Large Synoptic Survey Telescope
www.lsst.org

Fabricating the LSST Mirrors: A Progress Report

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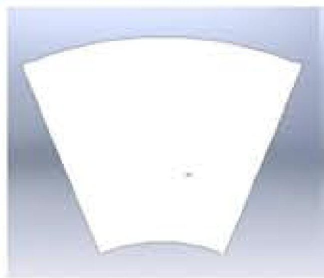
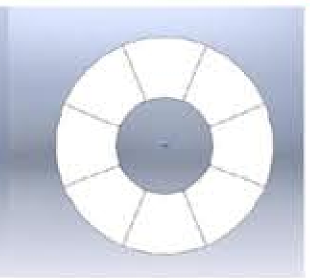
The LSST uses a modified Paul-Baker 3-mirror optical design with 8.4-m primary, 3.4-m secondary and 5-m tertiary mirrors feeding a 3 element refractive corrector to produce a 3.5-degree diameter field of view over a 63-cm flat focal surface in 6 spectral bands with excellent image quality. The proximity of the primary and tertiary surfaces enables fabrication of both mirrors from a single substrate. This unique design, referred to as the M1M3 monolith, offers significant advantages in the reduction of degrees of freedom during operational alignment and improved structural stiffness for the otherwise annular primary surface. The convex secondary will be the largest of its kind. As with all large optical elements, both of the LSST mirrors have long procurement times. In order to meet the LSST's first light schedule for the fall of 2014 we have started the fabrication process on both mirrors using private funding. The M1M3 monolith is being fabricated at the Steward Observatory Mirror Lab using their structured borosilicate spin casting technology. The M1M3 was successfully cast over the summer of 2008. The mold refractory cleanout process and detailed inspections are underway in preparation for back side processing. The casting includes special design features to enable the mirror to operate under the increased loads caused by the high accelerations needed by the LSST. The secondary mirror substrate is being made using Corning's Ultra Low Expansion (ULE) process, resulting in an annular meniscus mirror 100mm thick and a 1.8m diameter central hole. Glass selection for the secondary mirror has begun and the substrate will be fused early in 2009. Both mirrors are on schedule and their early start has substantially reduced risk within the LSST project.

