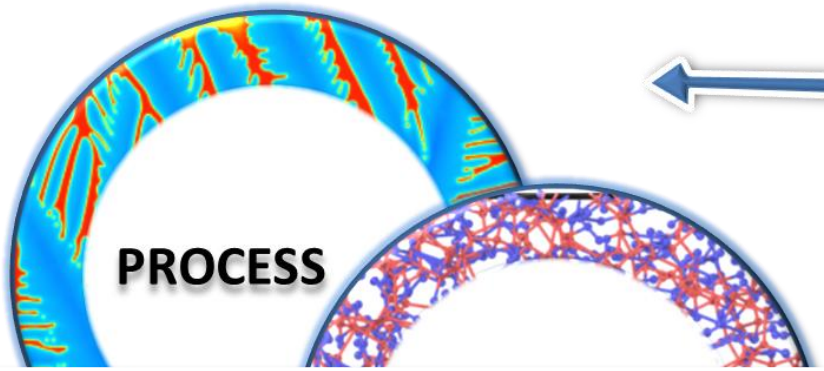
RAMI partner viewpoint: Potential of XCT for material modelling

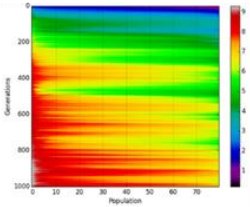
Launch meeting for XCT at GTK
Nov 9, 2017

Vice President, Dr Tarja Laitinen

Process-Structure-Properties-Performance Concept in Application of ICME



performance driven material design



Material informatics and

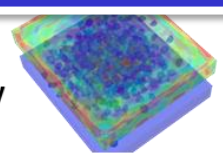
Typical applications of ICME relate to:

1) Material design: Systematic design and improvement of e.g. steel (microstructures) in the frame of structure-property-performance causality and wear performance (“material design”)
2) Material solution optimization: Optimization and evaluation of lifetime of case specific material solutions (“material solution design”)
3) Troubleshooting: Complex material affiliated problems (“product material selection & design rules”)

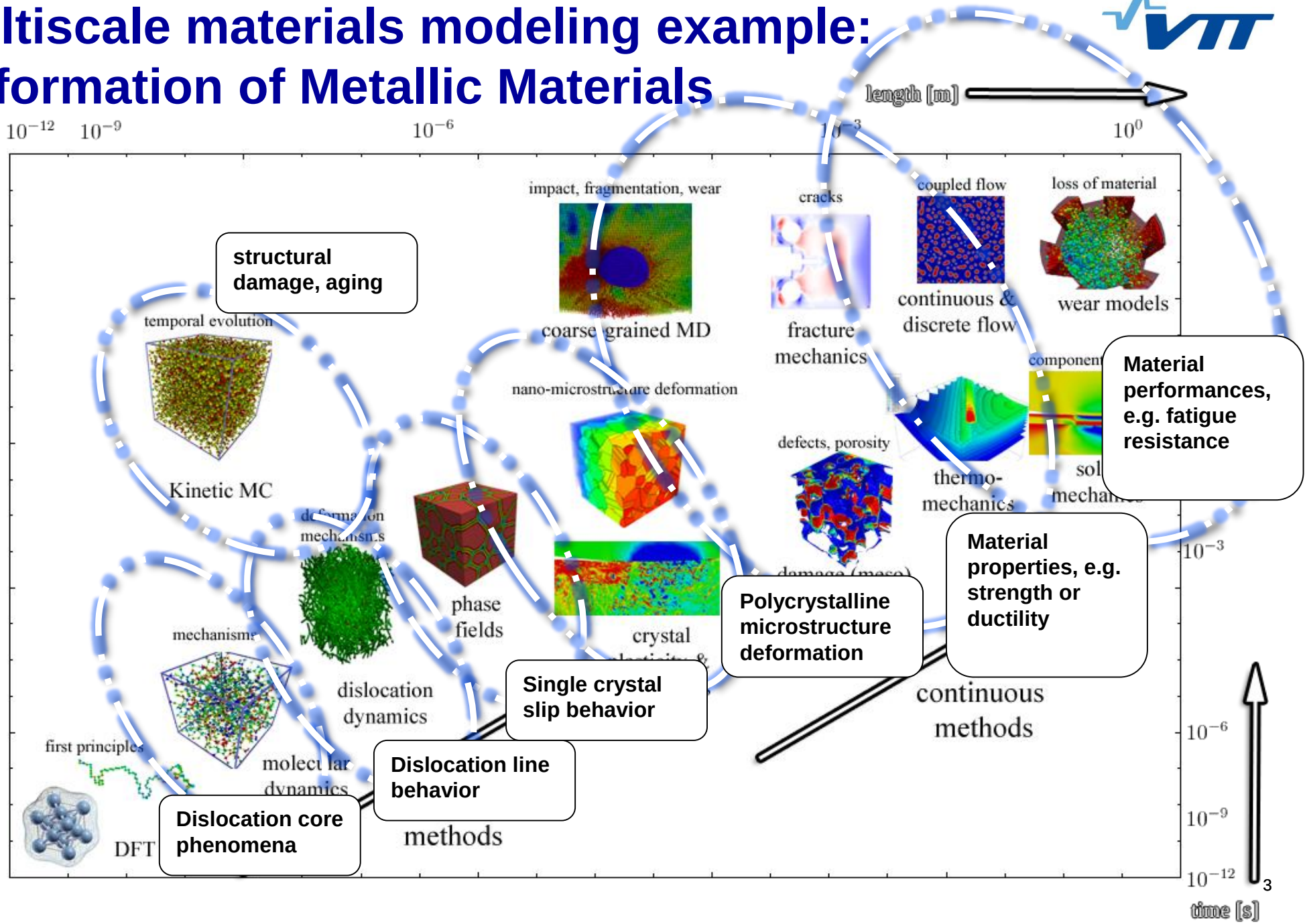
These are typical cases where ICME produces added value over traditional & trial-and-error approaches.

