Karlsruhe Institute of Technology

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# A look inside with X-ray Tomography

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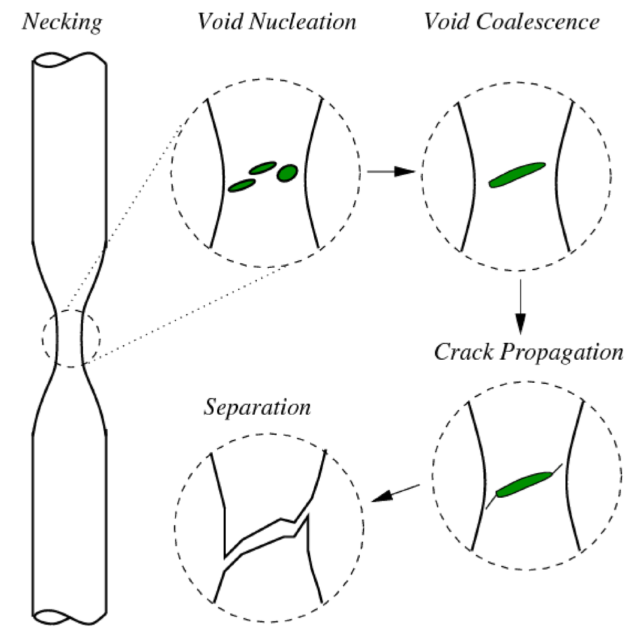
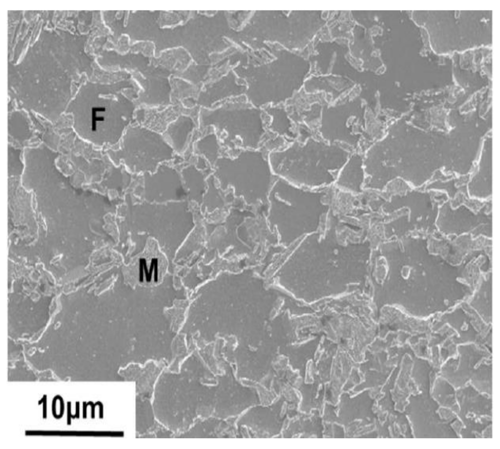
- Motivation: Looking into the first stages of ductile fracture in dual phase steels, void nucleation and early void growth, in 3D.
- X-ray Tomography allows for a non destructive 3D reconstruction of internal structures.
- @KIT INT: Nano CT with two modes of operation:
  - Absorption Contrast Tomography(ACT)
  - Phase Contrast Tomography(PCT)
- NanoCT is not equipped to perform diffraction based techniques.
- Complementing the NanoCT results with different synchrotron based diffraction techniques: DCT, 3DµLaue and Dark-field X-ray microscopy.



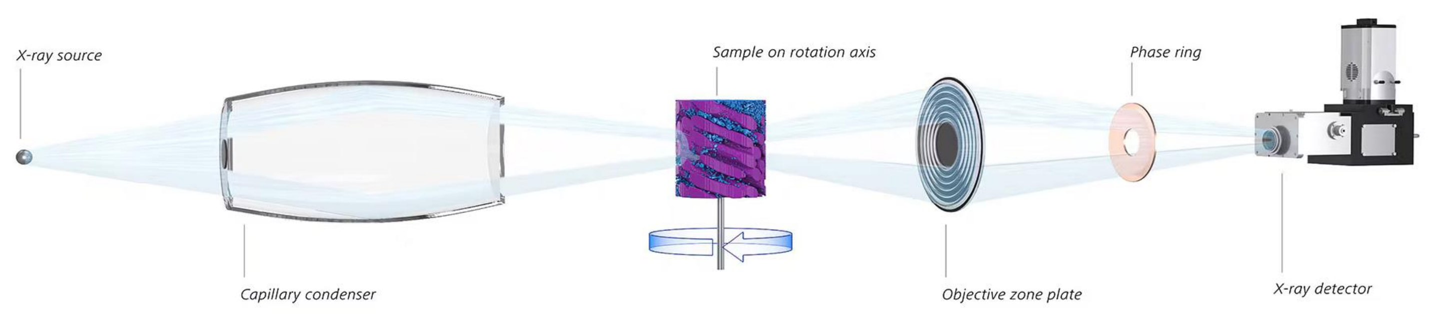

Stages of the ductile fracture process. (cc) [1]

