HOT PRESS DIRECT SLUMPING: AN OPTION TO MANIFACTURE DEFORMABLE OPTICS

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Here is illustrated a possible approach for the realization of deformable mirror shells. This study derive from an experience gained from an ongoing R&D program at INAF-OAB on the thermal slumping of thin glass sheets. This investigation has been financed by ESO ("E-ELT Design Study" contract) for adaptive optics for the next generation of ground based optical telescopes.

The approach developed in INAF-OAB is shown in fig. 1 and named "Hot Press Direct Slumping"[1, 2]. It foresees the use of a convex ceramic mould having a good microroughness and acting essentially as a "master". The optical surface of the glass sheet is placed in contact with the mould and pressed actively, with an uniform pressure, against it during a part of the thermal cycle in which the glass is plastic and can change its shape permanently. The overall process is done using a muffle to remove the air and to reduce the convection in order to reach a better temperature distribution homogeneity. Also, it protects the mould and the glass from the dusty environment of the oven. Afterward, a slow and controlled cooling down phase is applied and then the slumped glass sheet is released from the mould, optically characterized and integrated in an ad-hoc supporting structure.

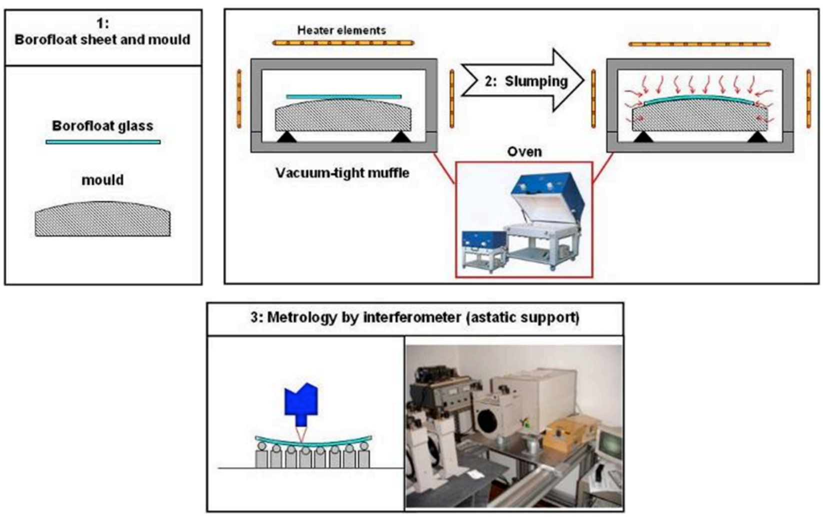

Fig. 1: Concept scheme for the "Hot Press Direct Slumping" process developed in INAF - OAB

As a brief review of some results obtained during the past two years, in fig. 2-left is shown a slumped Borofloat 33 glass segment having a diameter of 130 mm and thickness 2 mm placed onto a spherical convex mould made in Zerodur K20, having a radius of curvature of 4000 mm. The pattern of interference fringes generated from Sodium light depicts the shape difference between mould and glass: it is quite circular and regular that means that no high spatial frequencies are present and almost no dust was trapped between glass and mould. In fig. 2-right instead is shown an interferometric measure of the same slumped segment on a diameter of 80 mm that gave a residual error respect to a sphere of 57 nm rms. This means that the optical surface that was slumped had a quality of $\lambda/11$. On the overall size of 130 mm the optical quality was $\lambda/3$.

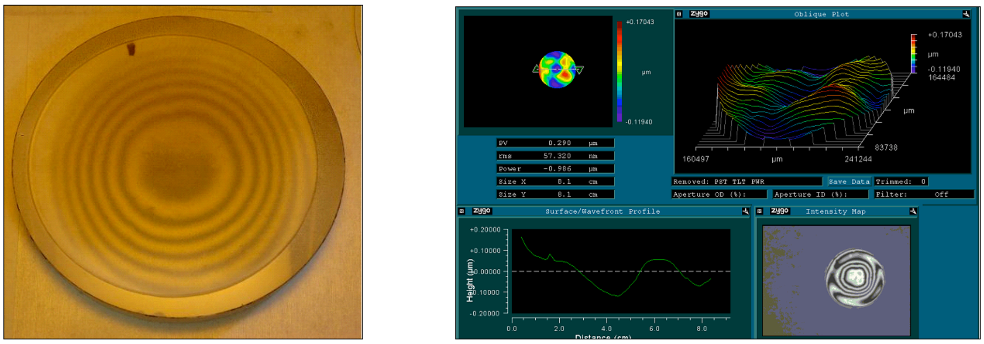

Fig. 2: (left) Interference fringes between mould surface and slumped glass. (right) Interferometric measure of a typical slumped glass shell.

During the last months we have started to scale-up the process to produce a demonstrative 50 cm diam. concave spherical mirror, with a radius of 5 m and thickness of 1.6 mm. The first tests were to fix some problems related to the larger dimension and the results are quite promising.

Ending, even if the mould shape adopted (spherical surface) and probably the thickness of the glass used are not useful for the application in the field of the X-ray optics, the investigation has permitted to INAF-OAB to gain precious experience and to put the "hands" on the slumping technique and on the related problems. In the next months we have planned to start an R&D program dedicated to X-ray optics for the next generation of large X-ray telescopes like IXO of NASA/ESA/JAXA [3].

References

[1] M. Ghigo, R. Canestrari, et al., *Development of lightweight optical segments for adaptive optics*, SPIE Proceeding 6691 (2007).

[2] R. Canestrari, M. Ghigo, et al., *Lightweight optical segment prototype for adaptive optics manufactured by hot slumping*, SPIE Proceeding 7015 (2008).

[3] M. Ghigo, R. Canestrari, et al., *Slumped glass option for making the XEUS mirrors: preliminary design and ongoing developments*, SPIE Proceeding 7011 (2008).

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