ESRF

Experiment title:
Feasibility study of diffraction computed tomography: first cross-sectional image of a pathological bone.

Experiment number:
MI 116

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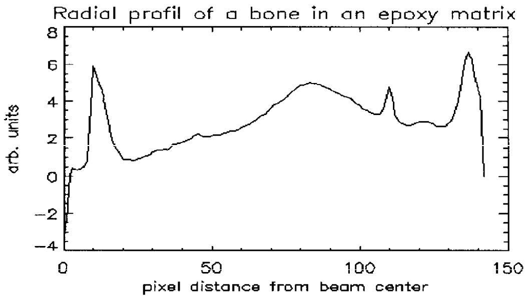
Report:

Since several years diffraction computed tomography has been thought to be an useful imaging tool in many areas (medical and material science) but never really extend over the cross-sectional imaging of (well chosen!) plastic samples (latest publication [1]). For highly structured objects the contrast produced in the reconstructed images is immense (compared to conventional absorption images) but it does not really reflect imaging problems in medical applications. In this experiment we performed a pilot study on human trabecular bone embedded in an epoxy matrix using diffraction computed tomography. The experiment was done at a diagnostic favorable energy of 60 *keV* using a 500 μm by 500 μm beam. The cross-sectional size of the sample was 10 by 10 mm, which was not ideal for that energy (size could have been larger). Because the superconducting wavelength shifter was in operation the expected flux could not be reached and a favorable 100 μm by 100 μm beam had to be rejected. An image intensifier coupled to a CCD unit was utilized to registrate for each point in the tomographic reconstruction a 2 dim diffraction pattern. At the same time we tried to collect through a semi-transparent beamstop the absorption signal. Each data point took around 5 sec.

A few preliminary results are evaluated until now. Figure 1 shows a typical radial profil of one data point obtained by integrating azimuthally around the transmitted beam. This profil not yet corrected for flatfield and non-uniformity shows 2 relatively sharp peaks stemming from hydroxyapatite micro-crystals in the bone and a rather broad peak belonging to the diffraction in the resin. The exponential decrease near the beam center (neg. value because the white field image (beam without object) was subtracted) reflects part of the small angle contribution. Integrating these peaks gives for each material a specific data point in the reconstruction algorithm.

Figure 1:

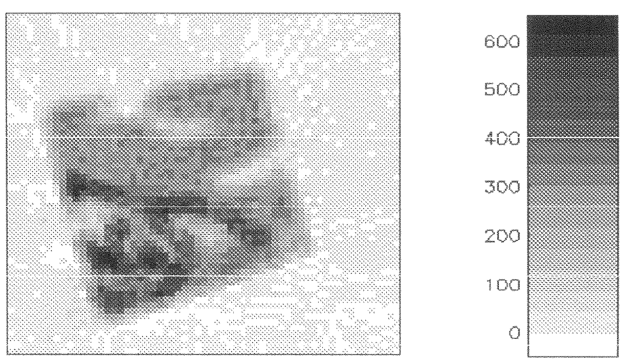


For the reconstruction technique the cross-sectional image is divided into a grid. In principle the material specific data point represents the line integral of contributing scatterers through certain pixels on that grid. Using the in parallel obtained absorption map each pixel has to be weighted for the absorption on the incoming beam and for the absorption on the scattered photons, along the path between the pixel and the detector.

The absorption map obtained with our semi-transparent beamstop was extremly poor mainly due to the fact that at 60 *keV* small changes in the absorption of the sample are far below the absorption in several mm of lead used as beamstop. Another point could be the spectral filtering through the lead and therefore the amplification of third harmonics. Consequently we skipped the absorption correction of our data points. Figure 2 shows a first reconstructed image of a cross-section through the bone sample. The resolution is poor (probably worse through copying) but nevertheless trabecular bone structure is visible (black). The grey rectangular object shows the epoxy matrix with some air inclusions.

For further experiments we think of using a small absorption detector in front of the beamstop. The sensibility of this method to diagnose bone diseases with structural losses has still to be proved in a larger, statistical significant, batch. Also the question has to be answered how much quantitative conclusions can be drawn from diffraction computed tomography.

Figure 2:



reconstructed cross section of a trabecular bone

Reference :

(1) A. Westmore, A. Fenster, I. A. Cunningham, Angular-dependent coherent scatter measured with a diagnostic x-ray image intensifier-based imaging system, Med. Phys. 23 (5), 1996, pp 723-733

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