Images of Animal's Organs using Dual-Energy X-ray Computed Tomography

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In a method of a dual-energy x-ray CT, the spatial distributions of both an electron density and an effective atomic number can be obtained in CT images. We experimentally confirmed that the agreement between the measured electron density and the theoretical value was less than 1%1. In 2003B experiments, we measured various organs of a pig and a rat in the method to investigate the ability to distinguish pathological tissues from normal tissues.

The experiment was carried out in the third hatch of BL20B2. The beam size was about 20 cm × 1 cm. Monochromatic x-rays used in the experiments were 40 keV and 70 keV. A 2D scintillation array detector (256×256 pixels, 0.892 × 1.02 mm² pixel size) was used for the collection of projections. In a case of a large object, the x-ray intensity passed through the center of the object is much lower than that of out of the object. This means that the statistical precision of the numbers of photons counted by the detector corresponding to the center of the object is worse, while that out of the object is unnecessarily good. In the experiment, the spatial distribution of the intensity after passing through the object was roughly uniformed by the absorber made of aluminum. Due to this absorber, the dynamic range of the CT system in terms of the intensity became nominally wider and the quality of reconstructed images was improved.

As samples, organs of a pig: brain, pancreas, spleen, liver, and kidney were used. These organs were extracted from pigs of 6 months old, and were put into a vessel respectively. The position of the organs was fixed with the agar which dissolved in physiological salt solution including sodium azide. In addition, a chest and thighs of a rat were scanned. A liver tumor was transplanted to one of thighs of the rat.

The result of a rat's chest was discussed as a typical example. The rat's lung clearly appeared in the image of electron density shown in Figure 1(a), but it was difficult to distinguish the lung from the soft tissue around the lung in the image of effective atomic number shown in Figure 1(b). It should be pointed out that these images represent the characteristics of a lung: the electron density is much lower than that of the normal tissues, however the constituents are essentially same as the normal tissues.

(a) The image of electron density
(b) The image of effective atomic number

Figure 1. The results of a rat's chest.


In-situ observation of fracture behaviour of porous metal materials by X-ray CT

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Introduction: The porous aluminum as advanced structural materials has complicated shapes and the 3D analysis is one of the major roles in order to progress the mechanical qualities. In this study, the in-situ compressive tests with reflector contrast imaging apply to investigate the microstructure and fracture behavior in Al foams. The fatigue tests of the Al foams have been carried out for the mechanism.

Experiments: The experiments were performed at BL20B2 beam line using X-ray CT with the energy 20keV. The combination of the CCD detector (4000×2624 pixels, 5.9×5.9 µm²) and the optical lens have a voxel size (2.73µm²)(2×2binning). The CT scan of a sample with 750 transmitted images was done during a 180° rotation and the total scanning time was 120min. The radiographs were reconstructed by the method of convolution back projection. The samples for in-situ compression testing were the pure Al foam “ALPORAS” and the Al-Zn-Mg alloy foam. The material test rig was specially designed for CT experiments using a poly-carbonate tube as a load frame. The actuator consists of an air pressure cylinder and an air servo valve. The max compression is 2kN and the max tension is 1kN. Due to the extremely precise sample stage, the weight of the rig is about 6kg.

Results: The 2D radiographs of the pure Al foam and the AlZnMg foam for compression tests with the 120 loads were taken, respectively. The pure Al foam has the ductility and the top cells of the sample were initially bent. On the other hand, the cracks were generated in the AlZnMg foam and it was destructed wholly. The results indicate the different fracture behaviors in the different foams. Figure 1 shows the 3D reconstructed volumes of an AlZnMg alloy for compression tests with the four loads. The cracks were generated in the thin cells and the cells on the top of the sample were broken due to the compression in Fig.1 (d). Also the microstructural features, such as micropores and particles in the foams were 3D visualized. Combined with the 3D quantitative analysis of the microstructures in the cell walls at the BL47XU, we will make further investigations.

Fig.1. 3D reconstructed volumes of an AlZnMg alloy for compression tests with the loads (a) 0, (b) 100, (c) 200, and (d) 300µm.