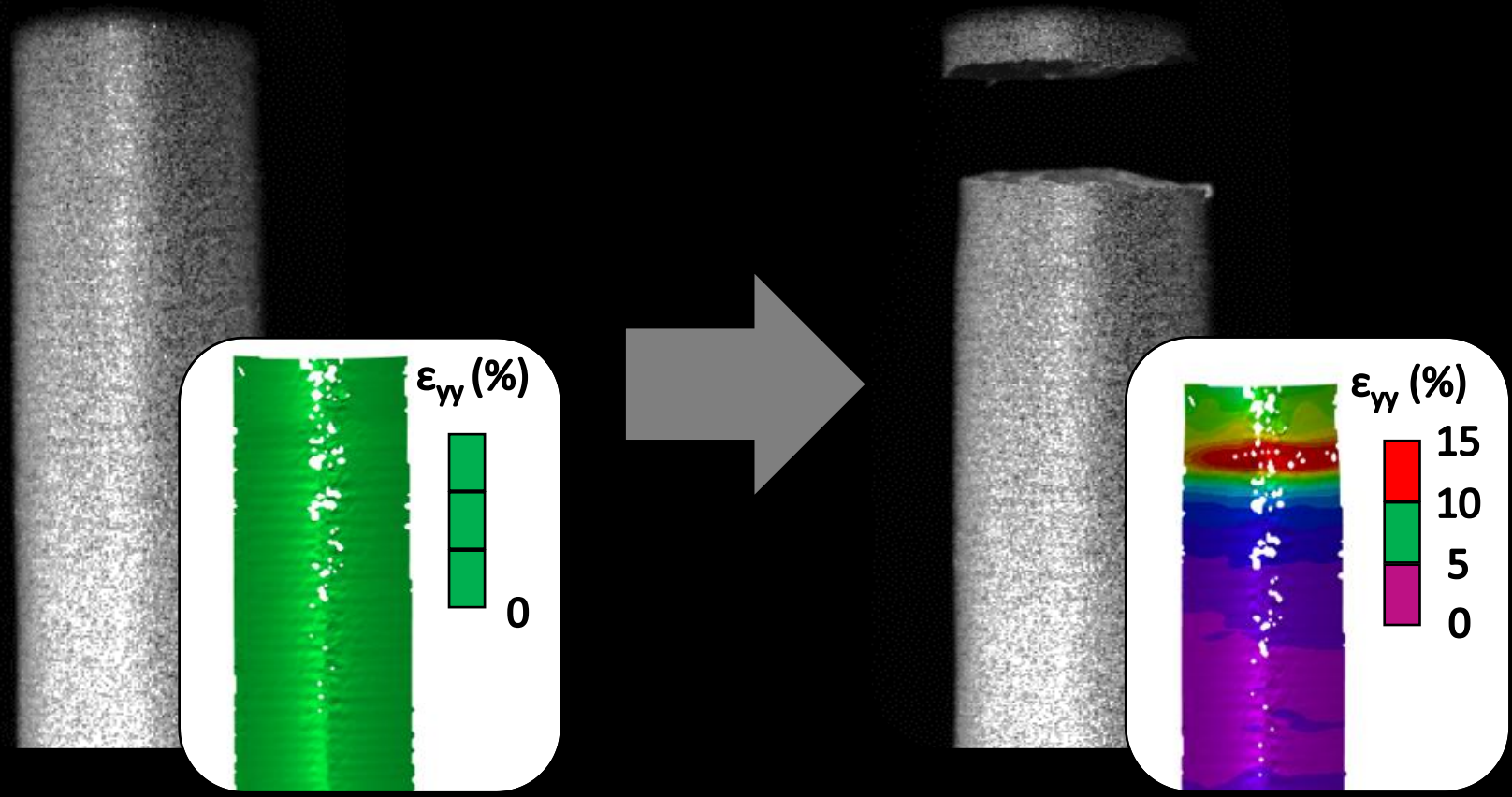
Microscale
Constituents



Swolfs et al.

