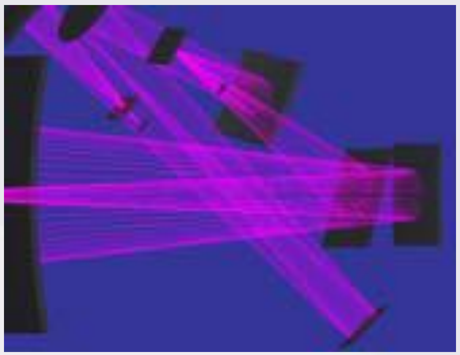
GSFC Optics Technologies

Dr. Petar Arsenovic

Optics Capabilities

Optical Design and Analysis



Opto-mechanical Design and Fabrication

Preparing 1m SPOT Mirror for Lapping

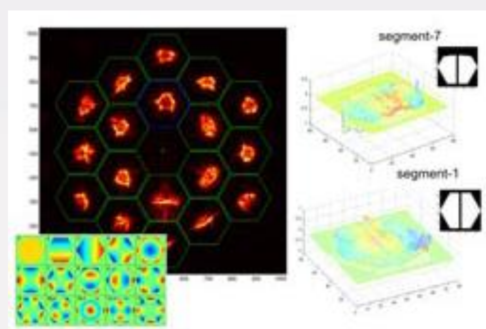
Materials and Thin Films

2-Meter Chamber in Class 100,000 Cleanroom

Component Development and Test

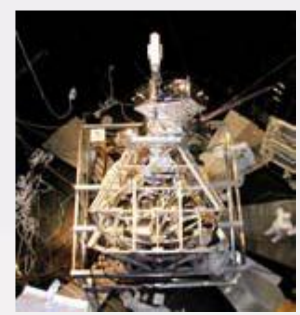
Doug Leviton, NASA Inventor of the Year, with His Optical Encoder

Wavefront Sensing and Control



Segmented Aperture Wavefront Sensing

System Alignment and Test



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

Optics Branch Facilities

- Diffraction Grating Evaluation Facility (DGEF)
- Advanced Interferometry and Metrology (AIM) Lab
- Optical Metrology Laboratory
- Optical Measurement Laboratory (EUV through Far IR Capability)
- Calibration, Integration, and Assembly Facility
- Horizontal and Vertical Flow Cleanrooms
- Cryo-test Facilities
- Optical Coating Facility (EUV through Far IR)
- Precision Optical Fabrication Facility including Diamond Turning Capability

Technology

The Optics Branch's Technology effort is geared toward developing new ways to do science. The key elements are participation and partnership. We collaborate with with our colleagues in the Division and across the Center on new ideas and new innovations. We partner with scientists, industry, and universities in a wide range of areas such as large lightweighted space optics, Visible Nulling Coronagraph technology, Wavefront Sensing and Control, and development of high resolution x-ray mirrors.

Branch Members serve as COTRs on SBIR Phase I and Phase II contracts, such as:

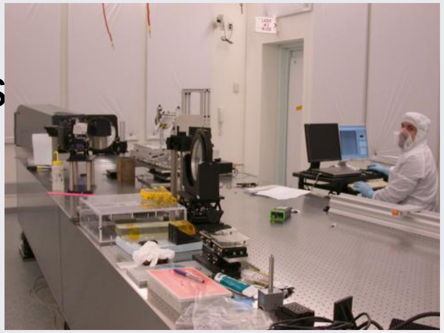
- Polishing of Replicating Mandrels
- Coherent Laser Radar Metrology Systems
- Hyperspectral Image Projectors
- High Strength Beryllium Alloys for Large Space Flight Optics

Picture shows John Hagopian , who is leading a team developing a nanotube based material that is 10 times blacker than what is currently state of the art. Work is featured in Goddard TechTrends.

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

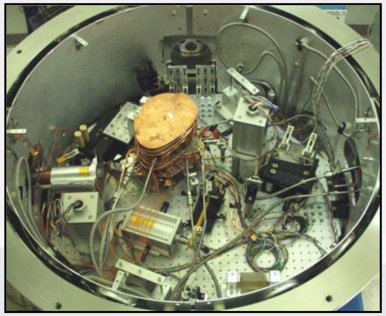


Advanced Interferometry and Metrology Lab

- 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 S2.05 Development

Topic: S2: Advanced Telescope Systems

Subtopic: S2.05: 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

S2.05 Subtopic Description

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:

Dark Energy Mission concepts (e.g., http://universe.nasa.gov/program/probes/jdem.html),
Large X-Ray Mission concepts (e.g., http://ixo.gsfc.nasa.gov/),
Gravity Wave Science Mission concepts (e.g., http://lisa.gsfc.nasa.gov/)
ICESAT (http://icesat.gsfc.nasa.gov/), CLARIO, and ACE
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. A new area of interest is large lightweight monolithic metallic aspheres manufactured using innovative mirror substrate materials that can be assembled and welded together from smaller segments.