steels

Performance modeling for 2- and 3-body abrasion

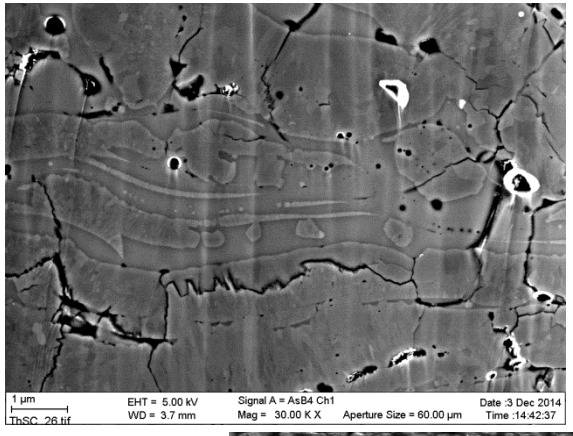


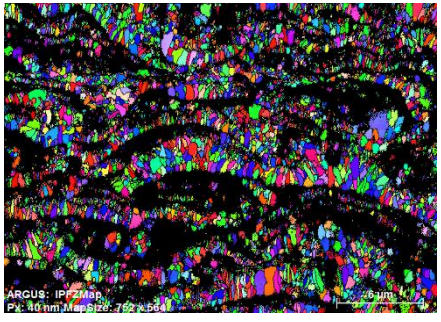
Multiscale materials modeling example: Deformation of Metallic Materials

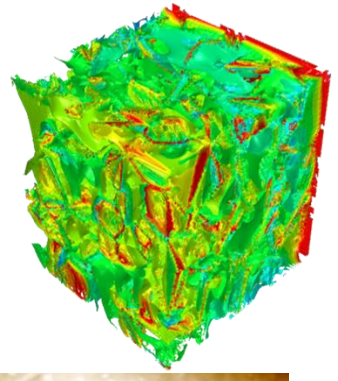


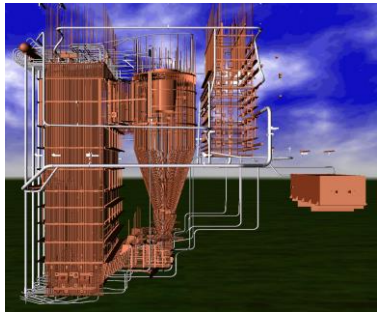
From material microstructure to full scale components and systems

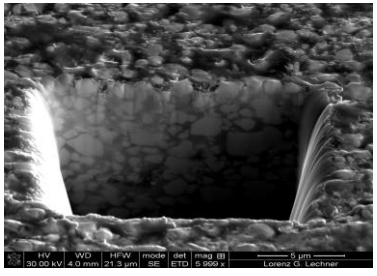
- Tools to create the microstructure: SEM, FIB, EBSD, µ-CT, TEM, APT
- Tools to characterize the properties: Nanoindentation, AFM and SPM for mechanical property mapping
- Tools to validate the models: Laboratory or component/ system level testing

