Medical Application

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Phase-contrast x-ray imaging for biomedical application at 35keV

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Introduction

Phase-contrast x-ray imaging with an x-ray interferometer, has great potential to reveal the structures inside soft tissues without a contrast agent because this technique has 1000 times higher sensitivity than that of the conventional absorption method [1]. Phase-contrast x-ray CT (PCCT) demonstrated rabbit cancer lesions [2] and human cancer lesions [3]. To image the larger objects, a phase-contrast x-ray imaging system with larger monolithic x-ray interferometer [4] and separated types of interferometer [5-6], has developed to obtain a field of view with 25 mm x 25 mm at 17.7 keV. Since the x-ray exposure to large object increases significantly at low x-ray energy of 17.7 keV, we performed phase-contrast x-ray imaging at high x-ray energy of 35 keV and described recent experimental results.

Methods and material

The phase-contrast x-ray imaging system consisted of a Si (220) asymmetric cut crystal, a monolithic x-ray interferometer, a phase-shifter, an object cell and an x-ray CCD camera. An experiment was performed at a vertical wiggler beam line of the Photon Factory. The x-ray energy was set at 35 keV. The cell was placed in a beam path between mirror and analyzer of the interferometer. Phase map and PCCT was obtained for rat livers perfused by physiological saline and human breast cancer specimens.

Results and discusion

At 35 keV x-ray energy, vessels in rat's liver were clearly depicted as gray contrast (Fig.1) and the spiculae and micro-calcifications of breast cancer specimens were revealed. PCCT of VX2 rabbit cancer was also demonstrated clearly. Image quality at high x-ray energy is not degraded significantly by visual inspection comparing to previous study [3, 7]. However, the acquisition of image data became significantly difficult because the stability time of interference fringe at 35 keV was shorter than that at 17.7 keV. To improve this problem, x-ray CCD camera with high speed data acquisition will be needed instead of presently used x-ray detector [8], and much clear images will be obtained without imaging blur.

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References

1. Momose A, Fukuda J. Med. Phy. 22, 375-379, 1995
2. Momose A, Takeda T, Itai Y, Hirano K. Nature Medicine, 2, 473-475, 1996
3. Takeda T, Momose A. Hirano K, Haraoka S, Watanabe T, Itai Y. Radiology 214, 298-301, 2000
4. Takeda T, Momose T, Yu Q, Wu J, Hirano K, Itai Y. J. Synchrotron Rad. 7, 280-282, 2000
5. Yoneyama A, Momose A, Seya E, Takeda T, Itai Y. Rev. Sci. Instrum. 70, 4582-4586, 1999
6. Yoneyama A, Momose A, Takeda T, Itai Y. J. Synchrotron Rad. 7, 280-282, 2000
7. Takeda T, Momose T, Wu J, Yu Q, Zeniya T, et al. Circulation 105, 1708-1712, 2002
8. Momose A, Takeda T, Yoneyama A, Koyama U, Itai T. Analytical Science 17S, i527-530, 2001

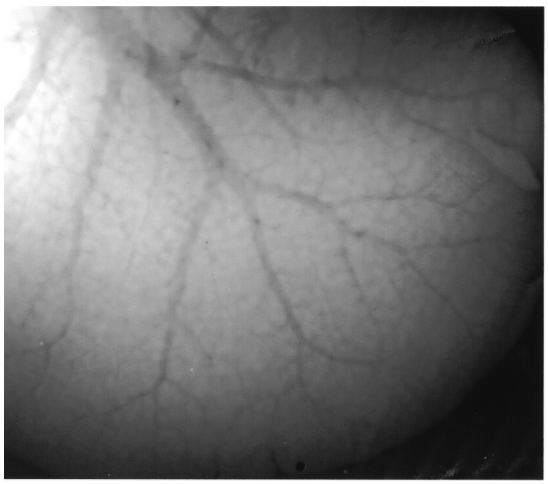

Fig.1 Phase map of hepatic vessel at 35keV x-ray energy. Minimal diameter of 0.035mm vessels is revealed well.