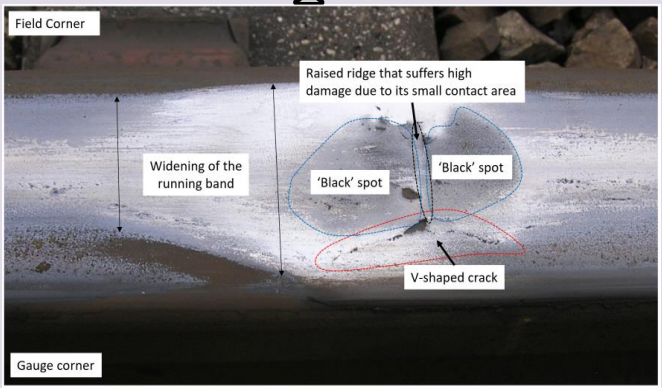
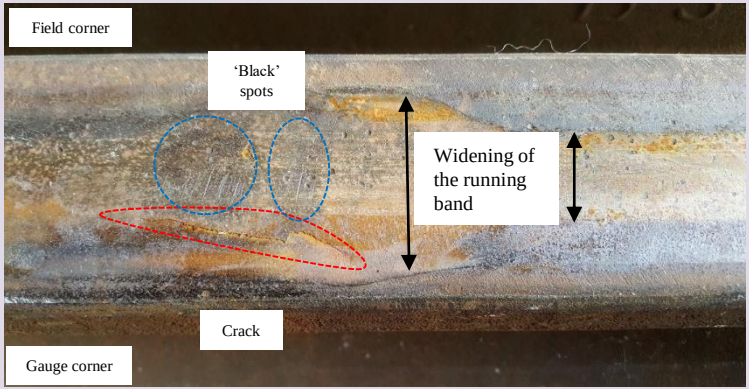
Comparison of Squats and Studs from different traffic environments

Squat



STUD



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Dr Kathryn E. Rankin: University of Southampton
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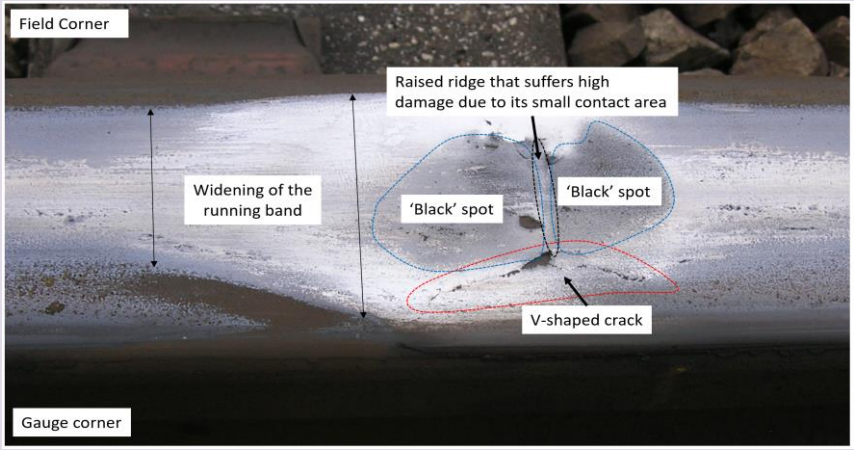
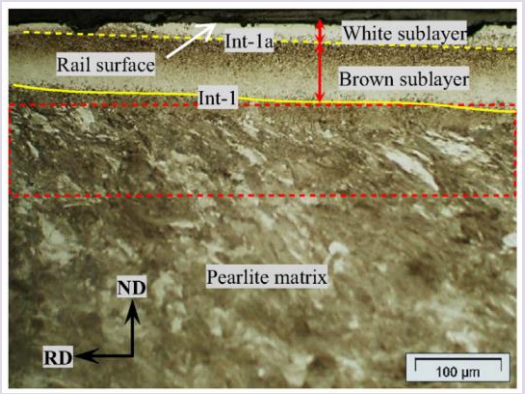
Overview

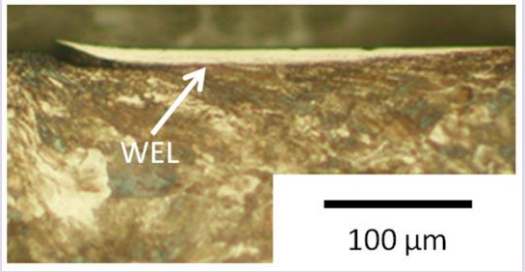
1. Squats and STUDs
2. The use of μ-CT scanning on rail defects
3. X-ray Micro-Computed Tomography (μ-CT) Scanning
4. Scan verification
5. Sample 1
6. Sample 2
7. Sample 3
8. Sample 4
9. Concluding remarks

Squats



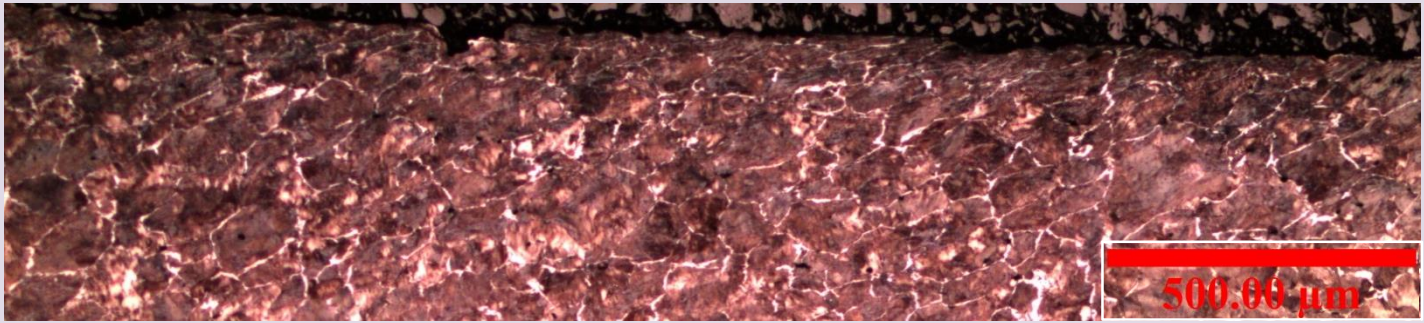
S. Li, J. Wu, R. H. Petrov, Z. Li, R. Dollevoet, and J. Sietsma, "'Brown etching layer': A possible new insight into the crack initiation of rolling contact fatigue in rail steels?," *Eng. Fail. Anal.*, vol. 66, pp. 8–18, 2016.