Mesoscale
Ply - Laminate

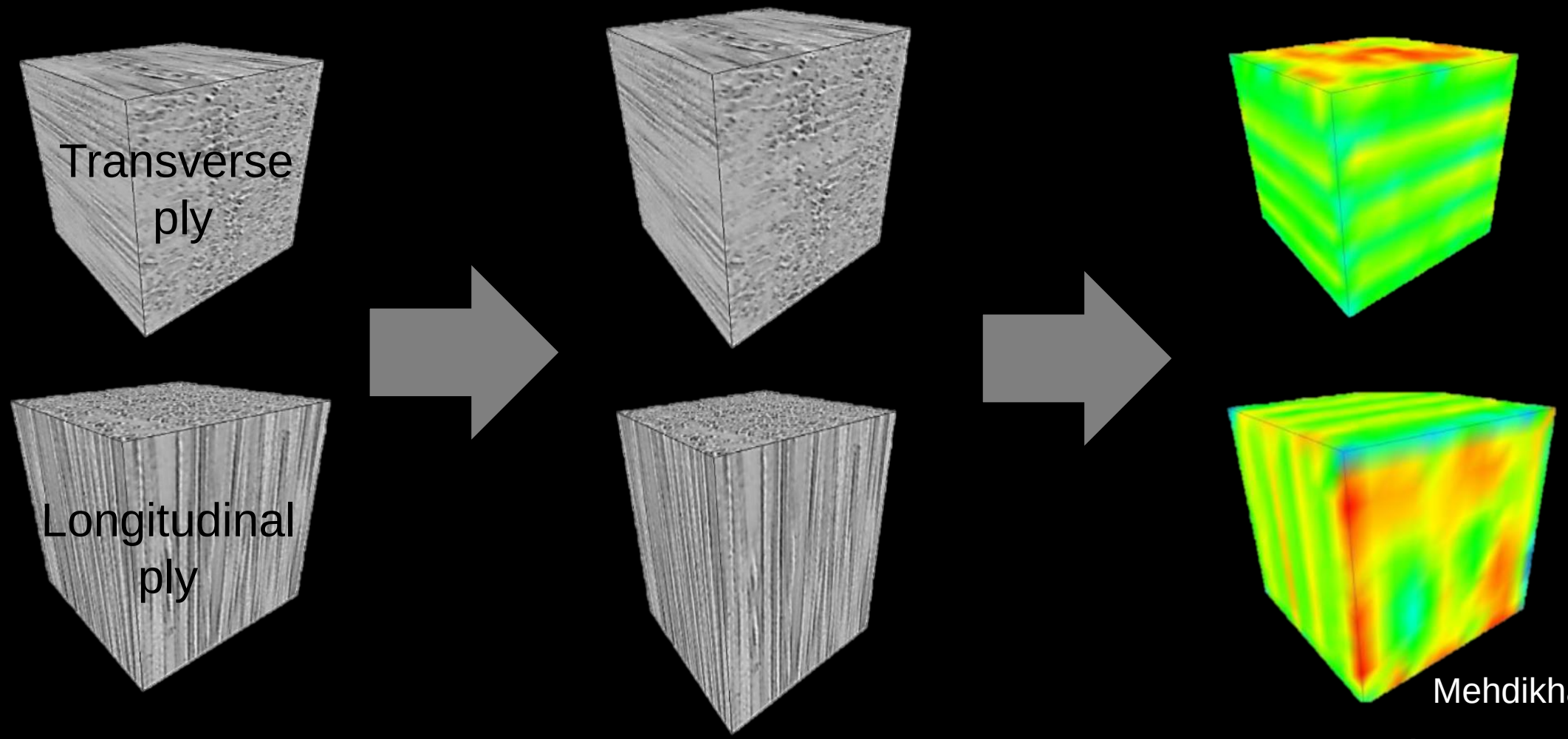
From digital images…



Undeformed image

Deformed image

…to digital volumes

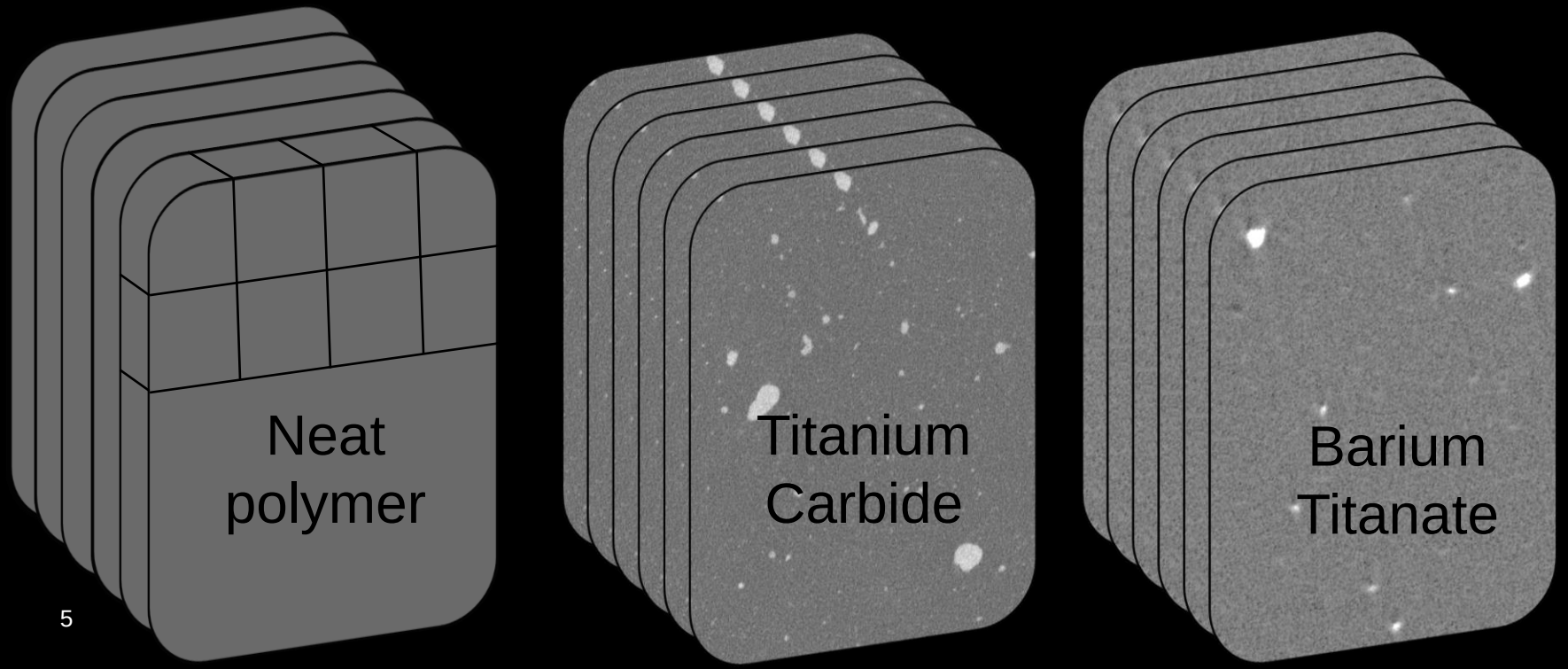


The need for heterogeneity

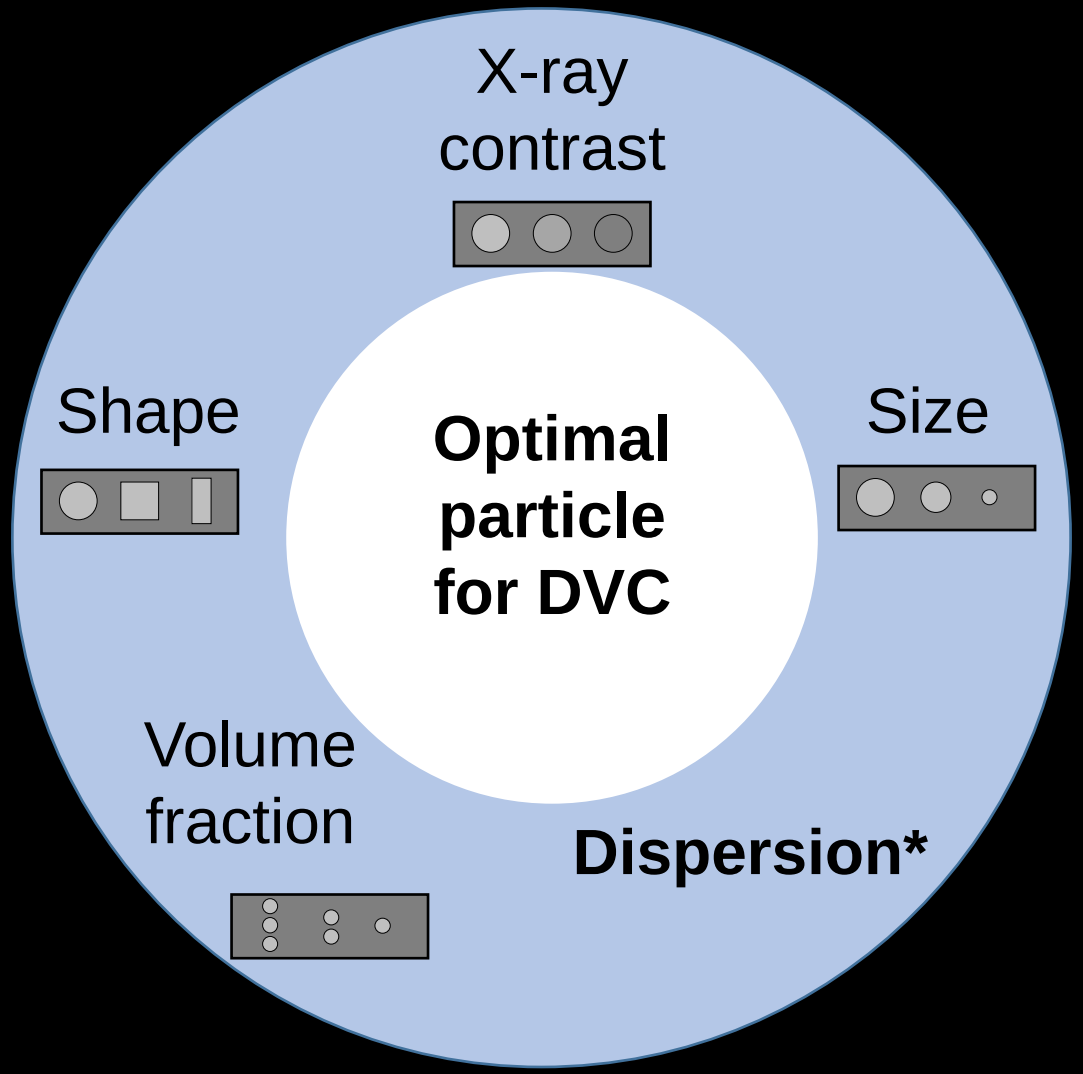
Intrinsic, temporally stable, microstructural variation

