signal rose 7 times higher than the initial value. The optimized pulsewidth and output power were 80 fs and 100 mW. After the GA alignment, the pumping power was changed to 5.0 W and the system underwent re-alignment. From the Fig. 2, we can see that the output power improved by 2.2 times with the re-alignment. The position of M4 concave mirror was different by 9.5 μm from the optimized position at the pump power of 4.0 W. This shows that our system can automatically compensate nonlinearity in the laser cavity. We believe development of this technology will make more reliable and stable laser system in the future.

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CMN3 **10:45 am**

High Speed, Compact, Adaptive Optics Using MEMS Silicon Deformable Mirrors

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In the work described here, a MEMS DM having good optical quality was used for compensation of static aberrations in an optical system. The MEMS DM, manufactured by Boston Micromachines Corporation, is a 140 actuator, continuous silicon mirror. Its optoelectromechanical performance characteristics, which have been detailed elsewhere.[1–3]

To characterize the ability of the DM to correct for aberrations, the introduced aberration needed to be quantifiable and repeatable. For this, a second 37 element membrane deformable mirror manufactured by Flexible Optical BV was used.

A schematic of the optical test bed used is seen in Figure 1. The optical system was built to enable measurement of optical image quality both with and without MEMS DMs. A plane silicon mirror can be interchanged with a MEMS DM in the optical path. Both have front surfaces of uncoated silicon. The plane mirror has roughness of approximately 10 Angstroms (RMS), and is optically flat to within 10 nm (RMS) over the aperture of the beam, as measured using an optical contour-mapping interferometer. The plane silicon mirror was left uncoated, so that its inherent reflectivity would match that of the MEMS DM. Coatings on the MEMS DM and the plane mirror would increase reflectivity, and improve optical performance.

The controller uses a stochastic gradient descent algorithm for optical compensation.[4] While this algorithm is inefficient in comparison to model-based approaches employing Hartmann-Shack wavefront sensor feedback, its speed, parallelism, and simplicity make it attractive for use in a MEMS DM compact AO system.

Normalized peak intensity, defined as the peak intensity of an aberrated point image divided by the peak intensity of an unaberrated point image, was measured for several test cases:

1. No intentionally introduced aberrations, no DM in the beam path ($P \equiv 1.0$)
2. Static aberration, no DM in the beam path;
3. Static aberration, with DM in the beam path, uncontrolled; and
4. Static aberration, with DM in the beam path, controlled with AO feedback

The next generation compact, optical setup including a high speed photodetector, BU/BMC deformable mirror and an OKO deformable mirror is currently under development. The OKO deformable mirror and a software algorithm will be used to dynamically generate changing aberrations that resemble natural distortions in an optical wavefront. These aberrations will be corrected in real time with a BU/BMC deformable mirror and a high speed control system.

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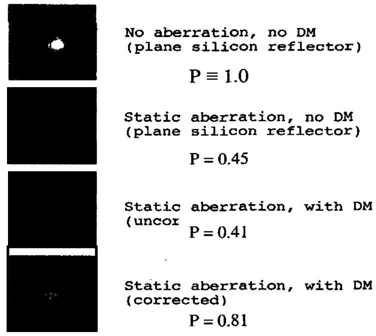
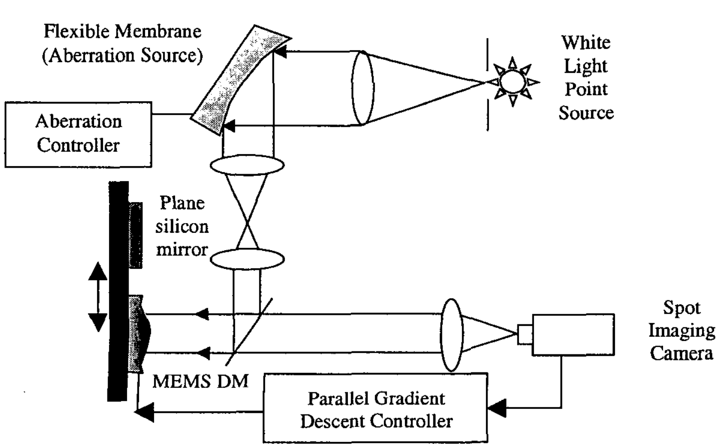


CMN3 Fig. 2. Measured spot images for optical test bed experiments with and without introduced aberrations and with and without MEMS DM control. Uncorrected Normalized Peak Intesity: 0.45. Corrected Normalized Peak Intensity: 0.81.



CMN3 Fig. 1. Schematic of the Adaptive Optics Test Bed, including the aberration source, the MEMS DM, and silicon reference mirror.

CMN4 **11:00 am**

The Use of a MEMS Mirror for Closed Loop Adaptive Optics in the Human Eye

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Introduction

AO can correct the wave aberration of the human eye, allowing high-resolution imaging of the retina in vivo and giving improvements in human vision beyond those provided by spectacles. However, the components of AO systems tend to be prohibitively expensive, especially the deformable mirror (DM) (~\$1000 per channel). In addition AO systems tend to physically large, primarily because of the size of the DM. MEMS mir-