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High-energy diffraction-enhanced X-ray imaging

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Introduction

Diffraction-enhanced X-ray imaging (DEI), which uses the refraction caused by samples as the image contrast, is more than 10 times higher than that of conventional X-ray imaging. Therefore, it enables us to perform detailed observation of samples mainly composed of light elements such as biological soft tissues and organic materials without any supplemental measures.

To broaden the scope of DEI in biomedical and material imaging, the energy of X-rays in our DEI imaging system has been increased from 17.7 keV to 70 keV. The usage of high-energy X-rays makes it possible to observe larger samples having greater variation in density within shorter measurement periods and at lower X-ray doses.

Imaging system and test observation

Figure 1 shows a schematic view of our high-energy DEI system. The system consists of an asymmetric crystal (Si(220)), a sample positioner, an analyzer crystal (Si(220)), and an X-ray imager. The incident X-ray is enlarged by the asymmetric crystal and then irradiates the sample positioned by the sample positioner. The X-ray passing through the sample is diffracted by the analyzer crystal positioned by using a precise rotational table and is detected by the X-ray imager [1]. To perform the computed tomography, the sample was rotated over 180 degrees by using the rotational table of the sample positioner. The refraction angle caused by the samples was calculated from many images obtained by scanning the analyzer crystal throughout the rocking curve [2].

Figure 2 shows the obtained three-dimensional image of a signal coaxial cable (provided by Hitachi Cable, Ltd.). The region of the front quarter was changed to transparent numerically. The dark area indicates a high-density region, and the light area indicates a low-density region. The image clearly reveals not only the core and mesh ground wire made of copper but also the jacket made of organic material. The total measurement time for obtaining one CT data set was about 5 h.

This result indicates that high-energy DEI has the potential to be a powerful imaging method for visualizing and quantitatively analyzing not only soft materials but also complex materials.

References

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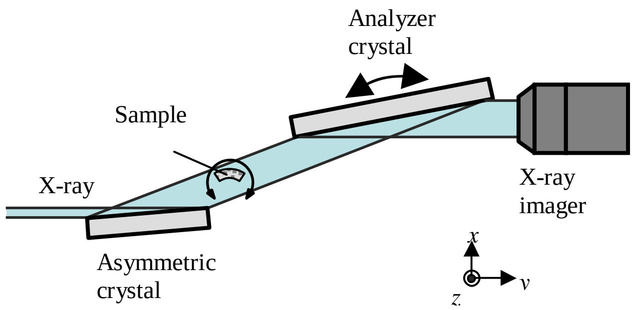

Fig. 1 Schematic view of high-energy DEI system

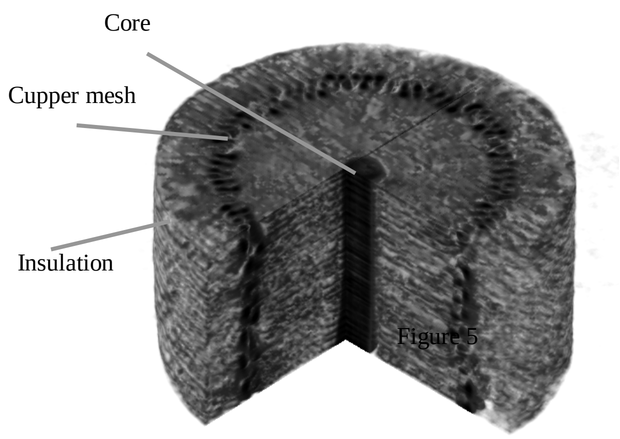

Fig. 2 Three-dimensional image of signal coaxial cable obtained using 70-keV.