Journal of
Synchrotron
Radiation
ISSN 0909-0495

Notes for Authors
Proceedings of the 2nd International Symposium on Diffraction Structural Biology (ISDSB2007)

1. Submission

Authors should submit their paper ***via* the web** at http://journals.iucr.org/s/services/conferenceproceedings.html. Papers are expected to be submitted by **1 August 2007**.

2. Manuscript preparation

2.1. File formats

The manuscript should be prepared using Word, TEX or LATEX. Authors should use the templates available from http://journals.iucr.org/s/services/authorservices.html where full instructions are given.

Figures should be prepared in PostScript, encapsulated PostScript or TIFF formats. The resolution of bitmap graphics should be a minimum of 600 d.p.i.

For submission, the text and figures should be provided as a single Word/RTF, PostScript or PDF file. Once the paper is accepted separate source files for the text and figures should be uploaded at the URL provided in the acceptance message.

2.2. General

Contributions should not exceed four pages in journal article format. This equates to approximately 3500 words including figures and tables (a standard figure equates to 250 words).

2.3. Title and authors

The title should be short and informative. The contact author should provide an e-mail address and a fax number. The e-mail address will be used for editorial communications and despatch of electronic proofs and reprints.

2.4. Abstract and synopsis

All contributions must be preceded by an *Abstract* in English. The *Abstract* should be no more than 200 words and it should make no reference to tables, diagrams or formulae contained in the body of the paper. Literature references in the *Abstract* are discouraged but if a reference is unavoidable it should be sufficiently full within the *Abstract* for unambiguous identification, *e.g.* [Jones (2001). *Acta Cryst.* D**57**, 1–10].

Authors should supply a synopsis of no more than two sentences for inclusion in the contents listing of the journal.

2.5. Units

The International System of Units (SI) is used except that the ångström (symbol Å, defined as 10^{-10} m) is generally preferred to the nanometre (nm) or picometre (pm) as the appropriate unit of length. Recommended prefixes of decimal multiples should be used rather than '$\times 10^n$'.

2.6. Figures

Figures should be prepared using one of the file formats listed in §2.1.

2.7. Tables

Tables which are produced in Word should be prepared using the Word table editor.

2.8. Mathematics

Displayed mathematical equations which are produced in Word should be prepared using the Word equation editor.

2.9. Multimedia

Multimedia additions to a paper are welcomed and will be made available *via* **Synchrotron Radiation Online** (http://journals.iucr.org/s/). Please contact the IUCr Editorial Office for submission details.

2.10. References

References to published work must be indicated by giving the authors' names followed immediately by the year of publication, *e.g.* Neder & Schulz (1998) or (Neder & Schulz, 1998). Where there are three or more authors the reference in the text should be indicated in the form Smith *et al.* (1998) or (Smith *et al.*, 1998) *etc.* All authors should be included in a full list at the end of the paper. This list should be arranged alphabetically and conform with the following style:

Andrews, M. D., Wright, H. E. & Clarke, S. A. (2005). In preparation.

Brünger, A. T. (1992). *X-PLOR. Version 3.1. A System for X-ray Crystallography and NMR*. Yale University, Connecticut, USA.

Collaborative Computational Project, Number 4 (1994). *Acta Cryst.* D**50**, 760–763.

Crowther, R. A. (1972). *The Molecular Replacement Method*, edited by M. G. Rossmann, pp. 173–178. New York: Gordon and Breach.

International Union of Crystallography (2001). *(IUCr) Structure Reports Online*, http://journals.iucr.org/e/journalhomepage.html.

Note that **inclusive** page numbers must be given.

3. Copyright

Except as required otherwise by national laws, an author must sign and submit a copy of the Transfer of Copyright Agreement form for each manuscript before it can be accepted. Authors will be asked to transfer copyright during the electronic submission procedure.

4. Crystallography Journals Online

All IUCr journals are available on the web *via* **Crystallography Journals Online**. Full details of author services can be found at http://journals.iucr.org/s/services/authorservices.html.

4.1. Reprints

After publication the correspondence author will be able to download the electronic reprint of the published article, free of charge. Authors will also be able to order printed reprints at the proof stage.

5. Contact information

Papers accepted for publication will be technically edited at the IUCr Editorial Office in Chester. Contact details for this office are as follows:

The Managing Editor
International Union of Crystallography
5 Abbey Square
Chester CH1 2HU, UK
Telephone: +44 1244 342878
FAX: +44 1244 314888
E-mail: med@iucr.org
ftp: ftp.iucr.org

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

Harutaka Mekaru,[a] Tsuneo Urisu,[b]* Yoshiyuki Tsusaka,[c] Shin Masui,[d] Eijiro Toyota[d] and Hisataka Takenaka[e]

[a]The Graduate University for Advanced Studies, Institute for Molecular Science, Myodaiji, Okazaki 444, Japan, [b]Institute for Molecular Science, Myodaiji, Okazaki 444, Japan, [c]Department of Material Science, Himeji Institute of Technology, Kamigori, Akou-gun 678-12, Japan, [d]Sumitomo Heavy Industries Ltd, Yato, Tanashi, Tokyo 188, Japan, and [e]NTT Advanced Technology Corporation, Midori, Musashino, Tokyo 180, Japan. E-mail: urisu@ims.ac.jp

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 [illegible] synchrotron radiation experiments. In this work, a d[illegible] type MLM monochromator equipped with [illegible] been designed on the basis of t[illegible] driving system and of Mo[illegible] has been evalua[illegible] shown th[illegible] with an [illegible] practical [illegible] backgroun[illegible] 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.

