NASA SBIR Subtopic S2.03
“Advanced Optical Systems”

H. Philip Stahl, Ph.D.
Sub-Topic Manager

S2.04 & S2.05 Award Statistics Total

	Phase 1	Phase 2
2005	21% (8/38)	71% (5/7)
2006	28% (8/29)	63% (5/8)
2007	36% (4/11)	50% (2/4)
2008	59% (10/17)	50% (4/8)
2009	56% (9/16)	50% (4/8)
2010	50% (11/22)	11% (1/9)
2011	28% (7/25)	
Total	36% (57/158)	48% (21/44)

S2.04 Award Statistics

	Phase 1	Phase 2
2005	22% (2/9)	100% (1/1)
2006	29% (6/21)	50% (3/6)
2007	33% (1/3)	100% (1/1)
2008	75% (3/4)	50% (1/2)
2009	66% (2/3)	66% (2/3)
2010	33% (4/12)	00% (0/3)
2011	33% (4/12)	
Total	34% (22/64)	50% (8/16)

2010 SBIR S2.04

Phase I 12 Submitted 4 Funded

Scale-up of Nano-Engineered AR Coating Process for Large Plastic Optics, Nanotrons

Low Cost High Specific Stiffness Mirror Substrate, United Materials and Systems

Silicon Carbide Corrugated Mirrors for Space Telescopes, Trex Enterprises Corporation

Enhanced ORCA and CLARREO Depolarizers Using AR Microstructures, TelAztec

Phase II 3 Submitted 0 Funded

2011 SBIR S2.04

Phase I 12 Submitted 4 Funded

Diamond Turned Super Alloy Mandrel for X-Ray Mirrors; Dallas Optical Systems

Lightweight Composite Mirrors for Telescopes; Materials Modification

Carbon Nanotube and Carbon Fiber Reinforced SiC Optical Components; M Cubed

Dual Band EUV Multilayer Coatings for Solar Physics; Reflective X-Ray Optics

Phase II 2012

NASA SBIR/STTR Technologies

S2.04-9735 - Diamond Turned Super Alloy Mandrel for Slump Forming X-Ray Observatory (IXO) Mirrors

PI: John Casstevens
Dallas Optical Systems, Inc. - Rockwall, TX

Identification and Significance of Innovation

With current technology, the cost to fabricate and the time to produce large mirrors is one of the limiting factors for many missions. A major emphasis in achieving a successful IXO is reducing the cost of the grazing incidence mirrors.

Diamond turning is proven to be able to quickly produce highly aspheric grazing incidence optical contours to visible wavelength tolerances with extremely smooth surfaces.

Because diamond turning can produce mandrels with extremely repeatable contour accuracy, the process allows manufacture of mandrels which can be adjusted in dimension to compensate for the thermal expansion of the borosilicate glass and the mandrel so that the curvature of the slumped glass can be adjusted. Any number of slumping mandrels can be produced with exactly the same contour with repeatability of approximately 1/100 wave visible light. This uniformity and rapidity of production of a relatively low cost mandrel will be enabling technology for IXO mirror fabrication.

Estimated TRL at beginning and end of contract: (Begin: 3 End: 5)

Technical Objectives and Work Plan

The objectives of the Phase I SBIR effort will be the evaluation of machineability of several different super alloys after a study of material availability and thermal and mechanical properties for use as IXO mirror slumping mandrels. Selected super alloys will be processed as follows:

?Select super alloys with respect to mechanical and thermal properties, machineability, availability in the sizes required and cost that are potentially suitable for use as x-ray optics slumping mandrels.

?Develop electroless nickel plating processes to plate super alloys to obtain flawless electroless nickel plating with good adhesion and low residual stress.

?Diamond turn and polish flat mirrors which will be measured before and after heat cycling to evaluate dimensional changes. Evaluate oxidation of the polished electroless nickel surface and super alloys. Ultra precision turning of super alloys with cutting tool materials cubic boron nitride and special tungsten carbide cutting tools will evaluate direct machining of a super alloy mandrel contour.

?Design a diamond turned slumping mandrel utilizing the results from conventional machining, heat treatment, electroless nickel plating and diamond turning and data from measurements of the effects of multiple applications of the x-ray mirror glass slumping cycle.

NASA Applications

Mandrels for slump forming of x-ray mirror optical segments will lower costs to the point of enabling large space borne x-ray optical instruments.

