PAUL SCHERRER INSTITUT

PSI

Materials Science at Large Scale Facilities

Imaging - exercises

Challenges

- Visualize evolution of the 3D dislocation structure in a single grain of aluminium during heating
- Visualize onset (~100nm) of cracking and delamination during tensile loading of a carbon fiber – expoxy laminate. Fiber diameter is 7 µm, volume fraction 60%.
- Study the influence of the microstructure on the stress induced martensitic phase transformation (austenite -> hexagonal close-packed martensite), with particular focus on grain size, orientation and environment.
- Quick measurement on the quality of a Si wafer (i.e. low defect density)

Dislocation structures

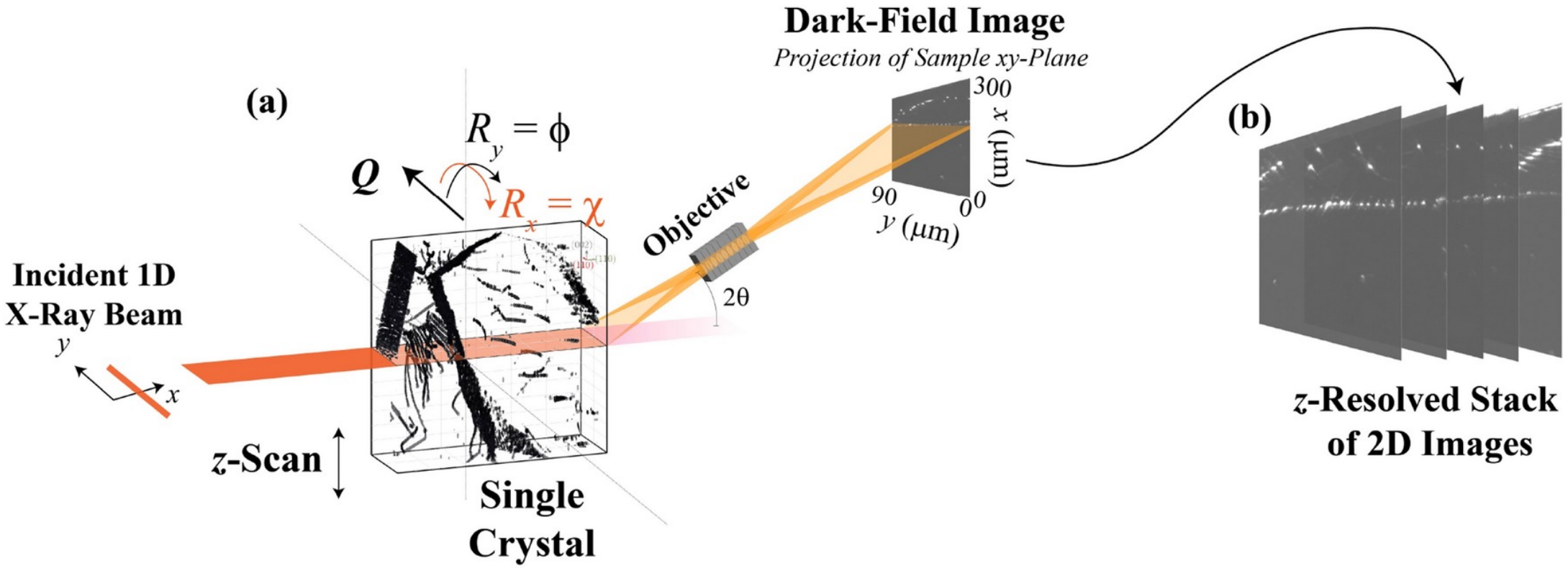
- **Challenge**: visualize evolution of the 3D dislocation structure in a single grain of aluminium during heating

- Method?

