

APPENDIX B

Instructions for electronic publication-ready papers

All papers will be printed in publication-ready format. Publication-ready copy should be prepared according to the following instructions. Please read these carefully, as publication-ready copy that does not conform to these instructions will be returned for correction.

(1) The paper should be submitted according to Section 3 of Notes for Authors. You do not need to prepare the publication-ready copy until your paper has been **accepted** by the Co-editor.

(2) The style of a publication-ready paper in the *Journal of Synchrotron Radiation* is shown on the following pages. The detailed typographic specifications are as follows:

Layout details

Page size (text area):	183 × 238 mm
Column width:	88 mm
Space between columns:	7 mm

Fonts and spacing

Title:	12 pt bold Helvetica
Authors:	10 pt bold Helvetica
Affiliations:	<i>9 pt oblique Helvetica</i>
Abstract:	9 pt Times Roman
Keywords:	8 pt bold Helvetica
Headings	
Level 1:	8 pt bold Helvetica, aligned left
Level 2:	8 pt bold Helvetica, aligned left
Level 3:	8 pt bold Helvetica, at start of paragraph
Text:	9 pt Times Roman
References:	8 pt Times Roman
Figure captions:	8 pt Times Roman
Table captions:	8 pt Times Roman
Table text:	7 pt Times Roman
Footnotes:	8 pt Times Roman

If you do not have Helvetica fonts available, please use Univers or another sans-serif font.

(3) Electronic templates (L^AT_EX and WORD) are available by ftp from the address ftp.iucr.org in the directory 'templates/jsr'. The above styles are already set up in these templates.

(4) Once your paper has been accepted, the Co-editor will ask you to provide (a) the completed publication-ready copy, (b) an electronic version of the paper in L^AT_EX or WORD, (c) originals of all figures and (d) electronic versions of all figures in PostScript, Encapsulated PostScript or TIFF format. Please send the material to the Co-editor in a rigid card envelope to ensure it is not damaged in the post.

(5) When the publication-ready copy has been approved by the Co-editor, it will be forwarded to the Editorial Office in Chester for publication. If additional material is required by the Editorial Office, it should be submitted following the procedures given in Section 3.11 of Notes for Authors.

Design and performance of a multilayered mirror monochromator in the low-energy region of the VUV

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For the energy region from tens to hundreds of electron volts, the multilayered mirror (MLM) monochromator has never been realized due to the difficulty of reducing the background noise of the total reflection component, in spite of its usefulness in synchrotron radiation experiments. In this work, a double-crystal-type MLM monochromator equipped with a novel driving system has been designed on the basis of the trial fabrication of MLMs. The driving system and of Mo/Si multilayered mirror has been evaluated. It has been shown that the background level is low enough to be used with an etching process. The present prototype driving system has successfully covered an incident beam angular range (θ) of 10–80°.

Keywords: multilayered mirror monochromators.

1. Introduction

Studies of synchrotron-radiation-stimulated processes such as etching and chemical vapour deposition (CVD) began about 12 years ago (Urisu & Kyuragi, 1987) and are still attracting much interest from many researchers. The vacuum ultraviolet (VUV) photons in synchrotron radiation can excite almost all the electronic states of molecules, so a large variety of chemical reaction channels different from that in the usual thermal-CVD are expected to be opened by synchrotron radiation irradiation. In particular, core electrons, which cannot be excited using lasers, are efficiently excited by the VUV photons in synchrotron radiation. The excitation-energy dependence of a photochemical reaction is important basic data. However, it has not been sufficiently investigated in the VUV region, because of the difficulty in obtaining energy-tunable monochromated light with sufficient photon flux ($>10^{13}$ photons s^{-1}) in the VUV region.

A multilayered mirror (MLM) monochromator is already in use in the high-energy region of the VUV (Barbee *et al.*, 1987). Concerning the low-energy regions, one of the present authors previously tried to use an MLM as a dispersion element in synchrotron-radiation-stimulated experiments. However, this was unsuccessful due to the difficulty in removing the background noise, consisting of total reflection components appearing at less than a few tens of eV. Therefore, in this work, we have designed a double-crystal-type MLM (Golovchenko *et al.*, 1981; Murata *et al.*, 1992) monochromator combined with an appropriate thin-film filter. The design is based on the trial fabrication of MLMs

and the driving system for them. We have found that the low-energy background noise is sufficiently removed by using the MLMs at low incident angles combined with a carbon or molybdenum filter.