Non-NASA Applications

Diamond turned electroless nickel plated mirrors are in wide use in commercial and military applications. Molds for injection and compression molding of plastic and glass optics and other products utilize diamond turned electroless nickel plated molds. Electroless nickel plated mirrors are used for synchrotron light source installations around the world.

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NASA SBIR/STTR Technologies

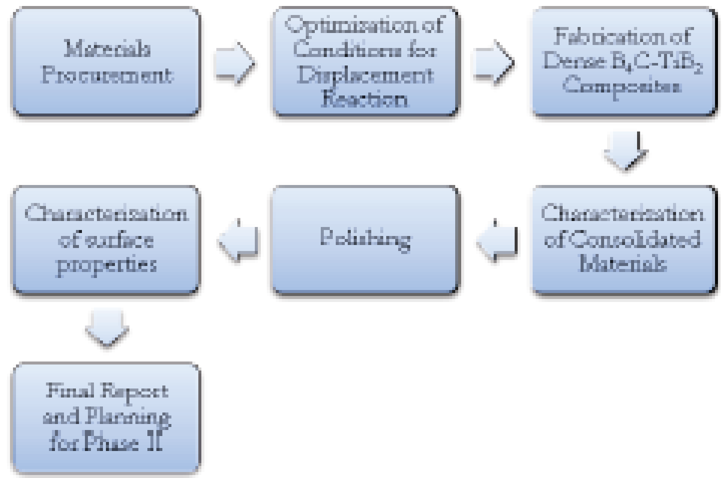
S2.04-8273 - Lightweight composite mirrors for telescopes

PI: Tirumalai Sudarshan

Materials Modification, Inc. - Fairfax, VA

Identification and Significance of Innovation

- Lightweight, steady and stiff mirrors are necessary to decrease cost of telescopes such as IXO and GenX used in special NASA missions.
- Beryllium has been traditionally considered ideal for lightweight mirrors requiring high rigidity The toxicity of beryllium poses a major problem.
- CVD to produce silicon carbide mirrors is a complex and expensive technique and the quality of SiC produced is very sensitive to the processing conditions.
- MMI proposes to utilize a novel displacement reaction to obtain fully dense B4C based composite mirrors with unique microstructural features



Estimated TRL at beginning and end of contract: (Begin: 1 End: 3)

Technical Objectives and Work Plan

- To produce B4C-TiB2 composites with novel microstructures by initiating a displacement reaction between titanium carbide and boron.
- To utilize rapid densification (< 15 min) using Plasma Pressure Compaction (P2C) to retain fine grain sizes generated in displacement reaction and ensure better mechanical properties in the consolidated part.
- Optimize the consolidation parameters such as time, temperature and pressure to achieve theoretical density reproducibly.
- To characterize the consolidated materials for phases present and microstructure using X-Ray Diffraction (XRD), optical and Scanning Electron Microscopy (SEM).
- Polishing the compacts by centrifugal float polishing
- Preliminary studies on the mechanical, thermal and optical properties of the composite

NASA Applications

- optical mirror for vacuum ultraviolet (VUV) and X-ray applications
- used in UV telescopes for space astronomy because of its high normal incidence reflectance
- space applications with adequate cryogenic stability and high resistance to degradation from atomic oxygen, trapped charges such as electrons, protons and high energy photons

Non-NASA Applications

- laser focusing mirror applications (LIDAR)
- optical materials for synchrotron applications (mirror used for synchrotron radiation in large electron storage rings must withstand high X-ray flux without degradation or excessive thermal distortion, which affects transmission and energy resolution.)

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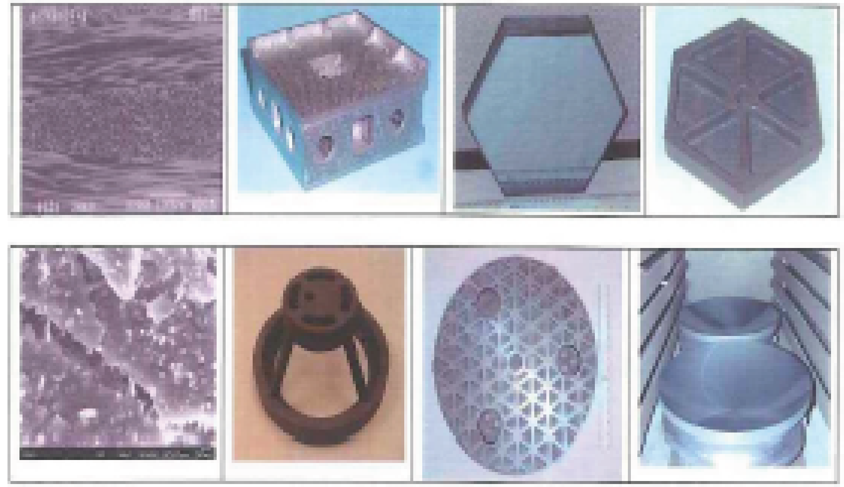
S2.04-8762 - Carbon Nanotube (CNT) and Carbon Fiber Reinforced SiC Optical Components

