Mem. S.A.It. Vol. 84, 817

Memorie della

High angular resolution optics for the next generation of wide field X-ray telescopes beyond e-Rosita

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Abstract. The next generation wide-field X-ray telescope (WFXT), to be implemented beyond eRosita and proposed within the NASA RFI call 2011, requires an angular resolution of less than 10 arcsec (with goal of 5arcsec) constant across a wide field of view (1 deg^2). To achieve this requirement the design is based on nested modified grazing incidence mirrors with polynomial profiles. Our goals in terms of mass and stiffness can be meet with the use of fused silica glass, a well-known material with good thermo-mechanical properties and polishability characteristics, together with an innovative polishing approach. Here we summarize the results obtained on the first prototype shell that has been calibrated in full-illumination mode at the Panter/MPE facility.

Key words. X-ray – shell – wide field – polynomial – fused silica – direct polishing

1. Introduction

The next generation wide-field X-ray telescopes (WFXT Murray et al. 2011), to be implemented beyond eRosita, will require an angular resolution of $5-10''$ constant across a wide field of view (1 deg^2 diameter). To achieve this goal the design of the optical system has to be based on nested grazing incidence mirrors, realized with polynomial profiles, focal plane curvature and plate scale corrections. This concept, firstly introduced in Burrows, Burg & Giacconi (1992) and refined at the Brera Observatory in Conconi & Campana (2001), guarantees an improved angular resolution at large off-axis angles with respect to the normally adopted Wolter I configuration. This optical design is optimal for survey purposes. In order to increase significantly the effective area and the grasp with respect to eRosita, thin mirror shells (1-3 mm thickness for mirror diameters of 30-110 cm) have to be produced with high accuracy. A medium-size WFXT mission, based on two identical X-ray mirror modules of 55 nested thin polynomial shells, with diameter up to 1.1 m, can reach a grasp greater than 3500 cm^2 deg^2 at 1 keV, 800 cm^2 deg^2 at 4 keV and a constant HEW of 5" across the field. Since several years, a research program is on going at the INAF-OAB to develop the technology for the thin shells

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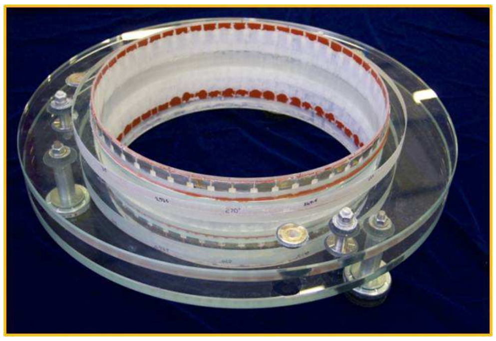

Fig. 1. The first prototype shell of thin glass assembled. The focal length is 5500 mm. The diameter at intersection plane is 487 mm. The glass thickness is 2 mm. The total length is 200 mm. The mirror optical profile is polynomial. It is made of fused silica and weights is 1.37 kg.

production. The epoxy replication process with SiC polynomial mirror shells has already been proved to be a valuable technology to meet the angular resolution requirement of 10”. We are now developing the technology to produce thin shells made of fused silica as this material could meet our goals in terms of mass and stiffness (Citterio et al. 2011). Hereafter we present the results achieved with the first prototype thin glass shell that has been realized and tested with X-rays.

2. Prototype shell realization

In order to reach the required mirror surface accuracy, we use the deterministic direct polishing method. This method has already been used for past missions (as Einstein, Rosat, Chandra). The technological challenge now is to apply it to almost ten times thinner shells (Civitani et al. 2012). Starting from a fused silica glass tube, the shell is firstly grinded with a double cone profile at the required thickness of a few millimeters. The shell is integrated into a special supporting structure in order to perform the metrology, the machining and all the necessary steps up to the assembling into the final structure. By means of a fine grinding process on a high precision lathe, the Out of Roundness errors are corrected. Then the shell is figured and polished to the final polynomial profile, making use of a deterministic figuring method with a computer numerical control (CNC) polishing machine, that provides the corrective action according to the measured error matrix. A final super-polishing by a suitable pitch tool is necessary in order to remove the remaining mid-frequency errors. A prototype shell has been realized accordingly to this production flow. However, its machining was interrupted in November 2011 for a first X-ray verification at the Panter facility. The measured HEW of the shell was quite constant among the field of view, passing from 17” on axis to 22” at 30′ off-axis. Although we have not yet reached our final goal, the X-ray calibration results were considered successfully as they were in good agreement with the results inferred from metrological data. The removal of mid frequency profile errors and the surface micro-roughness optimization are considered the points to be improved during the production of future shells.

We conclude that the direct polishing machining of thin fused silica shells is a very promising technology in order to reach the high angular resolution performances required for the next generation wide field X-ray telescopes.

Acknowledgements. The prototype shell has been realized with *Heraeus*, *LT-Ultra* and *Zeeko Ltd.* equipments. X-ray calibration has been carried out at MPE-Panter facility.

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