Glass segmented mirrors for large X-Ray Optics

Extrapolation of the electroforming replication technique as it has been successfully applied to the XMM-Newton mirror systems is not feasible for mirror systems with diameters of 5-10 m because of constraints on the mirror mass. Realistic launch masses of up to 10 tons require a ratio of mass to geometric aperture being a factor of more than 20 below Chandra and a factor of about 5 below XMM-Newton. Combining high angular resolution and mass requirement is a challenge.

Segmented Mirrors:

X-ray mirrors with diameters of several meters cannot easily be manufactured as closed shells. Instead, the mirror shells should be azimuthally divided in segments. The question of how many segments and how many nested shells are the optimum is closely related to the dynamical stability (eigenfrequencies) of the mounted mirror system; thinner mirrors must therefore be generally smaller in their azimuthal extension.

Technical approach ("glass slumping"):

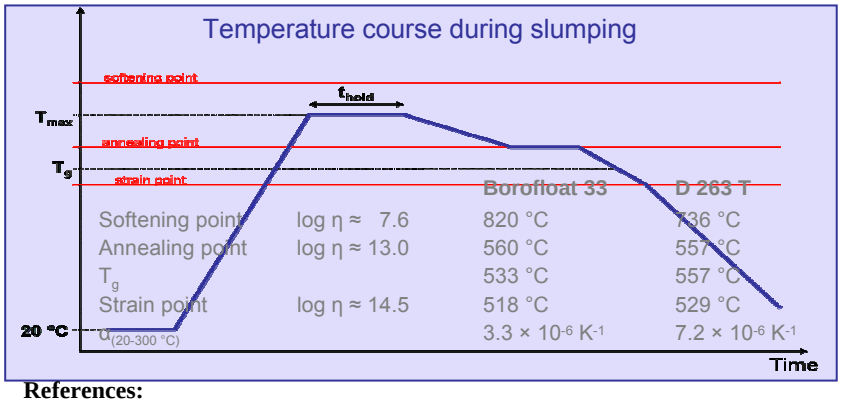
Although replicated electroformed nickel mirrors are too heavy with respect to their stiffness the replication technique itself is very attractive for large segmented mirror systems for the number of equal and similar mirror pieces is large and calls for series production.

Our approach is based on industrially manufactured float glass or display glass, respectively. Its advantage is low surface micro-roughness which is already sufficient for X-ray optics, high flexural rigidity compared e.g. to nickel and that it comes from mass production. Flat glass sheets can easily be deformed by thermal treatment (slumping) to get the desired shape of the optical element.

Current Experiments:

At temperatures between the annealing point and the softening point the viscosity of the glass is such that it slumps into (or onto) a given mould. How the many process parameters have to be adjusted to optimize the accuracy of the reproduction of the mould's shape is an essential part of our investigations. Some of these parameters are closely connected with each other.

Together with our industry partners we have experimentally investigated the slumping parameters and confined the interesting part of the parameter space. We are now planning for a small demonstration model of a Wolter mirror segment.



Essential slumping parameters:

- Glass type
- Mould material
- Slumping temperature T_{max}
- Holding time at T_{max}
- Cooling rate
- …

References:

- Citterio et al. 2004, "The manufacturing of XEUS X-ray glass segmented mirrors: status of investigation and last results", Proc. SPIE v. 5168, p. 180
- Parmar et al. 2004, "Science with XEUS – the X-ray Evolving Universe Spectroscopy Mission", SPIE 5488-24

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