Keywords: [illegible] 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 [illegible] lines, respectively. A pulsed motor drive sli[illegible] of the XYZ linearly, keeping the rot[illegible] second mirror fixed. The first mi[illegible] second mirror so that it [illegible] the apex Y [illegible] so that [illegible] in an [illegible] using the [illegible] arrangement is also effective [illegible] higher-order photons. The [illegible] decreases as the incident angle to the [illegible] mechanical linkage and driving system have [illegible] so that the beam incident angle can be adjusted [illegible] 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

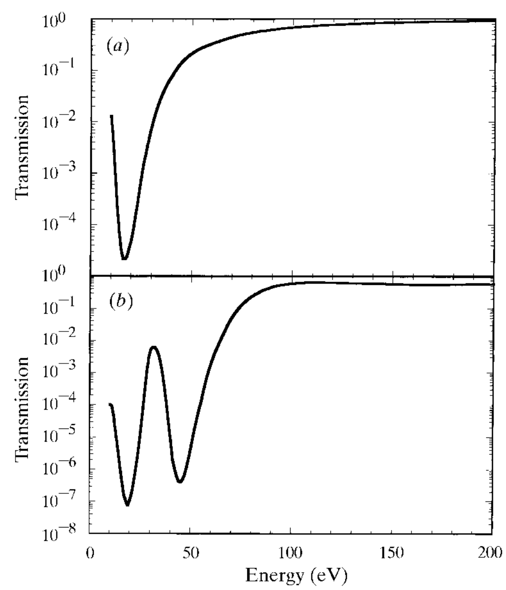

Figure 1
The calculated transmission for (*a*) a 100 nm-thick carbon filter and (*b*) a 100 nm-thick molybdenum filter.

238 mm

88 mm

183 mm

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)†
	Interface roughness, σ	(0.4 nm)†
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 (2*s*: 119 eV; 2*p*: 74 eV) and Si (2*p*: 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 2*s* and 2*p* and Si 2… binding energies in the incident angle range of 10–50°… more, the detailed structural parameters hav… that the reflectivity is high and the r… trical. Both Mo/Si and Mo/C … meters listed in Table … using the Cu … Corpora… between … roughness … ett & Porteus, 19… iffraction data, are listed in …

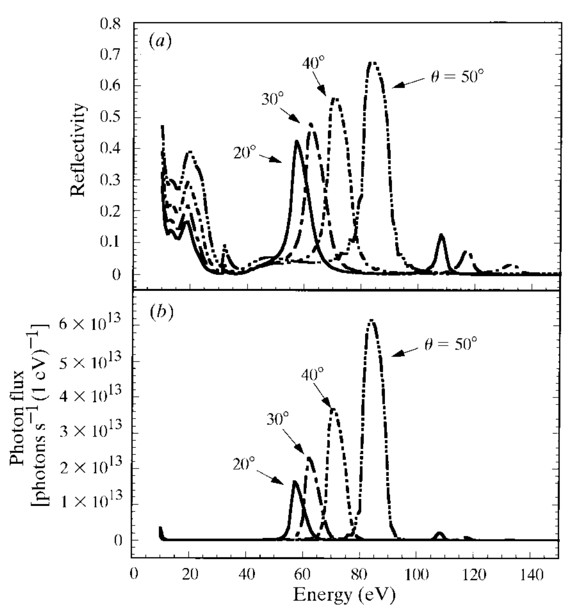

Figure 2
(*a*) Calculated reflectivity for the Mo/Si MLM and (*b*) output photon flux of the monochromator using Mo/Si MLMs plus C filter for a 100 mA ring current and a 16.56 × 12.79 mrad^2 acceptance angle of the pre-mirror, assuming that the monochromator is set up in the beamline BL-4A1 of the UVSOR.

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 (BL4A… synchrotron radiation storage ring at the UVS… ne, the beam emitted from the bendin… is reflected by an elliptical … ngle of 4°. The hori… 0 cm and 3… m from … 6.1 m … about 0.5 × … as calculated for a … n the recurrent equation (Spiller, … and Mo/C MLMs were first calculated by … ror parameters listed in Table 1, as shown in Fig. 2(*a*) … e Mo/Si case. It is known that extremely large total-reflection components appear at less than 40 eV in the case of Mo/Si.

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.

This research was supported in part by a Collaboration Program of the Graduate University for Advanced Studies.

References

Barbee, T. W. Jr, Pianetta, P., Redaelli, R., Tatchyn, R. & Barbee, T. W. III (1987). *Appl. Phys. Lett.* **50**(25), 1841–1843.
Bennett, H. E. & Porteus, J. O. (1961). *J. Opt. Sci. Am.* **51**(2), 123–129.
Golovchenko, J. A., Levesque, R. A. & Cowan, P. L. (1981). *Rev. Sci. Instrum.* **52**(4), 509–516.
Murata, T., Matsukawa, T., Naoe, S., Horigome, T., Matsudo, O. & Watanabe, M. (1992). *Rev. Sci. Instrum.* **63**(1), 1309–1312.
Spiller, J. (1981). *AIP Conf. Proc.* **75**, 124–130.
Urisu, T. & Kyuragi, H. (1987). *J. Vac. Sci. Technol.* B**5**, 1436–1440.