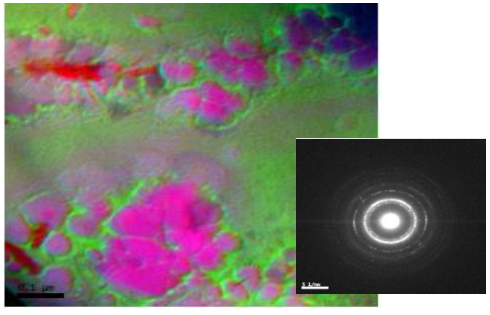


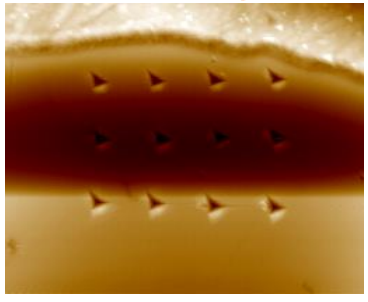




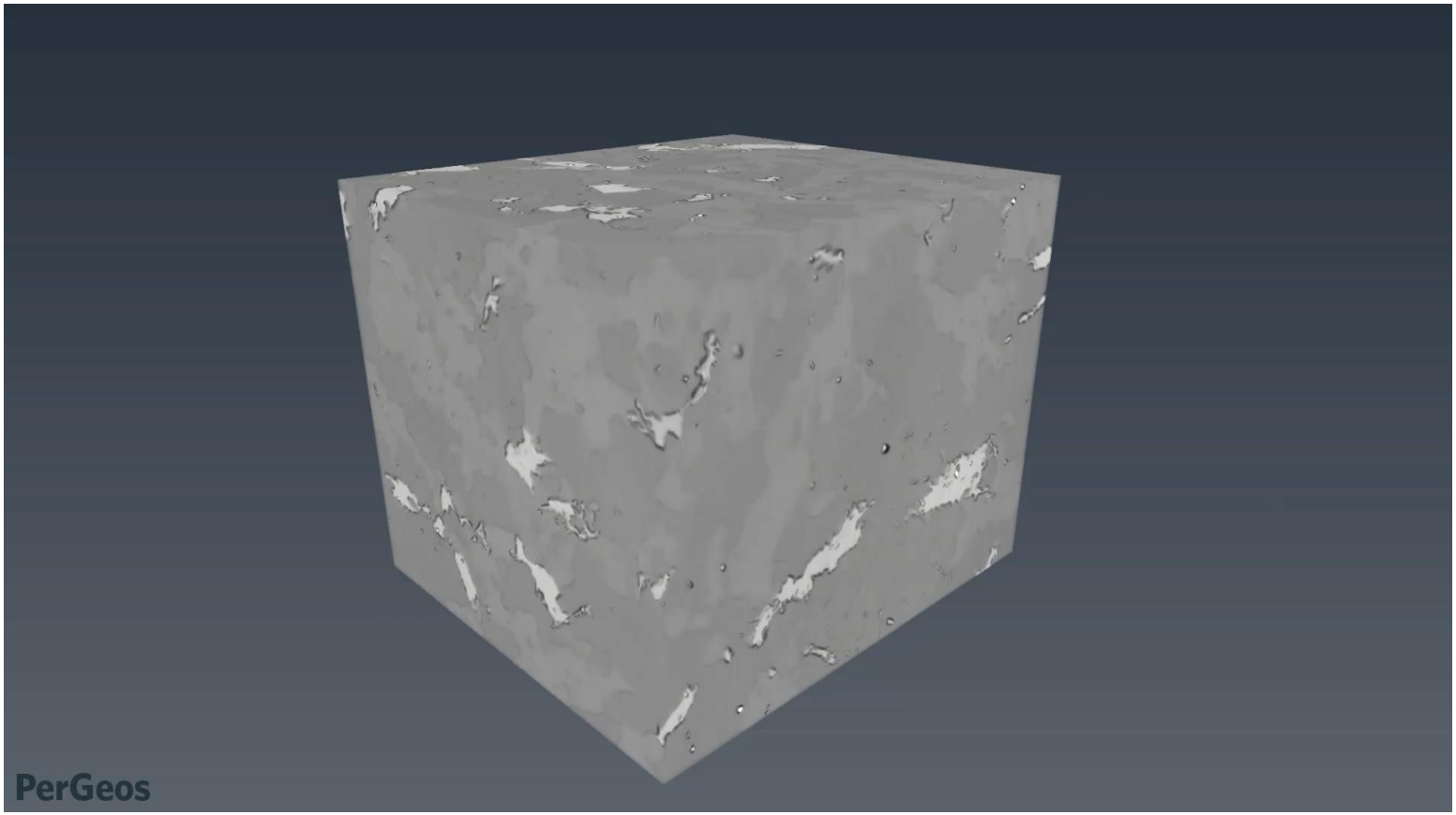




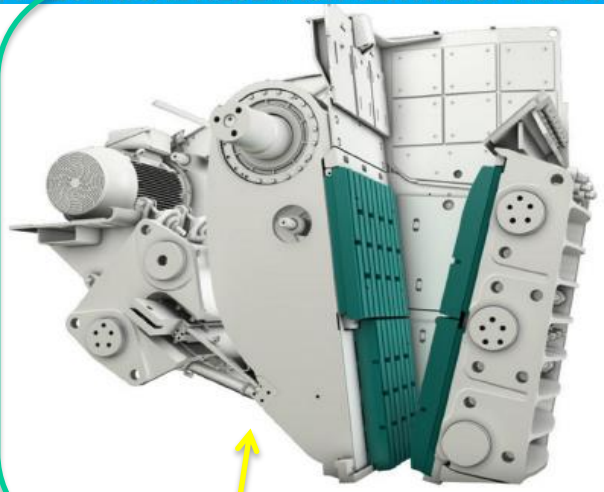


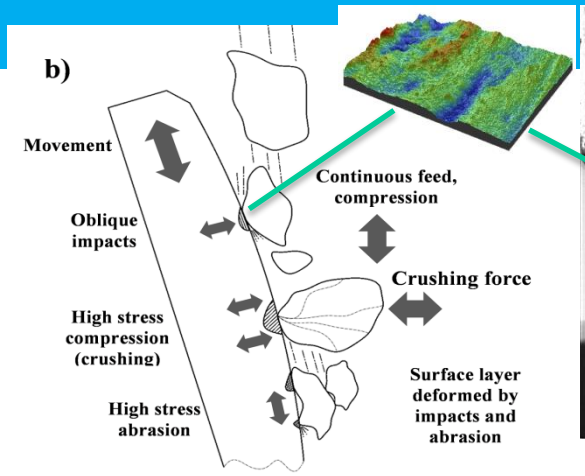


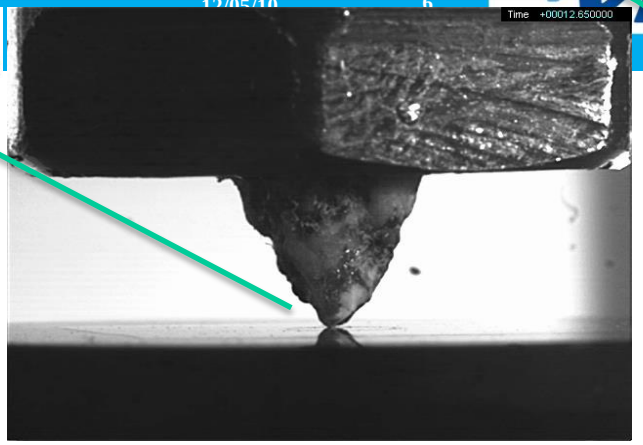
X-Ray Tomography of Granite sample



Experiments & Characterization



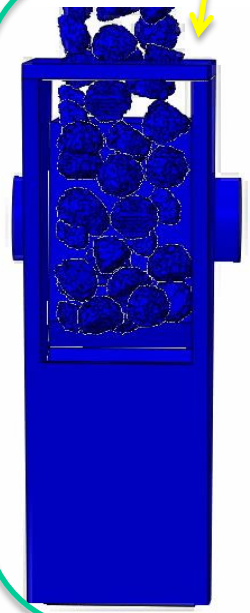


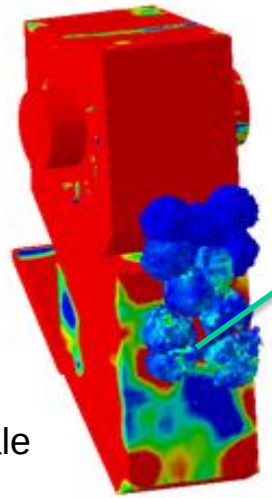


Characterization

Experiments

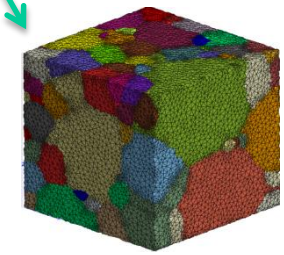
Simulations



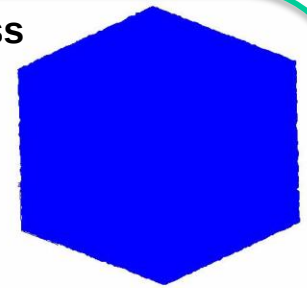


Application scale model

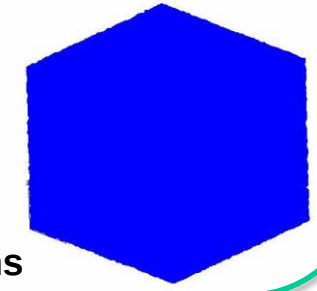
Macro-to-micro scale



Stress



Microscale



Twins

CRUSHER DESIGN AND DYNAMICS

DYNAMIC CRUSHER MODEL RESULTS

MICROSTRUCTURAL MODELING

ROCK CHARACTERISTICS

Rock generation and topography

Rock material and failure model

Crusher CAE design model and crushing parameters

Dynamic crusher model

Crusher efficiency and operation

Wear plate loading

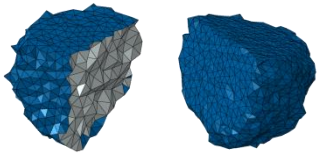
Rock crushing and product

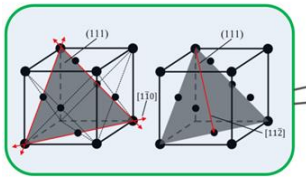
Crystal plasticity and microstructural modeling

