Low-Voltage, High-Precision MEMS SLM

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The goal of this project is to make LLNL a leader in spatial light modulators (SLMs). By designing new lower voltage actuators, and bonding those actuators directly to controlling circuitry, we will overcome the fundamental limitations to the performance and scalability of MEMS SLMs (see Fig. 1).

SLMs are arrays of tiny movable mirrors that modulate the wavefronts of light. SLMs can correct aberrations in incoming light for adaptive optics or modulate light for beam control, optical communication, and particle manipulation. The first-generation MEMS SLMs have improved the functionality of SLMs while drastically reducing per-pixel cost, making arrays on the order of 1000 pixels readily available. By the nature of their designs, these MEMS SLMs are very difficult to scale above 1000 pixels, and have very limited positioning accuracy. By colocating the MEMS mirrors with CMOS electronics, we will increase the scalability and positioning accuracy. This requires substantial advances in SLM actuator design and fabrication (see Fig. 2).

Project Goals

The ultimate goal of this project is to make LLNL a leader in SLM technology. We will do that by demonstrating a small array (19 pixels) of MEMS mirrors that have an integrated closed-loop control system and a clear path to scaling that system up to thousands of pixels. We will also learn about bonding MEMS structures directly to controlling electronics.

Relevance to LLNL Mission

This work is relevant to a number of Laboratory projects, such as efforts in astronomy; nanolaminate deformable mirrors; laser control and beam-steering; and potentially in NIF preamplifiers. In biology, SLMs are useful for imaging and for particle manipulation.

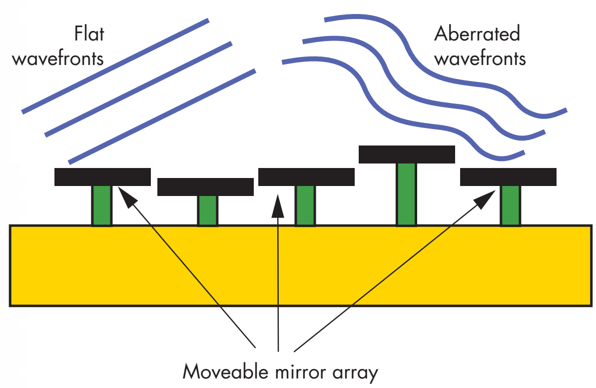

Figure 1. Schematic drawing of MEMS spatial light modulator.

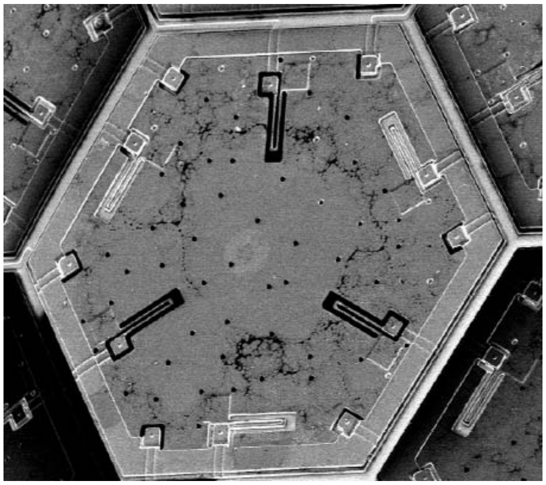

Figure 2. SEM of an actuator.

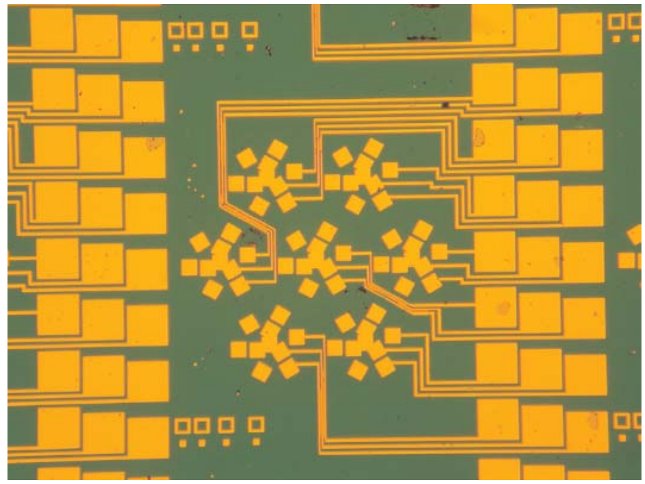

Figure 3. Microphotograph of dummy chip for bonding tests.

The bonding of MEMS to electronics has wide ranging applications, such as large-array chemical and biological sensors.

FY2004 Accomplishments and Results

We have made substantial progress in actuator design, fabrication, and electronics design.

We have created first-principles models of actuator structure; created optimal designs based on modeling work; designed a layout of the first-generation MEMS structures; fabricated the first-generation MEMS structures; demonstrated unbonded MEMS structures; and fabricated and delivered MEMS and dummy wafers to our bonding subcontractor (see Fig. 3).

We have moved toward a layout for the electronics chip that will eventually be bonded to the MEMS and control the SLM pixels. We have a schematic design for the analog circuits, and are poised to create a layout once software, technology files, and patent issues have been worked out.

Related References

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FY2005 Proposed Work

In the second year of this project, we will concentrate on integrating simple electronics with MEMS. We will fabricate the electronics that are currently being designed. We will make improvements to the SLM technology, and use the bonding technology for second-generation MEMS devices.