M2 MIRROR

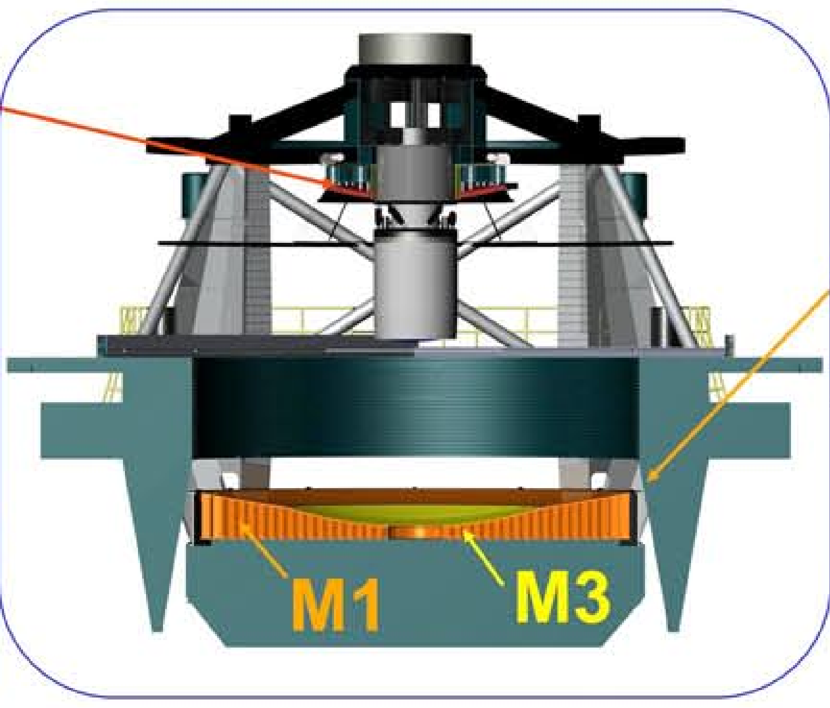

M2 Petals Selected


Substrate Boule Petal


8-Petal Layout


Machined M2 Petal


Corning Furnace Construction



M1 M3 MONOLITHIC MIRROR


January 2008
Mold Completion

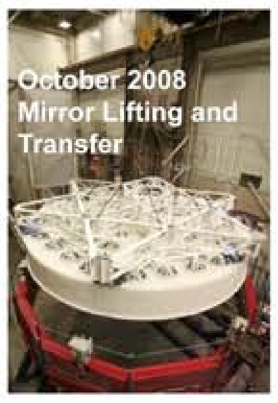

February 2008
Glass Loading


March 2008
Mirror Spin-Casting


August 2008
Cast Mirror Complete



September 2008
Preparation of the mirror lifter


October 2008
Mirror Lifting and Transfer

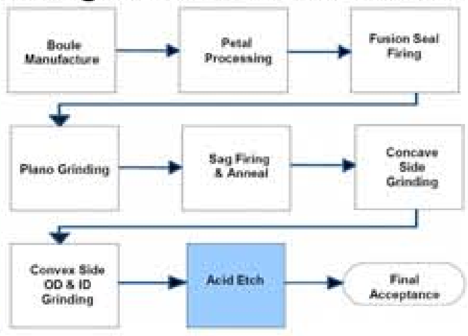
M1 M3 Mirror

1st year @ SOML


November 2008
Vertical Position

M2 Fabrication Status

Corning was awarded the M2 Substrate fabrication contract in August 2008. Material inspection and selection of eight ULE boules is complete. The boules will be machined into petal shape and arranged to form a 3.5-meter diameter annulus for fusion seal firing.

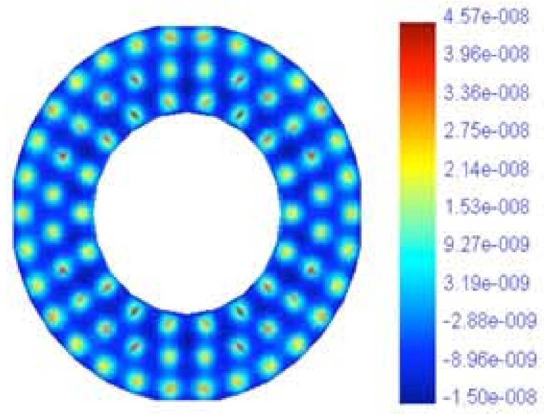


M2 Substrate Processing Plan

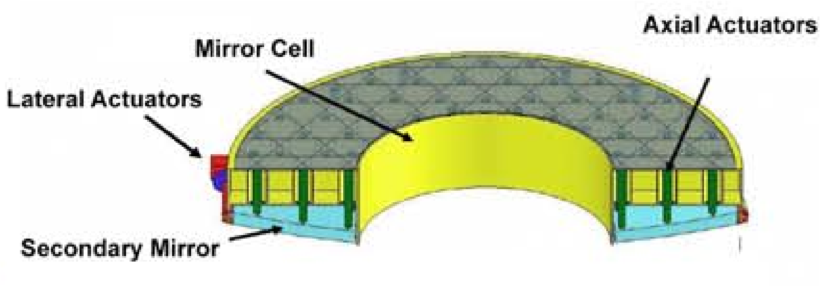
This process will produce a fused plano-plano substrate by March 2009. Additional sag firing over a convex mandrel and subsequent annealing will produce the 100mm thick meniscus substrate. Final aspheric contour grinding of the convex surface will be completed on Corning's 4-meter CNC machine. Acid etching of the mirror will be performed, with final acceptance and delivery scheduled for December 2009. Optical fabrication of the M2 Substrate will be an open competitive bid, with award scheduled for late 2010.