PI: Prashant Karandikar
M Cubed Technologies, Inc. - Newark, DE

Identification and Significance of Innovation

SiC is a candidate material for lightweight components for optical systems in defense and commercial fields. M Cubed has conducted extensive work on fabricating SiC mirrors and structures for defense and commercial markets. Some of the drawbacks of SiC include low toughness and high finishing costs. With carbon nanotube (CNT) and carbon fiber (Cf) reinforcements M Cubed has increased the toughness, reduced CTE, and reduced weight (density) of SiC. Preliminary work has been done to demonstrate the feasibility of making mirrors and structures out of these materials (See graphic). In this program, M Cubed will further develop and optimize the technology with innovative processing and combining the two reinforcements. Two 0.25m and one 0.5m spherical demonstration components will be designed, coated and finished during the proposed program.



Estimated TRL at beginning and end of contract: (Begin: 4 End: 6)

Technical Objectives and Work Plan

The over all objective of this work is to demonstrate the feasibility of fabricating high toughness, lightweight, low-CTE SiC optical components out of carbon nanotube (CNT and carbon fiber reinforcements. The specific objectives are as follows:

1. Develop process to make SiC composite with combined CNT and carbon fiber reinforcements
2. Characterize properties of this material
3. Scale up the process to fabricate 0.25m flat, 0.25m spherical and 0.5m spherical mirror substrates
4. Demonstrate the ability to Si coat the composite
5. Demonstrate the ability to finish the mirrors
6. Develop a path towards making 1-2 m class spherical/asphere mirrors

The work plan involves 6 tasks designed to meet the above objectives. These tasks are as follows:

1. CNT/Cf/SiC composite fabrication process development and optimization.
2. Characterize composite properties
3. Design mirror components
4. Scale up process and fabricate mirror components
5. Deposit Si coating
6. Polish/finish the mirrors
7. Reporting and review meetings

NASA Applications

Mirrors, Optical Benches, Optical Structures, Precision Components, Deployable Components

Non-NASA Applications

Automobile Brakes, Aircraft brakes, Wafer Substrates, Precision Structures

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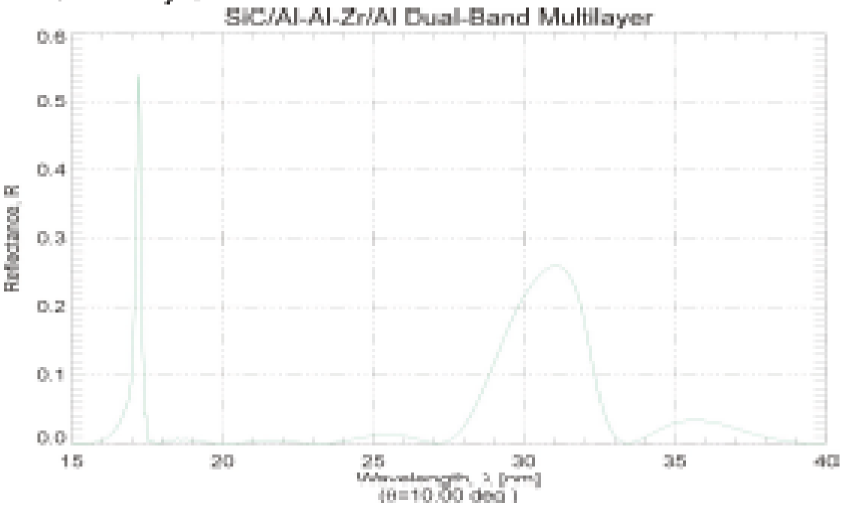
S2.04-9684 - Dual-Band EUV Multilayer Coatings for Solar Physics

PI: David Windt
Reflective X-ray Optics, LLC - New York, NY

Identification and Significance of Innovation

We propose to develop and commercialize 'dual-band' EUV multilayer coatings that provide high reflectance at normal incidence in two EUV wavebands. The coatings will enable future solar imaging and spectroscopy instruments to operate in two wavebands using a single instrument aperture, resulting in much higher collection efficiency, lower mass and volume, and lower cost.