Dislocation structures

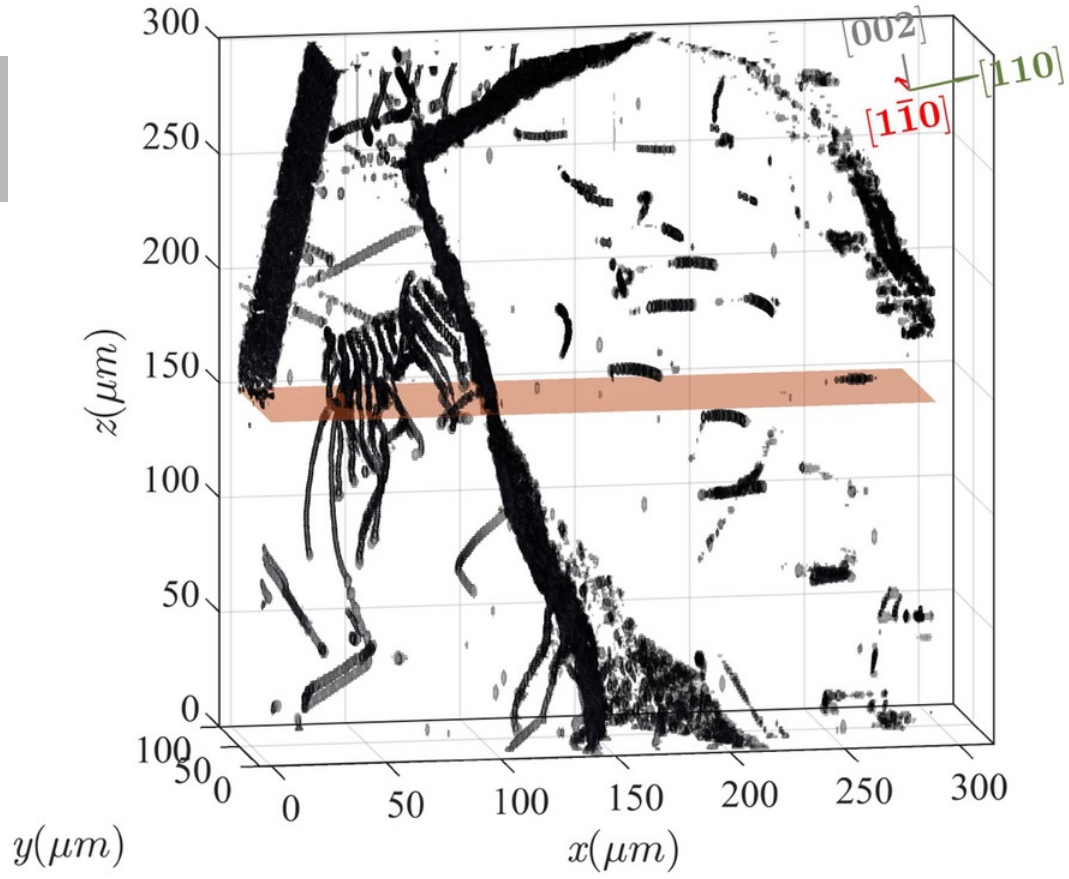
- **Challenge**: visualize evolution of the 3D dislocation structure in a single crystal of aluminium during heating
- Method?
- Solution: diffraction-based dark field x-ray microscopy

Dark field X-ray microscopy



Can Yildirim *et al* Extensive 3D mapping of dislocation structures in bulk aluminum, Scientific Reports **13** (2023) 3834