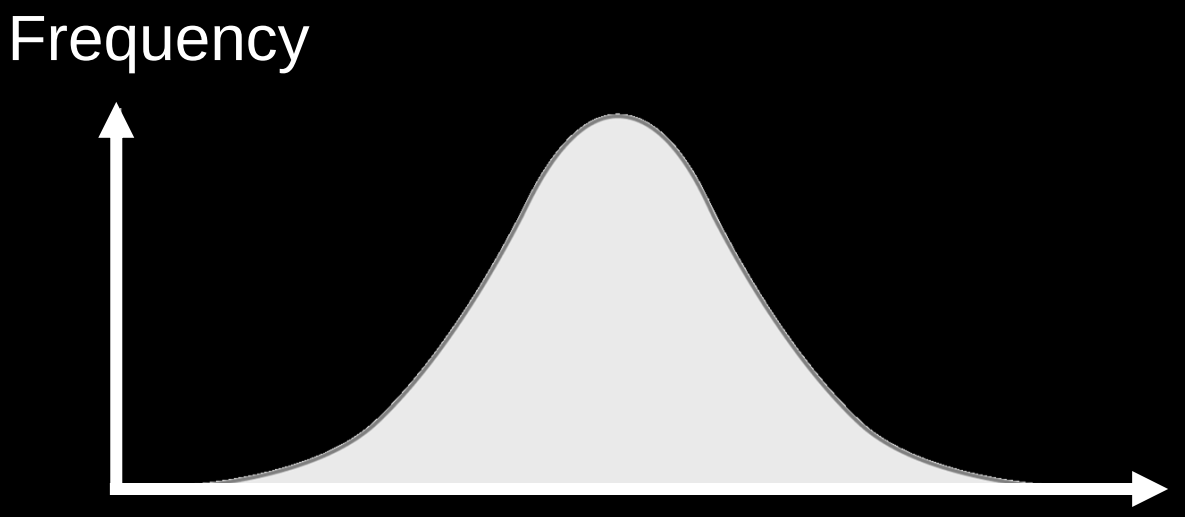
Absent in conventional polymers

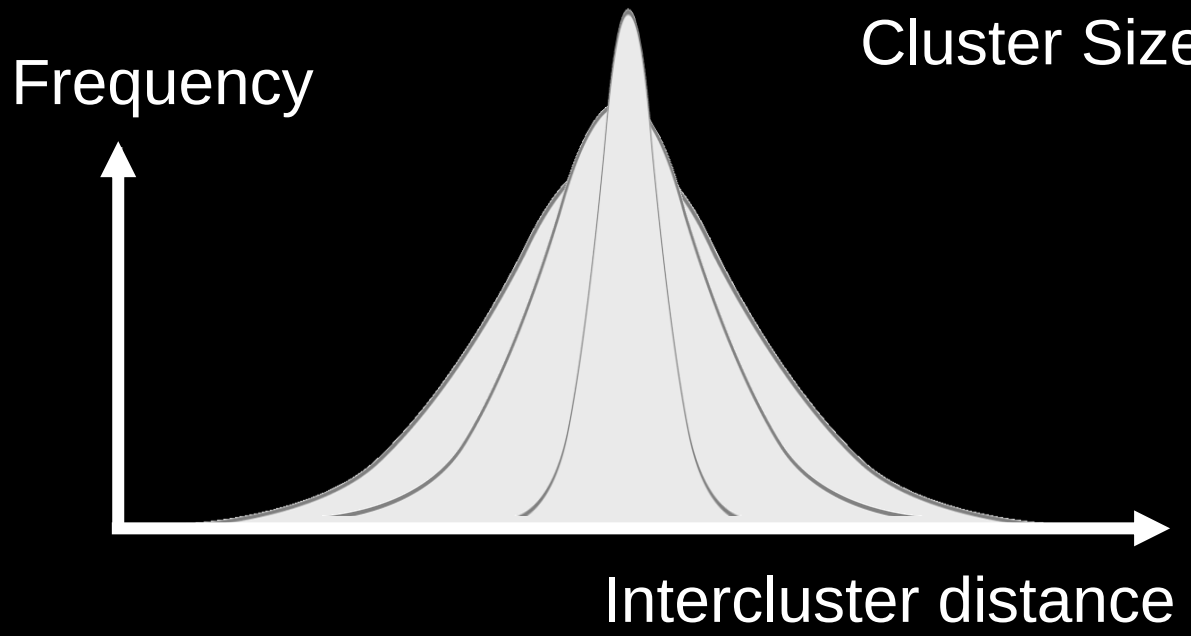
Insufficient in the fibre-direction of composites Schöberl et al.