Estimated TRL at beginning and end of contract: (Begin: 2 End: 4)

Technical Objectives and Work Plan

Phase I Technical Objectives:

Experimentally investigate the performance of new dual-band EUV multilayers comprising (a) two periodic multilayers with a low-absorption spacer layer, and (b) periodic multilayers with novel capping layers that operate in two Bragg orders.

Phase I Work Plan:

1) Fabricate and test B4C/Si-Si-B4C/Mo/Si dual-band coatings.

2) Fabricate and test SiC/Al-Al-Zr/Al dual-band coatings.

3) Fabricate and test periodic dual-band coatings with novel capping layers.

NASA Applications

The high-performance dual-band coatings we propose to develop will enable solar imaging and spectroscopy instruments that are more efficient, more compact and less expensive, in order to meet the performance requirements of future NASA missions such as FACTS, RAM, Solar-C and others that will need higher cadence, better signal-to-noise, and better spatial and spectral resolution.

Non-NASA Applications

High-performance dual-band EUV multilayers will find application in a variety of other areas of research,including plasma diagnostics, high-harmonic generation sources, X-ray lasers, and other emerging EUV applications.

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S2.05 Award Statistics

	Phase 1	Phase 2
2005	21% (6/29)	67% (4/6)
2006	25% (2/8)	100% (2/2)
2007	38% (3/8)	33% (1/3)
2008	54% (7/13)	50% (3/6)
2009	46% (6/13)	33% (2/6)
2010	70% (7/10)	17% (1/6)
2011	23% (3/13)	
Total	36% (34/94)	45% (13/29)

2010 SBIR S2.05

Phase 1 10 Submitted 7 Funded

Innovative Deterministic Optical Surface Finishing, Nanotrons

ELID Grinding of Large Aspheric Optics, Flemming Tinker Inc.

Fabrication Technology for X-Ray Optics and Mandrels, Flemming Tinker

Removing Mid-Spatial Frequency Errors on Curved Surfaces with VIBE, Optimax Systems, Inc.

High-Resolution Detector for At-Wavelength Metrology of X-Ray Optics, Radiation Monitoring Devices, Inc.

Cryogenic Optical Metrology Through a Chamber Window, Flexure Engineering

In-Situ Extended Lateral Range Surface Metrology, 4 D Technology Corporation

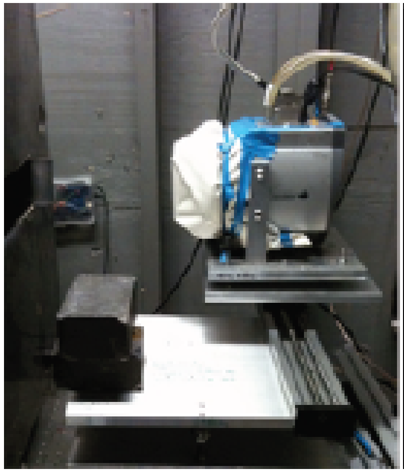
Phase II 6 Submitted 1 Funded

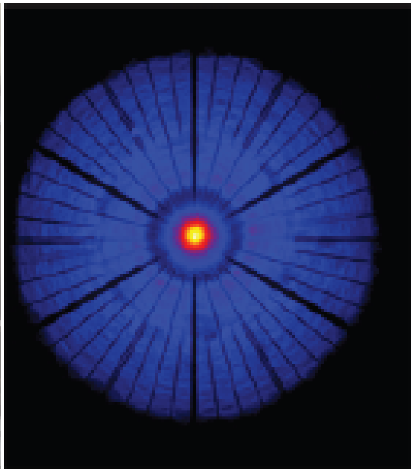
High-Resolution Detector for At-Wavelength Metrology of X-Ray Optics, Radiation Monitoring Devices, Inc.

NASA SBIR/STTR Technologies

S2.05-8926 - High-Resolution Detector for At-Wavelength Metrology of X-Ray Optics

PI: Vivek Nagarkar
Radiation Monitoring Devices, Inc. - Watertown, MA





Identification and Significance of Innovation

Since the launch of the first X-ray focusing telescope in 1963, the development of grazing incidence X-ray optics has been crucial to the development of the field of X-ray astronomy. The recent Decadal Survey highlights the important contribution that X-ray astronomy can make in addressing some of the most pressing scientific questions about black holes, cosmology and the ebb and flow of energy and matter in the evolving universe, and recognizes the research needed to mature the key enabling technology of X-ray optics. The development of next-generation X-ray optics will also need better imaging data to quantify performance and to calibrate flight-ready instruments. The proposed development directly addresses this need by providing a unique detector designed specifically to support the development of the next generation of X-ray telescopes, allowing researchers and engineers to characterize such devices with high accuracy, and thereby optimize their performance.