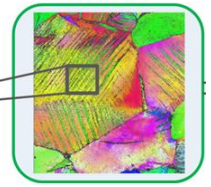
Wear process modeling

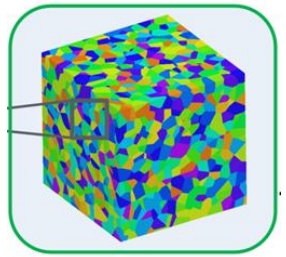
Material wear performance

MICROSTRUCTURAL MODELING RESULTS

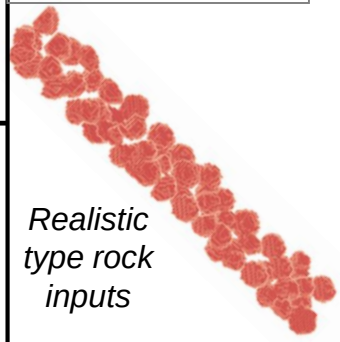




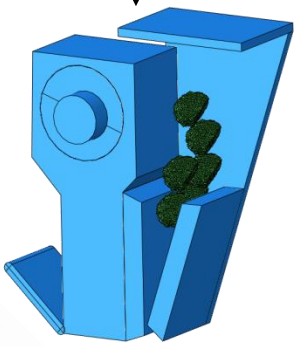




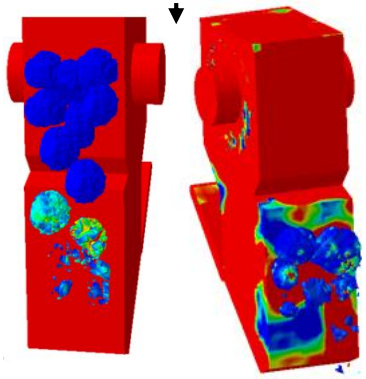
Visualization

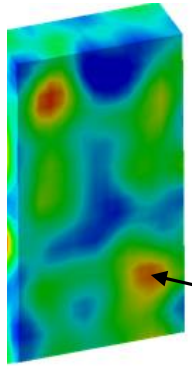


Realistic type rock inputs

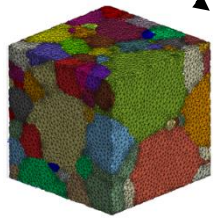


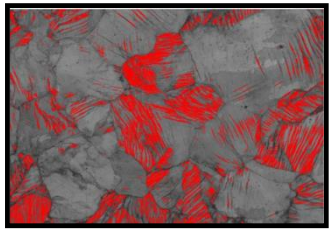
Dynamic model

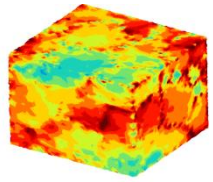


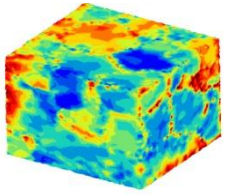


Crusher stresses, deformation, and wear









Crusher loads

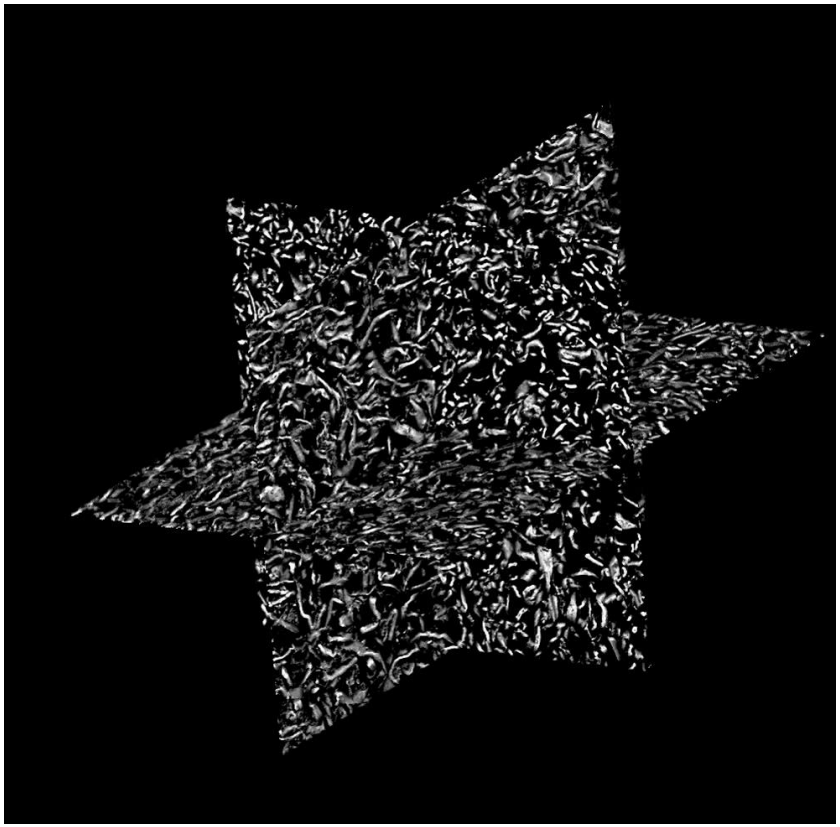
End product quality

Crushing efficiency

Crushing work & energy

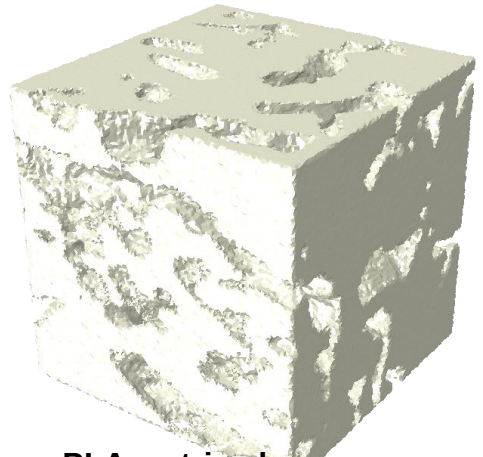
Material performance

Use case: 3D microstructural modelling of birch pulp (BP) reinforced polylactic acid (PLA) biodegradable polymer

