NASA SBIR Subtopic S2.04
"Advanced Optical Components"

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Guiding Philosophy

Define a customer or application

Define the problem based on clear criteria and metrics

Challenge the market place to develop a solution

Do Not Pre-Suppose or Pre-Select a Solution

Competition of Ideas

Deliver Demonstration Hardware not just a Paper Study

Customer / Application

Astrophysicists want bigger and better space telescopes:

- 4 to 8 m class monolithic primary mirrors for UV/optical or infrared
- 8 to 30 m class segmented primary mirrors for UV/optical or infrared
- 8 to 16 m class segmented x-ray telescope mirrors
- 8 to 10 m UV-transparent refractive Fresnel or diffractive lens

UV/optical telescopes require:

- 1 to 3 meter class mirrors with < 5 nm rms surface figures.

IR telescopes require:

- 2 to 3 meter class mirrors with cryo-deformations < 100 nm rms.

X-ray telescopes require:

- 1 to 2 meter long grazing incidence segments,
  angular resolution < 5 arc-sec to 0.1 arc-sec,
  and surface micro-roughness < 0.5 nm rms.

The Problem

Large Space Telescopes are Expensive.

And Budget and Constrained.

The Metric

For current launch vehicles, mass (areal density) is an important limitation, but this constraint is significantly relieved via the planned Ares V's 60,000 kg to L2 capacity.

Therefore, areal cost (cost per square meter of collecting aperture) rather than areal density is the single most important system characteristic of future advanced optical system.

Currently, both x-ray and normal incidence space mirrors cost \$3M to \$4M per square meter of optical surface area.

This research effort seeks a cost reduction for precision optical components by 20X to 100X to less than \$100K/m2.

The Challenge

The primary purpose of this subtopic is to develop and demonstrate technologies to manufacture ultra-low-cost precision optical systems for very large x-ray, UV/optical or infrared telescopes.

Potential solutions include but are not limited to direct precision machining, rapid optical fabrication, slumping or replication technologies to manufacture 1 to 2 meter (or larger) precision quality mirror or lens segments (either normal incidence for uv/optical/infrared or grazing incidence for x-ray).

An additional key enabling technology for UV/optical telescopes is a broadband (from 100 nm to 2500 nm) high-reflectivity mirror coating with extremely uniform amplitude and polarization properties which can be deposited on 1 to 3 meter class mirror.

Deliverables

Successful proposals will demonstrate prototype manufacturing of a precision mirror or lens system or precision replicating mandrel in the 0.25 to 0.5 meter class with a specific scale up roadmap to 1 to 2+ meter class space qualifiable flight optics systems. Material behavior, process control, optical performance, and mounting/deploying issues should be resolved and demonstrated. The potential for scale-up will need to be addressed from a processing and infrastructure point of view.

Phase I deliverable will be at least a 0.25 meter near UV, visible or x-ray precision mirror or lens or replicating mandrel, its optical performance assessment and all data on the processing and properties of its substrate materials. This effort will allow technology to advance to TRL 3-4.

Phase II deliverable will be at least a 0.50 meter near UV, visible or x-ray space-qualifiable precision mirror or lens system with supporting documentation, optical performance assessment, all data on materials and processing, and thermal and mechanical stability analysis. Effort will advance technology to TRL 4-5.

S2:04 Advanced Optical Component Systems.

The planned Ares V vehicle will enable the launch of extremely large and/or extremely massive space telescopes. Potential systems include 12 to 30 meter class segmented primary mirrors for UV/optical or infrared wavelengths and 8 to 16 meter class segmented x-ray telescope mirrors. UV/optical telescopes require 1 to 3 meter class mirrors with < 5 nm rms surface figures. IR telescopes require 2 to 3 meter class mirrors with cryo-deformations < 100 nm rms. X-ray telescopes require 1 to 2 meter long grazing incidence segments with angular resolution < 5 arc-sec down to 0.1 arc-sec and surface micro-roughness < 0.5 nm rms. Additionally, missions such as EUSO and OWL need 2 to 9 meter diameter UV-transparent refractive, double-sided Fresnel or diffractive lens.