Estimated TRL at beginning and end of contract: (Begin: 5 End: 6)

Technical Objectives and Work Plan

The goal of the proposed research is to develop a high spatial resolution detector for at-wavelength metrology of X-ray optics. In addition to its superior spatial resolution, the detector will provide spectral information over a wide energy range of 8 keV to 100 keV, permit X-ray photon counting with rates ex-ceeding tens of KHz, have a large active imaging area, and offer ease of use. The detector will undergo meticulous calibration using various X-ray sources. To realize the envisioned detector, the proposed research is divided into four main areas: 1) Fabrication and characterization of high-performance scintillator sensors, 2) Design and assembly of a specialized CCD camera, 3) Algorithm development for improved spatial and energy resolution, and 4) Detector integration and detailed evaluations at RMD and at NASA centers. The proposed development will be undertaken in collaboration with Lawrence Livermore Na-tional Laboratory (LLNL) physicists who are part of the team responsible for the development of flight X-ray telescopes for the Nuclear Spectroscopic Telescope Array (NuSTAR) mission.

NASA Applications

The value of this type of detector, a high performance X-ray imaging camera, is evident from our Phase I results where our prototype detector played a crucial role in the ground calibration of the two X-ray telescopes that will fly on the NuSTAR mission. The proposed detector, with its enhanced performance, will allow its use for several specific new missions and mission areas, including the future X-ray missions for space astronomical observatories, FOXSI, SRG/ART-XC, and the WHIMex Mission.

Non-NASA Applications

The proposed detector is expected find applications in the fields of high resolution X-ray/gamma-ray detection, medical X-ray imaging, nuclear medicine, time-resolved X-ray diffraction studies at synchrotron sources, dynamic X-ray imaging of hypervelocity projectiles, X-ray microscopy, low-light optical tomography and dynamic nondestructive evaluations (NDEs) of spacecraft and other components.

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2010 SBIR S2.05

Phase 1 13 Submitted 3 Funded

Cryogenic & Vacuum Compatible Metrology Systems; Flexure Engineering

Optical Fabrication & Metrology of Aspheric & Free Form Mirrors; OptiPro

Very Large Computer Generated Holograms for Precision Metrology of Aspheric Optical Surfaces; Arizona Optical Metrology

Phase II 2012

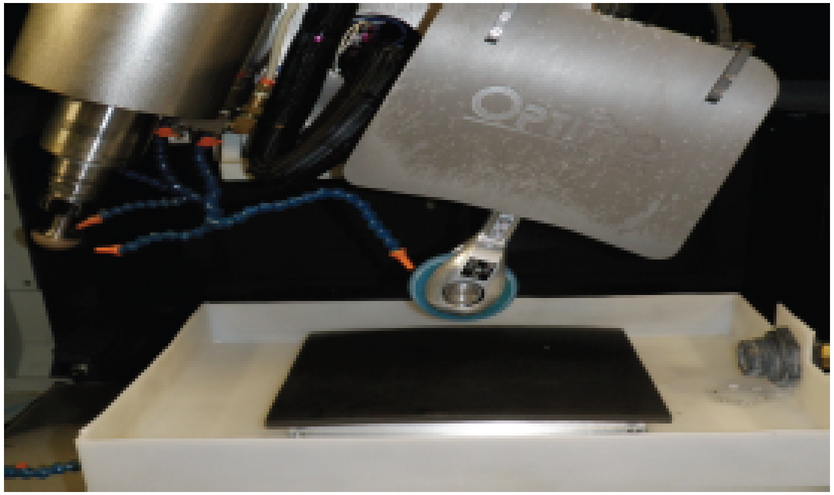
NASA SBIR/STTR Technologies

S2.05-8333 - Optical Fabrication and Metrology of Aspheric and Freeform Mirrors

PI: David Mohring
OptiPro Systems LLC - Ontario, NY

Identification and Significance of Innovation

OptiPro's UltraForm Finishing (UFF) is a sub-aperture compliant wheel and belt type grinding and polishing process for rapid material removal from the ground state to a finished optic. The UFF removes residual grinding sub-surface damage, mid spatial frequency errors, and provides the mechanism required for surface corrections. The UFF, with its 5 axis of motion provides a platform to polish traditional flats and spheres as well as aspheres and freeform shapes. The UFF was designed for deep concave shapes and it is suitable for finishing conformal optics. Large optics and mirrors require cost effective fabrication and in-situ metrology solutions. Currently the UFF and UltraSurf platforms have addressed the fabrication requirements for small aspheric and freeform optics. This proposal implements new tool designs on these platforms required for the fabrication of large mirrors with stringent mid spatial waviness error requirements.



