MAPEX Bremen
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05
12-2017

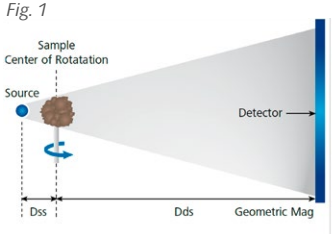
INSTRUMENT DATABASE
Non-destructive 3D imaging and testing of materials

Universität Bremen

X-RAY COMPUTED TOMOGRAPHY (X-CT)

3 D X-ray micro-computed tomography (micro-CT) provides non-destructive access to the internal microstructure and composition of materials.

Fig. 1



The sample, situated between x-ray source and detector, sequentially rotates in steps of less than 1°. During a full 360° rotation several hundred projection images are taken. After numerical back projection of the images, the volumetric data can be visualized and analysed using software tools such as Volume Graphics that provide access to any desired 3D view or 2D cross section of the sample. The magnification using conventional CTs depends on the source-sample-detector distance (Fig. 1).

Using X-CT it is possible to non-destructively:

- investigate microstructural properties at multiple length scales;
- characterize and quantify pore structures and inclusions;
- investigate grain and fibre orientation;
- characterize and observe fracture mechanics;
- visualize biologic structures including cellular and subcellular features;
- investigate historic artefacts.

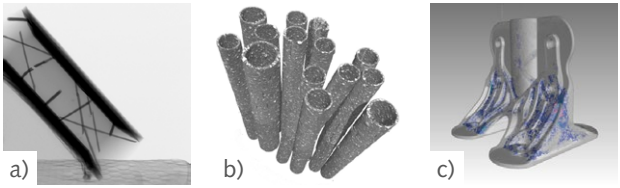


Fig. 2: a) X-ray image of a compression- and impact-loaded pin-reinforced sandwich structure; b) 3D view of bi-component fibers (Ø 200 µm); c) short fibre injection moulded T-bracket, 3D view and color-coded pore analysis.

II X-RAY CT: PHOENIX-XRAY VITOMEIX M

01 II General Information

Keywords: X-ray computed tomography, tomography, non-destructive testing, in situ, X-CT, CT, NDT

Categories: Material Properties, Dimensional Properties, Surface / Interface Characterization

Main Application: 3D material characterisation, in situ experiments and non-destructive testing of metals, compound materials, and opto-electronic components

Measured Quantities: 3D-shape, defects, interfaces, volume

Year of Fabrication: 2014, funded by Wirtschaftsförderung Bremen WFB

Manufacturer: General electric (GE); Phoenix-xray vltomelx m; research edition

Features: special in situ equipment for time dependent 4D studies during heating, cooling, under tension or tensile compression.

02 II Specifications

- 180 kV / 15 W nano-focus x-ray tub
  Detail Detectability: down to 1 µm (object size 2 mm)
- 240 kV / 320 W micro-focus x-ray tube (up to 40 mm steel)
  Detail Detectability: down to 3 µm
- Max. Object Size (height x diameter) 600 mm x 500 mm;
- Max. Object Weight 50 kg

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II X-RAY MICROSCOPY (XRM)

3 D X-ray microscopy provides non-destructive access to the internal microstructure and composition of materials. In contrast to conventional X-CT (only geometric magnification), the X-ray microscope Versa 520 offers a two-stage magnification. The additional optical magnification (Fig. 1) enables high resolution at large source-sample distances and therefore provides a large flexible working distance while maintaining submicron resolution (Fig. 2). This allows high-resolution for large samples as well as for in-situ experiments. The latter can be performed with the 5kN in situ tensile stage (Deben CT5000), operating from -20°C to 160°C.

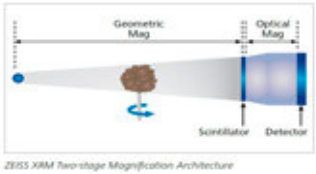

Fig. 1: Two-stage magnification architecture (Zeiss).

Fig. 2: Resolution as a function of source to sample distance (Zeiss).

Additional unique features of the XRM are laboratory **diffraction contrast tomography (DCT)** for the mapping of grain orientations in polycrystalline materials even without grain contrast and **propagation phase contrast** for the visualization of low absorbing or low contrast materials such as: low atomic number (low Z) materials, soft tissue, polymers, fossilized organisms encased in amber, and other materials of low contrast. This enables e. g. the separation of carbon fibres from its polymer matrix and consequently the analyses of fibre orientation (Fig. 3).

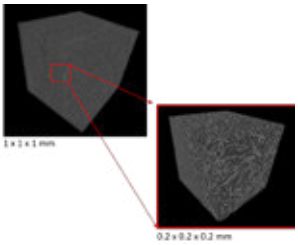

Fig. 3: Section of a short fibre (length 200 µm, diameter 7 µm) injection moulded part. The unique combination of high resolution and phase contrast enables the 3D determination of single fibre orientation

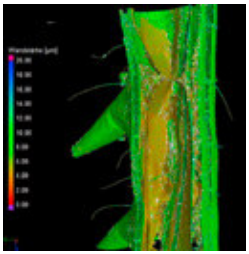

Fig. 4: Wall thickness analyses of a grasshopper leg.

II X-RAY MICROSCOPE ZEISS XRADIA VERSA 520

01 II General Information

Keywords: X-ray, non-destructive testing, tomography, CT, XRM, X-CT, NDT

Categories: Microscopy, Material Properties, Dimensional Properties

Main Application: non-destructive testing, material characterization, 3D microstructure, in situ experiments

Measured Quantities: 3D-shape, pores, defects, interfaces

Features:

- spatial resolution <700 nm
- Flat panel and CCD (2K x 2K) detector high contrast
- 5 kN tensile & compression testing system, operating between -20°C and 160°C

Year of Fabrication: 2016

Manufacturer: ZEISS

02 II Specifications

- Two-stage magnification providing resolution at a distance, enabling large, flexible working distances while maintaining submicron resolution.
- Direct visualization of 3D crystallographic grain orientation in a non-destructive tomography environment, with diffraction contrast tomography (DCT).
- Scout large samples to identify a region of interest (ROI), and then zoom to image targeted volumes at high resolution,
- Tunable propagation phase contrast to visualize low Z materials and biological samples that tend to have limited absorption contrast. (Fig. 3 and Fig. 4).

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