

Lemoptix MEMS Scanning Micromirrors

MEMS Technology

MEMS (MicroElectroMechanical-Systems) technologies are derived from the classic microelectronics industry. MEMS components are today fabricated and integrated in a large range of applications (e.g. in the automotive industry to control airbags). Excellent long-term reliability of silicon-based MEMS is one of the main reasons for adoption.

Optical MEMS Scanning Micromirrors: Resonant or static operation

Lemoptix's micromirrors made of single-crystal silicon demonstrate very high robustness and long-term stability. Unique features of MEMS scanning micromirrors are:

- **Ultra-small size**
 - **Low operating voltage (below 5V)**
 - **High operating frequency**
 - **Static operation**
 - **Low power consumption**
 - **Linear mirror deflection with applied signal**
- The surface reflectivity is enhanced by a thin coating of metal material. The fabrication being highly flexible, a large variety of materials can be coated, depending on the wavelength used.
 - Lemoptix's resonant and static scanning micromirrors are designed to periodically rotate and deflect light.



Chip on 3mm x 10mm standard PCB board (including magnets)

Possible Applications

Due to the unique combination of performance and size, many optical applications can benefit from Lemoptix's scanning micromirrors:

- **Barcode scanners:** MEMS scanning micromirrors are ideal for long range laser barcodes and small scanning module heads.
- **Endoscopy/confocal microscopy:** Tiny scanning micromirrors can be used in endoscope heads or in confocal microscopes.
- **Optical spectrometers:** Lemoptix's technology is suitable for low cost, high sensitivity and ultra-large spectrum optical spectrometers.
- **Medical imaging:** Suitable for high speed high resolution medical imaging.

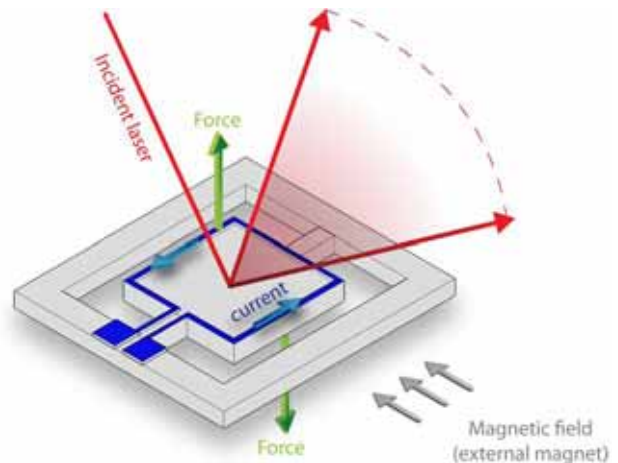
Lemoptix MEMS Scanning Micromirror Technology

Magnetic actuation principle and characteristics

MEMS mirror actuation does not use gearing effects or any other mechanical contact-based effects. It uses an innovative fatigue-free magnetic actuation: an electric current flowing on the mirror itself, under a magnetic field, induces mechanical displacement, advantageously used for optical scanning.

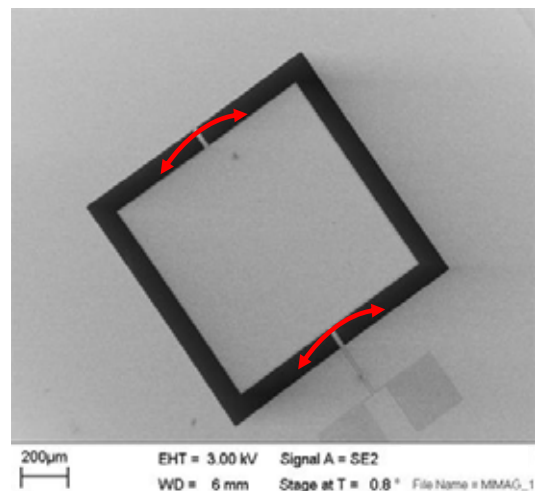
Resonant actuation: specifically designed MEMS mirrors to be actuated at their mechanical resonant frequency. The maximum intrinsic silicon material gain is used to obtain the widest possible scanning angle at an ultra-low power consumption level.

Static actuation: specifically designed MEMS mirrors to be actuated in static operation, meaning that the mirror is tilted and the position is held stable.



Achievable performance range

| | |
|---------------------------|----------------------------|
| Actuation | 1D (1 axis) or 2D (2 axis) |
| Micromirror size | Up to 6mm |
| Scanning angle | Up to 60° (optical) |
| Light reflection | > 90% in visible and IR |
| Shock resistance | > 2000g |
| Actuation voltage | < 5V |
| Resonant Frequency | From 500 Hz to 70 kHz |
| Static actuation | From fix steps to 400Hz |
| Consumption | From 0.1mW to 100mW |
| Chip size | Down to 3mm x 3.5mm |