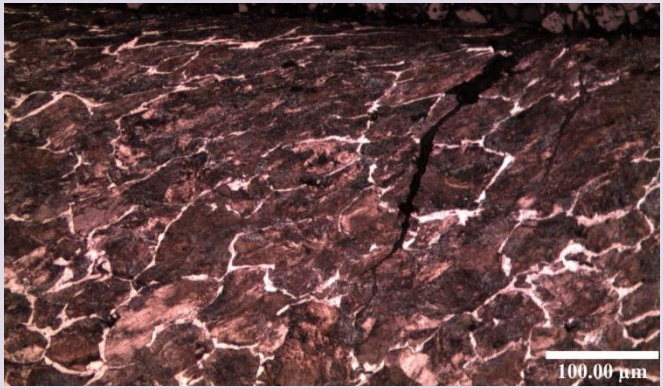


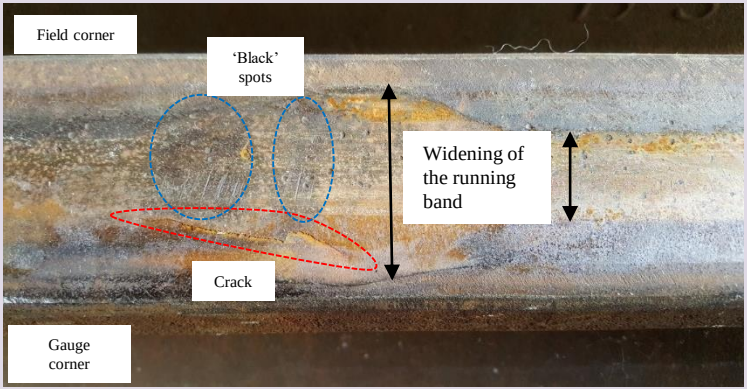


C. Bernsteiner, G. Muller, A. Meierhofer, K. Six, D. Kunstner, and P. Dietmaier, "Development of white etching layers on rails: simulations and experiments," *Wear*, vol. 366–367, pp. 116–122, 2016.

STUDs

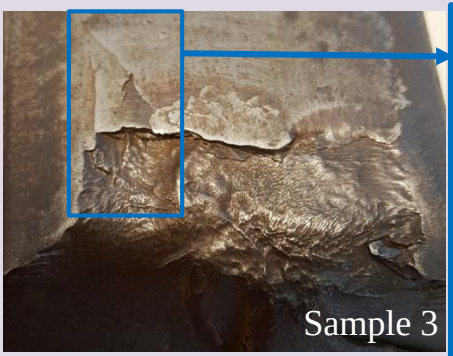

500.00 µm

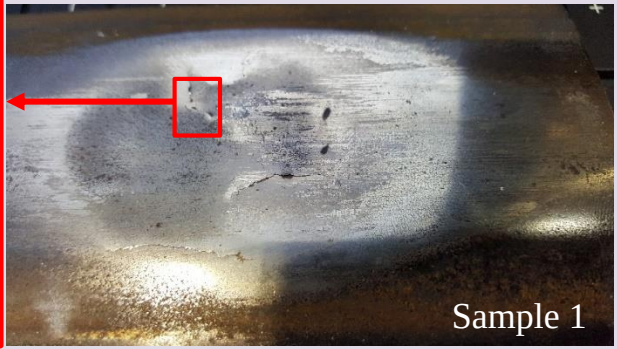

100.00 µm

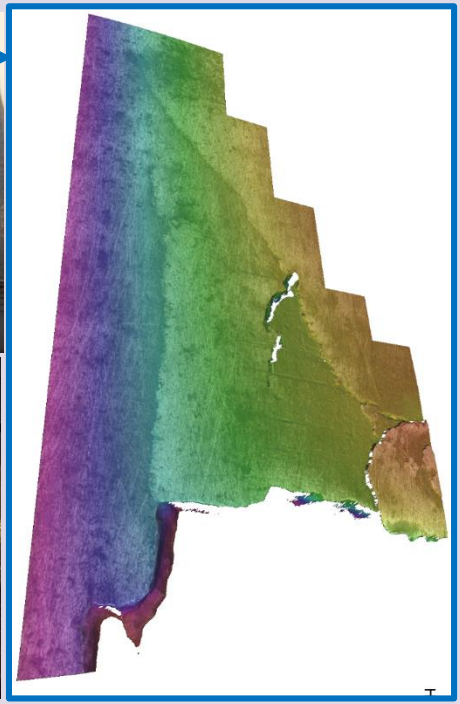

Field corner
'Black' spots
Widening of the running band
Crack
Gauge corner

The use of μ-CT scanning on rail defects

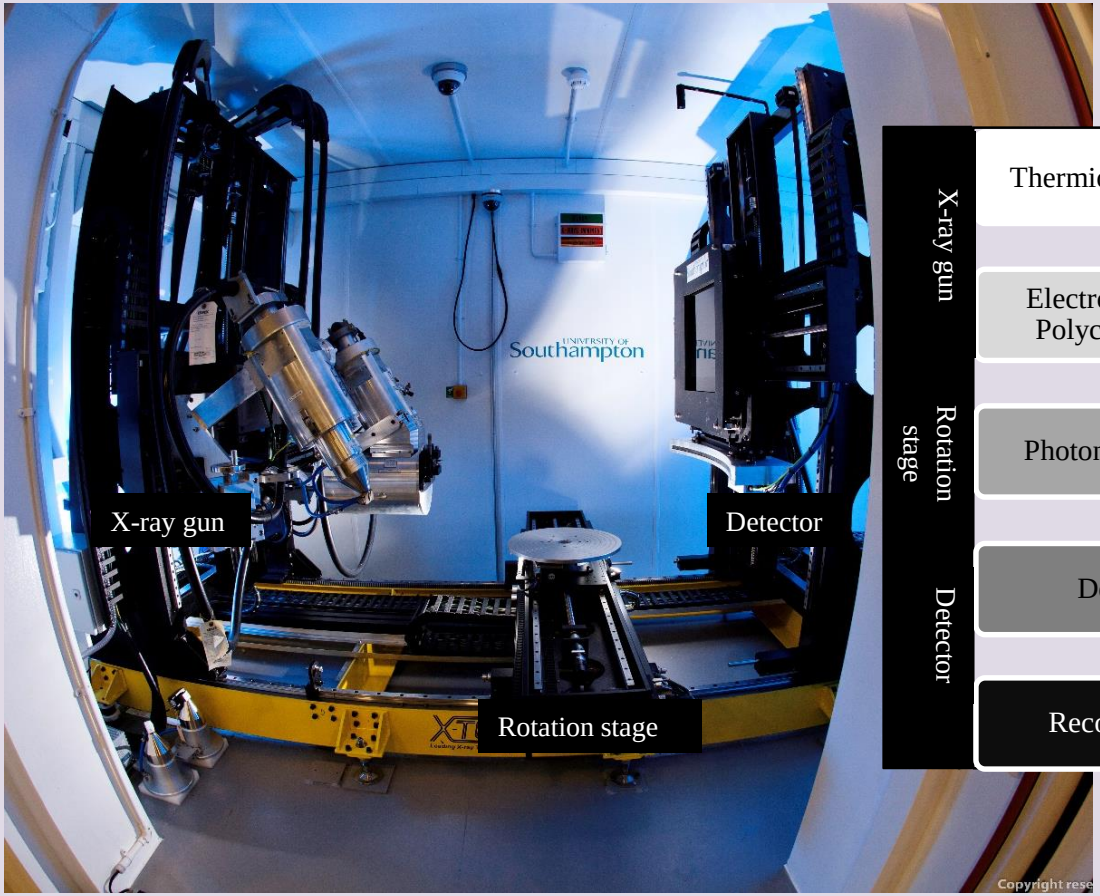
Colour framed images obtained using Infinite Focus microscope