Estimated TRL at beginning and end of contract: (Begin: 2 End: 4)

Technical Objectives and Work Plan

The main objectives of this phase I is to develop and demonstrate new tooling and metrology techniques for the fabrication of precision optical mirrors, utlizing the UltraForm Finishing (UFF) platform and UltraSurf techniques. The UFF platform is commercially available and cost effectively manufactures aspheres up to 300mm diameter. The scaling up of the UFF UltraWheel and process for large work piece grinding and polishing will require the analysis and optimization of the forces using finite element analysis (FEA) techniques. OptiPro Systems will test and analyze the machine, tooling and process requirements for large optical mirror and mandrel fabrication. The developed tooling and process parameters required for cost effective fabrication will drive the design of a new large mirror fabrication platform. A key component to this cost effective platform and process, is the in-situ metrology. New technologies and sensors will be tested and analyzed on existing equipment for scalability to large optics and integration into the fabrication platform. The above testing will provide the steps required for a robust process, special attention will be made to overall cycle time improvements with the large UltraWheel and belt design. With our MasterCAM and UFF toolpath generation software we will analyze various process scenarios to optimize the process parameters and reduce the cycle times while maintaining the required surface accuracy.

NASA Applications

Beneficiary NASA applications include the fabrication of forming mandrels used to produce multiple segmented shell mirrors for the International X-Ray Observatory (IXO) as well as aspheric and off axis parabolic or freeform optical surfaces required by LISA and WFIRST. These programs require cost effective solutions for the fabrication of large optics and mirrors.

Non-NASA Applications

The DOD and commercial applications for this technology is for 10mm to 300mm diameter optics and windows. The scaling up of this technology to larger optics, windows and mirrors will enable cost effective fabrication and metrology of military vehicle windows, satellite optics and telescope components.

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NASA SBIR/STTR Technologies

S2.05-9090 - Very large computer generated holograms for precision metrology of aspheric optical surfaces

PI: Chunyu Zhao

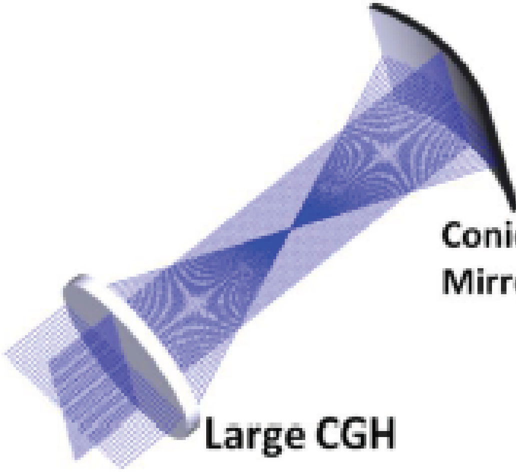
Arizona Optical Metrology LLC - Tucson, AZ

Identification and Significance of Innovation

Aspheric surfaces of space optics can be measured with Computer Generated Holograms (CGH) in combination with commercial interferometers. Large CGHs (>6") provide many advantages in precision metrology of aspheric surfaces: they can measure correspondingly large convex surfaces or concave near cylindrical surfaces, and they offer more measurement accuracy. CGH substrate quality is another factor that limits the accuracy of a CGH null test. Current technology is still unable to accurately fabricate a large (>6") CGH of arbitrary symmetry on a high quality substrate.

Arizona Optical Metrology LLC proposes to work with our collaborators at JPL to write large CGHs on high quality substrates. We expect the writing is not perfect, so we propose to calibrate the writing error in software to achieve high wavefront accuracy. We will develop the software and fabricate a couple of large CGHs and experimentally validate the technology in Phase 1.

