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WHITE LIGHT FOCUSING MIRROR

Eric Johnson, Aaron Lyndaker, Alex Deyhim, Michael Sullivan*, Mark Chance*, Don Abel*, John Toomey *, Steven Hulbert**

Advanced Design Consulting USA, 126 Ridge Road, P.O. Box 187, Lansing, NY 14882, USA
** Case Western Reserve University, Center for Synchrotron Biosciences, Building 725A, Upton, NY 11973*
***National Synchrotron Light Source, Upton, NY 11973,*

Abstract. The NSLS X28C white-light beamline is being outfitted with a focusing mirror in order to increase, as well as control, the x-ray intensity at the sample position. The new mirror is a 50 mm x 100 mm x 1100 mm single crystal silicon cylindrical 43.1mm radius substrate bendable to a toroid from infinite to 1200 m radius. The unique feature of this mirror system is the dual use of Indalloy 51 as both a mechanism for heat transfer and a buoyant support to negate the effects of gravity. The benefit of the liquid metal support is the ability to correct for minor slope errors that take the form of a parabola. A bobber mechanism is employed to displace the fluid under the mirror +/- 1.5 mm. This allows RMS slope error correction on the order of 2 urad. The unique mounting of the mirror ensures the contributions to slope error from errant mechanical stresses due to machining tolerances are virtually non-existent. After correction, the surface figure error (measured minus ideal) is <= 0.5 urad rms.

Keywords: White-light, Mirror, Silicon, Cylindrical, Toroid
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INTRODUCTION

Advanced Design Consulting USA, Inc. in collaboration with Case Western Reserve University, Center for Synchrotron Biosciences has completed the design of a bendable mirror for the X28C beamline. It is a 50 mm x 100 mm x 1100 mm single crystal silicon with a cylindrical cut with a radius of 43.1 mm bendable to a toroid from infinite to 1200 m radius. The unique feature of this mirror system is the dual use of Indalloy 51 as both a mechanism for heat transfer and a buoyant support to negate the effects of gravity.

FIGURE 1 MIRROR SYSTEM DESIGN

DESIGN PRICIPALS

The rigid tubular steel base provides a sound support for the vacuum chamber and the mirror manipulation mechanism. A kinematic mount is formed between the manipulating jacks and slides and the external mirror support plate through the three ball transfers (shown) and three tool steel groove blocks (not shown). The arrangement of three jacks and two slides provides 5 degrees of freedom for the mirror. DC servo motors with gearheads and rotary encoders drive ADC standard jacks and slides.

