Bent Crystal Monochromators for High Energy Synchrotron Radiation (I)

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1. Introduction

In the SPring-8 two kinds of monochromators will be installed at wiggler beamline BL08W for inelastic (Compton) scattering experiments[1]. One monochromator covers the energy rage from 100 to 150 keV for high-resolution Compton scattering experiments and another around 300 keV for magnetic Compton scattering experiments. Here we report design of monochromators and results of some calculations conserning heat load analyses and reflectivity for bent crystals briefly.

2. Basic design

We will take the following focusing system to realize that energy resolutions, $\delta E/E$, and beam spot size are less than 10^{-3} and 0.5x0.5 mm^2 for 100-150 keV monochromator and about 5 x 10^{-3} and 3(v)x1(h) mm^2 for 300 keV monochromator, respectively.

For the 100-150 keV monochromator we take doubly-bent crystal monochromator which has been originally developed at AR NE1 of KEK[2]. A symmetric Johann Si 400 crystal will be used in the first phase. It is bent to get vertically focused beam at q/p=1 position, where p and q are distances from source to crystal and crystal to focused point. Sagittaly the crystal is bent with fixed radius as to get q/p=1/3 focus. For the 300 keV monochromator an asymmetric Johann type will be employed. Si 771 crystal will be used with asymmetrical angle of about 1 degree to make crystal length smaller and focal point forward. The crystal will be set to focus vertically-diverged beam. We take Bragg geometry because we can get efficiently-focused beams for both monochromators compared to Laue geometry. Mechanical designs of the monochromators are done. We take one crystal monochromator system and four-point crystal bender because of simplicity. Figure 1 shows a schematic diagram of the BL08 wiggler beamline optics.

3. Bent crystal

Effects for angle resolution when the crystal is bent are studied by using analytical formula and simulation with Takagi-Taupin equation. Figure 2 shows results of the simulation for 110 keV x-ray on Si 400 crystal. Critical curvature of radius from dynamical to kinematical reflection is of the order of 100 m. Both analytical and simulated results show that around 100 keV dynamical effect is dominant for bent radius of curvature of about 1000 m, while around 300 keV kinematical effect becomes dominant almost anytime for bent crystal. Mosaic crystal such as annealed or polished crystal would be one of the candidates to get much more integral intensity. Study of mosaic crystals is under way.

4. Heat load and radiation effects

In this beamline insertion device is elliptic multipole wiggler (EMPW) of which parameters are l=12 cm, Ky=11.2, Kx=0~1.1, N=37, L=4.5 m and total power of 18 kW for Kx=0, respectively. Before the optics 36 mm thick graphite filter and 20 mm thickness Al filter will be inserted. At the 100-150 keV monochromator position, incident power is reduced to be about 800 W. For the 300 keV monochromator Al filter of more than 10 mm thick is inserted and results incident power of about 470 W. Finite-element analyses are performed by using ANSYS for bent crystals. The results indicate that for the 300 keV monochromator thermal problem is not serious, on the other hand for the 100-150 keV monochromator the performance of bent crystal of which energy resolution of about 10^{-3} is possible only for the center region. Improvemnet of efficient cooling geometry would be necessary from a thermal view point for the 100-150 keV monochromator.

Radiation problem is more serious in this beamline due to the wiggler source that gives relatively high energy components. Thick lead cover will be set near the scattering sources such as monochromator crystals except experimental hutch shields. On silicon crystal for the energy more than about 50 keV, Compton scattering process becomes dominant compared with the others like Rayleigh and photoionization processes. Figure 3 indicates an example of the power ditribution as a function of crystal thickness for 300 keV monochromator. Compton scattering is large and gives power of about 100 W continuously. Water-cooled system will be set to surround the crystal.

