GSFC Optics Technologies

Optics Manufacturing and Metrology for Telescope Optical Surfaces

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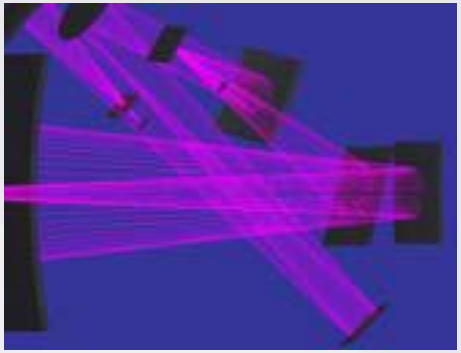
Optics Capabilities

Optical Design and Analysis



Opto-mechanical Design and Fabrication

Preparing 1m SPOT Mirror for Lapping

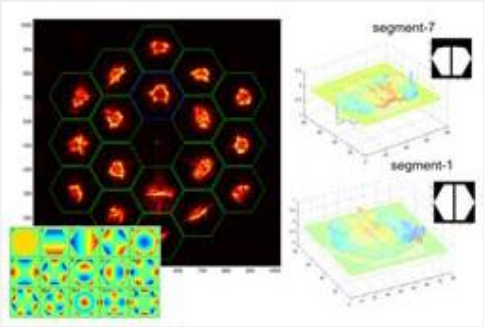
Materials and Thin Films

2-Meter Chamber in Class 100,000 Cleanroom

Component Development and Test

Doug Leviton, NASA Inventor of the Year, with His Optical Encoder

Wavefront Sensing and Control



Segmented Aperture Wavefront Sensing

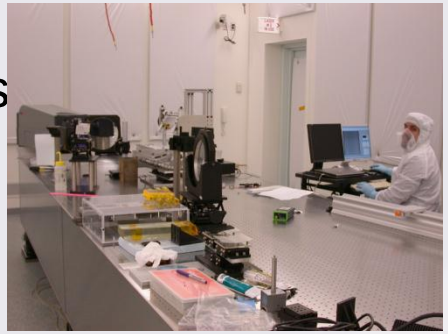
System Alignment and Test

HST-WFC3 and Optical Stimulus in SES Thermal-Vacuum Chamber at GSFC

Facilities for Partnering – Optics

Integrated Optical Design Lab

- Synergetic real-time design in a peer-group environment
- Detailed stray light analysis
- Extensive global optimization runs
- Intensive physical optics propagation modeling tasks

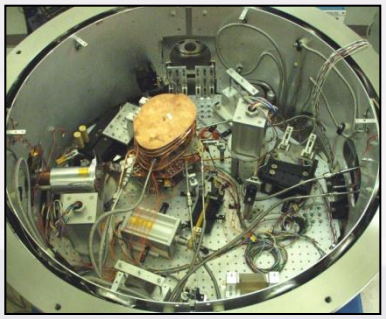


Advanced Interferometry and Metrology Lab

- High level of mechanical and thermal stability
- Temperature (0.5 deg C) and vibration controlled (3 Hz)
- For projects where temperature and acoustic control is vital

Cryogenic, High Accuracy Refraction Measuring System (CHARMS)

- Minimum deviation refractometer
- Measures absolute refractive index
  - 0.4 μm to 5.6 μm in wavelength
  - 15 K to 340 K in temperature
  - Absolute accuracies as good as 0.00001



SBIR Subtopic Development

Topic:	S2: Advanced Telescope Systems
Subtopic:	S2.04: Optics Manufacturing and Metrology for Telescope Optical Surfaces

Solicitation Development Objectives

Subtopics with science traceability and infusion potential

- Should articulate specific benefits for NASA missions and goals
- When possible, should trace to timely science mission requirements

Development tasks appropriate to small businesses

- No “critical path” deliverables or large, complex systems
- End product/capability should also provide a path to an attractive return on investment for small business

Planning for approximately three Phase 1 and one Phase 2 awards with superior infusion potential per Subtopic

- Topics that are too broad or too narrow may miss this goal
- Good proposals should get “cradle-to-grave” support from NASA
- Good Phase 1 proposals should have clear path to Phase 2 and then commercialization

S2.05 Subtopic Description

S2 Advanced Telescope Systems

S2.05 Optics Manufacturing and Metrology for Telescope Optical Surfaces

This subtopic focuses primarily on manufacturing and metrology of optical surfaces, especially for very small or very large and/or thin optics. Missions of interest include:

WFIRST concepts (http://wfirst.gsfc.nasa.gov/),
NGXO (http://ixo.gsfc.nasa.gov/),
SGO (http://lisa.gsfc.nasa.gov/)
ATLAST (http://www.stsci.edu/institute/atlast/)

Optical systems currently being researched for these missions are large area aspheres, requiring accurate figuring and polishing across six orders of magnitude in period. Technologies are sought that will enhance the figure quality of optics in any range as long as the process does not introduce artifacts in other ranges. For example, mm-period polishing should not introduce waviness errors at the 20 mm or 0.05 mm periods in the power spectral density. Also, novel metrological solutions that can measure figure errors over a large fraction of the PSD range are sought, especially techniques and instrumentation that can perform measurements while the optic is mounted to the figuring/polishing machine. Large lightweight monolithic metallic aspheres manufactured using innovative mirror substrate materials that can be assembled and welded together from smaller segments are sought. Also, optical system design and tolerancing requires software analysis tools capable of accurately ray tracing a broader range of materials and effects than are currently treated with conventional optical software. Updated software algorithms code is a technology of interest.