Dark field X-ray microscopy



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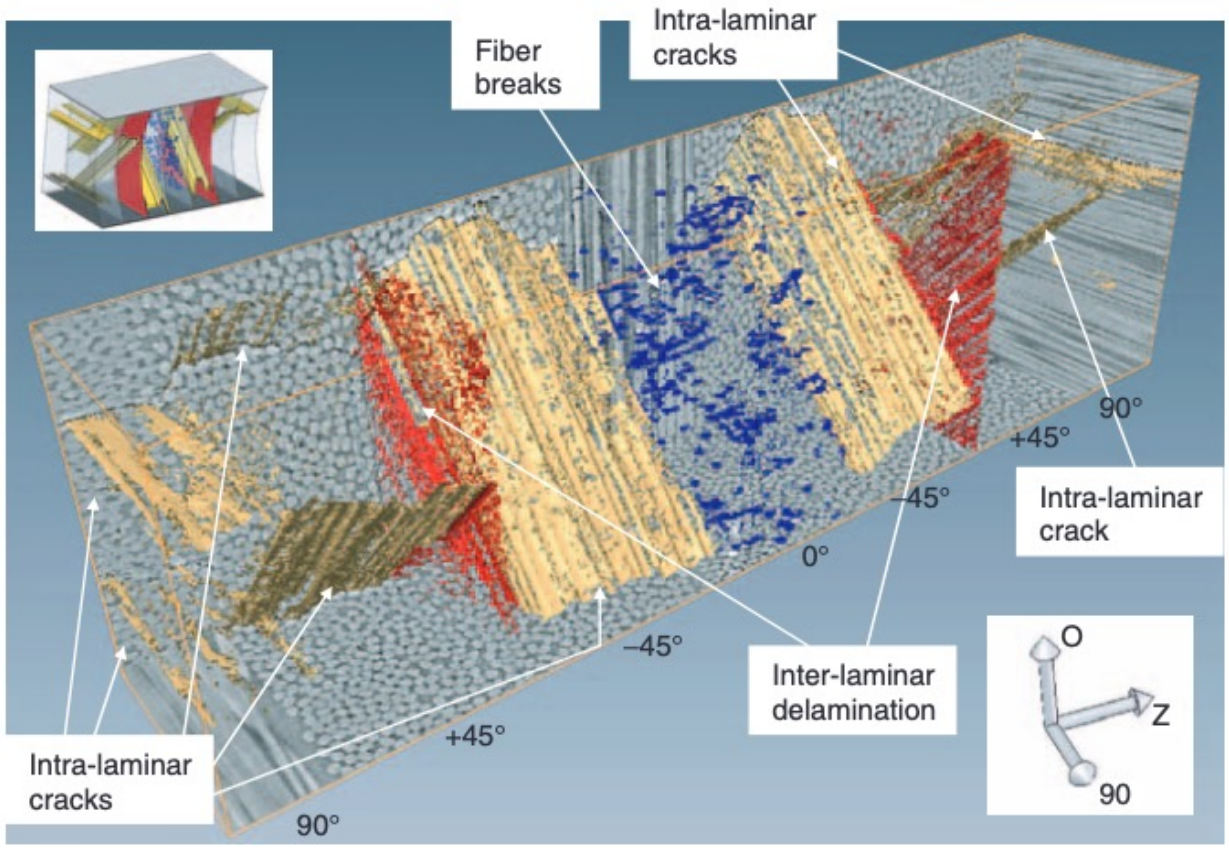
Damage in polymer-matrix composites

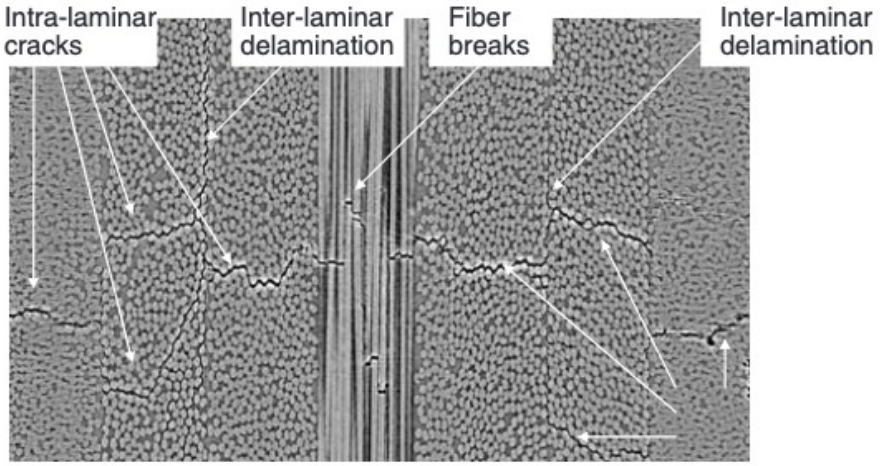
- **Challenge**: visualize onset (~100nm) of cracking and delamination during tensile loading of a carbon fiber – expoxy laminate. Fiber diameter is 7 µm, volume fraction 60%.
- Method?
- What if the sample is extended in two directions?