Choosing the tracer particle



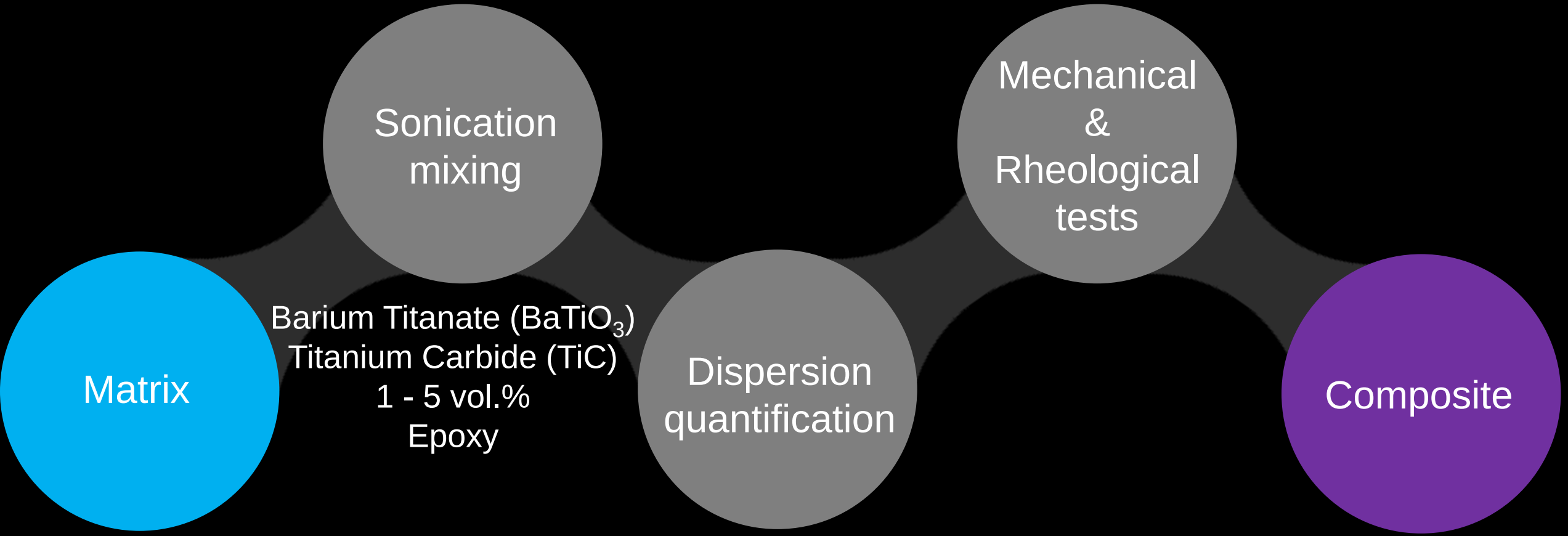




Incorporating the tracer particle

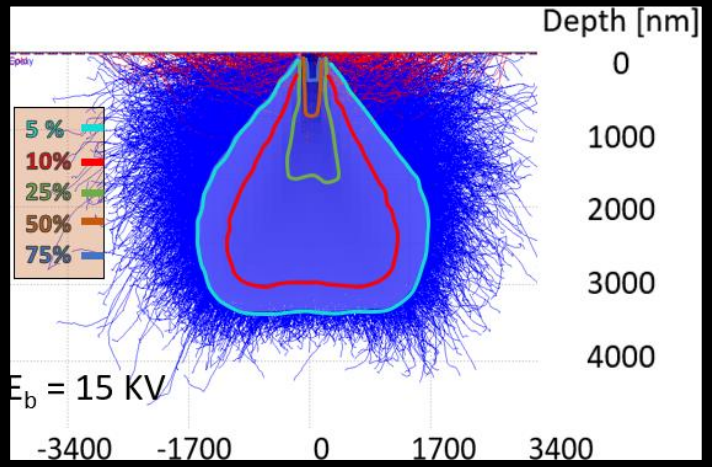
Ensuring mechanically consistent materials

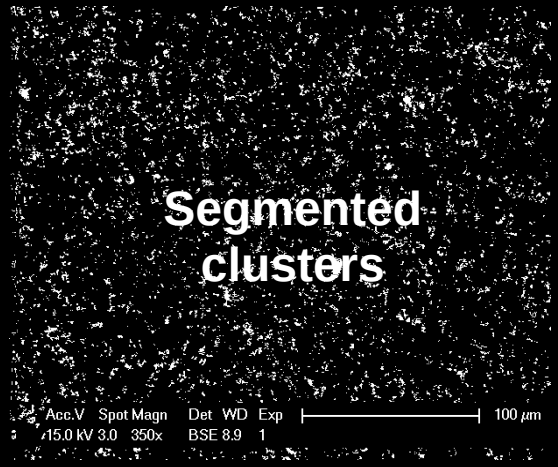
Securing a suitable microstructure for DVC



