



NASA SBIR 2011 Phase I Solicitation

S2.04 Advanced Optical Component Systems

Lead Center: MSFC

Participating Center(s): GSFC, JPL

The National Academy Astro2010 Decadal Report specifically identifies optical components and coatings as key technologies needed to enable several different future missions, including:

- X-ray imaging mirrors for the International X-Ray Observatory (IXO).
- Active lightweight x-ray imaging mirrors for future very large advanced x-ray observatories.
- Large aperture, lightweight mirrors for future UV/Optical telescopes.
- Broadband high reflectance coatings for future UV/Optical telescopes.

X-ray mirrors are identified by the Decadal as the most important, critical technology needed for IXO. IXO requires 3 m² collecting aperture x-ray imaging mirror with 5 arc-second angular resolution. Mirror areal density depends upon available launch vehicle capacities. Additionally, future x-ray missions require advanced multilayer high-reflectance coating for hard x-ray mirrors (i.e., NuSTAR) and x-ray transmission/reflection gratings.

Future UVOIR missions require 4 to 8 or 16 meter monolithic and/or segmented primary mirrors with 2 for a 5 m fairing EELV vs. 60 kg/m² for a 10 m fairing SLS). Additionally, future UVOIR missions require high-reflectance mirror coatings with spectral coverage from 100 to 2500 nm.

Heliophysics missions also require advanced lightweight, super-polished precision normal and grazing incidence optical components and coatings. Potential missions which could be enabled by these technologies include: Origins of Near-Earth Plasma (ONEP); Ion-Neutral Coupling in the Atmosphere (INCA); Dynamic Geospace Coupling (DGC); Fine-scale Advanced Coronal Transition-Region Spectrograph (FACTS); Reconnection and Micro-scale (RAM); and Solar-C. Heliophysics missions need normal incidence mirror systems ranging from 0.35 meter to 1.5 meters with surface figure errors of 0.1 micro-radians rms slope from 4-mm to 1/2 aperture spatial periods, roughness of 0.2-nm rms and micro-roughness of 0.1-nm rms; and, grazing incidence mirror systems with an

effective collecting area of $\sim 3 \text{ cm}^2$ from 0.1 to 4 nm, 4 meter effective focal length, 0.8 degree angle of incidence and surface roughness of 0.2-nm rms. Additionally, future Heliophysics missions require high-reflectance normal incidence spectral, broadband, dual and even three-band pass multi-layer EUV coatings.

The geosynchronous orbit for 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. GEO-CAPE will need a lightweight large aperture (greater than 0.5 m) diffuse solar calibrator, employing multiple diffusers to track on-orbit degradation. 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.

Finally, NASA is developing a heavy lift space launch system (SLS). An SLS with a 10 meter fairing and 100 mt capacity to LEO would enable extremely large 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. These potential future space telescopes have very specific mirror technology needs. UV/optical telescopes (such as ATLAST-9 or ATLAST-16) require 1 to 3 meter class mirrors with

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 \$3 million to \$4 million per square meter of optical surface area. This research effort seeks a cost reduction for precision optical components by 20 to 100 times, to less than \$100K/m².

The subtopic has three objectives:

- Develop and demonstrate technologies to manufacture and test ultra-low-cost precision optical systems for x-ray, UV/optical or infrared telescopes. Potential solutions include, but are not limited to, new mirror materials such as silicon carbide, nanolaminates or carbon-fiber reinforced polymer; or 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 mirror or lens segments (either normal incidence for UV/optical/infrared or grazing incidence for x-ray). Solutions include reflective, transmissive, diffractive or high order diffractive blazed lens optical components for assembly of large (16 to 32 meter) optical quality primary elements. The EUSO mission requires large-aperture primary segmented refractive, Fresnel or kinoform PMMA or CYTOP lenses with
- Develop and demonstrate optical coatings for EUV and UVOIR telescopes. UVOIR telescopes require broadband (from 100 nm to 2500 nm) high-reflectivity mirror coating with extremely uniform amplitude and polarization properties. Heliophysics missions require high-reflectance (> 90%) normal incidence spectral, broadband, dual and even three-band pass multi-layer coatings over the spectral range from 6 to 200 nm. Studies of improved deposition processes for new UV reflective coatings (e.g., MgF₂), investigations of new coating materials with promising UV performance, and examination of handling processes, contamination control, and safety procedures related to depositing coatings, storing coated optics, integrating coated optics into flight hardware are all areas where progress would be valuable. In all cases, an ability to demonstrate optical performance on 2 to 3 meter class optical surfaces is important.
- 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.

In regard to large-aperture diffusers material needs to be stable in BTDF/BSDF to 2%/year from 250nm -2.5 microns and highly lambertian (no formal specification for deviation from lambertian).

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.