ESRF	**Experiment title: CHARACTERIZATION OF REPLICATED MULTILAYER MIRROR OPTICS FOR HARD X-RAY ASTRONOMICAL APPLICATIONS**	**Experiment number**: MI-293
Beamline: BM5	**Date of experiment**: from: 05-mai-99 7:00 to: 10-mai-99 7:00	**Date of report**: 12-Aug-99
Shifts: 15	**Local contact(s)**: A.Souvurov - E. Ziegler - M. Sanchez del Rio	*Received at ESRF:*

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Report:

The Brera Astronomical Observatory has recently undertaken an activity addressed to the development of a reliable technology for the production of astronomical Wolter I or double-cone optics with multilayer coatings for hard X-ray astronomy (E > 10 keV) by means of replication techniques. Our approach foresees the direct deposition of the multilayer stack onto a mandrel surface by ion-beam sputtering, followed by the deposition of the Nickel into an electrolytic bath. The electroformed Nickel gives the mechanical strength to the mirrors.
All deposited materials are later on separated from the mandrel by cooling it. It is worthy to note that this is a natural extension of the method already successfully used for the production of the soft X-ray optics with Au mono-layer coating of the SAX, JET-X and XMM space telescopes, all characterized by a large throughput but still with good imaging capabilities.
The main aim of the experiment **MI-293** was the characterization by means of X-ray reflectivity tests at 8 keV photon energy of a first flat multilayer sample produced using the method above described and hereafter we will report on the results of this investigation. Moreover, a number of measurements at 8 keV and 20 keV photon energy were also carried out on other multilayer samples (with both constant and graded d-spacing) deposited on substrates of different nature (superpolished electroless Nickel, Si and Fused Silica samples). The analysis of these data is currently being done and it will be reported elsewere.
The examinated replicated multilayer samples was produced following these steps:

- An Aluminum flat disc (100 *mm* diameter) coated with electroless Nickel has been superpolished down to 0.2 *nm*;
- A Ni/C multilayer (19 bi-layers, d-spacing = 6.4 *nm*, gamma = 0.73) has been grown on the Nickel substrate via ion-beam sputtering by CETEV (Rome, Italy);

- The multilayer film has been afterwards put into an electrolytic bath and a layer 0.3 *mm* thick of Nickel has been grown on the multilayer surface. The multilayer mirror attached to the Nickel electroformed support has then been separated from the mandrel.

Exploiting the high intensity, the very low angular divergence (< 5 *arcsec*) and the high spectral resolution ($\Delta E/E=1.6 \times 10^{-4}$) of the monochromatized beam at the BM5 facility of the ESRF during the experiment MI-293 it has been possible to perform a very accurate mapping of the replicated multilayer measuring the reflectivity at 8 keV photon energy in several position of the sample surface. The comparison of the experimental data with theoretical simulations shows that the Debye-Waller roughness of the multilayer is 4 Å (see

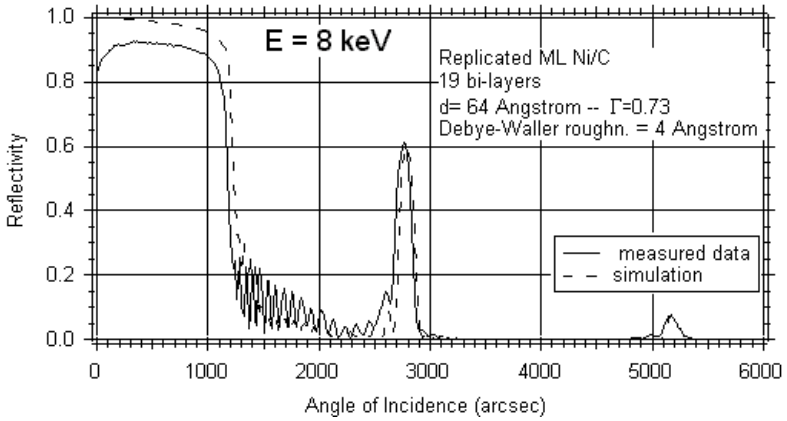

Fig 1).

Fig. 1. *Comparison of experimental data taken during the MI-293 experiment with a theoretical model assuming a Debye-Waller roughness of 4 Å.*

We also compared (see Fig. 2) these experimental data with the reflectivity profile measured on the same sample before the replication of the multilayer film (the data were in that case previously taken at the same photon energy using a Bede D1 diffractometer). As can be observed, the behaviour of the two profiles is very similar and the replication process did not deteriorate the mirror performances.

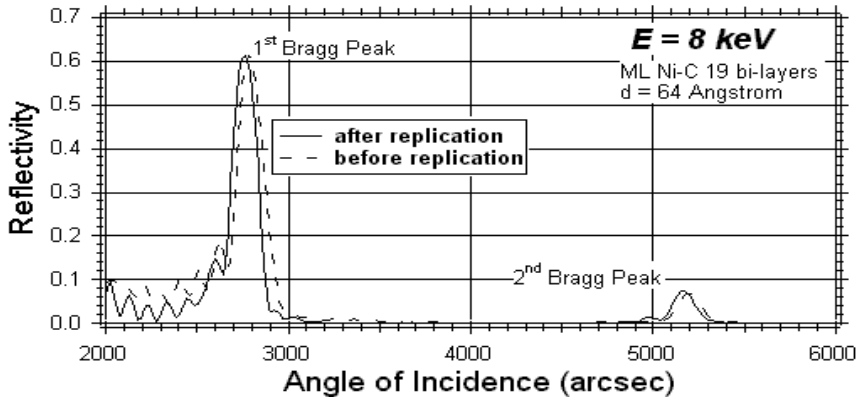

Fig. 2. *Comparison of the X-ray reflectivity profiles of the multilayer before and after the replication*

More details about this work can be found in the paper: O. Citterio, P. Cerutti, F. Mazzoleni, G. Pareschi, E. Poretti, P. Lagana', A. Mengali, C. Misiano, F. Pozzilli and E. Simonetti, 'Multilayers optics for hard X-ray astronomy by means of replication techniques', SPIE Proc. **3766**, 1999 (in press).