2. Design of the monochromator and mirrors

2.1. Monochromator

We adopted the monochromator driving system proposed by Golovchenko *et al.* (1981). The centres (*A* and *B*, respectively) of the first and the second MLMs are set on the *XY* and *YZ* lines which form a rigid right angle *XYZ*, with the first MLM parallel and the second perpendicular to the *XY* lines, respectively. A pulsed motor drive slides the second mirror linearly, keeping the rotation angle of the *XYZ* fixed. The first mirror is rotated around the apex of the *YZ* line so that it is perpendicular to the *XY* line. The driving system is using the mechanical linkage and driving system. The angle of the higher-order photons. The angle of the higher-order photons increases as the incident angle to the monochromator. The mechanical linkage and driving system have been designed so that the beam incident angle can be adjusted to incident angles as small as possible. The present prototype driving system has successfully covered an incident beam angular range (θ) of 10–80°.

2.2. MLMs

The important photon energy region for the experimental investigation of synchrotron radiation processes, especially of the core-electron excitation processes, is from a few tens to hundreds of electron volts. In the present work our attention was focused on the region between 60 and 120 eV, a region for which fairly high reflectivity is obtained by using Mo/Si (for 60–90 eV) and

Sample electronic publication-ready paper (not to scale)

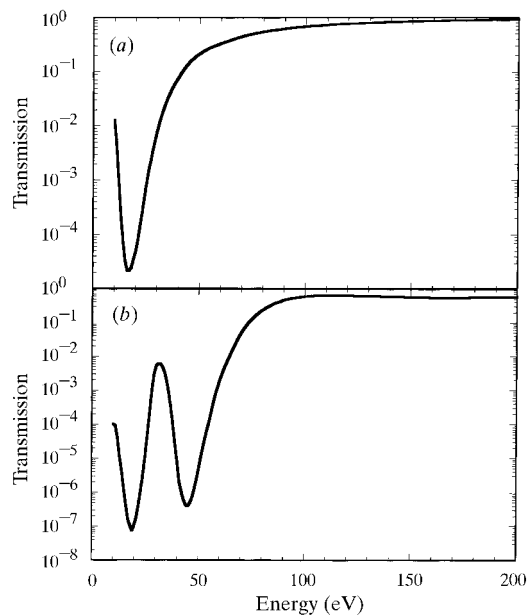


Figure 1 The calculated transmission for (a) a 100 nm-thick carbon filter and (b) a 100 nm-thick molybdenum filter.

Table 1
Specifications of optical components.

Component	Specifications		
Mo/Si MLM	Substrate	Si wafer (40 × 40 mm)	
	Number of layers	20	
	Period, d	12.5 nm (12.4 nm) [†]	
	Thickness ratio, Mo/Si	3/7 (3.25/6.75) [†]	
Mo/C MLM	Substrate	Si wafer (40 × 40 mm)	
	Number of layers	50	
	Period, d	7.5 nm (7.9 nm) [†]	
	Thickness ratio, Mo/C	1/1 (5.5/4.5) [†]	
		Interface roughness, σ	(0.4 nm) [†]

[†] Values determined by fitting to the observed Cu $K\alpha$ line diffraction curves.

Mo/C (for 85–120 eV) MLMs. This energy region includes the core-electron binding energies of Al (2s: 119 eV; 2p: 74 eV) and Si (2p: 103 eV), which are important materials in semiconductor processes. To reduce the background noise in the low-energy region due to the total reflection, it is necessary to use the MLM at low incident angles. The Mo/Si and Mo/C MLMs were therefore designed so that they could cover the Al 2s and 2p and Si 2p binding energies in the incident angle range of 10–50°. Moreover, the detailed structural parameters have been determined so that the reflectivity is high and the reflection is nearly total. Both Mo/Si and Mo/C MLMs were designed with the parameters listed in Table 1. The reflectivity was calculated using the Cu $K\alpha$ line diffraction data, and the transmission spectra were calculated using the CTEC program (Spiller, 1981) for parameters listed in Table 1, as shown in Fig. 2(a) for the Mo/Si case. It is known that extremely large total-reflection components appear at less than 40 eV in the case of Mo/Si.

