Objectives

In future coronagraph flagship missions, wavefront control and phasing of primary mirror (PM) segments need to be stable to levels of tens of picometers to achieve mission goals. This project’s innovation is a segmented microelectromechanical (MEMS) deformable mirror (DM) that can be used in NASA test beds as a surrogate for segmented PMs, or as a compensator for wavefront shaping or phasing errors of PM segments.

There were three specific objectives:

• Fabricate prototype tweeter DMs to demonstrate concept feasibility.
• Develop a process to planarize existing TTP DMs, reducing unpowered topography to 30 nm RMS.
• Characterize amplitude of controllable spatial frequencies of the deformable segments and their ability to self-flatten.

ACCOMPLISHMENTS

Notable Deliverables Provided

There were no physical deliverables in this Phase I program. All three technical objectives were attained.

Seventeen distinct designs of prototype primary tweeter segment devices were produced, comprised of hexagonal deformable mirror segments supported by varying numbers of underlying electrostatic actuators.

A process to lower the unpowered wavefront error on a released DM to a level of 15nm RMS was developed (2X lower than proposed). Using ion beam figuring, the device topography was reduced from 297nm P-V and 39nm RMS to 87nm P-V and 15nm RMS, removing essentially all topography at spatial scales larger than the ~1mm ion beam source diameter. We successfully demonstrated that the primary tweeter DM surface can be controlled to compensate or emulate topography of a simulated PM segment.

Key Milestones Met

We fabricated multiple versions of a prototype tweeter DM to demonstrate concept feasibility and to evaluate design parameters. We developed a process to planarize DMs, reducing unpowered topography substantially using ion beam figuring. Finally, we characterized the controllable spatial frequencies of the deformable segments, their ability to self-flatten, and their ability to conform to shapes associated with simulated PM segments envisioned for NASA space-based telescopes.

FUTURE PLANNED DEVELOPMENTS

Planned Post-Phase II Partners

We plan to continue to partner with groups both inside and outside NASA to continue to develop devices that are applicable in NASA space-based telescope missions, ground-based telescope programs and telescope testbeds. In space telescopes, these include groups working on LUVOIR and HabEx. In ground telescopes these include instrumentation design groups for the TMT, E-ELT and GMT.

Planned/Possible Mission Infusion

Deformable mirrors with controllable segmented surfaces to be used as high order correctors of primary mirror segments have a few potential NASA mission infusion examples. These include the Large UV/Optical/Infrared Surveyor (LUVOIR) and Habitable Exoplanet Imaging Mission (HabEx) telescopes.

Planned/Possible Mission Commercialization

Deformable mirrors have a few commercial applications. All BMC mirrors benefit from the new manufacturing process developed for this program. BMC has had success developing arrays for imaging systems and testbeds. BMC can achieve similar results for other installations such as the planned Extremely Large Telescopes (TMT, E-ELT and GMT) and testbeds used to develop new instruments.