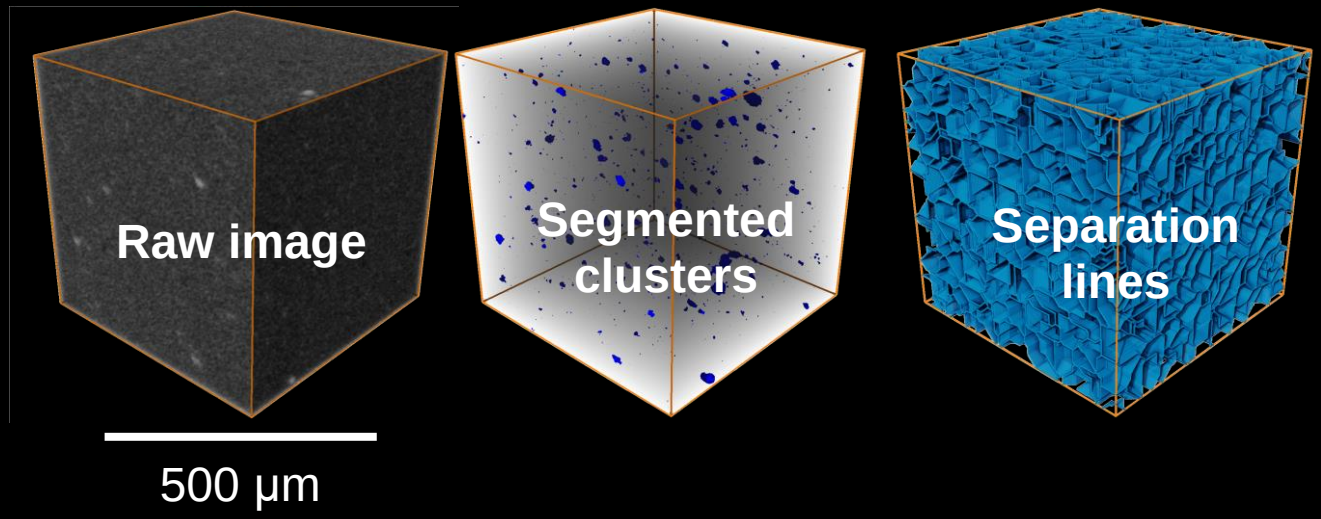
From localised dispersion…

SEM
ROI: 60 × 60 µm²
Screening



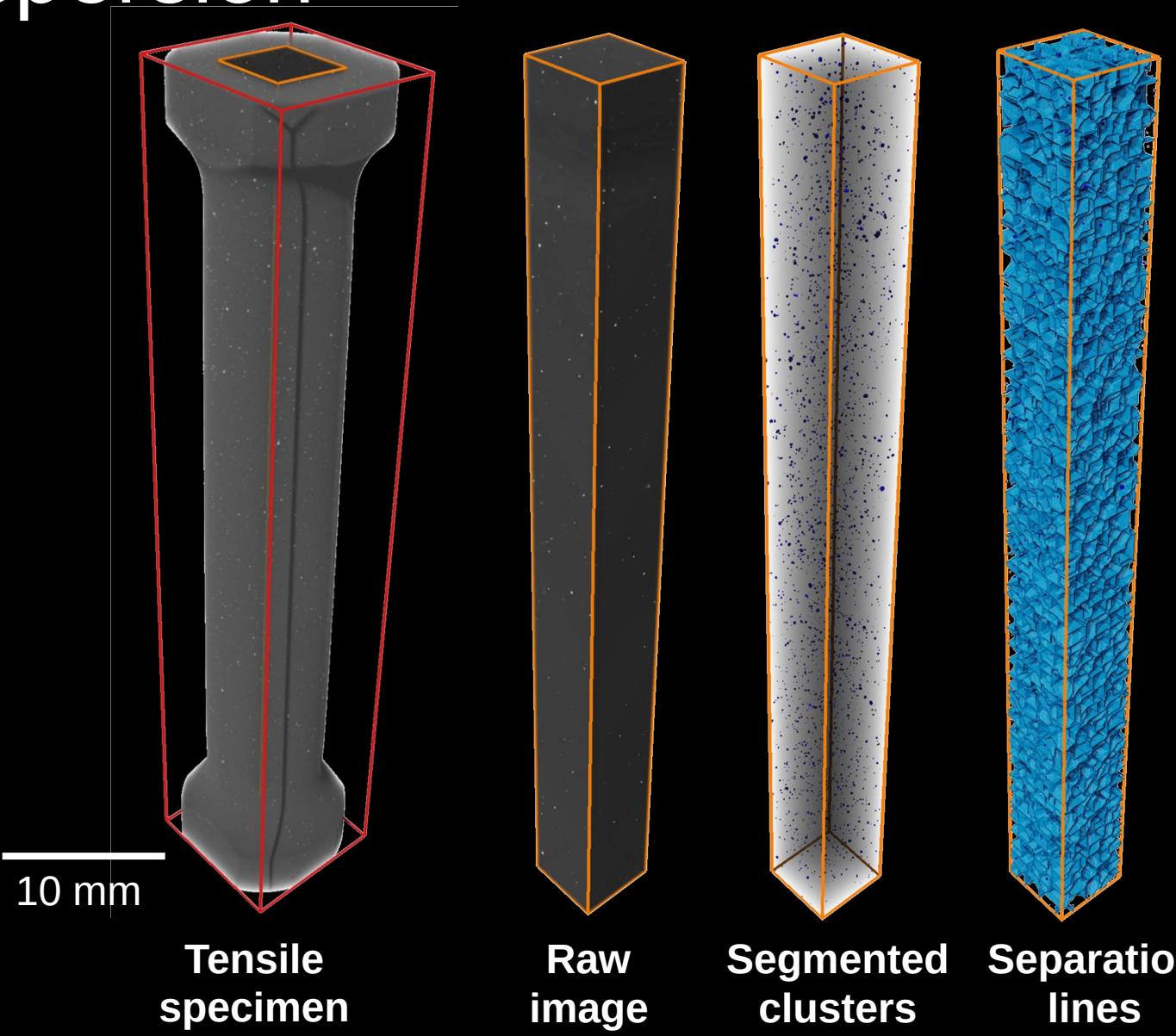


High-resolution XCT
Voxel size: 500 nm
VOI: 500 × 500 × 500 µm³
Analysis of **all** clusters



…to globalised dispersion

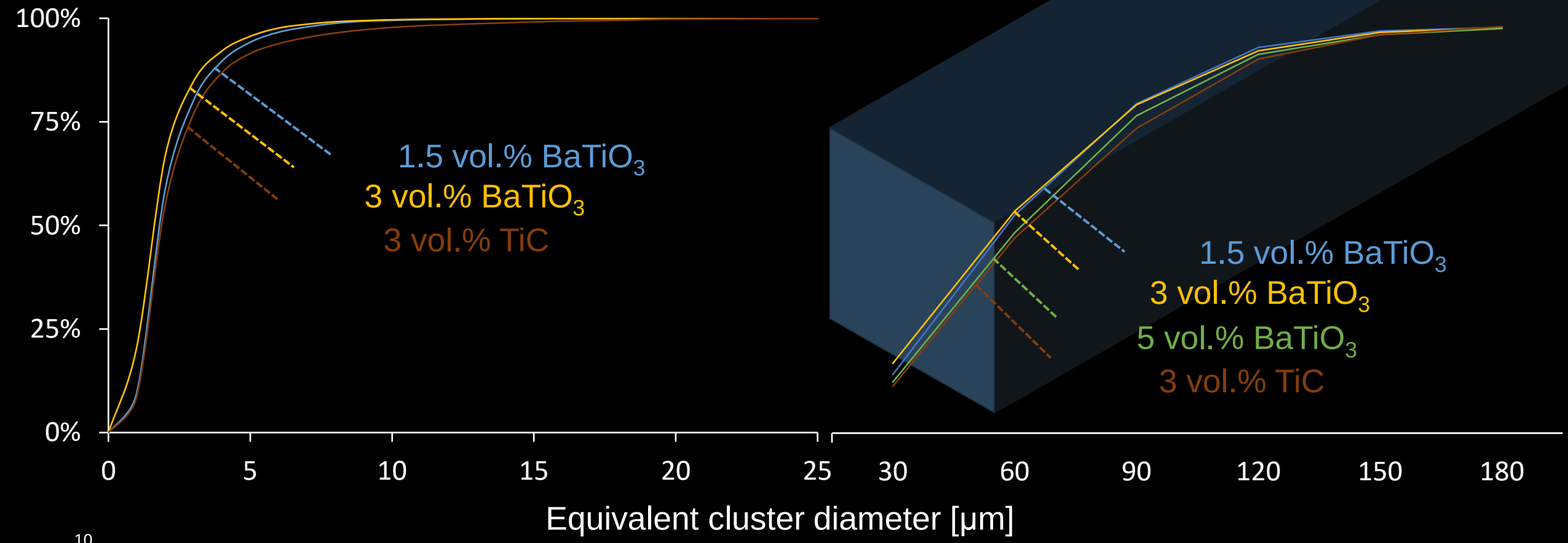
Low-resolution XCT
Voxel size: 25 µm
VOI: 10 × 10 × 50 mm^3
Analysis of **large** clusters



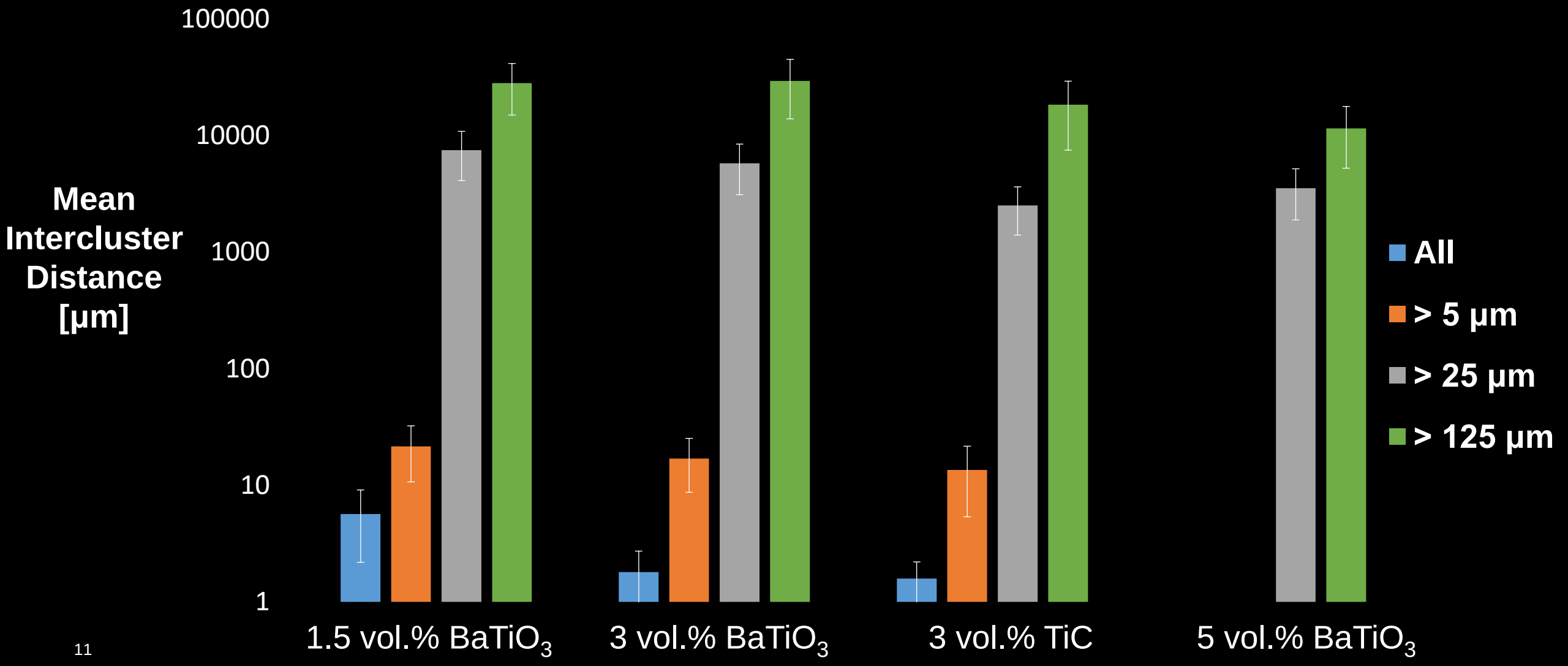
The presence of a multiscale speckle pattern

