Advanced Manufacturing Techniques for High Precision X-Ray Optics and New Technology Spin-Offs

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Abstract

Focusing mirrors manufactured via galvanic replication process from negative shape mandrels is the selected solution for the approved X-ray astronomy mission eROSITA and the candidate solution for some of the next future X-ray astronomy missions. Media Lario Technologies (MLT) is the industrial enabler for manufacturing (in collaboration with the Max Planck Institute (MPE) and the German Space Agency (DLR)) of the Optical Payload for eROSITA - including the flight quality mandrels. Media Lario Technologies (MLT) is also now developing, in collaboration with Brera Astronomical Observatory (INAF/OAB), the Optical Payload for the New Hard X-ray Mission (NHXM).

For the eROSITA mandrels production an evolution of the approach used for the manufacturing of past mission mandrels (JET-X, XMM) have been developed. The low energy angular resolution of the eROSITA mirror payload needs to be 15 arcsec HEW or better; and at 8.05keV the angular resolution needs to be 20 arcsec HEW or better. Replicated mirrors with performance in this range for the low energy radiation have been obtained in the past by using mandrels that have superior geometrical shape accuracy. A proprietary multistep surface finishing process has now been developed for reaching the aggressive performance requirements demanded by the mission. The status of the eROSITA series mandrels manufactured so far, by using the advanced polishing process, are presented. In the paper, the x-ray performance of mirror shells (as measured at MPE PANTER facility) replicated from a flight quality eROSITA mandrel, are reported.

1 High Precision X-ray Optics

With fully integrated capability in optical design, mandrel manufacturing, electroforming, deposition of customized reflective layers, metrology, and system integration, MLT continues to support and align to Astronomy X-ray missions [1].

A number of X-ray astronomy missions, currently under study, plan to utilize high throughput grazing incidence optics capable of focusing the X-ray emission of astrophysical objects. For optics in the hard X-ray spectral range, rather than the traditional single layer reflective coatings used in these earlier missions, there is a need to employ depth-graded multilayer coatings.

One convenient manufacturing process for high throughput grazing incidence mirrors is based on galvanic electroforming replication from a master, where the mirrors can be manufactured in a monolithic structure, thus avoiding the need for further relative alignment.

2 X-ray Mandrels at the Center of Excellence (CoE)

The Centre of Excellence (CoE) has been established in March 2010 via INAF-OAB and MLT Memorandum of Understanding and is fully operational since June 2010. The centre has been established by the two parties with the intention to:

- design and fabricate mandrels/optics exploiting the technological know-how developed in scientific field and leveraging off for commercial applications;
- consolidate and develop partnership with Italian and worldwide top level scientific, technology and industrial entities;
- establish a top level facility equipment, instrumentations and skilled personnel.
- The CoE is 120 m^2 clean room with a full comprehensive set of polishing and metrology equipments and is currently operating for the manufacturing of the flight-quality eROSITA mandrels.

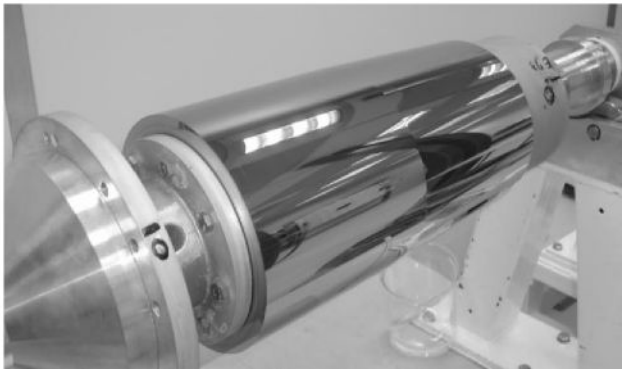

Figure 1: eROSITA mandrel superpolished at CoE.