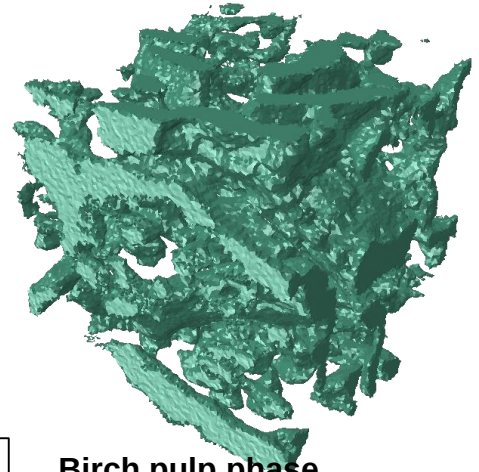


Tomography based ortoslice of the 3D material image

3D microstructural finite element modelA



PLA matrix phase



Birch pulp phase

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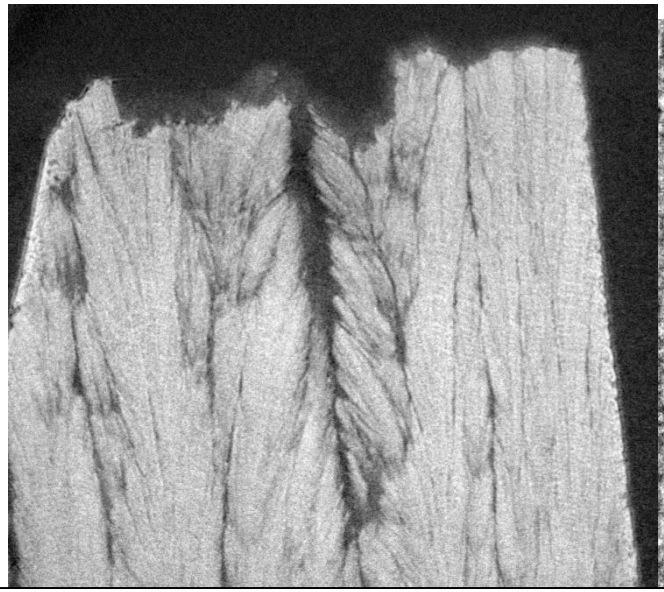
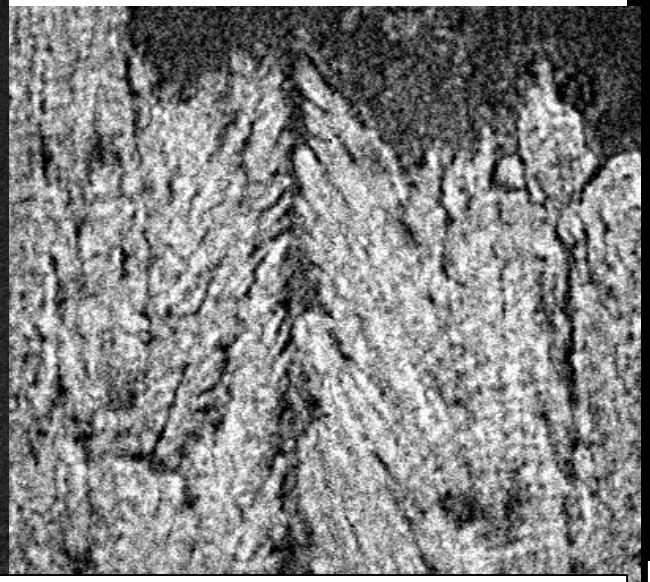
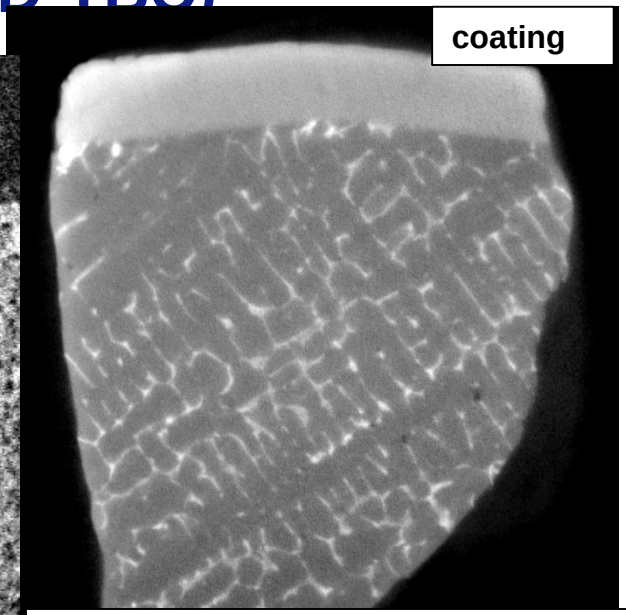
Use case: thermal barrier coating (EB-PVD-TBC)