S2.05 Subtopic Description

By the end of a Phase 2 program, technologies must be developed to the point where the technique or instrument can dovetail into an existing optics manufacturing facility producing optics at the R&D stage. Metrology instruments should have 10 nm or better surface height resolution and span at least 3 orders of magnitude in lateral spatial frequency.

Examples of technologies and instruments of interest include:

*Innovative metal mirror substrate materials or manufacturing methods such as welding component segments into one monolith that produce thin mirror substrates that are stiffer and/or lighter than existing materials or methods.
*Interferometric nulling optics for very shallow conical optics used in x-ray telescopes.
*Segmented systems commonly span 60 degrees in azimuth and 200 mm axial length and cone angles vary from 0.1 to 1 degree.
*Low stress metrology mounts that can hold very thin optics without introducing mounting distortion.
*Low normal force figuring/polishing systems operating in the 1 mm to 50 mm period range with minimal impact at significantly smaller and larger period ranges.
*In-situ metrology systems that can measure optics and provide feedback to figuring/polishing instruments without removing the part from the spindle.
*Innovative mirror substrate materials or manufacturing methods that produce thin mirror substrates that are stiffer and/or lighter than existing materials or methods.
*Extreme aspheric and/or anamorphic optics for pupil intensity amplitude apodization.
*Metrology systems useful for measuring large optics with high precision.
* Innovative method of bonding extremely lightweight (less than 1 kg/m2 areal density) and thin (less than 1 mm) mirrors to a housing structure, preserving both alignment and figure.
* Innovative method of improving the figure of extremely lightweight and thin mirrors without polishing, such as using the coating stress.

Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.

NASA SBIR/STTR Technologies

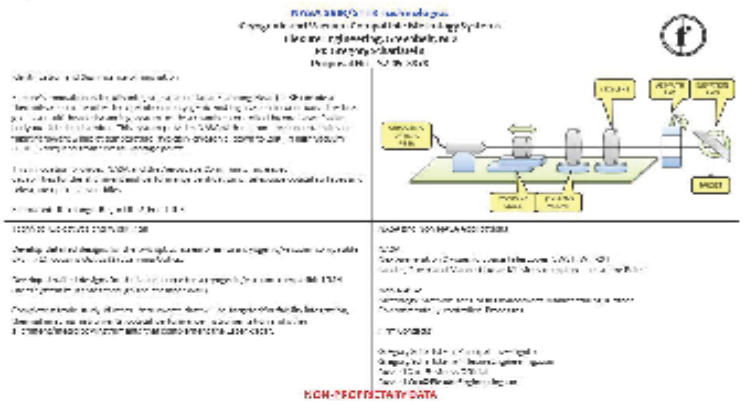
S2.05-8878 - Cryogenic and Vacuum Compatible Metrology Systems

PI: Gregory Scharfstein
Flexure Engineering - College Park, MD

Identification and Significance of Innovation

Flexure's innovation is to fully integrate a Laser Radar Scanning Head (LRSH) inside a thermal-vacuum chamber for operation in cryogenic and high vacuum conditions. The final goal is a multi-headed scanning system inside a chamber controlled by one Laser Radar body outside the chamber. This system provides NASA with micron-level uncertainties on flight hardware while at temperature (typically cryogenic, down to 20K) in high vacuum (>10E-6 torr) and from several vantage points.

This innovation provides NASA and the Aerospace Community increased capabilities for the alignment and performance verification of telescope optical surfaces and telescope optical assemblies.



Estimated TRL at beginning and end of contract: (Begin: 2 End: 3)

Technical Objectives and Work Plan

Develop detailed designs for the two optics assemblies for a cryogenic/vacuum compatible LRSH, (1)Focusing Optics (2) Scanning Optics.

Develop detailed designs for the laser source for a cryogenic/vacuum compatible LRSH (laser system must pass through the chamber wall).

Complete a trade study of other instruments that will be targeted for facility integration; thermal imaging instruments, optical performance instrumentation and other alignment/metrology instruments that complement the Laser Radar.

NASA Applications

Next-generation Cryogenic Space Telescopes (JWST, WFIRST)
Lander, Rover and Manned Lunar Missions to explore ices at the Poles

Non-NASA Applications

Metrology Methods for Harsh Environment Manufacturing & other Environmentally-controlled Processes

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In Conclusion

GSFC has a robust and productive SBIR program in the Optics area, with high quality proposals being submitted every year, leading to advances in key Optics Technologies. Companies with successful SBIR efforts have submitted high quality NTRs (New Technology Reports)