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Deriving refractive angles in X-ray diffraction-enhanced imaging

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Introduction

Diffraction-enhanced imaging (DEI) method is a phase-sensitive imaging technology [1]. This modality derives contrast not only from absorption as conventional X-ray imaging, but also from refraction and scatter rejection. So even for low Z mater it can have high contrast. The high sensitivity to deflected angles is the predominance of this analyzer-based imaging method.

Using a PMMA sample, which has various slope angles, we carried out the experiments for the study of the nature of DEI. The different slope angles correspond to different electron density projection [2], so the refractive angles of the incidence X-rays were different.

In a interface composed of two kind of materials, the electron density of which is ρ_1 and ρ_2 respectively, the refractive angle $\Delta\varphi$ can be expressed as [2]:

$$\Delta\varphi = \frac{r_e \lambda^2}{2\pi}(\rho_2 - \rho_1) tg\varphi \qquad (1)$$

where λ is wavelength, γ_e=2.818 × 10^{-15}m is classical electron radius, φ is incidence angle.

Experiments and methods

Experiments were performed at beamline BL-14B with 15kev and 33.88kev X-rays. The experimental setup is shown in Fig. 1. Every image was recorded by an X-ray CCD detector, whose pixel size was 6.7 × 6.7μm.

In order to extract the angular deviation due to the slope angles, we took two series of images along the RC, one with sample and the other without sample. So we can obtain, respectively, an *object* RC (with sample) and a *reference* RC (without sample) [3]. Employing a simple Gaussian Fit, we can easily obtain the peak of the object RC (P_{obj}) and the peak of the reference RC (P_{ref}). Thus the angular deviation can be written as:

$$\Delta\theta = P_{obj} - P_{ref} \qquad (2)$$

Results and Discussion

DEI is sensitive to refractive angles, because only the X-rays of specific orientation chosen by analyzer get the image. It is important to research how the refractive angle be affected by the object and how to get the magnitude of the deviated angle (in fixed energy).

Fig. 2 shows the calculated and measured refractive angles versus slope of the incidence angle at 15kev and 33.88kev.

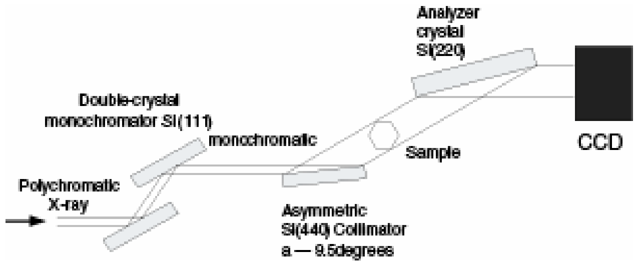

Fig. 1 Experimental setup of DEI method.

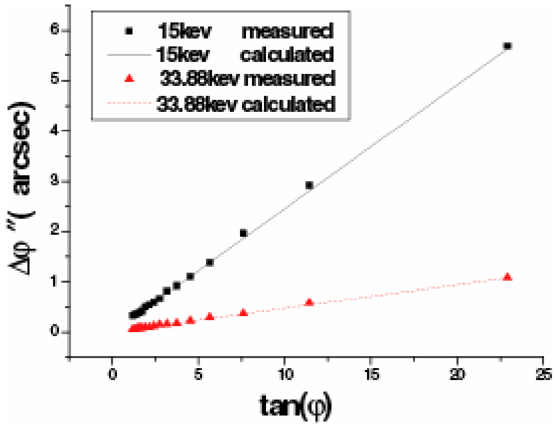

Fig 2 Calculated and measured refractive angles versus slope of the incidence angle φ

References

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