Project Introduction

The goal of this project is to develop and demonstrate a reliable, fault-tolerant wavefront control system that will fill a critical technology gap in NASA’s vision for future coronagraphic observatories. The project outcomes include innovative advances in component design and fabrication and substantial progress in development of high-resolution deformable mirrors (DM) suitable for space-based operation. Space-based telescopes have become indispensable in advancing the frontiers of astrophysics. Over the past decade NASA has pioneered coronagraphic instrument concepts and test beds to provide a foundation for exploring feasibility of new approaches to high-contrast imaging and spectroscopy. From this work, NASA has identified a current technology need for compact, ultra-precise, multi-thousand actuator DM devices. Boston Micromachines Corporation has developed microelectromechanical systems (MEMS) DMs that represent the state-of-the-art for scalable, small-stroke high-precision wavefront control. The emerging class of high-resolution DMs pioneered by the project team has already been shown to be compact, low-power, precise, and repeatable. This project will develop a system that eliminates the leading cause of single actuator failures in electrostatically-actuated wavefront correctors snap-through instability and subsequent electrode shorting and/or adhesion. To achieve this we will implement two innovative, complementary modifications to the manufacturing process. We will develop a drive electronics approach that inherently limits actuator electrical current density generated when actuator snap-down occurs, and we will modify the actuator design to mitigate adhesion between contacting surfaces of the actuator flexure and fixed base electrode in the event of snap-down. Phase II research will combine the actuator design and fabrication processes, and current-limiting drive electronics to produce a MEMS DM with 3072 actuators with enhanced reliability.

Anticipated Benefits

Potential NASA Commercial Applications: A universal benefit to all applications is a reliable MEMS device that can withstand voltage spikes and environmental changes that currently still cause failure in MEMS DMs, which in turn leads to more effective correction capabilities and longer device use in the field. Also, given the higher yield, manufacturing costs can be reduced. In addition, the following hold true for each individual application: 1) Optical communication: For long-range secure communication, large amounts of data can be sent over long distances using lasercomm systems. By creating more reliable deformable mirrors, deformable mirrors can better correct for atmospheric aberrations. 2) Pulse-shaping: Pulsed lasers are used in a variety of applications from material characterization to laser marking and machining. By creating arrays with fewer failed actuators, control of the pulsed beams can be enhanced, leading to a more shaped beam. This will allow scientists to better understand the composition of materials and allow manufacturers to make more precise, complex patterns. 3) Biological imaging/vision science: For the
imaging field, mirrors become almost ineffective if actuator failure occurs due to the smaller required size of the arrays. Therefore, fewer imaging instruments will need replacement mirrors due to actuator failure.

**Primary U.S. Work Locations and Key Partners**

<table>
<thead>
<tr>
<th>Organizations Performing Work</th>
<th>Role</th>
<th>Type</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jet Propulsion Laboratory (JPL)</td>
<td>Lead Organization</td>
<td>NASA Center</td>
<td>Pasadena, CA</td>
</tr>
<tr>
<td>Boston Micromachines Corporation</td>
<td>Supporting Organization</td>
<td>Industry</td>
<td>Cambridge, MA</td>
</tr>
</tbody>
</table>

**Primary U.S. Work Locations**

| California | Massachusetts |

**Organizational Responsibility**

- **Responsible Mission Directorate:** Space Technology Mission Directorate (STMD)
- **Lead Center / Facility:** Jet Propulsion Laboratory (JPL)
- **Responsible Program:** SBIR/STTR

**Project Management**

- **Program Director:** Jennifer L. Gustetic
- **Program Manager:** Carlos Torrez
- **Principal Investigator:** Steven A. Cornelissen

**Technology Maturity (TRL)**

- Start: 1
- Current: 2
- Estimated End: 3

**Closeout Documentation**

- Final Summary Chart: [https://techport.nasa.gov/file/13489](https://techport.nasa.gov/file/13489)
- Final Summary Chart Image: [https://techport.nasa.gov/file/21563](https://techport.nasa.gov/file/21563)
SBIR/STTR

Enhanced Reliability MEMS Deformable Mirrors for Space Imaging Applications, Phase I
Completed Technology Project (2011 - 2011)

Images

Briefing Chart
(https://techport.nasa.gov/image/)

Technology Areas

Primary:
- TX14 Thermal Management Systems
  - TX14.2 Thermal Control Components and Systems
  - TX14.2.8 Measurement and Control

For more information and an accessible alternative, please visit:
https://techport.nasa.gov/view/9489