Damage in polymer-matrix composites

- **Challenge**: visualize onset (~100nm) of cracking and delamination during tensile loading of a carbon fiber – expoxy laminate. Fiber diameter is 7 µm, volume fraction 60%.
- Method?
- Solution: X-ray phase contrast tomography / laminography

Damage in polymer-matrix composites





P. Wright et al *Ultra high resolution computed tomography of damage in notched carbon fiber-exposy composities*
Journal of composite materials **42** (2008) 1993

Influence microstructure on phase transformation

- **Challenge**: study the influence of the microstructure on the martensitic phase transformation (austenite -> hexagonal close-packed martensite), with particular focus on grain size, orientation and environment.

- Method?

Influence microstructure on phase transformation

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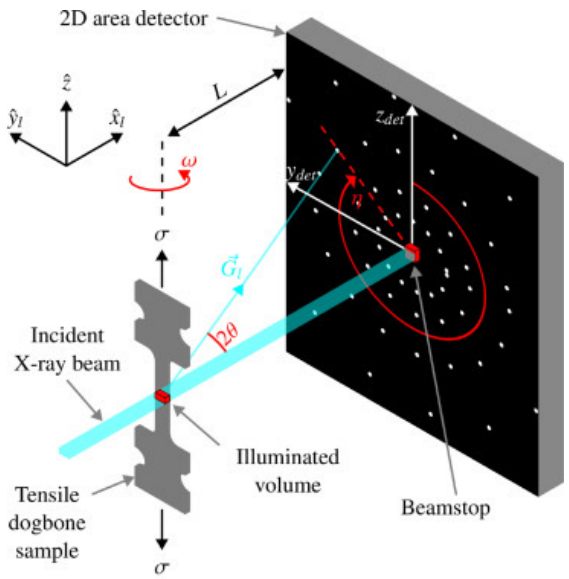
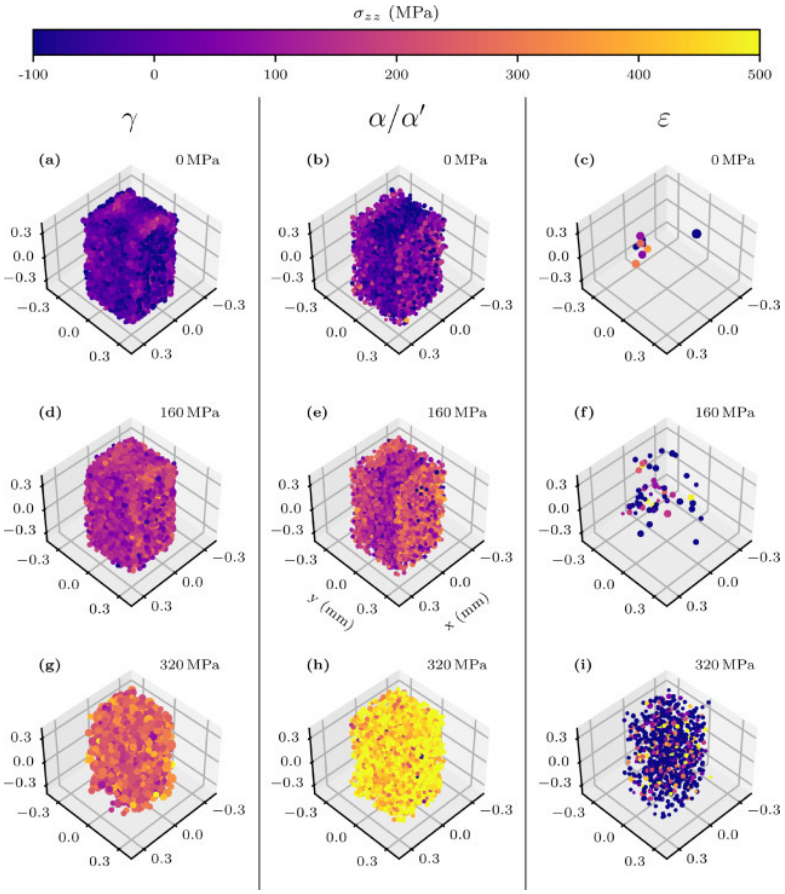
- Method?
- Solution: 3DXRD