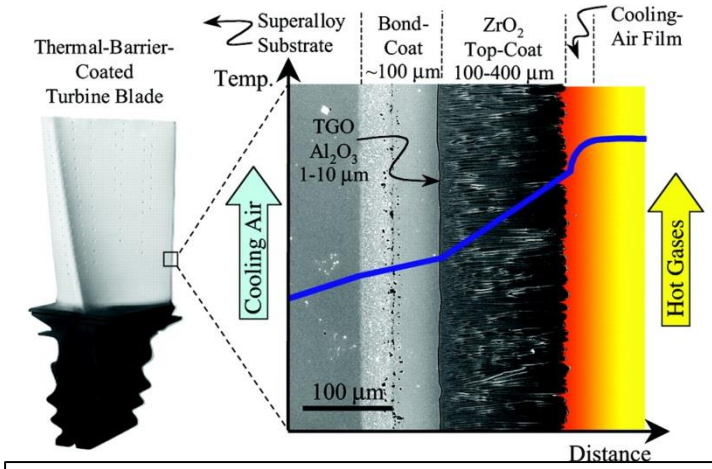


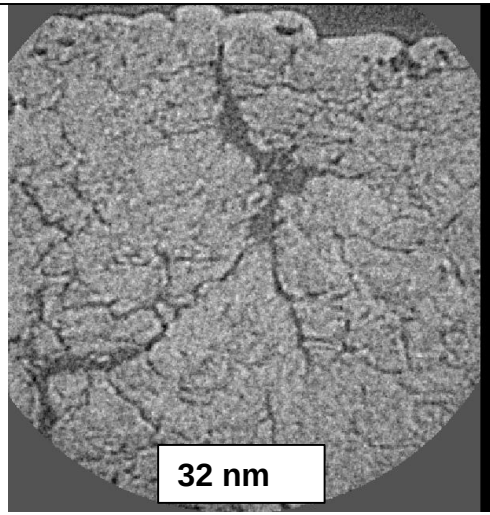


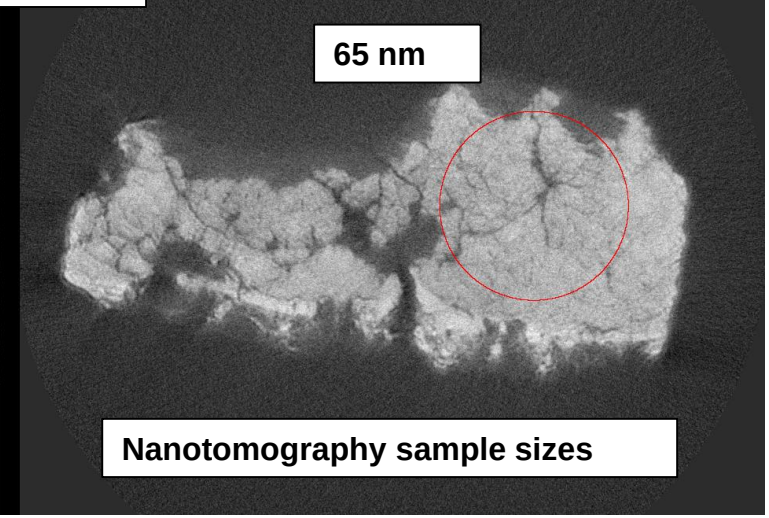


Nanotomography of top-coat structure: i) overall porous surface structure, (left), ii) high resolution image of surface details (right).