X-ray Micro-Computed Tomography (µ-CT) Scanning



X-ray gun

Rotation stage

Detector

Thermionic reaction = Electrons

↓

Electrons + Tungsten target = Polychromatic photon beam

↓

Photons interact with material

↓

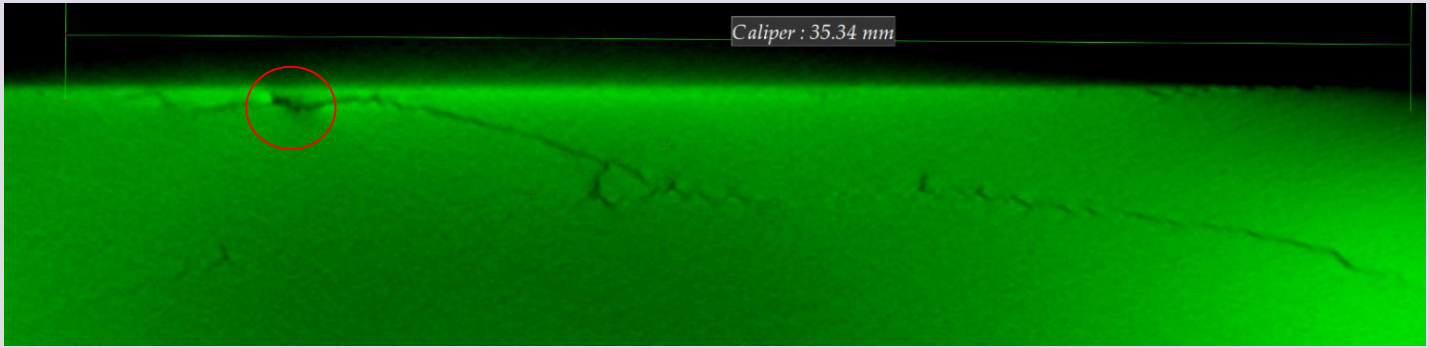
Detection of photons

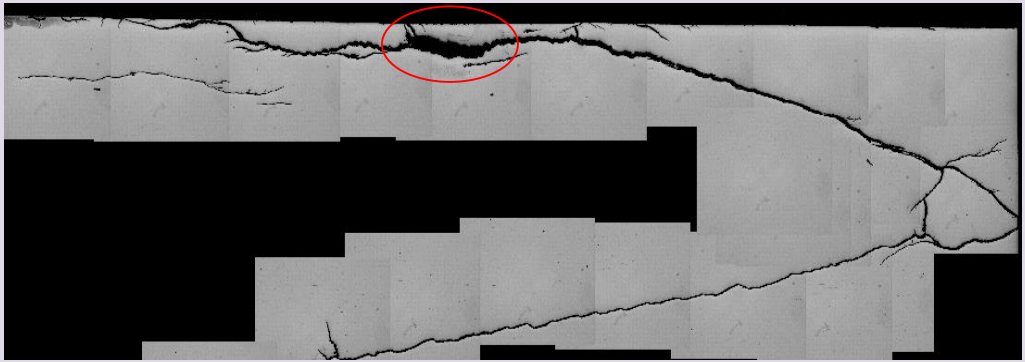
↓

Reconstruction of volume

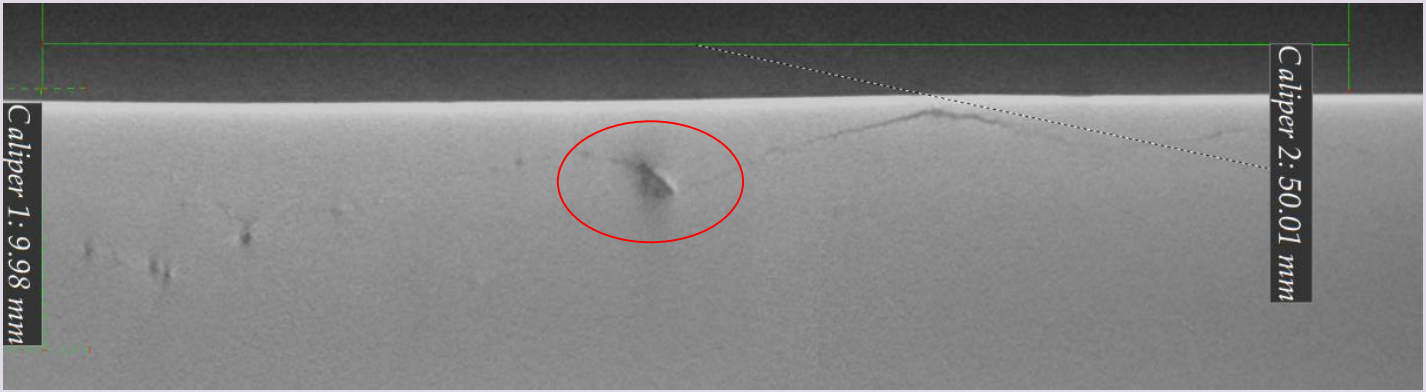
225/450 kV Hutch CT scanner image courtesy of Sharif Ahmed, µ-VIS X-ray Imaging Centre, University of Southampton

