EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office using the **Electronic Report Submission Application:**

http://193.49.43.2:8080/smis/servlet/UserUtils?start

Reports supporting requests for additional beam time

Reports can now be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** X-ray characterization of grazing incidence multilayer optics produced by Ni electroforming replication	**Experiment number**: MI-386
Beamline: BM-5	**Date of experiment**: from: 22 June 200 7:00 to: 27-June-2000 7:00	**Date of report**: 18 Aug 2000
Shifts: 15	**Local contact(s):** E. Ziegler – M. Sanchez del Rio	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

*Giovanni Pareschi – Osservatorio Astronomico di Brera - Italy

*Franco Mazzoleni – Osservatorio Astronomico di Brera – Italy

*Luca Peverini – Osservatorio Astronomico di Brera – Italy

*Adrian Ivan – Harward Smithsonian Center for Astrophysics (Cambridge, MA, USA)

Oberto Citterio – Osservatorio Astronomico di Brera - Italy

Mauro Ghigo– Osservatorio Astronomico di Brera - Italy

Report: A large part of the experiment was dedicated to the X-ray characterization at 8 keV photon energy of a double-cone Wolter I approximation multilayer (11 bilayers - Ni/C stack, d-spacing = 46 Å, $\Gamma = 0.5$) optics with the following parameters: max & min diameters =121.3 *cm* and 111.567 *cm*, total height = 300 *cm*, focal length = 185 *cm*. The mirror was realized by means of the direct multilayer replication process based on the Ni electroforming replication: an Al mandrel having the negative profile of the mirror to be realized is produced and coated with a thin (100 μm) layer of electroless Ni and then superpolished; afterwards the mandrel is mounted onto a rotational stage at the interior of a vacuum chamber where the multilayer film is deposited by ion-beam sputtering; the mandrel is then put into an electrolytic bath were a layer of Ni is electroformed to give a mechanical structure to the mirror. The Ni mirror shell with the multilayer attached is then separated from the mandrel by cooling it, exploiting the larger (roughly a factor 2) thermal expansion coefficient of the mandrel Al compared with the Ni mirror walls. This technique is derived from that successfully used for making the Au coated soft X-Ray mirrors of e.g. the XMM-Newton mission.

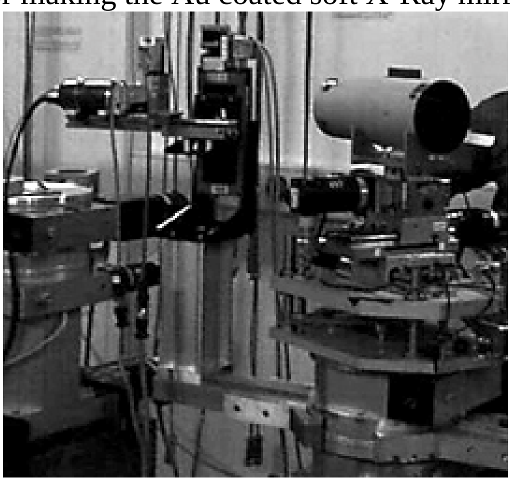

Fig. 1 The double-cone multilayer mirror mounted on the goniometer of the ESRF BM5 beamline

A picture of the optics mounted on the BM5 goniometer is given in Fig. 1. The X-Ray tests were carried out at 8 Kev photon energy by means of a highly monochromatized ($\Delta E/E = 1.6 \times 10^{-4}$) pencil beam (50 *μm* x 1 *mm*) with a low divergence (5 *arcsec*). The beam was addressed to impinge the internal surface of the first cone. In our measurements we started the scans at a sufficiently large reflection angle in order to avoid a further reflection from the second conical surface. In Fig. 2 it is shown the measured reflectivity profile until the 3^d Bragg peak, As can be noted the data are in good agreement with a model involving an average internal roughness of less than 7 Å.

