A Novel Soft X-ray Bending Magnet Beamline Using Active Grating Monochromator

Beamline

08B BM-AGM beamline

Authors

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Following the debut of novel Active Grating Monochromator (AGM) in the EPU-AGM/AGS beamline, we applied the AGM to the design of a soft X-ray bending magnet beamline, the BL08B BM-AGM beamline. This beamline can be viewed as a modified Dragon design with an AGM replacing the commonly used spherical grating or cylindrical grating monochromator. The surface curvature of the active grating is adjustable during energy scan to eliminate the need for a movable exit slit, and the surface is aspherically shaped to minimize the coma aberration. The ray-tracing program Shadow was employed to simulate the beamline performance, and the results show that the energy resolving power, with slit openings of 10 μm, is greater than 10,000 in the energy range from 300 to 400 eV. The energy resolving power decreases with higher photon energy, and reaches ~3,500 at 1200 eV. The total flux at sample position remains above 1×10^{12} (phs/sec/200mA/0.1%BW) up to 1000 eV, and the beam size (FWHM) is around 1 mm (H)$\times$0.2 mm (V).

With the advancement in source and beamline instrumentation, soft X-ray has become an indispensable tool for probing the electronic structures of a diversity of materials and systems, such as polymer, biological specimen, artificially structured-, interfacial-, and nano-materials, and highly correlated electron system. Since the demand of beamtime from users in these booming research fields has been growing rapidly in NSRRC, we started to build a new soft X-ray beamline to relieve the frequently over-booked schedules of our current beamlines. The new beamline incorporates our latest development in soft X-ray monochromator design, namely the AGM, to provide the users with another high-performance soft X-ray source.

There are five Dragon-type beamlines operated in the soft X-ray range at NSRRC: LSGM, HSGM, WR-SGM, U5-SGM and EPU-SGM. These beamlines are characterized by high throughput, high resolution, and simple optical layout. However, a movable slit system is required during energy scan to eliminate the defocused term, which is a drawback for image-type experiments. In addition, due to the fixed radius of the grating used in these beamlines, the coma aberration cannot be completely eliminated over the entire energy range, especially in the lower energy range where the resolution is compromised. Therefore, we have proposed a modified Dragon-type beamline with AGM for this project.

In the BM-AGM beamline, a novel active grating and a fixed exit slit are used. The curvature of the active grating is adjusted by two piezo-actuators during energy scan. The first active gratings used in the AGM/AGS system were made on Invar substrates, on which the Si layer for the gratings were adhered. To improve the mechanical property and reduce the complexity in manufacturing, the new active grating is made

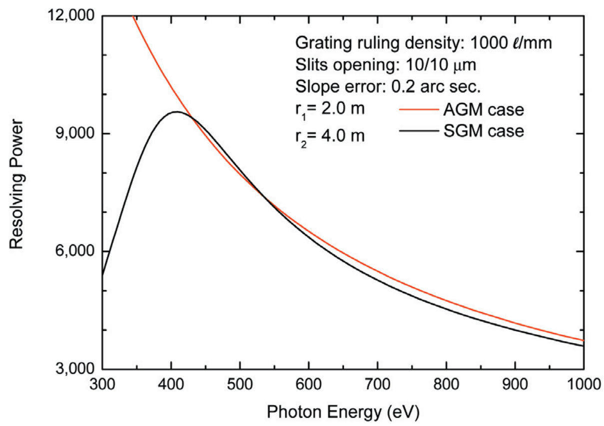

Fig. 1: Comparison of energy resolving power between the AGM and SGM designs.

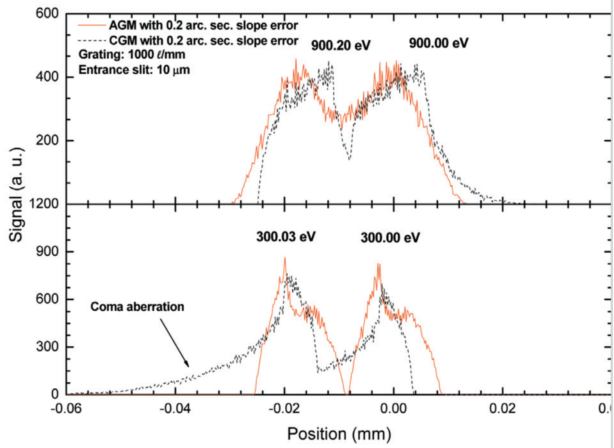

Fig. 2: t 300 eV of the lineshape of AGM is more symmetric and much smaller, because the aberration is greatly reduced.

on PH17-4 stainless steel substrate with Nickel-plating. The new grating with PH17-4 substrate are capable of wider range of adjustment of the grating radius and can go down as low as 40 m, compared with 80 m of the Invar substrate.