NiAl, Laves phase, precipitates in substrate [sample dimension ~ 1 mm]







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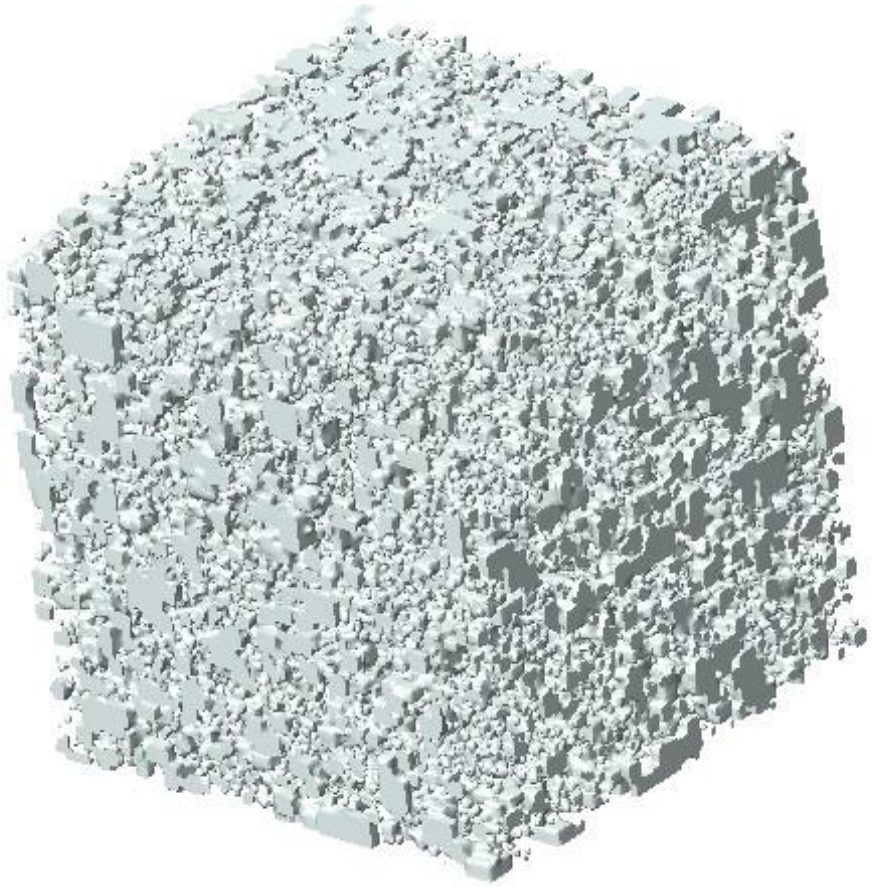
Collaboration with University of Jyväskylä/Arttu Miettinen

Thank You!



3D representation of tungstencarbides in WC-10Co4Cr-material