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.

S2.05 Subtopic Description

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.
- Metrology systems for measuring optical systems while under cryogenic conditions.

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

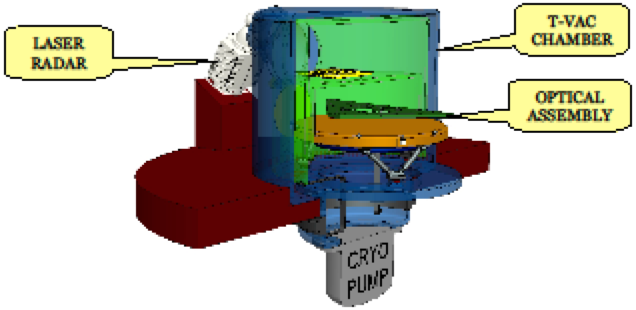
Cryogenic Optical Metrology Through a Chamber Window

Flexure Engineering, Greenbelt, MD
PI: Gregory Scharfstein
Proposal No. S2.05-9211

Identification and Significance of Innovation

Flexure's innovation marries the technologies of Thermal Vacuum Chambers and Non-Contact Metrology Systems providing NASA with sub-micron, three sigma uncertainties on Flight Hardware while at temperature (typically cryogenic, down to 30K) and in high vacuum (>10E-6 torr).

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



Expected TRL Range at the end of Contract (1-9): TRL 5

Technical Objectives and Work Plan

Develop specifications for a Vibration Control System to allow for sub-micron stability while pumping vacuum and flowing cryogen.

Develop specifications for a Thermal Control System to allow for 30K-hardware inside the chamber to be viewable through windows.

Develop specifications to enhance the Metrology System for modularity, ease of use and lower uncertainties. One example of each topic mentioned in this objective:

1. Modularity: a scalable system that can accommodate different size payloads
2. Ease of Use: Touchscreen GUI to control/monitor chamber/payload and obtain/analyze metrology data.
3. Lower Uncertainties: Integrating ESPI and PG to the system so that other metrology devices can be used to cross-reference measurements and bring down uncertainties.

NASA and Non-NASA Applications

NASA:

Next-generation Cryogenic Space Telescopes (JWST, WFIRST)

Lander, Rover and Manned Lunar Missions to explore ices at the Poles

Non-NASA:

Advancement of High Temperature Superconductor Technologies

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

Firm Contacts

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Russell.Cox@FlexureEngineering.com

NASA SBIR/STTR Technologies

Proposal No. S2.05-8494 – ELID Grinding of Large Aspheres

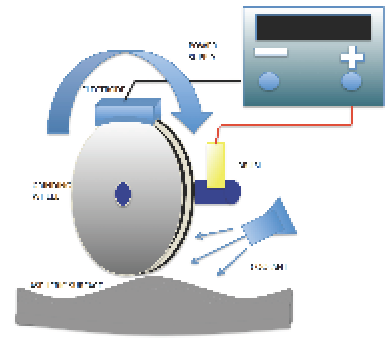
PI: Kai Xin PhD

Flemming Tinker LLC / Aperture Optical Sciences Inc. – Higganum, CT

Identification and Significance of Innovation

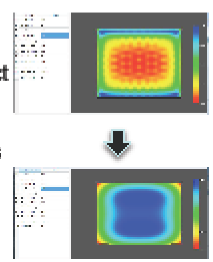
Mid-spatial frequency (MSF) and High spatial frequency (HSF) surfaces errors in the grinding of fast aspheres are amplified in hard ceramics like SiC due to cyclic tool wear rates, vibration, and tool deformation. Flemming Tinker LLC – Aperture Optical Sciences Inc. will examine Electro-Lytic In-Process Dressing (ELID) as a solution to mitigate these phenomena and reduce the creation of MSF and HSF errors. Doing so will reduce the overall cost of making fast aspheres from hard ceramics by increasing removal efficiency while subsequently reducing the need for downstream MSF error correction through smoothing.

Expected TRL Range at the end of Contract (1-9): 3-4



Technical Objectives

1. Construct ELID grinding module on conventional surface grinder
2. Model the impact of cyclic wear conditions to predict results
3. Demonstrate reduction in MSF/HSF surface errors with ELID Grinding on glass and SiC test samples
4. Determine plan for implementing on conventional large-format grinding machines for fabricating 1-3 meter size aspheric mirrors



Work Plan

1. Analytical model development
2. Preparation of experimental ELID grinder
3. Experiments on glass & SiC samples
4. Analyze results and determine plan for full-scale demonstration

NASA and Non-NASA Applications

IXO Replication Mandrels
GenX mandrels and optics
Precision Cylindrical Optics
Large Format Aspheres
Low Mid-Spatial Period Optical Surfaces
Deterministic Low Cost Fabrication

Firm Contacts

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Dr. Kai Xin, PI, Aperture Optical Sciences Inc. (860) 316-2589

NON-PROPRIETARY DATA

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)