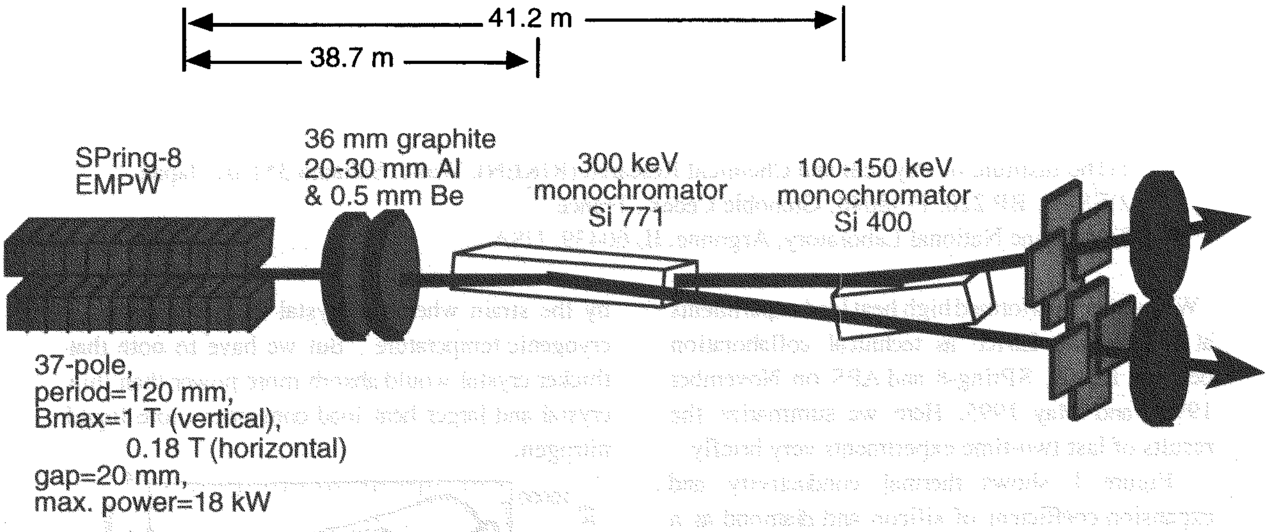

Fig. 1 Schematic diagram of SPring-8 BL08W beamline optics.

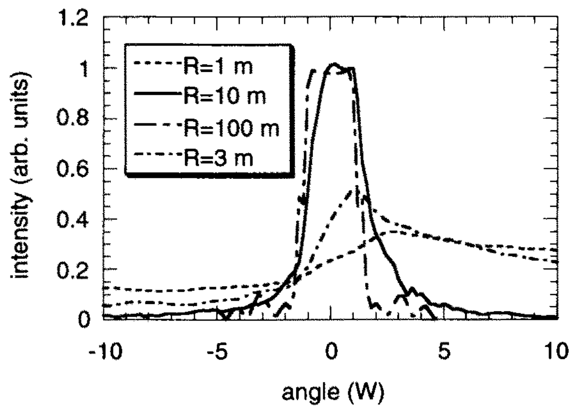

Fig. 2 Simulated results of the rocking curve width for Takagi-Taupin equation for various curvature of radius at 100 keV.

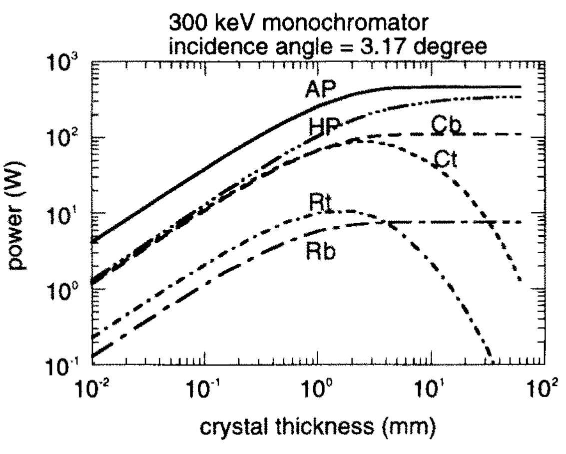

Fig. 3 Power distribution of a silicon crystal at the Bragg angle of 3.2 degree as a function of crystal thickness. *AP*, *HP*, *Cb*, *Ct*, *Rb* and *Rt* are absorbed power, pure heat power, Compton back scattered, Compton transmitted power, Rayleigh back scattered power and Rayleigh transmitted power, respectively.

References

[1] Y. Sakurai et al. Rev. Sci. Instrum. & Methods **66**, 1774 (1995).

[2] H. Kawata et al. to be published.

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