Estimated TRL at beginning and end of contract: (Begin: 2 End: 4)



Technical Objectives and Work Plan

Objectives and work plans:

1.Development of software for generating correction wavefront map (CWM) in order to calibrate CGH writing error
 a. Define input and output for the software
 b. Develop algorithm
 c. Write and test code

2. Validation of technology with a large CGH that has SMALL grating pitch, therefore, is more sensitive to writing error
 a. Design and fabricate the CGH
 b. Accurately measure the writing error; generate the CWM
 c. Accurately measure the wavefront error due to writing, and compare it with the CWM
 d. Tune the software if necessary

3. Validation of technology with a large CGH that has LARGE grating pitch and is less sensitive to writing error. This is to obtain the sensitivity of writing error correction
 a. Design and fabricate the CGH
 b. Accurately measure the writing error; generate the CWM
 c. Accurately measure the wavefront error due to writing, and compare it with the CWM

NASA Applications

All large aspheric optical surfaces to be launched into space can benefit from accurate testing with large CGHs. In particular, the thin shell mirrors for the X-ray telescopes can be measured with large CGHs to high accuracy, so can the mandrels for making these mirrors. The JWST primary segments, already measured with 6" CGHs, could be better tested with larger CGHs as well.

Non-NASA Applications

Large aspheric surfaces used in ground based telescopes, the lithographic lenses, the Extreme Ultra-Violet (EUV) lithography systems, as well as the large format aerial photography cameras will be better tested with large CGHs.

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NASA SBIR/STTR Technologies

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

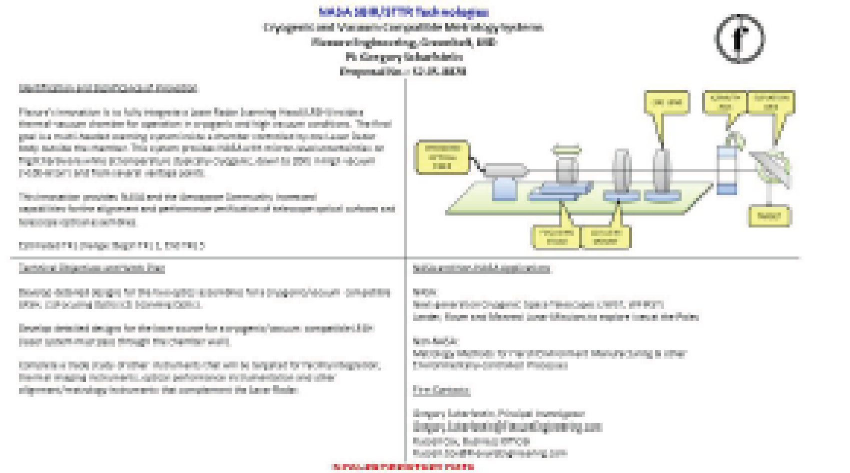
PI: Gregory Scharfstein
Flexure Engineering - College Park, MD

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

Firm Contacts

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Any Questions?

What I want to see in a Proposal

Define a customer or mission or application and demonstrate that you understand how your technology meets their science needs.

Propose a solution based on clear criteria and metrics

Articulate a feasible plan to:

- fully develop your technology,
- scale it to a full size mission, and
- infuse it into a NASA program

Deliver Demonstration Hardware not just a Paper Study, including :

- documentation (material behavior, process control, optical performance)
- mounting/deploying hardware

Customer / Application

Astro2010 specifically identifies optical components and coatings as key technologies:

Light-weight x-ray imaging mirrors for future large advanced x-ray observatories

Large aperture, light-weight mirrors for future UV/Optical telescopes

Broadband high reflectance coatings for future UV/Optical telescopes

National Academy "NASA Space Technology Roadmaps and Priorities" states that one of NASA's top challenges should be to develop a new generation of larger aperture, lower-cost telescopes:

Active align/control of < 1 arc-second angular resolution x-ray imaging

Active align/control of 500 nm diffraction limit imaging systems

Normal incidence 4-meter (or larger) diameter 5 nm rms WFE mirrors

Heliophysics Decadal will be released this summer.

Earth Science GEO-CAPE coastal ecosystem imager requires technology for alternative solar calibration strategies including new materials to reduce weight, and new optical analysis to reduce the size of calibration systems.

Desired Technologies

The subtopic has objectives:

Develop and demonstrate X-Ray Technologies

Develop and demonstrate UVOIR Mirror Technologies

Develop and demonstrate optical coatings for EUV and UVOIR telescopes.

Large aperture diffusers (up to 1 meter) for periodic calibration of GeoStationary Earth viewing sensors by viewing the sun either in reflection or transmission off the diffuser.

Desire is to go beyond simple components to sub-systems.

