Intellite

Affordable Adaptive Optics Systems

New MEMS deformable mirror manufacturing process and revolutionary designs brings affordable adaptive optics to a broader range of applications.

White Paper
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Contents

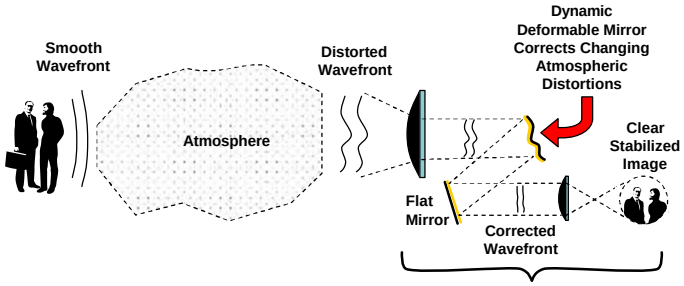
Adaptive Optics and Deformable Mirrors

Adaptive Optics:
Optical elements – typically mirrors – that can adapt their optical performance to compensate for poor optical quality of the light reflecting from them.

Deformable Mirrors:
Adaptive optics that have the ability to change the shape of a mirror surface to optimize the reflected light for a specific application.

Adaptive optics and deformable mirrors have been around almost as long as lasers. The use of adaptive optics has been limited by their significant complexity, and correspondingly high cost. Adaptive optic systems have typically cost over $100,000. These realities narrowed the application of adaptive optics to only the highest priced lasers or imaging systems. In the past, adaptive optics systems were hand built, and this lead to very long lead times, significant expense, and unpredictable functionality.

Deformable Mirrors (DMs) provide sharper images and tighter laser beams, even in a dynamic environment. For example, a long-range surveillance camera with a telephoto lens will record a distorted, fuzzy image due to wavefront aberrations caused by small variations in the atmospheric density between the camera and the subject being viewed. An extreme example of this effect can be observed above a blacktop road on a hot day. Adding a deformable mirror to the lens system, these "wrinkles" can be measured and removed to sharpen and clarify the image. The figure below illustrates this application.



Conceptual Illustration of Deformable Mirror Used to Improve Imaging in Long Range Surveillance Application

Intellite has lead the way in developing the first affordable, consistent quality, mass-produced deformable mirrors and adaptive optics that will revolutionize the laser and imaging world.

What Made This Breakthrough In Price Possible?

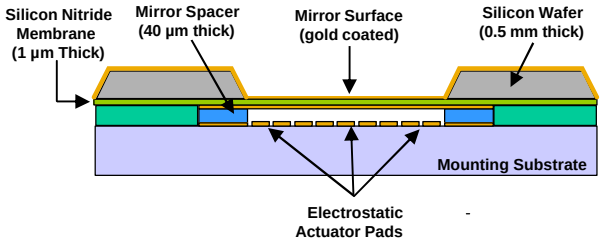
Development of MEMS (MicroElectroMechanical Systems) manufacturing technology, combined with unique mirror designs by Intellite, has allowed Intellite to fabricate deformable mirrors that are smaller, with greater functionality, at a fraction of the price of any previous Adaptive Optics components. Intellite's MEMS Deformable Mirrors start around $2,000 and turnkey Adaptive Optic Systems start at $15,000.

Using manufacturing processes similar to those used to make computer chips, Intellite has created a breakthrough in the price/performance ratio for deformable mirrors, which will open a new frontier of uses for Adaptive Optics. If you have backed away from considering Adaptive Optics for your laser or imaging projects because of cost, you need to seriously study our systems, and the multiple ways we can engineer our products to solve the most common problems of laser and imaging system users.

How Are Intellite Deformable Mirrors Made?
Intellite uses a technique called bulk silicon micro machining to fabricate its deformable mirrors. A standard 4-inch diameter, 1/2-mm thick silicon wafer is first coated on one side with a 1-micrometer thick layer of silicon nitride. Then a protective mask is applied to the other side of the wafer leaving a space the diameter of the finished mirror.

The wafer is then placed in an etch bath that eats away all of the bulk silicon in the area of the circular space, leaving only the thin layer of silicon nitride which is not affected by the etchant. Next, one side of the silicon nitride is gold coated to make it conductive and the wafer is placed over a hexagonal pattern of gold pads that will provide the electrostatic actuation for the silicon nitride mirror surface. The front side of the mirror can also be coated to improve reflectivity.

Finally, the unit is installed in an integrated circuit package and wires are bonded to the pads to connect them with the control circuit. The figure below is a side-view cross section of a deformable mirror illustrating the general structure of the device.