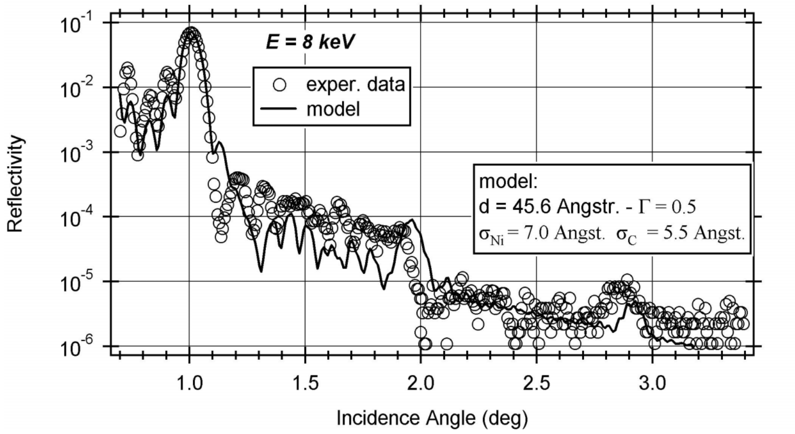

Fig. 2 Measured reflectivity profile

Diffuse scattering profiles were also performed around the first Bragg peak in both sample-scan geometry (detector fixed at the Bragg specular position and angular scanning with the sample stage) and detector-scan geometry (sample fixed at the Bragg position and scanning with the detector around the specular position). The two scattering profiles are reported in Fig. 3 (A-B). The data were fitted using the IMD software assuming a Distorted-Wave Born Approximation scattering formalism. For the Power Spectral Density (PSD) at each interlayer we assumed the Stearn's model for a multilayer grown, which describes the PSD of each interlayer due to a contribution of both the initial substrate roughness and of the intrinsic roughness originated by the deposition process. The internal multilayer roughness value derived in this way is of 6.5 Å, and it is completely dominated from the substrate (i.e. the mandrel) contribution. It should be noted that the derived value not only corresponds to what found from the reflectivity data fitting but it is also in good agreement with the rms medium-frequency roughness measured on the mandrel roughness before the deposition.

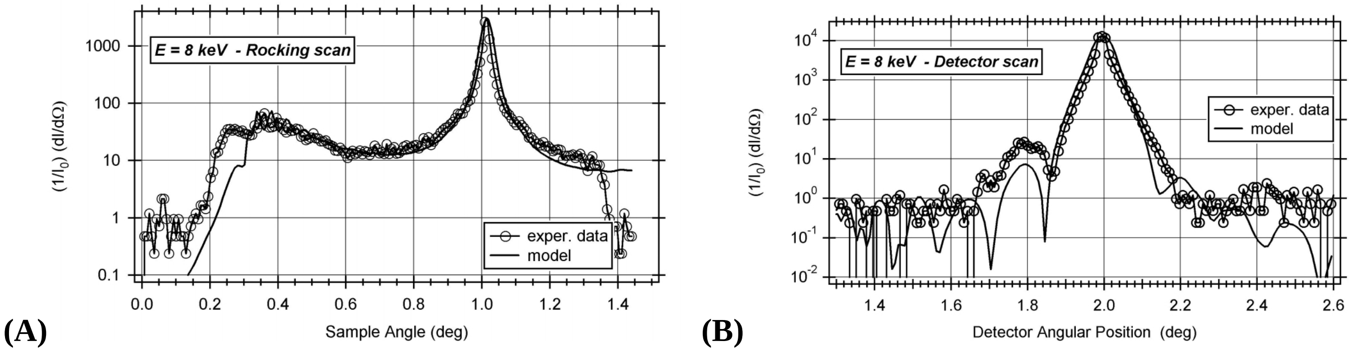

Fig. 3 Diffuse scattering profiles at 8 keV photon energy measured at ESRF for the multilayer double-cone optics realized using the mandrel SAX #12 around the first Bragg position A- Rocking scan; B- detector scan (see the text fore details)

<u>More details about this work can be foud in the paper</u>: O. Citterio, P. Conconi, M. Ghigo, F. Mazzoleni, and L. Peverini, "Development of Soft and Hard X-ray optics for astronomy", SPIE Proc., **4138**, in press (2000)

NB: The analysis of other data taken during the experiment onto different samples is currently going on.