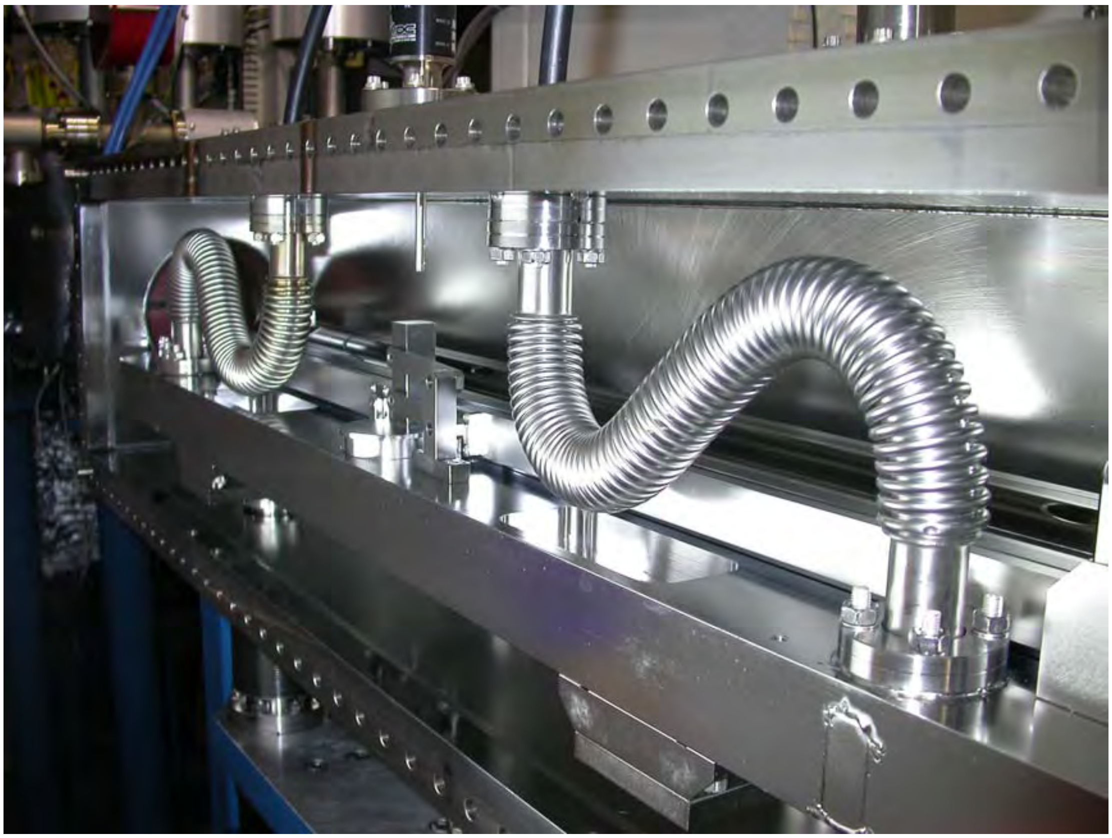

FIGURE 2 MIRROR CHAMBER

The rectangular vacuum chamber enclosing the optic opens on the front side to allow easy access to internal components. Features included on this chamber include an aluminum foil seal, twin vacuum pump ports, a vacuum gauge port, water and vacuum guard feedthroughs as well as two auxiliary ports. Three view ports are included in the cover at strategic places allowing observation of the critical components.

The mirror is secured to the 304 stainless steel "bathtub" that provides both mechanical support and water cooling to the optic. Indalloy 51, with a thermal conductivity equivalent to stainless steel and virtually no contact resistance, occupies a 3 mm gap surrounding the mirror. The primary mode of heat transfer though the thin layer of liquid is conduction from the optic, through the fluid, into the bathtub and finally into the coolant that circulates through the integrated cooling channels. Another feature employed in shape control is the Macor pucks that line the bottom of the mirror. When the mirror is pitched to 6 mrad, the pucks compensate for the linear taper of the buoyant force.

FIGURE 3. MIRROR BENDER AND BATHTUB

FEA ANALYSIS

ADC has recently fabricated a comparable mirror system for APS that uses a rectangular mirror bent cylindrical with two stripes different coatings. It is subjected to an off-axis 300W heat load leading to thermal distortions. The finite element analysis of the system included uneven heating loading, convective cooling, gravity, and buoyancy to model the effectiveness of this support and cooling mechanism. The results show a very small thermal and mechanical contribution to the overall slope error of the mirror.

An additional benefit of the liquid metal support is the ability to correct for minor slope errors that take the form of a parabola. A bobber mechanism is employed to displace the fluid under the mirror +/- 1.5 mm. This allows RMS slope error correction on the order of 2 urad. The unique mounting of the mirror ensures the contributions to slope error from errant mechanical stresses due to machining tolerances are virtually non-existent.

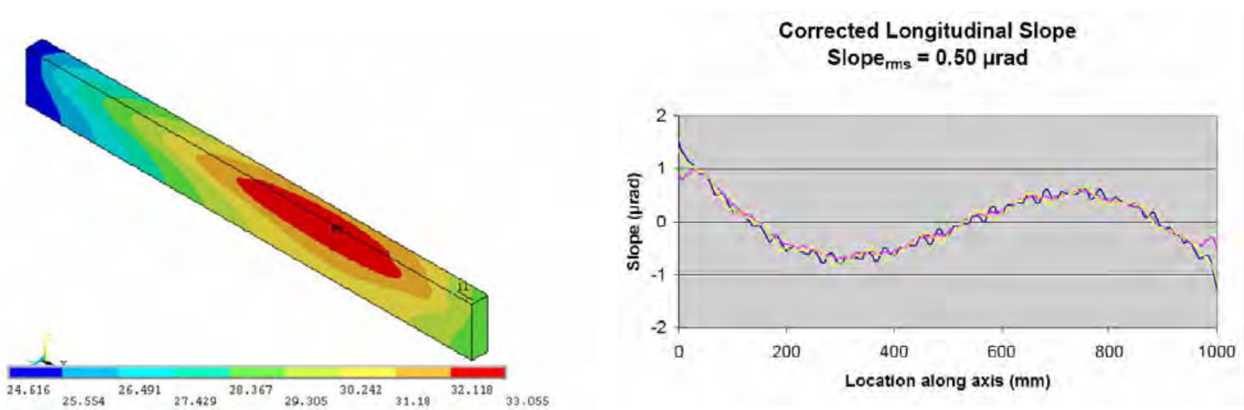

FIGURE 4. FEA CALCULATION

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