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Amplifier effect of crystal X-ray waveguide

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Part of the incident X-rays can be confined in a thin absorbing crystal when absorption is diminished by dynamical diffraction effect. The confined X-rays are propagating parallel to the crystal surface as a traveling wave. When the traveling wave arrives at a side of the crystal, it is emitted in the reflection and transmission beam directions[1]. We call this as "Crystal X-ray Waveguide" (CXW). The flux density of the traveling wave can be increased by injecting X-rays from wide range of the surface along the beam traveling direction[1] (amplifier effect). In this paper, we report on the experiment results of CXW and the amplifier effect.

The schematic diagram of measurement system is shown in Fig. 1. The thickness of a Ge thin crystal of CXW was approximately 20 µm. The reflection index was 220. IR is the reflected intensity from the incident surface of CXW and IT is the transmitted intensity from the back surface, and IR' and IT' are the emitted beam intensities in the reflected and transmitted directions. In Fig. 2, the measured rocking curves of IR, IT+IT' and IR' are shown. The peak heights of the three rocking curves are adjusted to show the same height. Photographs of IT, IT', IR' and IR shown in Fig. 3 were taken at the peak angle of IR' where the maximum confinement was expected. The interference fringes are clearly seen in IR' and IT'. In Fig. 3, the white contrast shows that no X-rays come out in the region between IR and IR' except for the diffuse dark contrast below IR'. The dark contrast seems to be caused by incoherent X-rays of thermal diffuse scattering (TDS) during multiple diffractions in CXW.

Fig. 4 shows the amplifier effect of CXW. When an X-ray beam is incident at the position 716µm from an edge of the crystal (L in Fig. 1) after passing through slit 1 of 50µm wide in Fig. 1, the emission rate (IR'/IR) is about 0.4%. The rate increases approximately 30% when the width of the slit 1 increases to 300µ m. The emission rate increases 75 times, when the beams width increases 6 times. The rate increase is larger than the increase in the beam width, which may be related to decrease of absorption of the traveling wave in the CXW as the traveling distance decreases. We will proceed to make more highly amplified CXW.

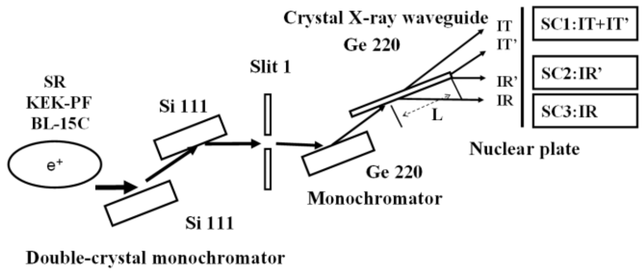

Fig. 1. Schematic diagram of measurement system.

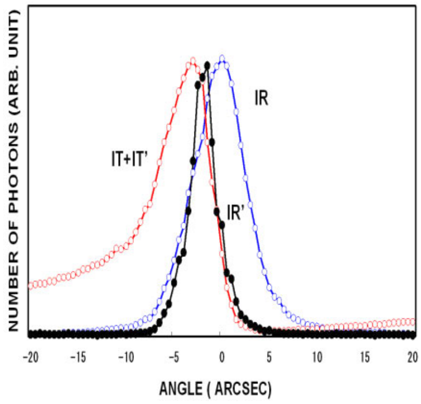

Fig. 2. Measured rocking curves. X-ray energy is 11101 eV.

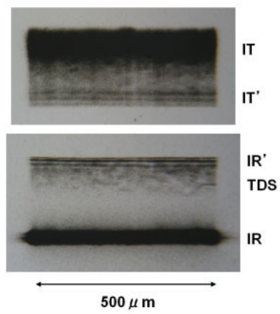

Fig. 3. Photographs of IT,IT',IR and IR'. X-ray energy is 11093 eV.

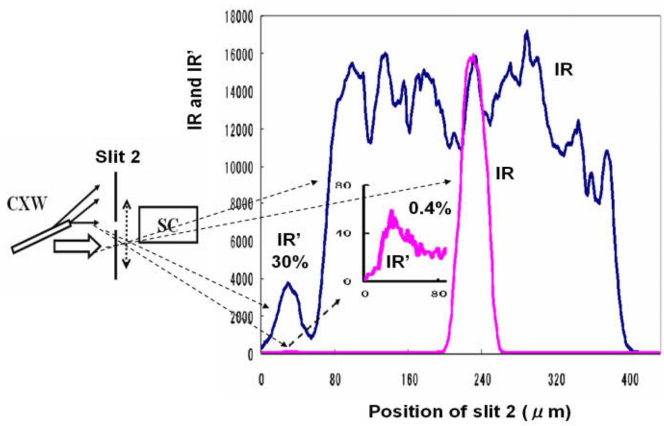

Fig. 4. The amplifier effect. X-ray energy is 11093 eV.

Reference

[1] T. Fukamachi et al., JJAP **43**, L865(2004).

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