Influence microstructure on phase transformation

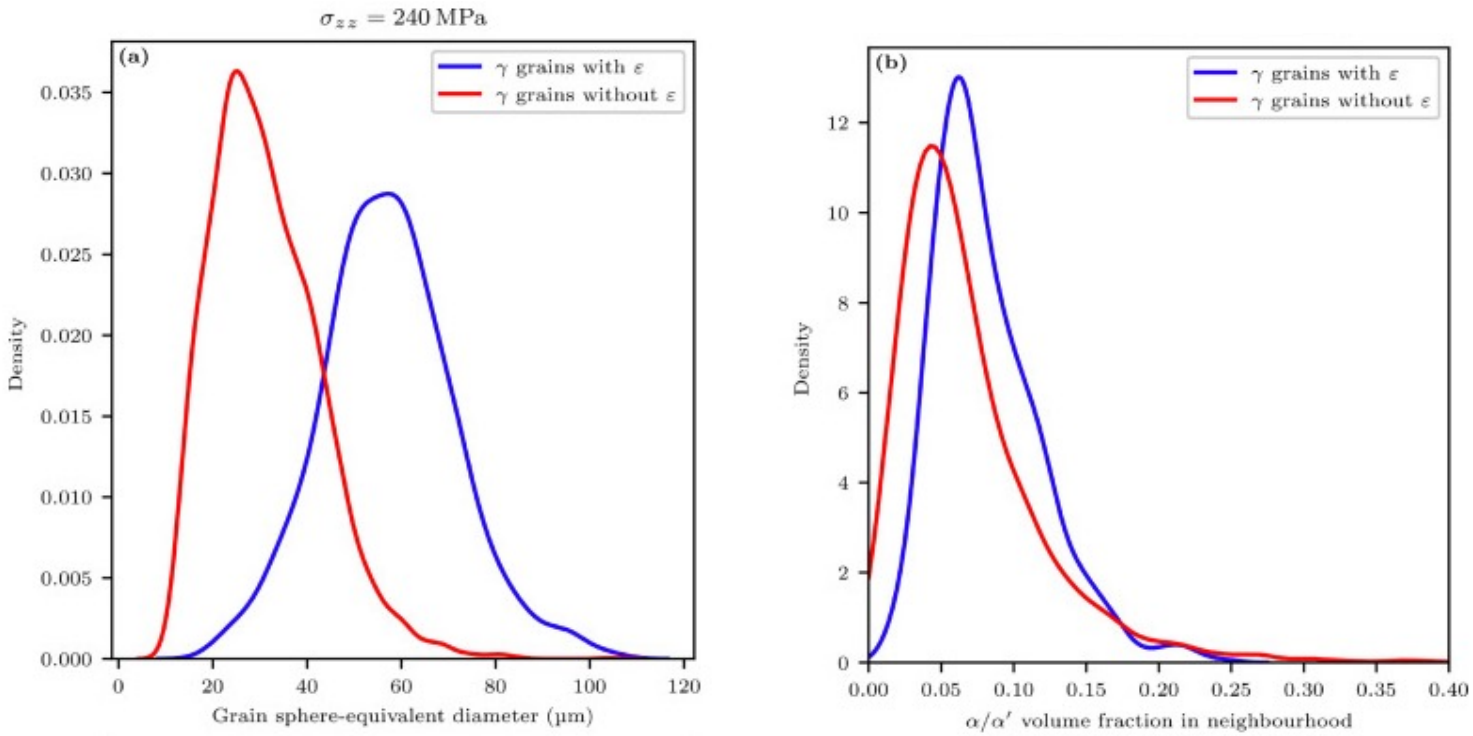


>10’000 grains were tracked!



J.A.D. Ball et al *Grain-level effects on in-situ deformation-induced phase transformations in a complex-phase steel using 3DXRD and EBSD*
Acta Materialia **265** (2024) 119608

Influence microstructure on phase transformation



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Quality control Si wafers

- **Challenge**: quick measurement on the quality of a Si wafer (i.e. low defect density)
- Method?