Technical Callenges

In all cases, the most important metric for an advanced optical system is affordability or areal cost (cost per square meter of collecting aperture). Currently both x-ray and normal incidence space mirrors cost $4 million to $6 million per square meter of optical surface area. This research effort seeks a cost reduction for precision optical components by 5 to 50 times, to less than $1M to $100K/m2.

Successful proposals shall provide a scale-up roadmap (including processing and infrastructure issues) for full scale space qualifiable flight optics systems. Material behavior, process control, active and/or passive optical performance, and mounting/deploying issues should be resolved and demonstrated.

X-Ray Technologies

Potential x-ray missions require

- X-ray imaging telescopes with <1 arc-sec angular resolution and > 1 to 5 m^2 collecting area;
- Multilayer high-reflectance coatings for hard x-ray mirrors (NuSTAR)
- X-ray transmission and/or reflection gratings

Multiple technologies are needed to enable < 1 arc-sec x-ray telescopes.

- new mirror materials such as silicon carbide, porous silicon, beryllium;
- improved techniques to manufacture (such as direct precision machining, rapid optical fabrication, slumping or replication technologies) 0.3 to 2 meter mirror shells or segments;
- improved testing techniques;
- active alignment of mirrors in a telescope assembly; and
- active control of mirror shape.

X-Ray Desired Outcomes

Successful proposals will demonstrate ability to:

manufacture, test & control 0.25 to 0.5 m prototype x-ray mirror assembly; or
coat a 0.25 to 0.5 m representative optical component.

Ideal Phase 1 delivers 0.25 m x-ray mirror.

Ideal Phase 2 advances technology to produce TRL 4/5 0.5 m mirror.

Deliverables include all necessary documentation, including optical performance assessment and all data on processing and properties of its substrate materials.

Phase 2 also includes a mechanical and thermal stability analysis.

UVOIR Technologies

Potential UV/Optical missions require:

- Large aperture, light-weight mirrors
- Broadband high reflectance coatings

Successful proposals will demonstrate an ability to:

- manufacture, test &control ultra-low-cost precision 0.25 to 0.5 m optical systems; or coat a 0.25 to 0.5 meter representative optical component.

Ideal Phase 1 deliverable would be a precision mirror of at least 0.25 meters; or a coated mirror of at least 0.25 meters.

Ideal Phase 2 advances technology to produce TRL 4/5 mirror > 0.5 m.

Deliverables include all necessary documentation, including optical performance assessment and all data on processing and properties of its substrate materials.

Phase 2 also includes a mechanical and thermal stability analysis.

Large UVOIR Mirror Technology

Future UVOIR missions require 4 to 8 or 16 meter monolithic or segmented primary mirrors with < 10 nm rms surface figures.

Mirror areal density depends upon available launch vehicle capacities to Sun-Earth L2 (i.e. 15 kg/m2 for a 5 m fairing EELV vs. 60 kg/m2 for a 10 m fairing SLS).

Potential solutions include, but are not limited to:

- new mirror materials such as silicon carbide, nanolaminates or carbon-fiber reinforced polymer;
- new fabrication processes such as direct precision machining, rapid optical fabrication, roller embossing at optical tolerances, slumping or replication technologies to manufacture 1 to 2 meter (or larger) precision quality mirrors or lens segments.
- reflective, transmissive, diffractive or high order diffractive blazed lens optical components for assembly of large (16 to 32 meter) optical quality primary elements.

Large Area UVOIR coatings

Large telescopes require broadband (from 100 nm to 2500 nm) high-reflectivity mirror coating with extremely uniform amplitude and polarization properties.

Proposals include, but are not limited to:

- investigations of new coating materials with promising UV performance;
- new deposition processes; and
- examination of handling processes, contamination control, and safety procedures related to depositing coatings, storing coated optics, and integrating coated optics into flight hardware.

An ability to demonstrate optical performance on 2 to 3 meter class optical surfaces is important.

Large Aperture Diffuser Technology

Geo Stationary Earth viewing sensors need large aperture diffusers (up to 1 meter) for periodic calibration by viewing the sun either in reflection or transmission off the diffuser.

New materials are needed to reduce weight.

- Typical materials of interest are PTFE (such as Spectralon® surface diffuser) or development of new Mie scattering materials for use as volume diffusers in transmission or reflection.
- Material needs to be stable in BTDF/BSDF to 2%/year from 250 to 2500 nm and highly lambertian (no formal specification for deviation from lambertian).

New designs are needed to reduce the size of calibration systems.

Any Questions?