In view of the very large total mirror or lens collecting aperture required, affordability or areal cost (cost per square meter of collecting aperture) rather than areal density is probably the single most important system characteristic of an advanced optical system. For example, both x-ray and normal incidence space mirrors currently cost $3M to $4M per square meter of optical surface area. This research effort seeks a cost reduction for precision optical components by 20X to 100X to less than $100K/m2.

The primary purpose of this subtopic is to develop and demonstrate technologies to manufacture ultra-low-cost precision optical systems for very large x-ray, UV/optical or infrared telescopes. Potential solutions include but are not limited to direct precision machining, rapid optical fabrication, slumping or replication technologies to manufacture 1 to 2 meter (or larger) precision quality mirror or lens segments (either normal incidence for uv/optical/infrared or grazing incidence for x-ray).

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Proposal must address technical need of a recognized future NASA space science mission, science measurement objective or science sensor for a Discovery, Explorer, Beyond Einstein, Origins, GOESS, New Millennium, Landmark-Discovery, or Vision mission. Missions of interest include: Constellation-X (http://constellation.gsfc.nasa.gov/); Generation-X (http://www.cfa.harvard.edu/hea/genx.html); Single Aperture Far-Infrared (http://safir.jpl.nasa.gov/technologies.shtml); Terrestrial Planet Finder (http://planetquest.jpl.nasa.gov/TPF/tpf_index.cfm); Orbiting Wide Angle Light Collector (http://owl.gsfc.nasa.gov/); Extreme Universe Space Observatory (http://hena.lbl.gov/EUSO/).

Award Statistics

	Phase 1	Phase 2
2005	33% (2/6)	100% (1/1)
2006	29% (6/21)	50% (3/6)
2007	33% (1/3)	100% (1/1)
2008	75% (3/4)	

2005 SBIR

Phase 1 6 Submitted 2 Selected (1 Funded)

S3.04-8120 Flextensional Microactuators for Large-Aperture Lightweight Cryogenic Deformable Mirrors, TRS Ceramics, Inc.

S3.04-9501 Scaling Actively Cooled SLMS Mirrors to the Meter-Class for Cryogenic Telescopes (SPIRIT, TPF-1, SPECS), Schafer Corp

Phase 2 1 Funded

S3.04-8120 Flextensional Microactuators for Large-Aperture Lightweight Cryogenic Deformable Mirrors, TRS Ceramics, Inc.

2006 SBIR

Phase 1 21 Submitted 6 Funded

- S3.04-8981 Nano-Enabled Low-Cost High-Performance UV Anti-Reflection Coatings AGILTRON Corporation
- S3.04-9129 Gadolinium EUV Multilayers for Solar Imaging Near 60 nm Reflective X-ray Optics, LLC
- S3.04-9254 Extremely Lightweight Segmented Membrane Optical Shell Fabrication Technology for Future IR to Optical Telescope Mevicon, Inc.
- S3.04-9363 Beam Combination for Sparse Aperture Telescopes Seabrook Engineering
- S3.04-9430 High Fidelity Multi-Mode Hyperspectral Multispectral Imager with Programmable Spectral Resolution Kent Optronics, Inc.
- S3.04-9665 Adaptive Lobster-Eye Hard X-Ray Telescope Physical Optics Corporation, EP Division

Phase II 3 Funded

- S3.04-8981 Nano-Enabled Low-Cost High-Performance UV Anti-Reflection Coatings AGILTRON Corporation
- S3.04-9129 Gadolinium EUV Multilayers for Solar Imaging Near 60 nm Reflective X-ray Optics, LLC
- S3.04-9363 Beam Combination for Sparse Aperture Telescopes Seabrook Engineering

2007 SBIR

Phase 1: 3 Submitted 1 Funded

S2.04-9624 Radiation Hard Multi-Layer Optical Coatings, Nanohmics, Inc.

Phase 2: 1 Funded

S2.04-9624 Radiation Hard Multi-Layer Optical Coatings, Nanohmics, Inc.

2008 SBIR

Phase 1 | 4 Submitted | 3 Funded

S2.04-9926 Low Cost Very Large Diamond Turned Metal Mirror, Dallas Optical Systems, Inc.

S2.04-9652 Silicon Carbide Lightweight Optics With Hybrid Skins for Large Cryo Telescopes, Optical Physics Company

S2.04-9748 A Low Cost Light Weight Polymer Derived Ceramic Telescope Mirror, United Materials and Systems

Any Questions?