High-resolution XCT

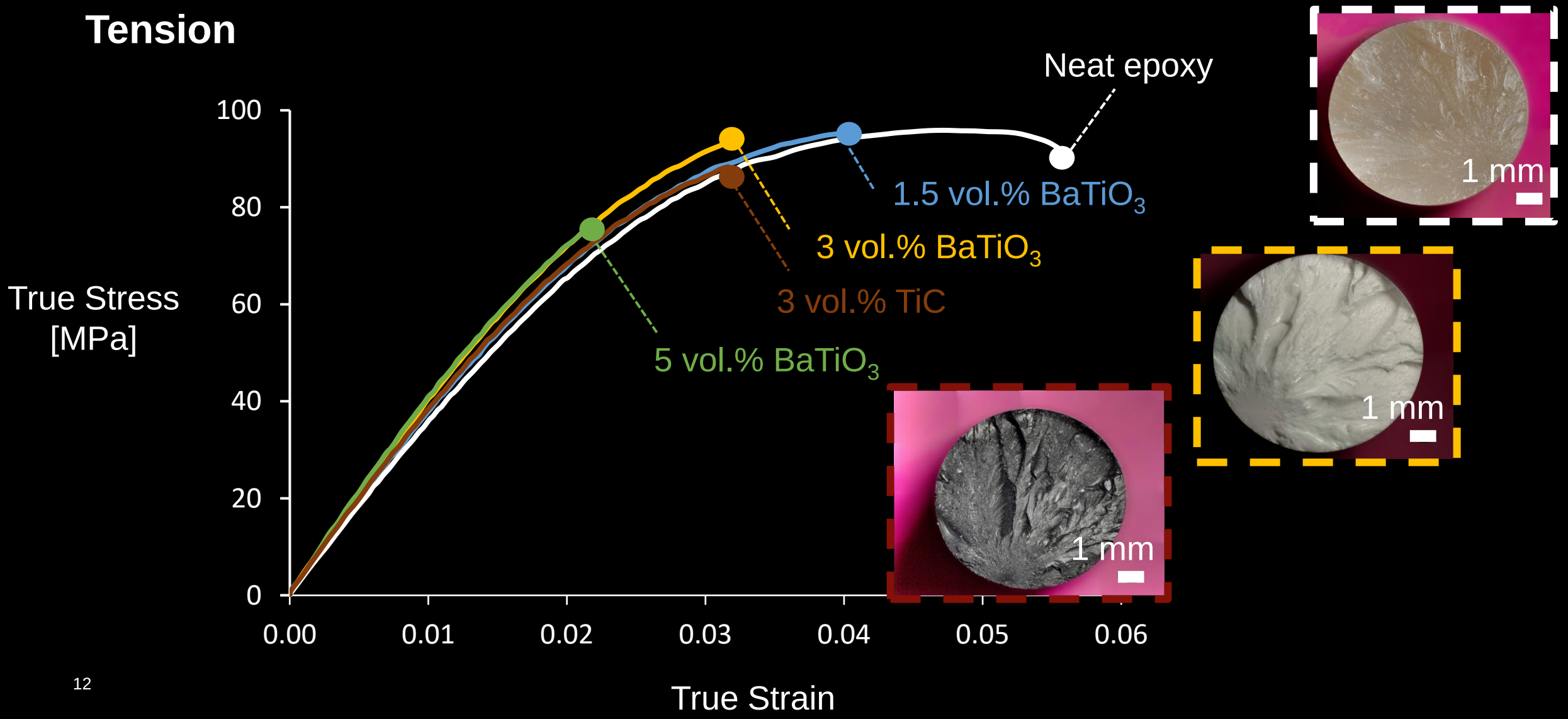
Low-resolution XCT



How uniform is the speckle pattern?