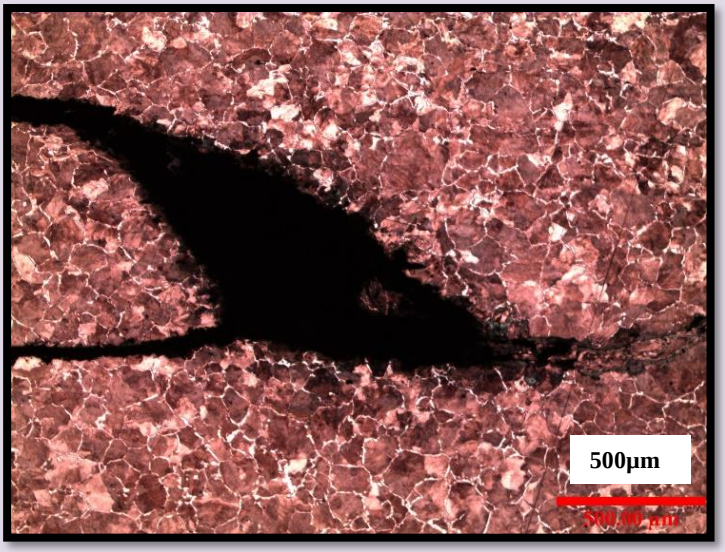
Scan verification



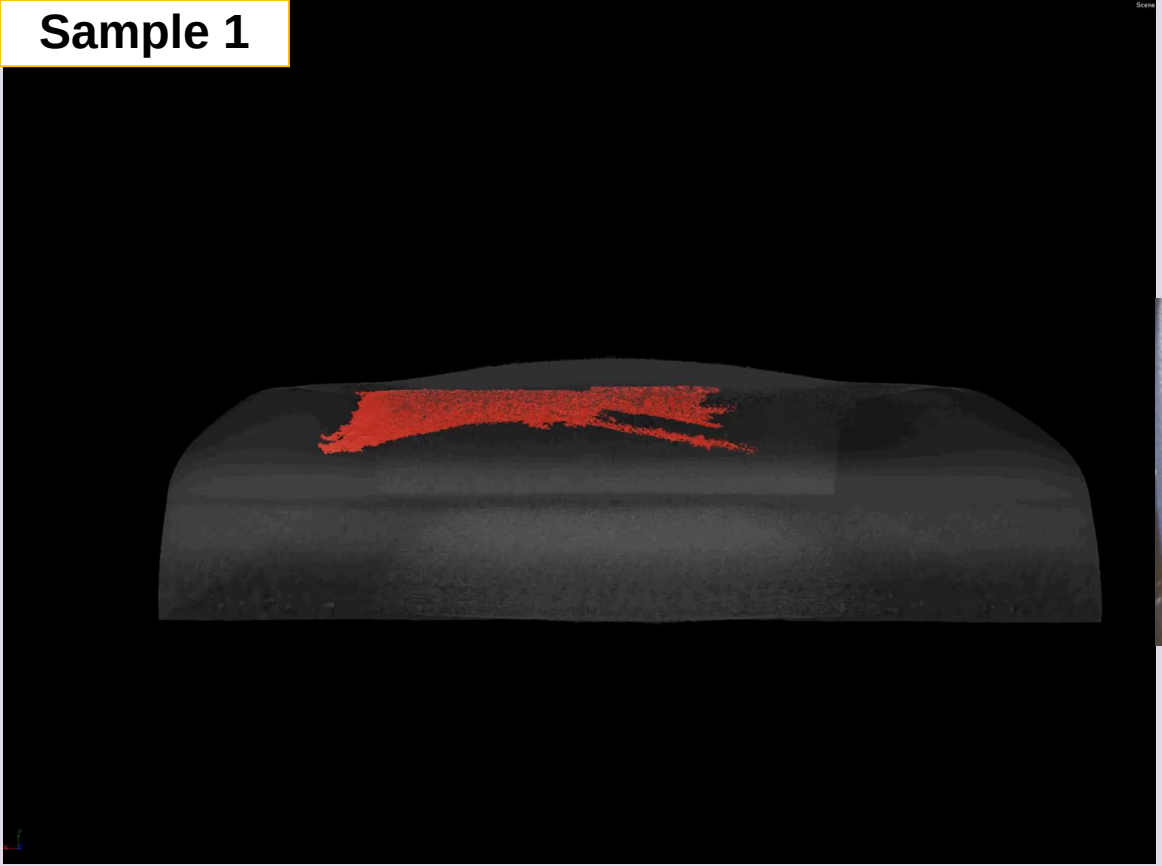


Scan verification



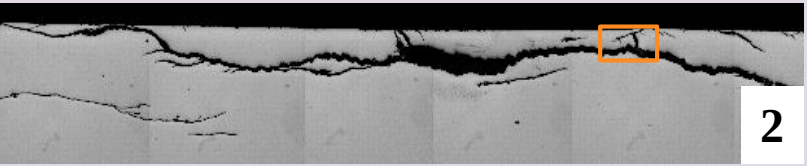


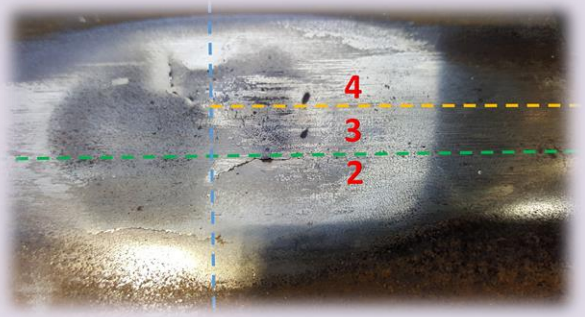
Sample 1

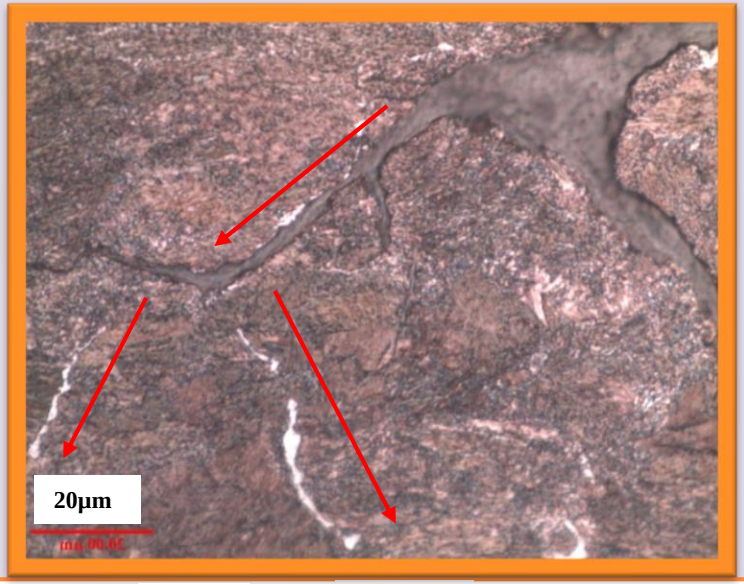


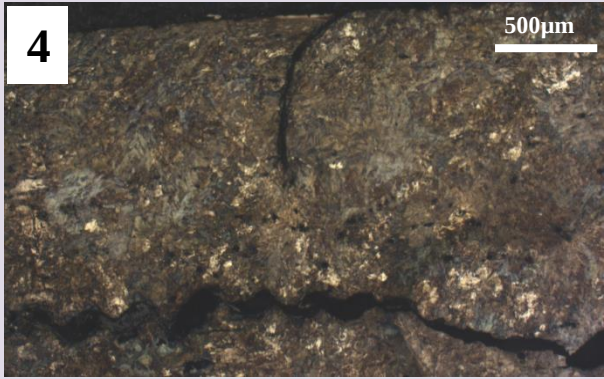
- From an incline just outside a station
- Multiple surface breaking cracks
- Typical crack structure that branches
- Initiated on the field corner

