Alignment and Bonding of Silicon Mirrors for High-Resolution Astronomical X-ray Optics [10699-141]

Kai-Wing Chan\textsuperscript{a,b}, James R. Mazzarella\textsuperscript{a,c}, Timo T. Saha\textsuperscript{a}, William W. Zhang\textsuperscript{a}, Ryan S. McClelland\textsuperscript{d}, Michael P. Biskach\textsuperscript{b,e}, Peter M. Solly\textsuperscript{b,c}, Ryan S. McClelland\textsuperscript{d}, Peter M. Solly\textsuperscript{b,c}, Raul E. Riveros\textsuperscript{e}, Ai Numata\textsuperscript{b,c}  
\textsuperscript{a}Center for Research and Exploration in Space Science and Technology & University of Maryland, Baltimore County, Maryland, USA; \textsuperscript{b}Stinger Ghaffarian Technologies, Inc., Maryland, USA; \textsuperscript{c}NASA/Goddard Space Flight Center, Maryland, USA

Mirror Alignment for Large X-ray Telescopes

- Future large x-ray astronomy missions require large area and high resolution
- Present consensus is to integrate thin, lightweight, segmented mirrors to form a compact but large telescope with high resolution (better than 1")
- Key technologies
  1. Accurate mirror substrates: polishing high quality mono-crystalline silicon
  2. Stress-free reflective coating: stress-based distortion cancellation
  3. Precise alignment and integration: kinematic mounting and distortion-free bonding
- Four-point alignment for quasi-cylindrically symmetric mirrors (segments)
  4. Point alignment: Pitch and yaw angles, image center (X, Y) are controlled by heights of the 4 mount points
  5. Alignment Precision: better than 1"
  6. Bonding error: ~ 0.1µm (~ 1")
  7. Current single mirror pair x-ray tested: 3" (Half-Power Diameter)
- Integration into (meta) shell
  - Shell structure has rotationally defined axis
  - Interlocking mirrors ⇒ lightweight, mechanically strong telescope

Focus and Precision of Alignment and Bonding

- Individual mirror statically determined by the 4 spacers
- Mirrors are acoustically settled
- Sub-aperture measurement of mirror images in a collimated beam qualifies the alignment
- Corrective spacer height is achieved by polishing
- Epoxy applied to round-top spacers bonds mirror in place

4-Point Alignment of Mirrors

- Pitch (θ\textsubscript{p}) and yaw (θ\textsubscript{y}): compactness of focus
- ΔX, ΔY: image center onto the optical axis of system
- Rotation (φ\textsubscript{x}) is invariant from cylindrical symmetry
- ΔZ\textsuperscript{1} is nearly invariant from small grazing angle (long focal length)
- Co-alignment of "primary" and "secondary" mirrors, and mirrors in the next [(n+1)\textsuperscript{2}] shell, are done through a common optical axis reference

Summary: X-ray Test Result

- Aligned and Bonded mirrors were tested at GSFC and MPE Panter
- Resolution of single pair of mirror is 3 arcsecond
- Flux is uniform (except at the spacers)
- Alignment of mirror in the second shell is achieved in optical beam at 1" (not x-ray tested yet)

 Planned work:
 - Complete alignment, bonding, and testing of multiple pairs (in progress)
 - Integration of mirrors onto meta-shell structure (in implementation)
 - New precision mirror positioning structure (in development)

For Further Information

Silicon Mirror Fabrication: Raul Riveros, 10699-23 [Monday, 2:00 PM] Raul.E.Riveros@nasa.gov  
Mirror Alignment and Bonding: Kai Chan, 10699-141 [this poster] Kai-Wing.Chan-1@nasa.gov  
Telescope Design and analysis: Peter Solly Peter.M.Solly@nasa.gov  
Optics design and analysis: 10699-179 [Wednesday, 6 PM Poster] Timo.T.Saha@nasa.gov  

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