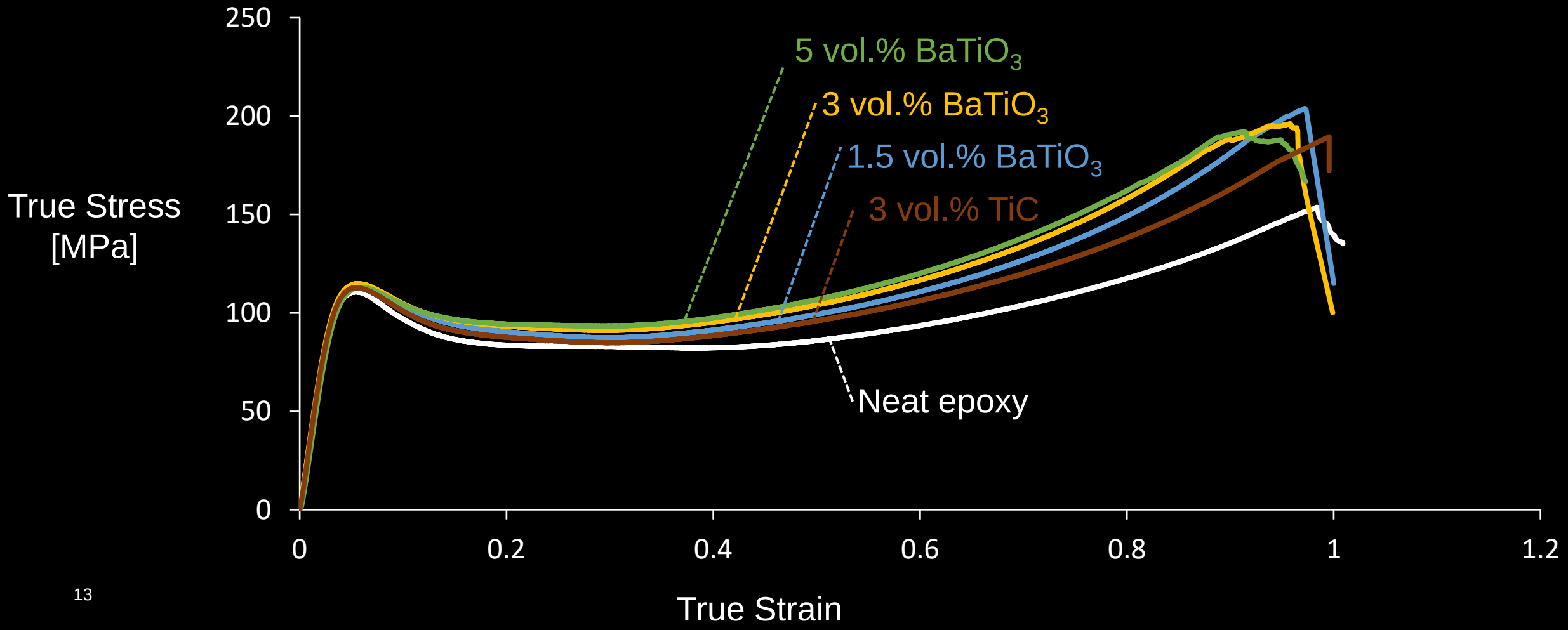


What about the mechanical representativity



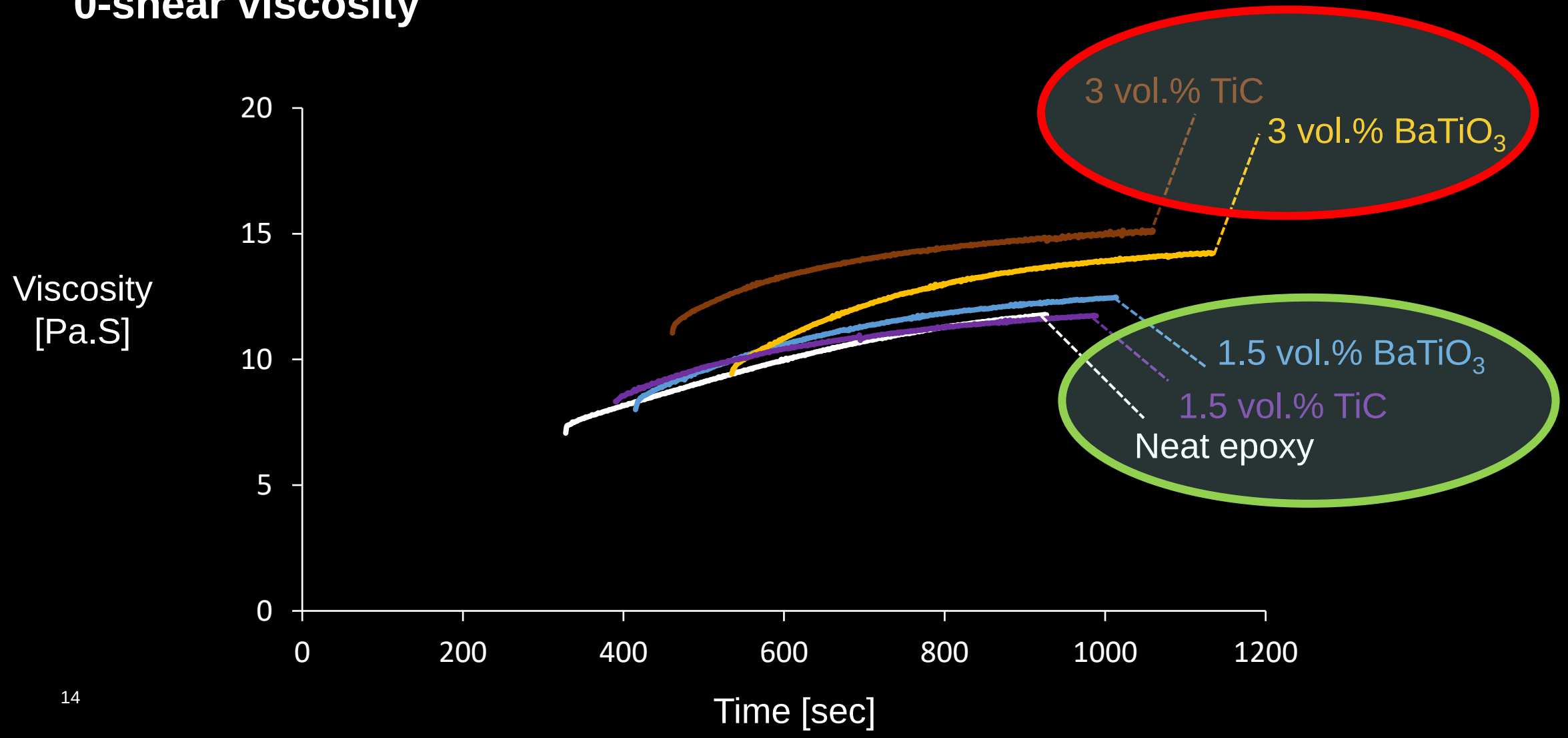
What about the mechanical representativity

Compression



What about the rheological representativity

0-shear viscosity



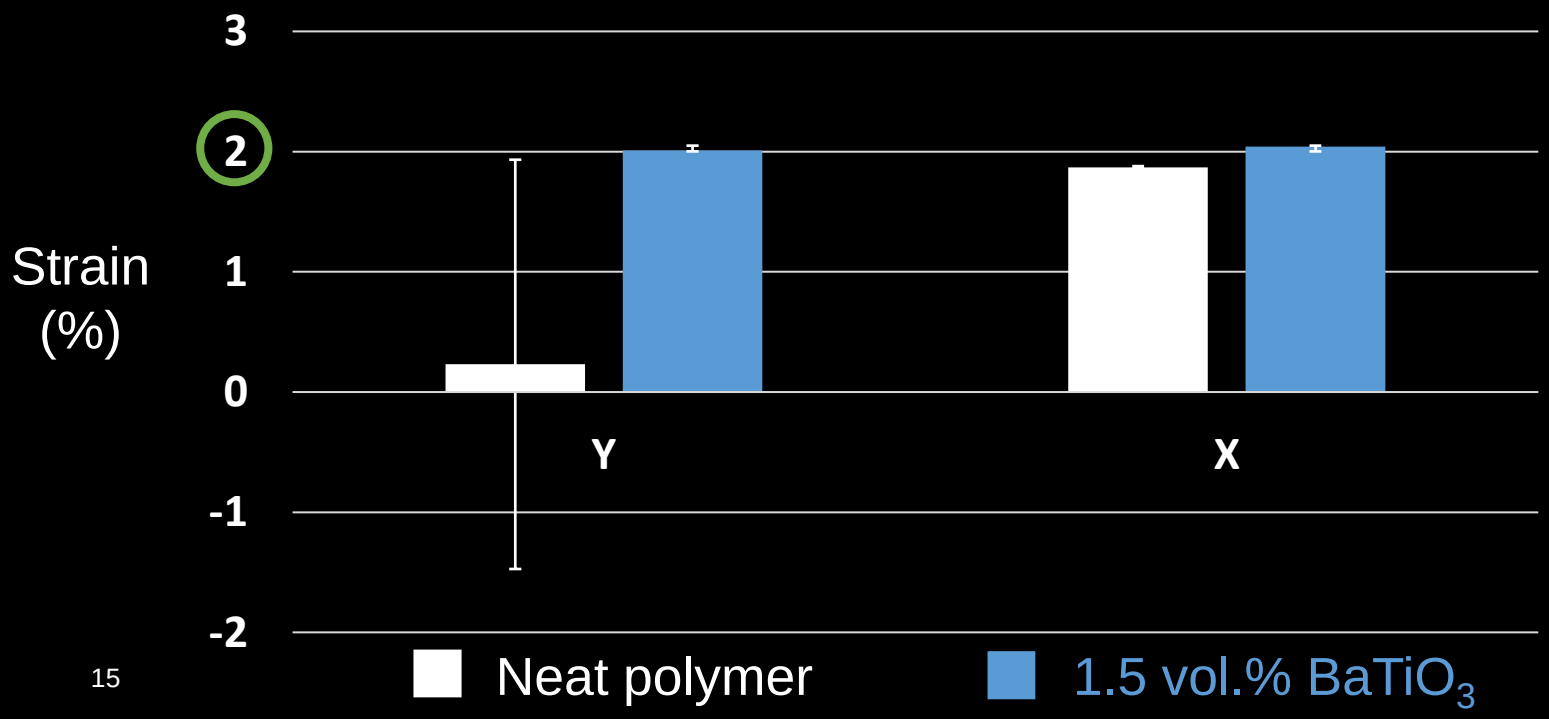
Are the particles essential?