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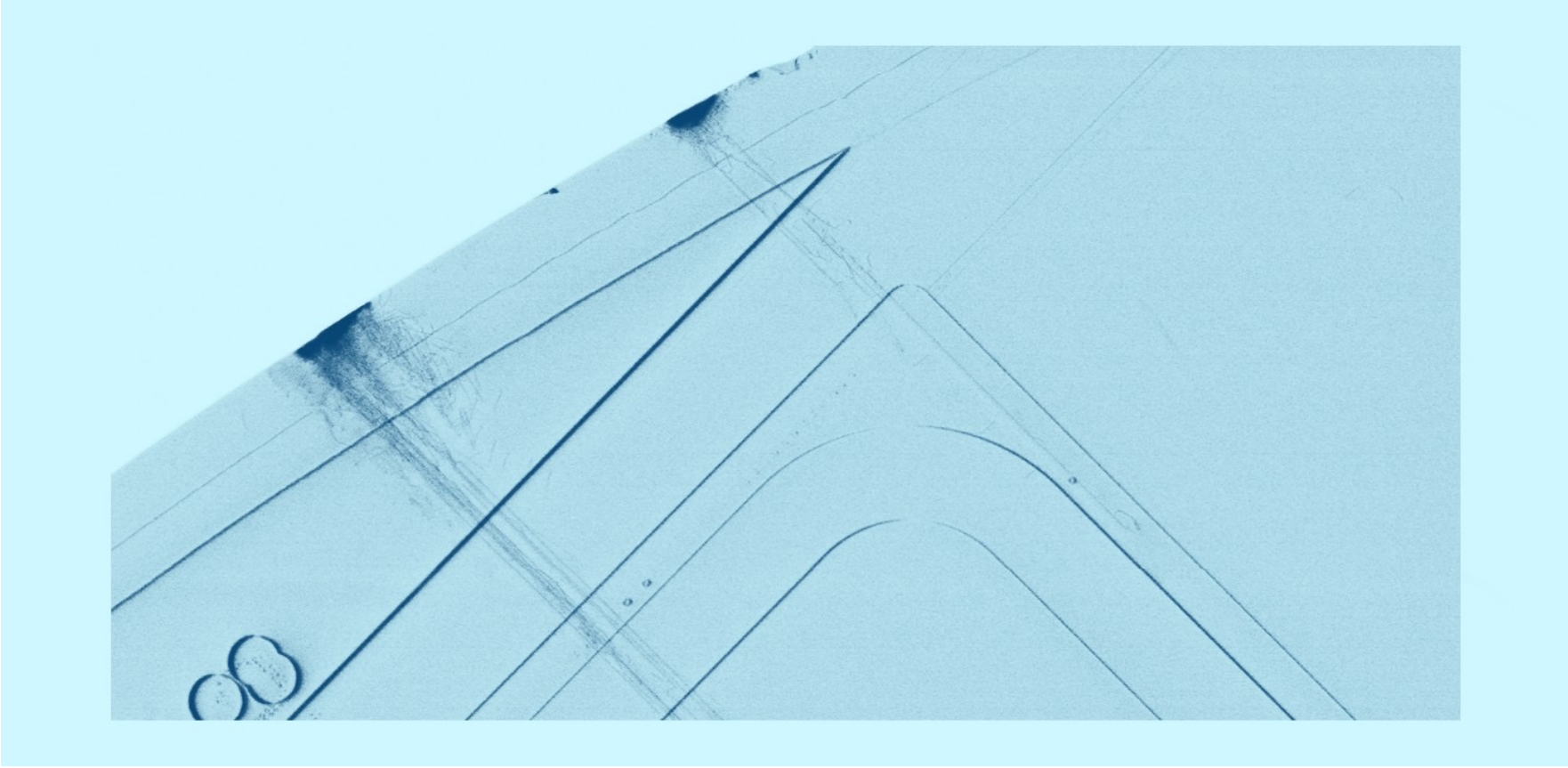
- Method?
- Solution: X-ray topography

Quality control Si wafers



https://www.iisb.fraunhofer.de/en/research_areas/materials/x-ray-topography.html