M1M3 Fabrication Status

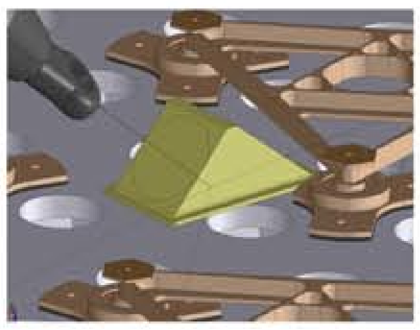
The M1M3 monolith is being fabricated at the Steward Observatory Mirror Lab (SOML) using their structured borosilicate spin casting technology. At the beginning of the year 2008, the mold and the oven were prepared for the casting. After a successful casting over the summer of 2008, the M1M3 lifting frame and bonding pads were attached to the top surface in September 2008 for a five-week silicone RTV cure. The 51-ton M1 M3 assembly was carefully lifted off the casting furnace and installed into the handling ring and tilted to the vertical position for refractory cleanout in October 2008. Cleanout is currently underway in preparation for back side processing in early 2009. Mirror support hardware will be attached to the backside and the mirror turned upright for optical polishing of the dual mirror surface. The finished light-weighted mirror will be 16,600 kg with the thickest outside edge height of 0.92 meters and thinnest inside edge of 0.26 meters ever made at the Mirror Lab. The polished mirror is scheduled to be complete in January 2012.

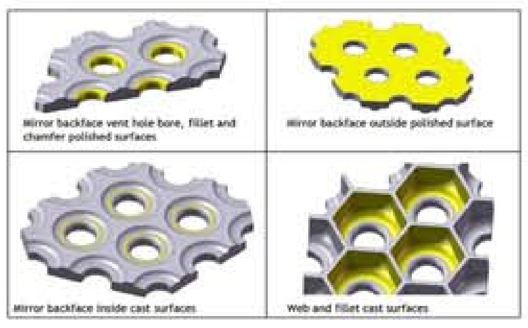


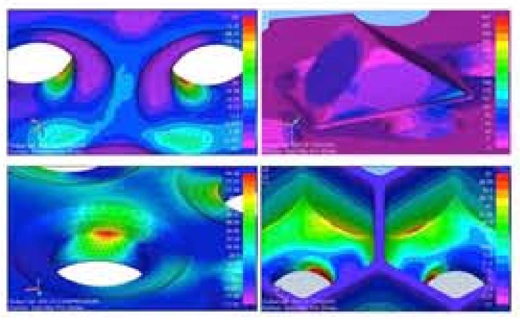
M2 Mirror Support System in Radial pattern
10nm RMS Axial Support Surface Error

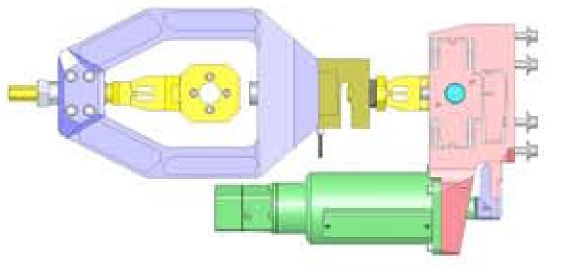


M2 Mirror Support Assembly Design


LSST Loadspreader/Hard Point Layout


Mirror Core Modifications


FEA of Mirror Backplate

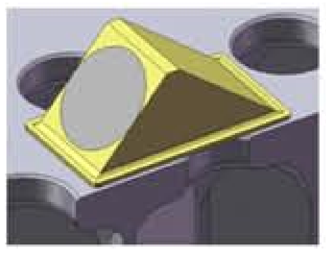

Active Tangent Link Actuator incorporated in the SOAR primary mirror support system

M2 Mirror Support Status

The M2 mirror support system consists of 72 axial figure actuators arranged in a radial pattern with six active tangent links for lateral support. FEA analysis was used to optimize the zonal design of the axial supports to minimize residual surface error. Lateral support design is based upon proven technology incorporated in the SOAR primary mirror system. The M2 assembly will be attached to the telescope top end assembly via a hexapod system to provide rigid body positioning within the telescope.