Sample 1

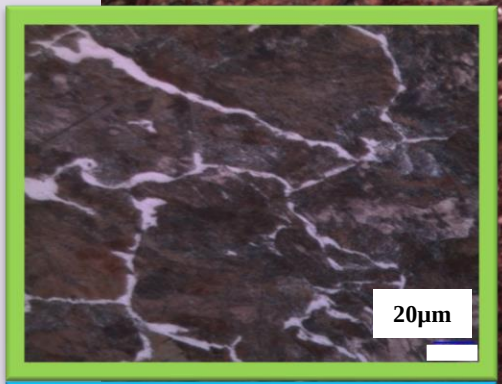


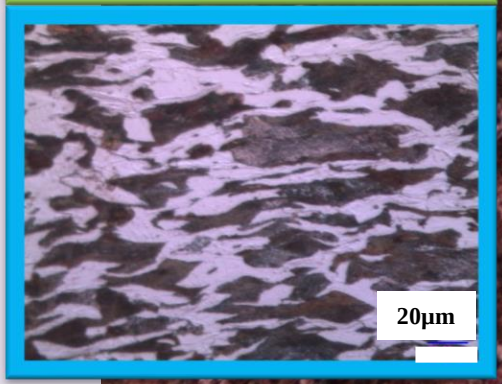






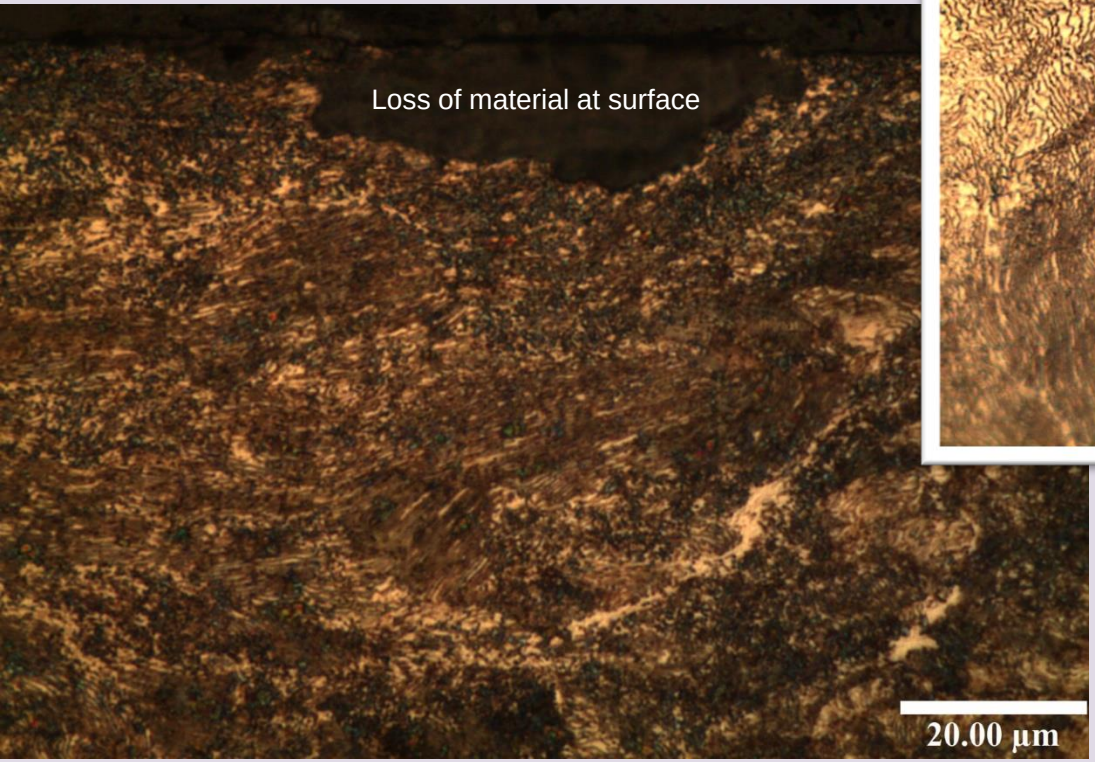
Sample 1

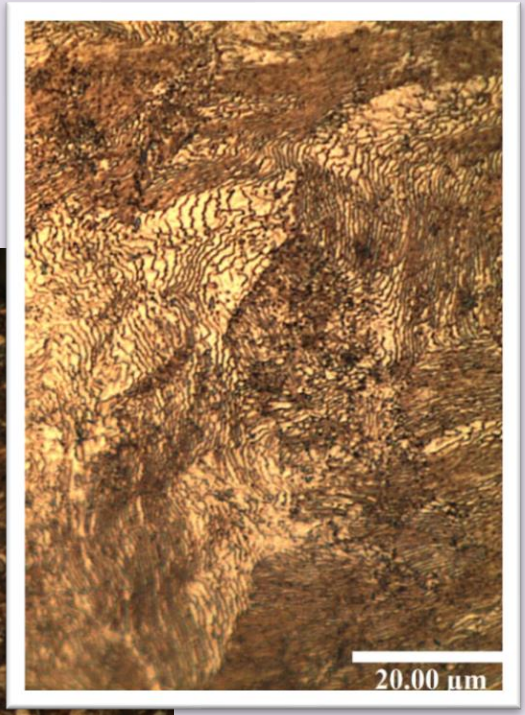




