NASA SBIR 2014 Phase I Solicitation

S2.04 Optics Manufacturing and Metrology for Telescope Optical Surfaces

Lead Center: GSFC

Participating Center(s): JPL, MSFC

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/).

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. Also, novel metrological solutions that can measure figure errors over a large fraction of the PSD range are desired, 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 of interest is analytical software to process, fit, and model large optics surface metrology data with the goals to characterize surface morphology over spatial frequency bandwidths determined by the desired angular resolution performance; to provide stitched metrology capabilities obtained with different surface measuring instruments with different fields of view and resolution; to provide a data analysis tool for defining the optical surface fabrication tolerances based on the desired x-ray optics angular resolution performance; to allow forecasting of the surface morphological properties of optics.

By the end of a Phase II 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 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/m^2 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.
- Manufacturing technology and wavefront sensing and control as applied to coronagraph applications for exoplanet detection.

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.