[1]Bbanerje at English Wikipedia (https://commons.wikimedia.org/wiki/File:Ductile_fracture_upd.png), „Ductile fracture upd", https://creativecommons.org/licenses/by-sa/3.0/legalcode

- Voids nucleate by martensite cracking and decohesion between[2,3,4]
  - the martensite islands and ferrite matrix
  - the matrix and inclusions
  - the ferrite grains
- NanoCT: Use of 50 nm resolution, two operating modes and in situ tensile testing to gain insight into different damaging mechanics.

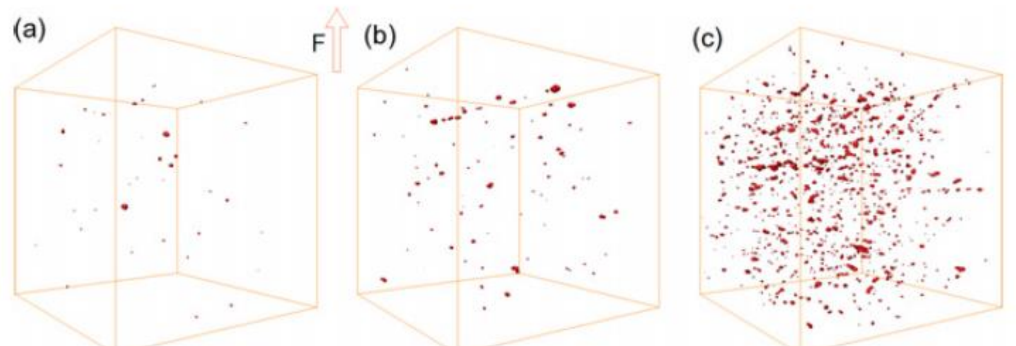



DP800 microstructure showing ferrite matrix (F) and martenisite islands(M). Image taken from[4].




Experimental setup of the nanoCT. Image taken from www.Zeiss.de

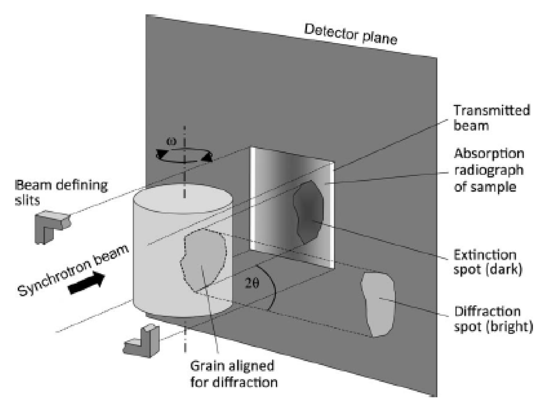
- Synchrotron based µCT studies [5,6] scanned bigger volumes with more grains but had lower resolution.
- Using 3D image correlations the newly nucleated voids can be isolated from void growth at different strains[5].



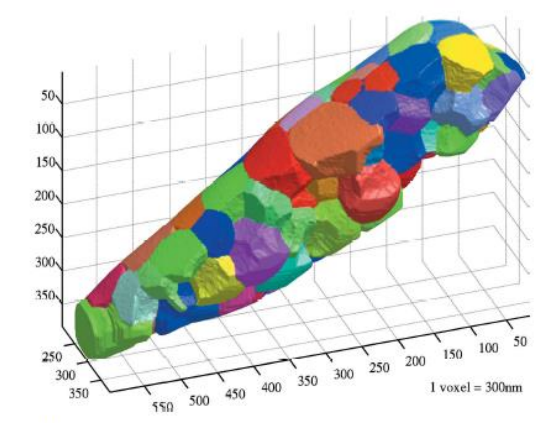

Different stages of void nucleation and growth. Image taken from [6].

