Absorbed Dose within Si Crystal Due to 40 keV Synchrotron Radiation with Linear Polarization

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1. Introduction

In order to establish an estimation method of absorbed dose within optical elements with photon polarization effect, we measured absorbed dose distribution within a Si crystal disk both in the axial and lateral directions to the incident beam, based on the plural TLD method[1]. Measurement was made using the monochromized 40 keV synchrotron radiation beam, originated from the superconducting vertical wiggler beam line (BL-14C) of KEK.

2. Experimental and Calculational Methods

We measured the absorbed doses within the Si disk using the LiF and $CaSO_4$ TLDs irradiated at the sametime. Arrangement of the experimental setup is illustrated in Fig.1. Specially fablicated Si disks with diameter 152.4mm and of 1.0mm and 2.0mm thickness were put together to make the bunched Si disk of 21mm thick. Polarization of the incident photons were determined to be 0.83 by measuring the intensity of photons scattered by the Be film of 80μm thickness at the azimuthal angles of 0° and 90°.

The calculational configuration consists of 25 semi-infinite slabs of various materials (one slab for Be, one for Al, 5 for air and 18 for Si). Rectangular photon beam was incident normal to the surface of the Be slab.

3. Results

In Fig.2 is given a comparison of the absorbed dose distribution within the Si disk along the axis of the photon beam between the measurement and the EGS4[2] calculation, showing a reasonable agreement with the accuracy of 20% except at a depth 15mm. Further, the EGS4 calculation was fitted by a single exponential function as $Y=C \cdot \exp(-0.158X)$. On the other side, the energy absorption curve was derived theoretically on the basis of the mass energy absorption coefficient and mass attenuation coefficient as, $Y=C' \cdot \exp(-0.162X)$. From the figure it is seen that the theoretical curve somehow underestimates the EGS4 calculation, although their gradients are almost the same.

We also obtained the absorbed dose distribution in the lateral direction. In Fig.3 is shown one of a lot of measurements at the point 20mm apart from the axis at five different depth points. Here the dose value is expressed by the distance from the origin to the data point. Besides, the vertical axis corresponds to the azimuthal angle of 0° and 180°, while the horizontal axis corresponds to 90° and 270°. The asymmetric distribution obtained is caused by the polarization effect. The dose ratio between the azimuthal angles of 90° and 0°approaches up to around 5.

References

[1] S.Tanaka and N.Sasamoto, J. Nucl. Sci. Technol., 22 (2) (1985).

[2] W.R.Nelson, et al.,"The EGS4 Code System", SLAC-265 (1985).

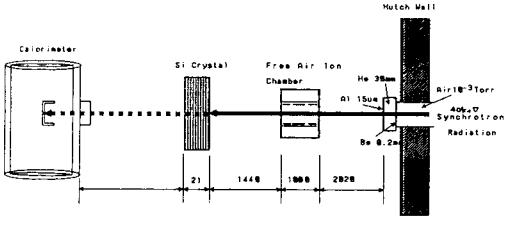

Fig.1 Arrangement of the experimental setup.

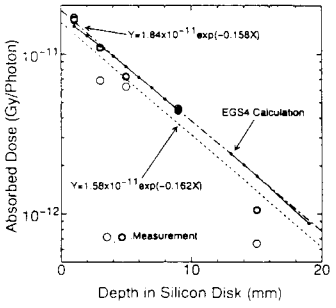

Fig.2 Absorbed dose distribution along the SR beam axis.

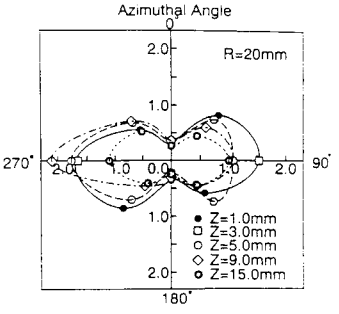

Fig.3 Absorbed dose distribution as a function of azimuthal angle.