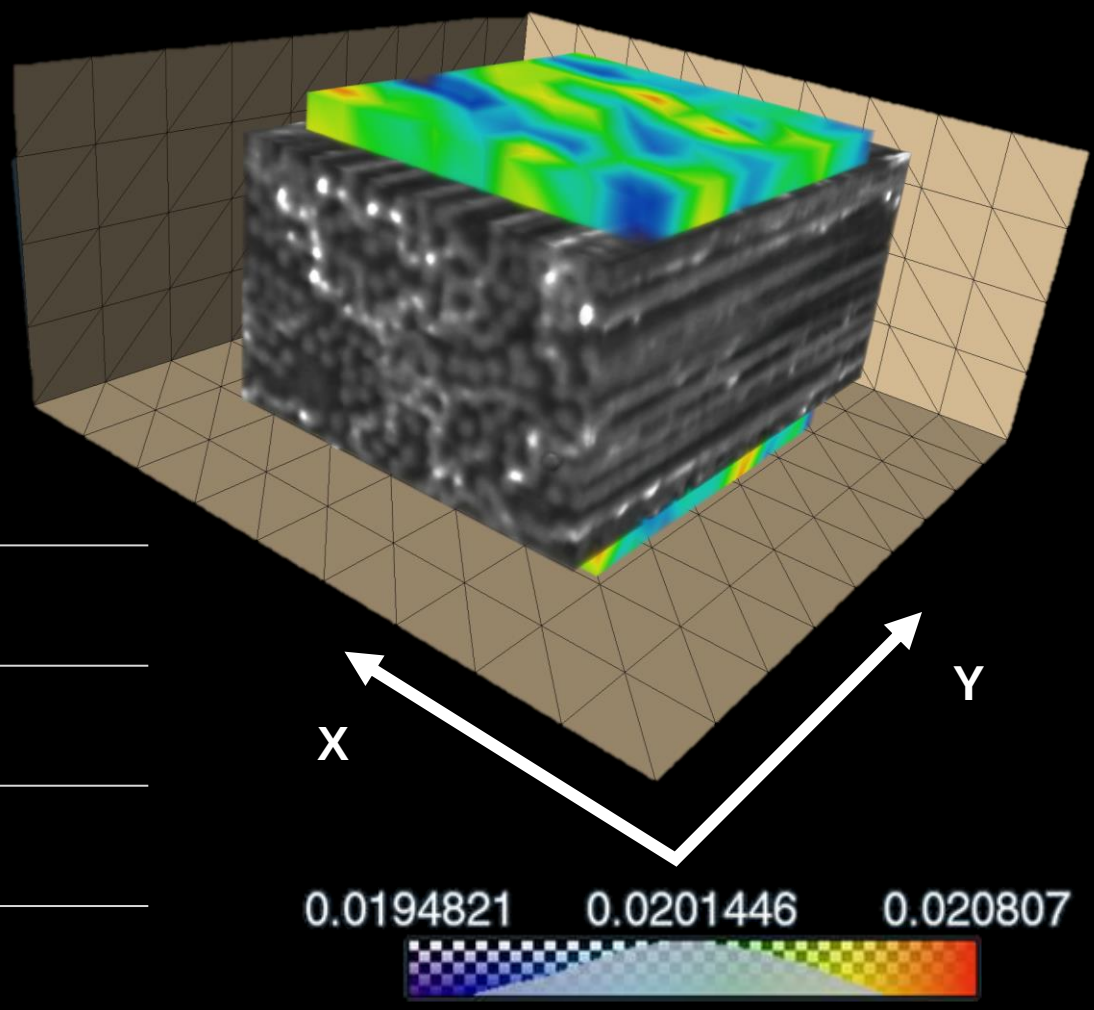
Virtual Displacement study Mehdikhani et al.

Applied strain ε = 0.02 (2%)

Longitudinal (Y)

Transverse (X)





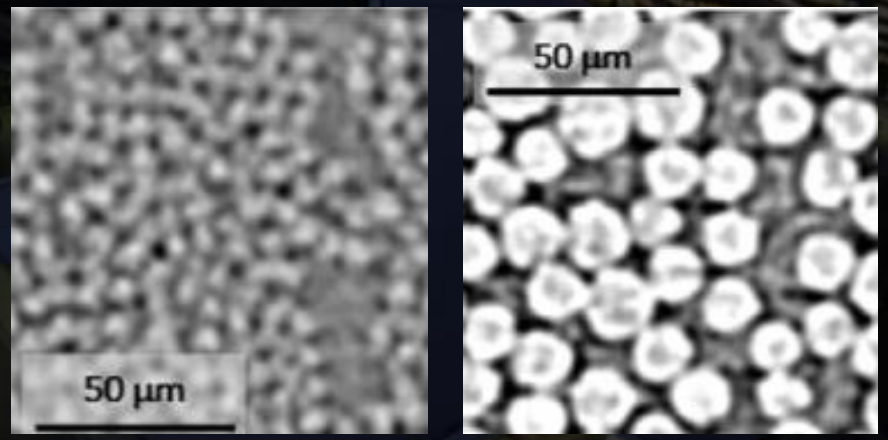
Summary and Future

- Particle incorporation for DVC of composites
- Quantification of dispersion
- Optimisation of particle type, volume fraction
- Investigation of mechanical and rheological behaviour

Heterogeneity
Uniformity
Efficiency
Representativity

ESRF ID16B

- In-situ experiments on multi-fibre and single-fibre
- $BaTiO_3$ and TiC fiducials
- From Carbon to Glass fibres



Carbon **Glass**

Mehdikhani et al.

Thank you for your attention

KU LEUVEN

MATERIALS ENGINEERING

Composite Materials Group