2.3. Thin-film filters

The transmission characteristics of the thin-film filter have been calculated for several materials and it has been found that carbon and molybdenum are useful for reducing the background noise at energies below 70 eV. The transmission spectra calculated for 100 nm-thick carbon and molybdenum film filters are shown in Figs. 1(a) and 1(b), respectively.

3. Performance of the monochromator

The performance of the MLM monochromator, designed as described above, was evaluated by calculating what the basic characteristics, such as output photon flux, resolution, monochromaticity and tuning range, would be if the monochromator were set up as part of the beamline (BL-4A1) of the synchrotron radiation storage ring at the UVSOR. The beam emitted from the bending magnet is reflected by an elliptical pre-mirror at an angle of 4°. The horizontal and vertical acceptance angles are 20.0 mrad and 2.5 mrad, respectively. The monochromator is 6.1 m from the pre-mirror. The transmission spectra were calculated for a 100 mA ring current and a 16.56 × 12.79 mrad² acceptance angle of the pre-mirror. The output beam photon fluxes calculated for various incident angles are shown in Fig. 2(b) for the case of Mo/Si MLM plus C filter. It is clearly shown that the filter drastically reduces the low-energy background noise. It is less than 1% (3%) of the main flux, where the value in parentheses is for the case of Mo/C MLM plus Mo filter. The higher-order photons background noise is less than 4% (0.1%). The calculated photon flux is 1×10^{14} to 5×10^{14} photons s⁻¹ (3×10^{13} to 4×10^{13} photons s⁻¹) and the resolution is 5–9 eV (2–4 eV) FWHM. The calculated results are similar to those obtained with a typical undulator. Given that the MLM monochromator can select the photon energy continuously and that the mixing of higher-order photons is small, it is suggested that the present monochromator will be better than an undulator for use in synchrotron radiation experiments. We conclude from this work that the background noise due to the total reflection, which prevented the MLM monochromator from being used in the VUV low-energy region, can be sufficiently reduced by using double-crystal-type MLMs at low incident angles combined with a carbon or molybdenum thin-film filter.

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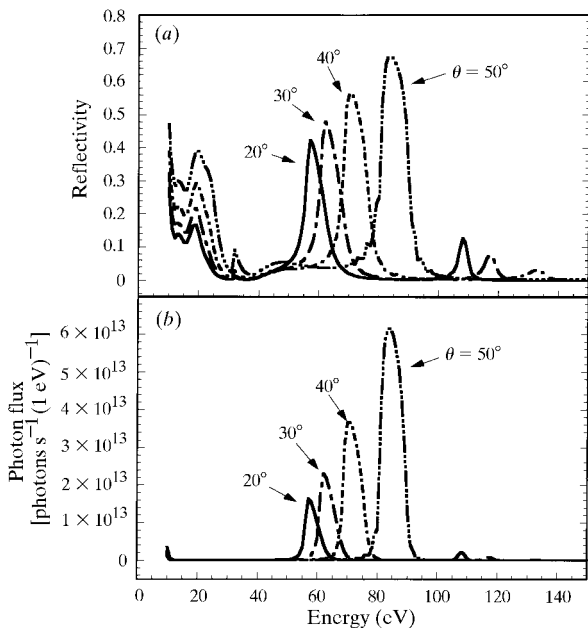


Figure 2
(a) Calculated reflectivity for the Mo/Si MLM and (b) output photon flux of the monochromator using Mo/Si MLMs plus C filter for a 100 mA ring current and a 16.56 × 12.79 mrad² acceptance angle of the pre-mirror, assuming that the monochromator is set up in the beamline BL-4A1 of the UVSOR.

238 mm