200µm

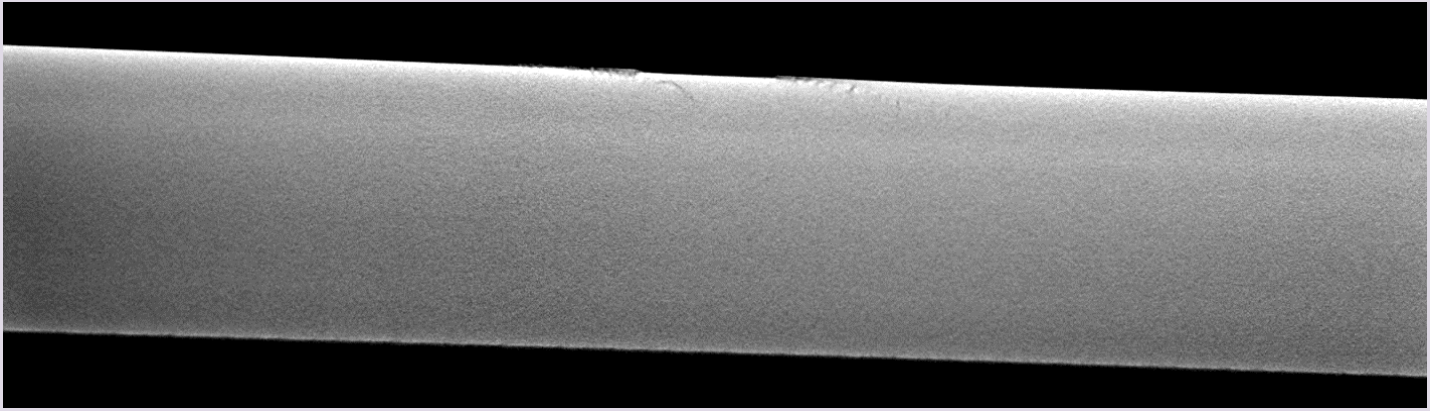
Sample 1

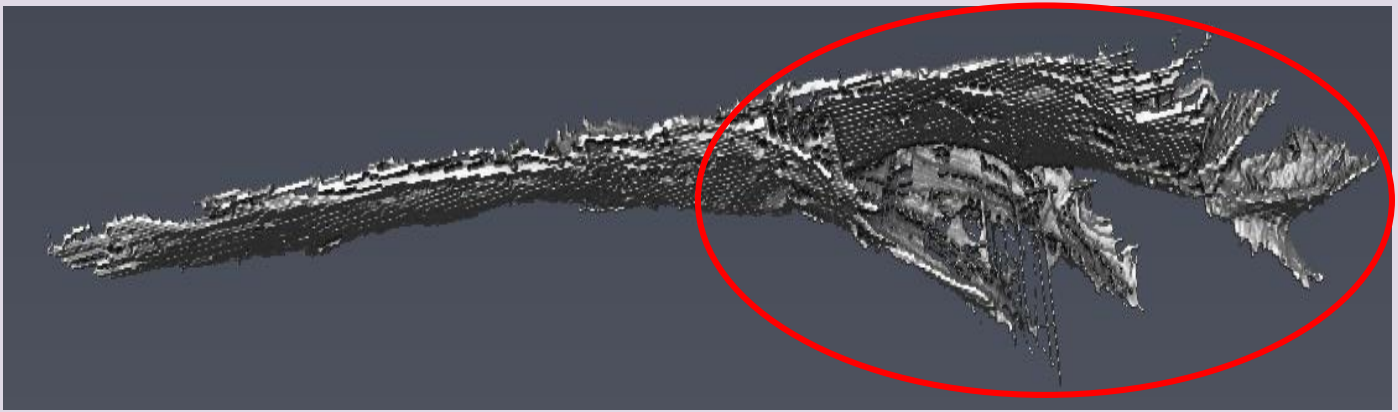




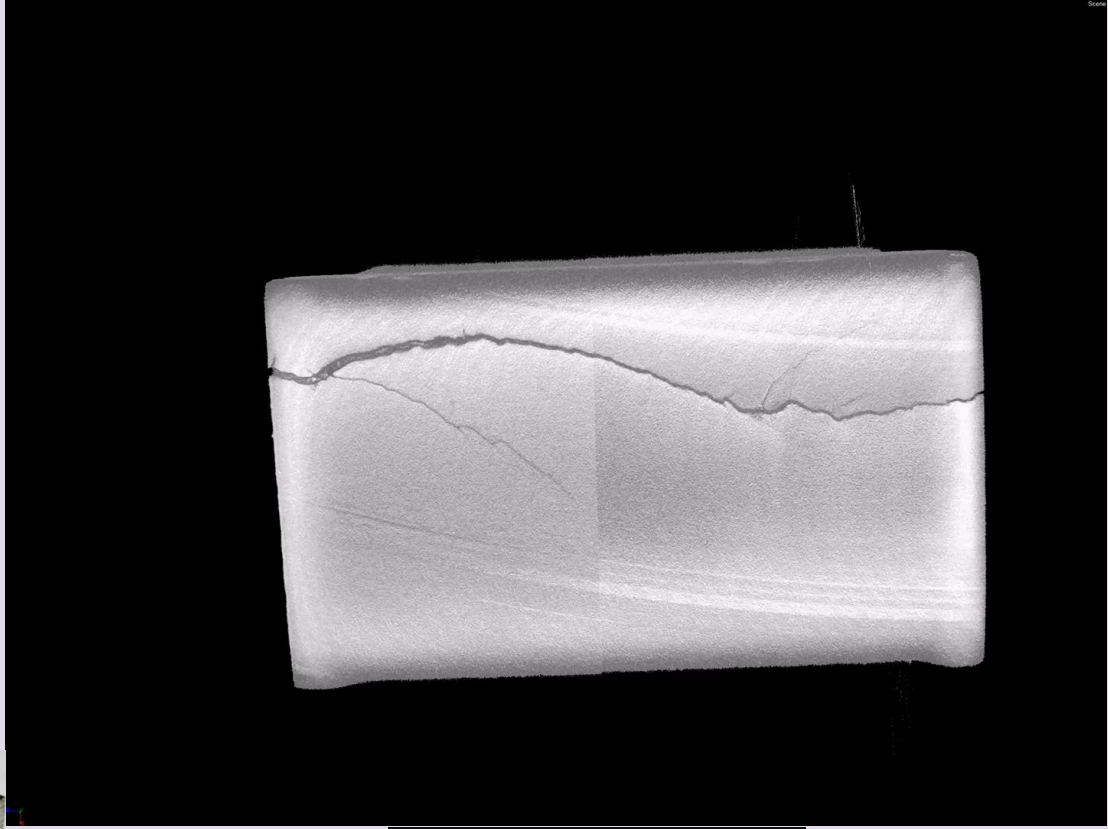
50 microns between images!

