Recently, various imaging techniques that produce contrast images from X-ray phase information have been proposed. Biological imaging is their main target because of expected sensitivity up to 1000 times higher than absorption-contrast X-ray imaging, whose performance is insufficient for soft tissues. Three-dimensional tomographic imaging using X-ray phase information has also been achieved [1,2] using an X-ray interferometer [3]. Its high sensitivity enables us to observe tissue structures, such as vessels, cancerous lesions, fibrous tissues, without the use of contrast media.

The method’s spatial resolution (roughly 30 μm × 30 μm × 60 μm), however, was not satisfactory for histological observation; the spatial resolution was not limited by our image detector, but by the X-ray interferometer itself, which was made by cutting the body out of a crystal. The interferometer produces interference fringes by generating and recombining two coherent X-ray beams using the dynamical diffraction at a set of lamellae. A blurring mechanism is involved in this process; that is, the wave field of X-rays downstream of the sample is altered by the third lamella, which functions as an X-ray half-mirror, due to the process of dynamical diffraction. We therefore fabricated a new X-ray interferometer with a 40-μm lamella (Fig. 1(a)), which was effective for suppressing the image blurring.

The interferometer successfully produced interference fringes and was installed at beamline BL20XU, where we developed an apparatus for phase-contrast tomography. In the measurements, we used 12.4 keV X-rays with a CCD-based image detector, whose pixel size was 6.5 μm × 6.5 μm. Tissue pieces (2 ~ 3 mm in diameter) were observed in a cell filled with formalin. The experimental setup shown in Fig. 1(b).

Figure 2(a) shows tomographic images obtained for a piece cut out of the cortex of a rat kidney fixed in formalin [4]. Convoluted tubules and vessels are revealed. Figure 2(b) shows an optical image of
the corresponding specimen sliced after the X-ray measurement for comparison. Glomeruli can also be identified in Fig. 2(a) in comparison with Fig. 2(b). Figure 2(c) shows a 3-D rendered view of the tomographic data. In earlier experiments [5], the structures could not be revealed as clearly as the present image.

![Image](image-url)

**Fig. 2.** Phase-contrast tomographic image of a cortex part of a rat kidney (a) and an optical image of the corresponding specimen sliced after X-ray measurement (b). G: glomeruli. (c) 3-D rendered tomographic view.

Atsushi Momose\(^{a,b}\), Ichiro Koyama\(^{a,b}\) and Tohoru Takeda\(^{c}\)

(a) The University of Tokyo
(b) SPring-8 / JASRI
(c) University of Tsukuba

E-mail: momose@exp.t.u-tokyo.ac.jp

**References**