The eROSITA x-ray mirror modules are extended versions of the ABRIXAS modules with the same focal length but with double diameter by adding 27 outer mirror shells. This similarity in the design allows re-using the existing ABRIXAS mandrels for the replication of the inner mirror shells. For the eROSITA development program a flight-quality mandrel (eROFM25) has been manufactured by MLT with the newly developed polishing technique in 2010. This mandrel has been replicated for x-ray testing in PANTER by MPE, obtaining excellent performance (HEW ~ 12 arcsec) [2].

In 2010 MPE commissioned MLT with the manufacturing of the additional outer 27 mandrels and is now being successfully completed at the CoE.

3 Technological Spin-Offs at the Center of Excellence (CoE)

Media Lario Technologies (MLT) has already adapted its proprietary manufacturing technology for space applications to successfully develop and manufacture grazing incidence collectors for Extreme Ultraviolet Lithography (EUVL) [3]. Currently, other spin-offs technologies are being engineered studying also the adoption of more conventional **non-metallic base materials** for the mirrors. These new technologies found application in the fields of terrestrial astronomical telescopes, defence/ surveillance/medical optical systems and space earth observation.

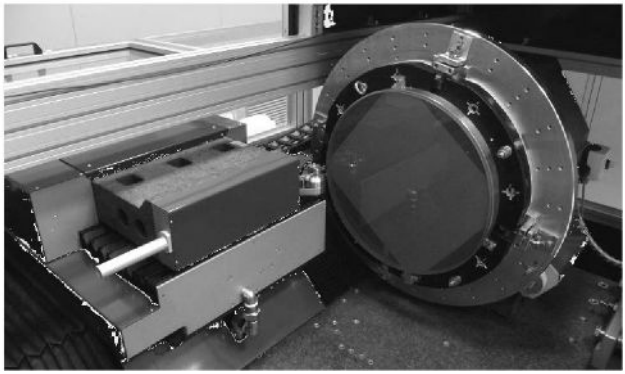

Figure 2: Glass mirror (~500mm diameter) during shape metrology at CoE.

The hyperspectral/multi-spectral technology is a solution for future airborne and space surveillance applications, thanks to the capability of performing chemical and physical analysis of the observed areas and to merge information coming from different light wavebands. MLT in this effort is demonstrating the technology

feasibility of Multispectral Optical Systems, based on an athermal Three-Mirror-Anastigmatic (TMA) design and consisting of **electroformed optical elements**, all reflective and characterized by complex surfaces. MLT is finalizing two EMSOM, one Defence and one for Space Applications and the CoE is taking care of the **manufacturing of the masters** to be used to replicate the mirrors.

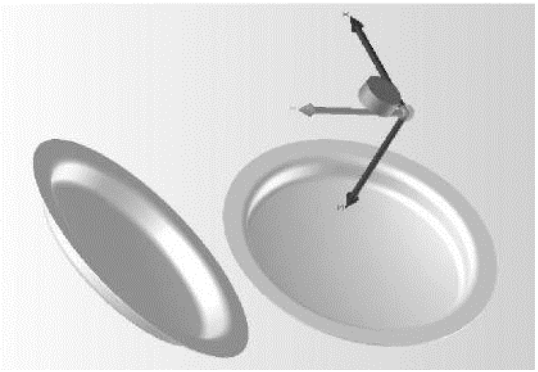

Figure 3: TMA electroformed solution by MLT.

4 Conclusions

With fully integrated capability in optical design, mandrel manufacturing, electroforming, thin films, metrology, and system integration, MLT continues to support and align to the EUVL technology roadmap and X-ray astronomy missions, and to open new spin-offs opportunities.

Acknowledgements

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References:

[1] G. Pareschi et al, “Design and development of the multilayer optics for the New Hard X-ray Mission”, SPIE Proc. 7437-03 (2009)

[2] D. Vernani et al, “Performance of a mirror shell replicated from a new flight quality mandrel for the eROSITA mission”, SPIE Proc. 8147-05 (2011)

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