Low Strain Mounting Techniques for Lynx X-ray Optics

State of the Profession

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Key Issue and Overview of Impact on the Field

Low strain mounting of the Lynx mirrors is essential to the telescope image quality. Mount strain must be managed during mirror assembly with precision fixturing, temperature and humidity control, as well as knowledge of the cure shrinkage of the adhesive system. For the silicon mirror design, the large number of segment and modules for Lynx necessitates a time-efficient, deterministic, and high-quality process.

For the Chandra program the design had several similar challenges as Lynx, including: (1) a mount pad / adhesive system that went thru an extensive qualification process considering materials, interfaces, strength, thermal sensitivity, creep, and cure shrinkage; (2) air temperature and humidity control that was imposed as part of the class 100 clean room / assembly area; and (3) process development and operator training required minimum personnel exposure time during bonding operations since radiative coupling of body heat was observable in the alignment and thermal telemetry.

Although the Chandra program design activities occurred over 20 years ago, the technical challenges and learnings from that program are still appropriate. Current mirror mounting techniques have followed similar historical best practices and the experiences now include a wider range of temperature capabilities due to mission observatories that operate at lower temperatures (such as JWDT). The focus in design is frequently on thermal expansion of all sides of the bonded interfaces and optimization of interfaces, but we expect the strain from moisture dry out to be a similarly large challenge for Lynx due to the thin optics.

Assessment of the mount adhesive systems and processes for the Lynx mirrors is proposed as a critical area of study to prove viability of meeting the image quality requirements.

Strategic Plan

This study will address the following key areas in the context of mounting the thin x-ray mirror segments:

- Current state of the art in thermal strain minimization of joints, including:
    - comparisons of high strength vs low modulus adhesives versus clamping techniques
    - optimization of each mating surface coefficient of thermal expansion (CTE)
- Material considerations including CTE and coefficient of moisture expansion (CME)
    - variability of expansion coefficients
    - variability of moisture uptake
    - consideration of new adhesive systems
- Math modeling
    - Joint strain for segments and modules

    - Moisture uptake and dryout – diffusion model
    - Moisture strain modeling method
- Assembly methods
    - Consider handling equipment and adhesive injection methods for high volume
    - Evaluate suitability of various metrology techniques to characterize alignment and surface errors.
- Testing
    - Develop a test configuration that simulates a flight hardware bond
    - Test joints under thermal and vacuum and ambient environmental conditions
    - Consider process variability such as adhesive bond line thickness, material property variability
- Final report
    - Study conclusions for flight system
    - Process recommendations
    - Final recommendations for further developments

Organization, Partnerships, and Current Status

L3Harris has expertise in the areas of interest for this study, but for this study we will engage personnel from several industrial organizations with experience in design, analysis, production, and test of mounted mirror assemblies, as well as materials experts in low moisture uptake adhesive systems.

Schedule

Key activities broken down by study phases are summarized here.

Activity		**Duration. months**
Phase 1 – Planning, Partnerships, Performance		3
	Review segment, module, and metashell alignment and figure goals to establish adhesive system goals	
	Evaluate material options and resulting joint behavior	
	Material design performance	
Phase 2 – Math modeling		3
	Adhesive behavior math modeling, including dryout diffusion model	

	Define modeling configurations, assumptions	
	Strain modeling under thermal and moisture environments	
Phase 3 – Producibility options		3
	Identify and evaluate options for high volume effort required for segment and module production options	
Phase 4 – Testing program		6
	Sample configurations defined	
	Develop alignment and figure mechanical and optical testing methods	
Phase 5 – Study Recommendations		3
	Report identifying further development recommendations to improve TRL of joint designs and modeling methods	

Cost Estimates

No cost estimates have been prepared at this time.

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