アルゴリズム開発とX線画像進歩Ⅰ：
Evolvement of Algorithm and Its Application to High Performance X-ray Imaging Ⅰ

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The physical quantity depicted by conventional x-ray computed tomography (CT) is absorption coefficient which is related to an imaginary part β in the complex refractive index $n = 1 - \delta - i\beta$. However, the imaging scheme has a problem that the contrast for low Z-materials constituting biological soft tissues is very low. On the other hand, the phase-contrast term δ related to refraction has about 1000 times higher sensitivity to the low-Z elements than β. Various methods to delineate δ distribution have been proposed.

Here, we propose a refraction-based CT system (Fig. 1) using a Laue-case analyzer (LA) referred to as dark field imaging (DFI). X-ray beam impinging on a thin Laue-case analyzer (LA) crystal at approximately 10^{-7} radians around its Bragg angle is divided into a forward diffracted beam (FD) and diffracted beam (D). DFI is an imaging method using LA made of a thin Si single-crystal plate, with the thickness of analyzer selected such that the intensity of FD is zero at the Bragg angle, which can visualize soft biological tissues at a high contrast with FD projection image only. So far, we have demonstrated various kinds of biological samples to show the imaging abilities [1].

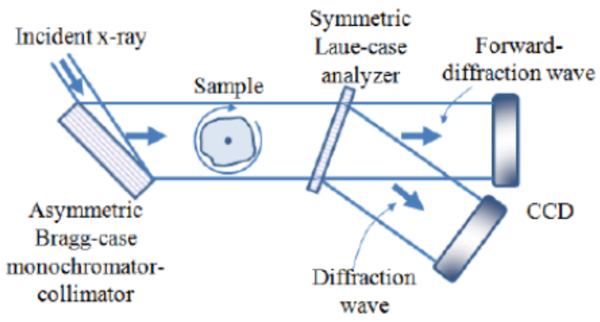

Fig. 1. Schematic of DFI (dark field imaging) system to measure angular deviation due to refraction.

On the other hand, using the DFI optics, a refraction-contrast CT imaging system for biomedical use can be realized, which has a high depicting capability on the soft tissues with lower radiation dose compared with conventional x-ray CT based on absorption contrast principles. Intensities of FD and D from LA are differently modulated against incident angle, so we can quantitatively estimate an angular deviation of an incident direction due to refraction by a sample from the intensities detected. We developed the data-processing method to extract refraction information from two measured entangled intensities with rocking curves fit using polynomials [2]. In addition, we devised its reconstruction algorithm based on geometrical optics [3]. In order to demonstrate its efficacy, we imaged a sample with DCIS (Ductal Carcinoma In Situ) removed from a breast cancer patient using a system constructed at the vertical wiggler beamline BL-14C in KEK.

References:
1) M. Ando, A. Maksimenko, H. Sugiyama, W. Pattanasiriwisawa, K. Hyodo and C. Uyama, Jpn. J. Appl. Phys. 41, L1016-L1018 (2002).
2) N. Sunaguchi, T. Yuasa, Q. Huo, S. Ichihara and M. Ando, Appl. Phys. Lett., 97, 153701 (2010).
3) N. Sunaguchi, T. Yuasa, Q. Huo and M. Ando, Optics Lett., 36, 391-393 (2011).