With the special design of the mechanical structure of the active grating, the grating radius can be continuously changed to eliminate the defocusing term and therefore a fixed exit slit can be used. Moreover, an aspherical shape of the grating can be formed to further eliminate the coma aberration to improve the energy resolution in the lower energy region. This effect can be seen in Fig. 1, where the resolving powers of an AGM and a spherical grating monochromator (SGM), calculated with analytic equation, are compared. In this comparison, the grating ruling density is 1000 ℓ/mm and similar operation conditions are chosen for both cases. It is clearly shown that the resolving power of the AGM is much higher than that of the SGM for energy range below 400 eV.

In Fig. 2, the focused beam shapes at the exit slit position are shown. The line widths show that the AGM resolving power exceeds 15,000 and is better than that of the SGM by a factor of 2 at 300 eV. Obviously, the energy resolving power is greatly improved due to effective suppression of coma aberration in the AGM design. For the 900 eV case, the improvement is less obvious. The reason is that the slit opening and the slope error of the grating surface limit the total energy resolving power in the higher energy region, such that the SGM and AGM show nearly the same performance.

The optical layout of the BM-AGM beamline is shown in Fig. 3. The photon source generated by a dipole bending magnet in the storage ring is collected and horizontally focused by a horizontal focusing mirror (HFM) to a position between the grating and the exit slit (S2). The HFM is a 1.2 m long plane-elliptic shape, Au-coated, water-cooled Si mirror, which collects 9 mrad horizontal radiation fan. After HFM, the photon beam is vertically focused by the spheri-

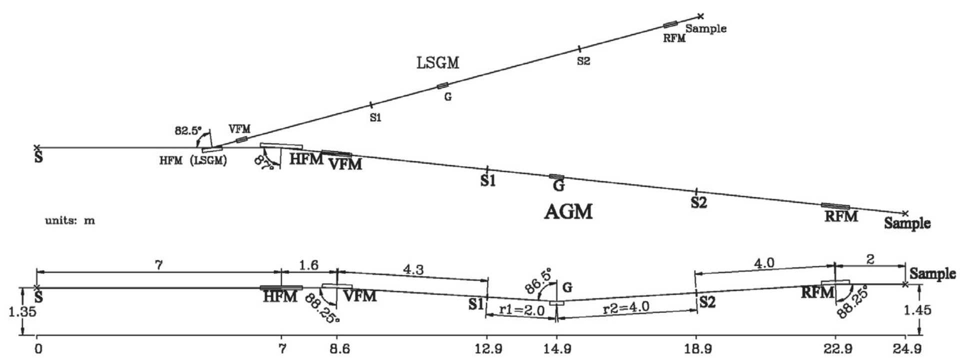

Fig. 3: The optical layout of the BM-AGM beamline.

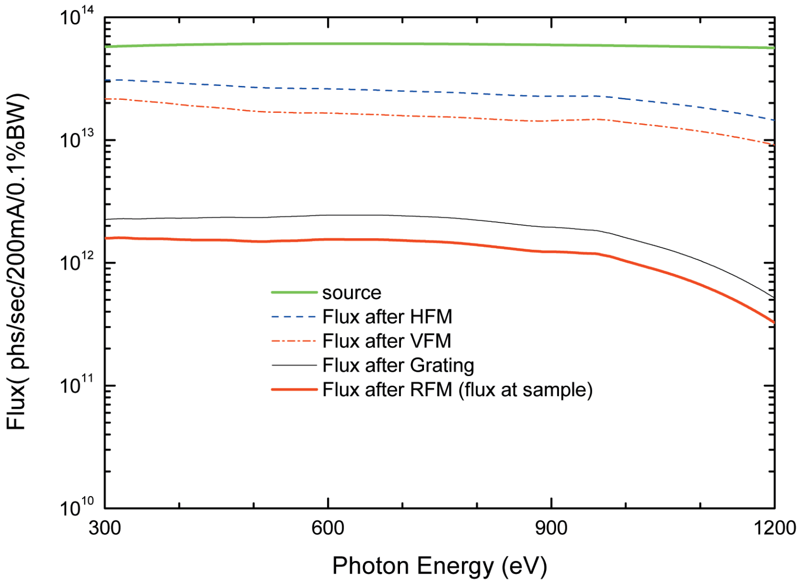

Fig. 4: The flux calculation of the BM-AGM beamline.

cal vertical-focusing mirror (VFM) onto the entrance slit (S1). After S1, the photon beam is vertically dispersed and focused by an active grating on S2, which is followed by a toroidal RFM to focus the monochromatic photon beam to the sample position.

The beamline performance was simulated by the XOP and Shadow programs. The calculated photon flux after each optical component is shown in Fig. 4. The results show that the total flux is about 1×10^{12} phs/sec/200mA/0.1%BW in the spectral range 300-1000 eV. The energy resolution will reach 10000, 6000, and 3500 in the energy ranges of 300-400 eV, 400-600 eV, and above 600 eV, respectively. The focused beam size (FWHM) is about 1 mm$\times$0.2 mm (H$\times$V). This BM-AGM beamline system is currently under construction and will be ready for commission in December 2006.

References

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