Major Frustrations Faced By Laser Makers And Users

Most lasers, particularly higher power devices, create an output beam with a less-than-perfect wavefront and “hot spots” – intensity variations – within the beam. This leads to the need to use more laser power than is actually required to accomplish the task (due to a varying spot size and quality), or results that are less than optimal because the focus is not as precise. A deformable mirror and Adaptive Optics system can correct most of the imperfections, and allow the laser to be lower powered and thus lower priced, and more productive. Intellite’s deformable mirrors and closed loop adaptive optics system called Clarifi™ have gone one better — it can continuously change the shape of the laser beam several hundred times per second.

What Applications Could Benefit From These Adaptive Optics Systems?

Deformable mirrors have the potential to revolutionize laser and optical systems. Here are some of the potential applications:

- **Laser Machining, Welding and Cutting** — by taking more of the laser's power and creating a tighter, more focused beam, with fewer hot spots, Clarifi will improve the output of many industrial laser systems, while lowering the initial cost of the hardware along with the ongoing operating expense. This was not possible before Intellite developed their cost effective Clarifi Adaptive Optics System that can be integrated either externally or internally to almost any laser.

- **Biomedical Imaging** — many of the instruments used in biomedical imaging could benefit from improved focus, clarity, and resolution. For example, experiments with Intellite's deformable mirrors show a significant improvement in the performance of an ophthalmoscope. This might help diagnose conditions like Macular Degeneration before any other known diagnostic technique, simply because adaptive optics can correct for optical aberrations and imperfections in the human eye's lens.

- **Large-Aperture Cameras** — the massive cost of large, high-quality lenses required for long range, high-resolution, low-light cameras is prohibitive for most applications and users. Low cost adaptive optics systems will correct the aberrations from inexpensive lenses, even lightweight plastic lenses, and allow the entire system to be far more affordable, while delivering high quality results.

- **Optical Communications** — free-space optical communications have a distinct advantage over radio-frequency communications– wireless links cannot be intercepted, are un-jammable, and low powered. However, they have two drawbacks beam divergence and atmospheric distortion. Deformable mirrors can correct both problems in an adaptive optics system. Applications include satellite communication space-to-space, space-to-aircraft, and space-to-ground, and the last mile of data transmission to link fiber optic trunks to end-user equipment.

- **Surveillance Imaging Systems** — atmospheric distortions and vibrations affect video monitoring and recording systems. Adaptive optics will overcome these problems with real-time deformable mirrors, at affordable prices.

Additional applications include Laser Rangefinders, Designators, and Trackers; and Space Observation and Photography. These areas are but a few of the potential applications for deformable mirrors and adaptive optics.

It is important to realize that Intellite's unique designs, combined with mass-produced, high quality, MEMS deformable mirrors, allows us to creatively discuss a wide array of potential solutions to your laser beam and imaging needs.

Intellite has done much more than produce some innovative deformable mirrors. Their systems approach means they have developed all of the necessary hardware and software to deliver a working solution for your applications. We also have the ability to customize much of our technology to fit the specific needs of our varied customer base.

Please review our website http://www.intellite.com, for additional details on our solutions to Adaptive Optics needs. We will also be keeping you updated on the newest developments in our deformable mirrors and complete systems through a series of educational briefings, and application stories.

CLARIFI™ System

Intellite's Products

Intellite's product line revolves around building deformable mirror systems to perform adaptive optics in our customer's optical system or product.

MULTI™

CLARIFI™ — An affordable closed loop adaptive optics system for a broad range of applications. Built around the Intellite MULTI / FOCI / ENDI™ mirror, our specialized Drivers, and your PC, CLARIFI**™** can be adapted to clean up your laser beam or image.

MULTI™ — A membrane deformable mirror in a clean, rugged package. Available in 16mm or 25mm sizes with 37 hexagon actuators or custom to your requirements.

FOCI™ — A membrane deformable mirror with five actuators or providing simple focus and/or tilt. Available in 5mm or 10mm sizes.

FOCI™

ENDI™ — A specialized deformable mirror/lens combination for laser resonator or beam expander applications. Available with a selection of lenses in a 16mm or 25mm diameter.

DRIVERS — Specifically designed or Intellite electrostatic deformable mirrors. DI models drive 32 or 40 actuators up to 4kHz. AX models stack in units of 32 channels, from 32 to 1024 channels. Provides a parallel port interface between your PC and MEMS devices. Specified for 200v at 1 kHz.

ENDI™

Visit the Intellite web site at http://www.intellite.com to view a demo of the CLARIFI System and for the specifications for each product.