LSST Loadspreader Design

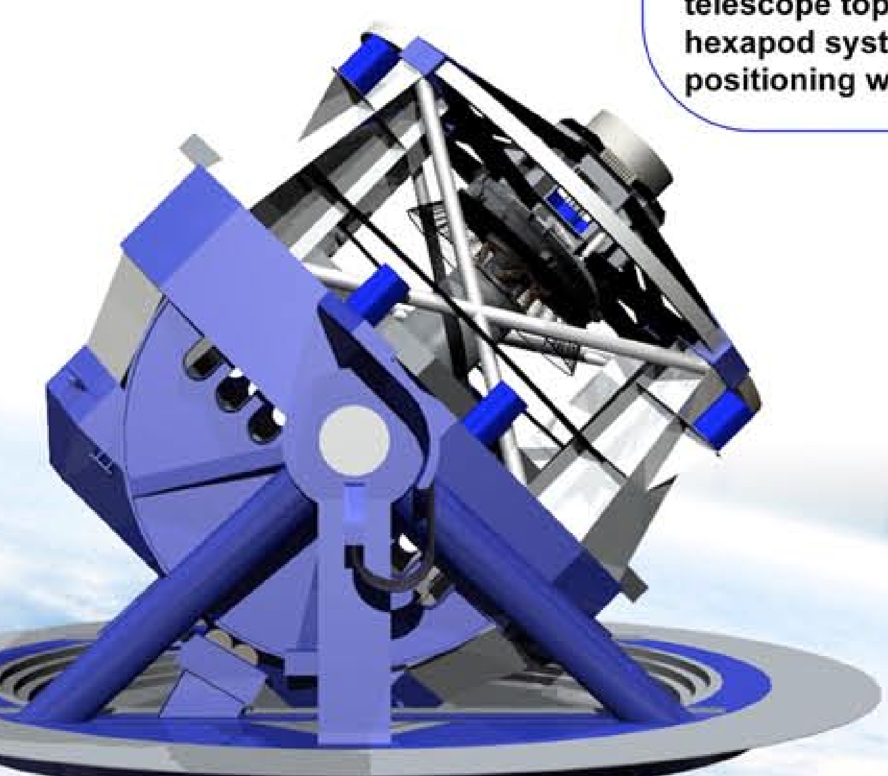

Fabricated LSST Loadspreader


Hardpoint Glass Wedge Design


Fabricated Glass Wedge

M1M3 Mirror Support Status

The M1 M3 active support system consists of a total of 162 actuators. There are six hardpoint actuators attached to glass wedges bonded to the mirror backplate that enable rigid body positioning of the mirror in the telescope cell and 156 support actuators attached to the mirror loadspreaders (104 bi-axis and 52 single-axis). High dynamic loads are applied at the hard points due to the high accelerations needed for the LSST cadence. The mirror backplate was reinforced at the hard point attachment locations to allow for a higher hard point load limit. The glass hardpoint wedge design was enhanced to include an outer lip to minimize local edge stress. In addition to polishing the mirror backplate, the core holes located at the hard point locations have increased backplate thickness and will have additional polishing of the outer chamfer, the interior of the bore hole, and the interior fillet. Acting in concert these modifications have increased the limiting load from 440 lbs to in excess of 900 lbs. The LSST invar loadspreader design provides improvements to legacy hardware, with a drastic reduction in piece part count, improved thermal performance attributes, and increased puck area to enable 30 year operation.



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