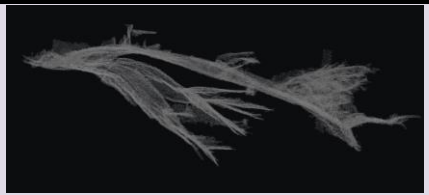
Sample 2





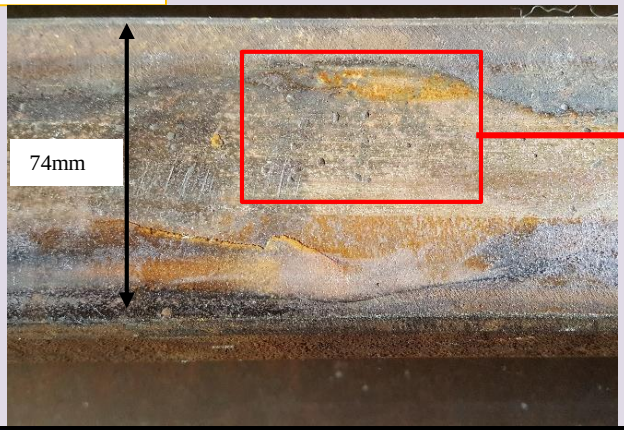
Sample 2

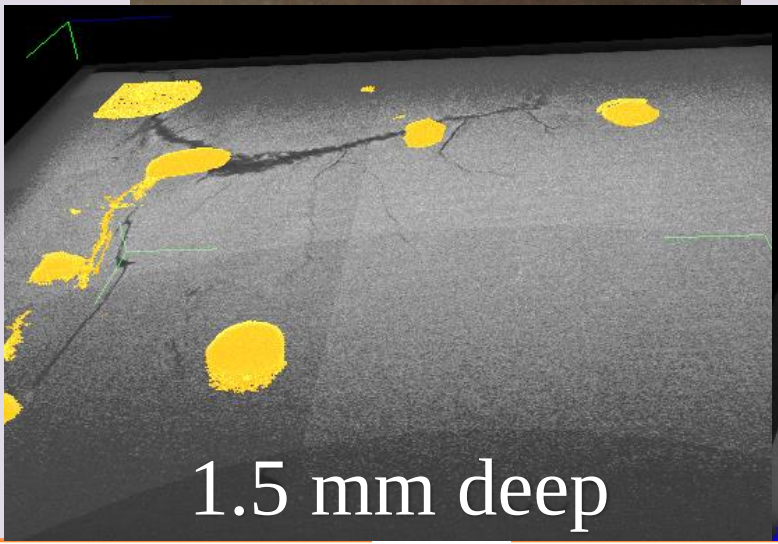


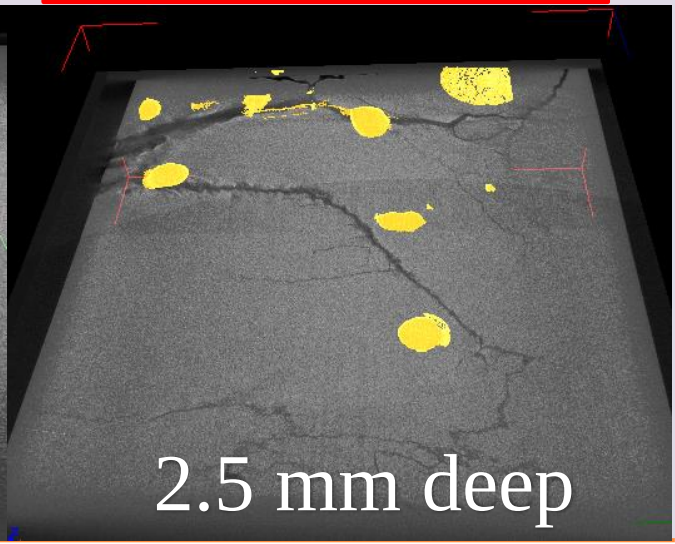


Sample 2

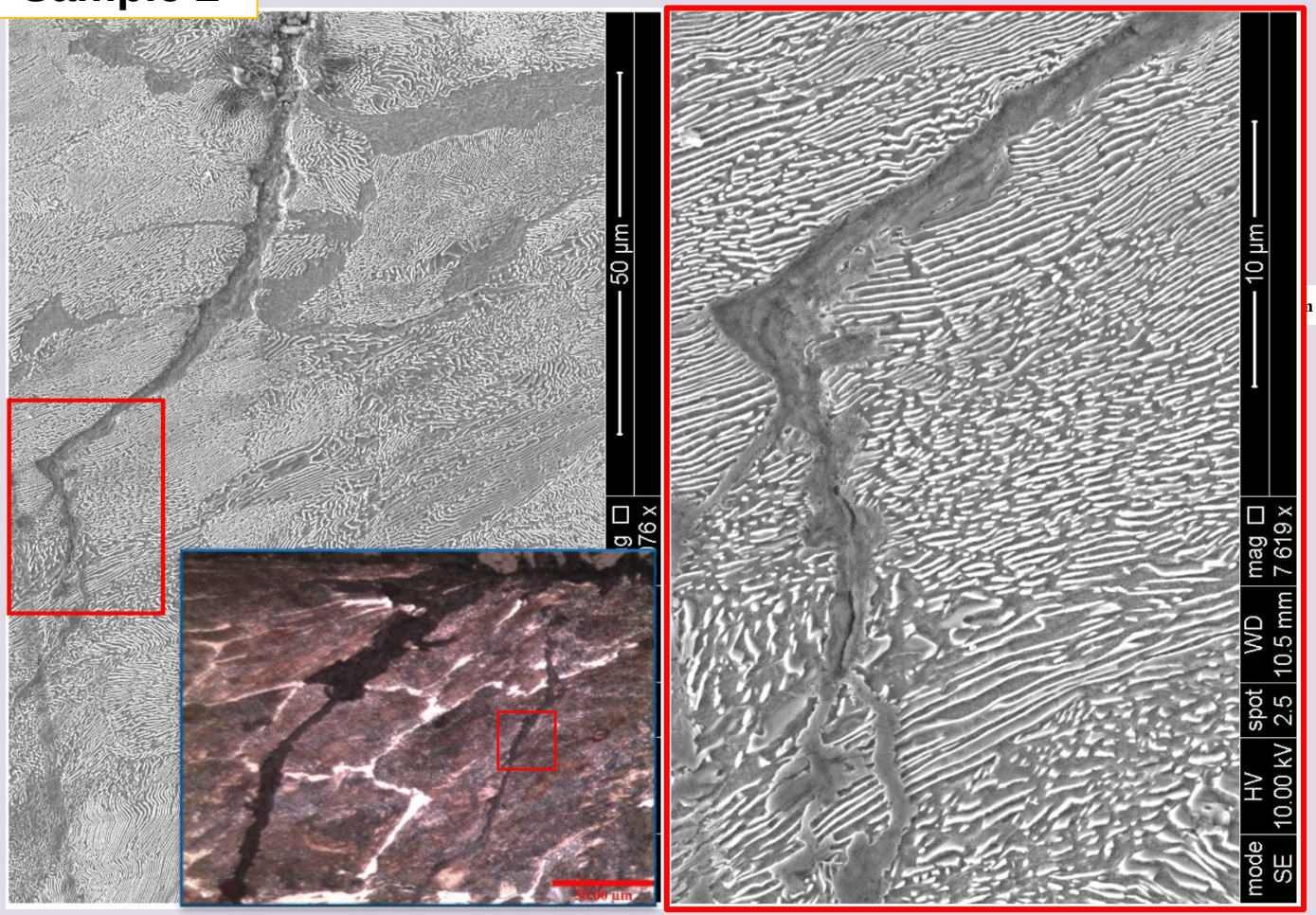
Crack paths compared to pit locations





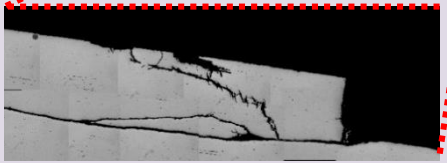


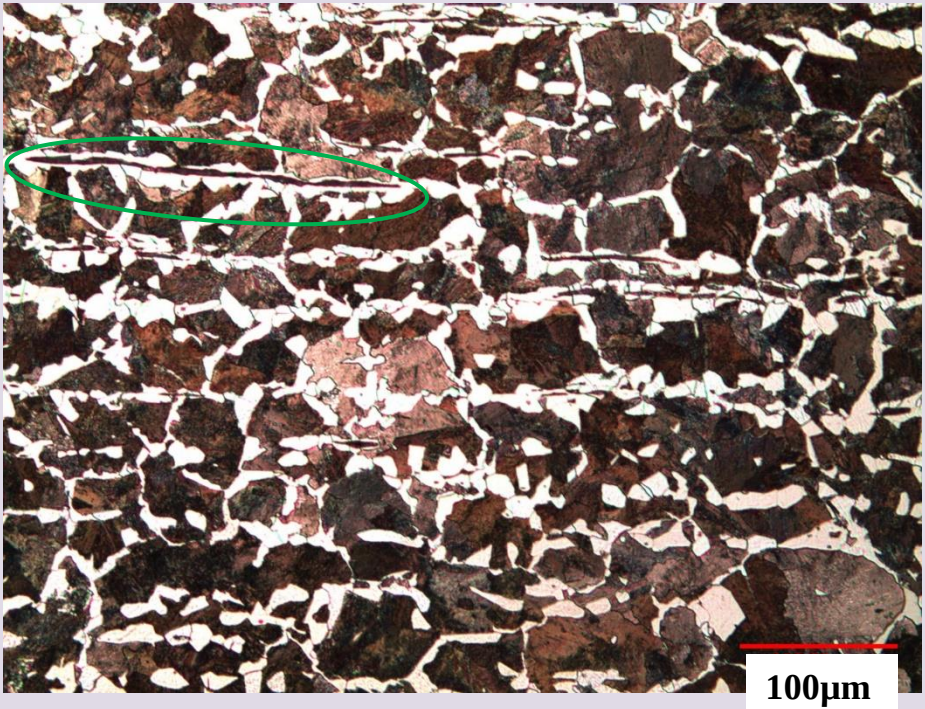
Sample 2



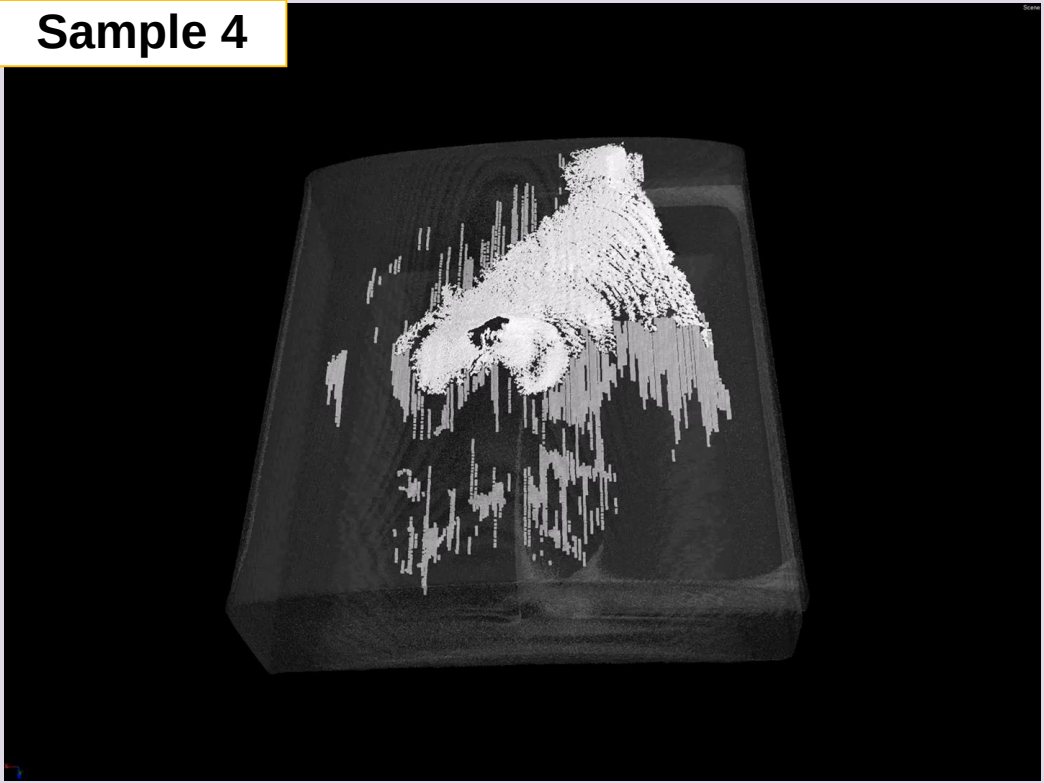
Sample 3

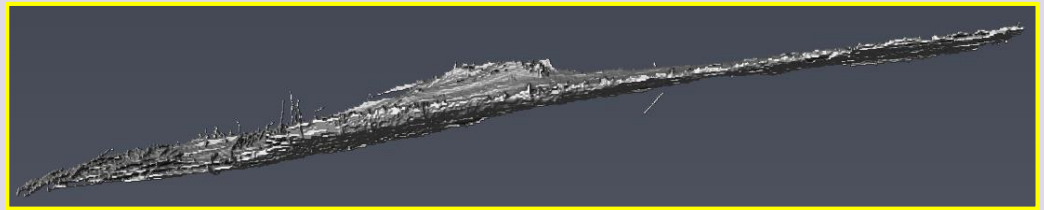
Inclusions found throughout sample and in multiple regions.
Inclusions run parallel to subsurface crack





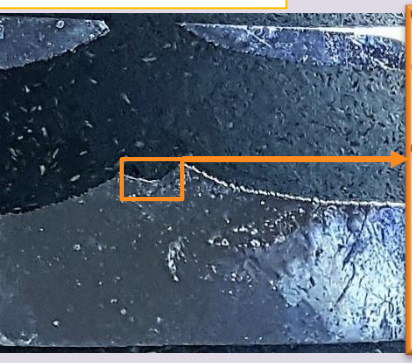
Sample 4

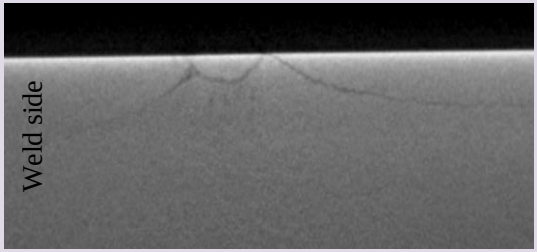


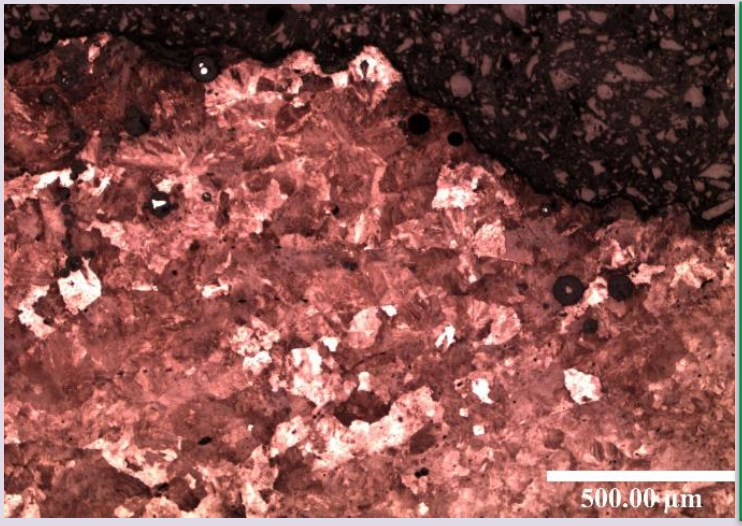


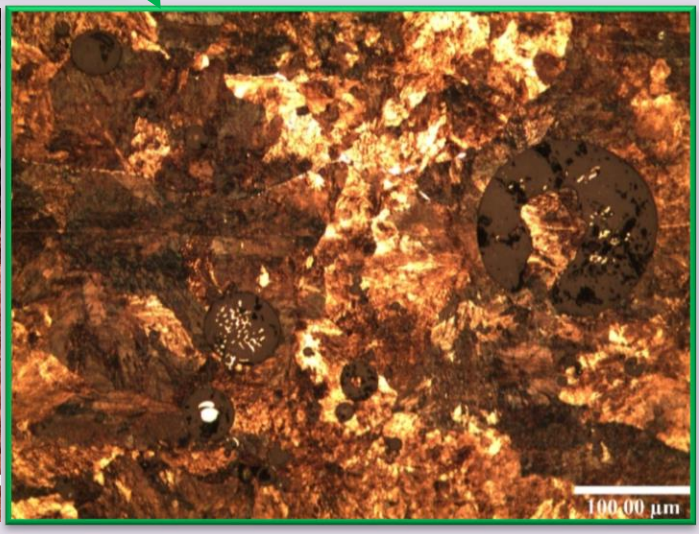
Automatic functions could not detect a large portion of the crack plane. Manual additions were made.

Sample 4









Concluding Remarks

Initiation

- Samples 1 and 2 initiated on the field corner
- Sample 2 has a crack that is believed to be developing transversely
- Sample 4 contains gas bubbles within the weld where initiation occurred

Thermal damage

- Vertical cracks were found due to thermal damage
- Microstructure varies across all samples (localised thermal damage)

3D volume data

- A 3D volume allows the tracing of a crack back to its origin, increasing the chances of finding an initiation site.
- Multiple 3D volumes of different samples would also allow full defect comparisons
- CT scanning is capable of imaging the crack network and identifying regions of interest for more accurate cutting

Relevance to the steel industry: Understanding these defects could lead to metallurgy that is resistant to these defects