[2] "Void Nucleation and Growth in Dual-Phase Steel 600 during Uniaxial Tensile Testing", G. Avramovic-Cingara et. Al.
[3] "Efficient characterization tools for deformation-induced damage at different scales", C. Kusche et al.
[4]" The fracture toughness of martensite islandsin dual-phase DP800 steel", C. Tian et al.
[5] "Separation of nucleation and growth of voids during tensile deformation of a dual phase steel using synchrotron microtomography", G. Requena et al.
[6] "Characterization and modeling of void nucleation by interface decohesion in dual phase steels", C. Landron et al.

- DCT provides the grain shape, size, orientation and average strain tensor for each grain.
- Samples will be made from Titanium and Armco Iron.
- Measurements will be performed at five different loading steps: unloaded, two loading steps in the elastic regime and one loading step each above and below the yield point.

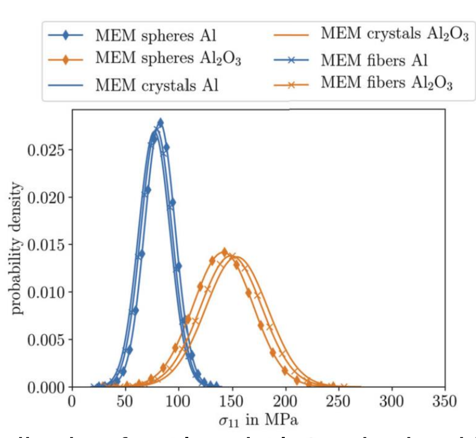



Experimental setup for DCT.

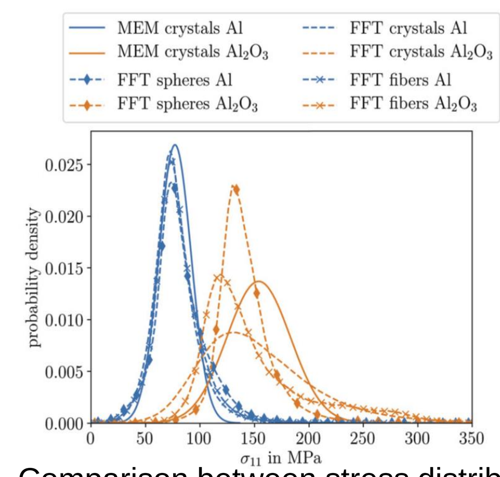


Grain map of $UO_2$ . Images taken from [7].

- Cooperation with Max Krause and Thomas Böhlke from ITM.
- Prediction of local stress distributions based on the Maximum Entropy Method.
- The comparison between the experimental data and the theoretical results can help to verify and extend the MEM framework .




Stress distribution for Al and $Al_2O_3$ obtained by MEM. Images taken from [8].




Comparison between stress distribution obtained by MEM and full field methods.

[7]" Advances in X-ray diffraction contrast tomography: flexibility in the setup geometry and application to multiphase materials", P Reischig et al.
[8] "Maximum-Entropy Based Estimates of Stress and Strain in Thermoelastic Random Heterogeneous Materials", Max Krause and Thomas Böhlke

Take Home Message:

- X-ray Tomography techniques provide a non-destructive way to observe different internal structures depending on the technique.
- This poster acts as an outlook for the work I will be doing during my PhD thesis.

First Steps:

- Preparing samples for the ESRF project: checking grain size, annealing, cutting samples into right shape.
- Prepare NanoCT samples from DP 800 tensile test samples and look at the evolution of voids at different strain levels.
- Start in situ testing based on the previous results to find void nucleation stress.

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DFG Deutsche Forschungsgemeinschaft
German Research Foundation

TRR SCHÄDIGUNGSKONTROLLIERTE UMFORMPROZESSE
B03 Schädigungsinitiierung auf Mikroebene