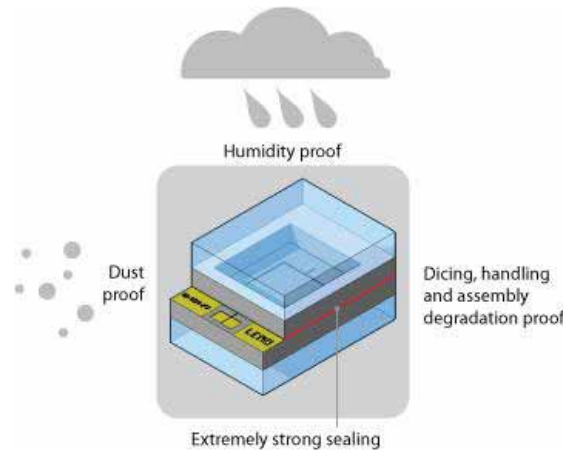


1D magnetic micromirror (deflection around central axis)

Fully Hermetic Packaged MEMS Mirrors

Lemoptix has developed unique and proprietary fully hermetically packaged MEMS scanning mirror technology. Packaged MEMS devices are a key requirement for high volume / low cost manufacturing, generating a high fabrication and assembly yield. Lemoptix packaged MEMS scanning mirrors are therefore totally protected:

- No manipulation damages
- No humidity
- No dust and particle contamination



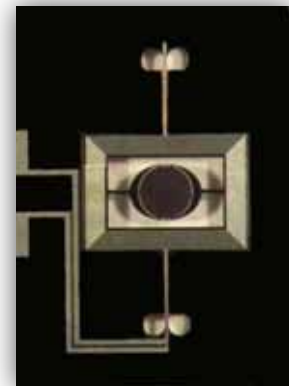
Lemoptix Services and Products

Customized scanning micromirrors design

- Specific design of 1-Dimensionnal or 2-Dimensionnal MEMS micromirrors to suite exactly your needs
- Micromirror frequency and size design. Various possible reflective materials (Al, Au) depending on wavelength.

Assembly and mounting

- MEMS micromirror can either be delivered fully encapsulated or not encapsulated, depending on the application
- MEMS micromirrors are usually mounted as a standard on a rigid PCB
- Other assembly options are compatible with Lemoptix MEMS micromirrors processes, including mounting on ceramic or flexible PCB



2D MEMS micromirror



Fully hermetically encapsulated MEMS micromirror

Driving and sensing electronics

- Lemoptix can provide high performance driving electronics to drive the MEMS mirror and give information of the mirror tilting position at any time.
- Analog and Digital electronics can be provided to ensure rapid and easy use of Lemoptix MEMS micromirror on any existing electronics platform.

Lemoptix standard 1D Scanning Micromirror Performances

1. Resonant MEMS mirrors

| Characteristics | F3 | F4 | F5 | F6 | F7 |
|---|----------------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| Mechanical resonant frequency (+/- 4%) | 3.3 kHz | 5 kHz | 11 kHz | 15 kHz | 19.5 kHz |
| Max total optical tilt angle (+/- 4%) | 60° (for +/- 1.5V) | 50° (for +/- 2.5V) | 30° (for +/- 5V) | 24° (for +/- 5V) | 18° (for +/- 5V) |
| Max mechanical tilt angle | +/-15° | +/-12.5° | +/-7.5° | +/-6° | +/-4.5° |
| Mirror size, rectangular shape (X,Y) in mm ² | 1 x 1 | 1 x 1 | 1 x 1 | 1 x 1 | 1 x 1 |
| MEMS chip size with magnets (Width, Length, Height) | All similar: 3mm x 3.5mm x 2.3mm | | | | |
| PCB mounted size (Width, Length, Height) | All similar: 3mm x 10mm x 3.1mm | | | | |
| Reflectivity (450 to 700 nm) | > 90% | > 90% | > 90% | > 90% | > 90% |
| Shock resistance | >4'000g | >4'000g | >4'000g | >4'000g | >4'000g |
| Input impedance (+/- 5%) | ~50Ω | ~50Ω | ~50Ω | ~50Ω | ~50Ω |
| Power consumption (instantaneous) | 10mW (at 1.5V) | 30mW (at 2.5V) | 130mW (at 5V) | 130mW (at 5V) | 130mW (at 5V) |
| Mirror flatness | < 100nm | < 100nm | < 100nm | < 100nm | < 100nm |
| Reliability testing | > 10 ¹¹ cycles | > 10 ¹¹ cycles | > 10 ¹¹ cycles | > 10 ¹¹ cycles | > 10 ¹¹ cycles |
| Product part number | 1D1-F3 | 1D1-F4 | 1D1-F5 | 1D1-F6 | 1D1-F7 |

- These standard available micromirrors are actuated with AC voltage, at mechanical resonance
- These standard available micromirror are delivered on rigid PCB without glass packaging

2. Static MEMS mirrors (steering mirrors)

| Characteristics | DC2 | DC3 |
|---|------------------------------------|---------------------------|
| Max optical tilt angle (in static mode) | 30° | 30° |
| Mechanical resonant frequency (+/-4%) | 700 Hz | 1200 Hz |
| Mirror size, rectangular shape (X,Y) in mm ² | 4.1 x 1.1 | 2.6 x 2.6 |
| MEMS chip size with magnets (Width, Length, Height) | All similar: 4.9mm x 7.8mm x 2.3mm | |
| PCB mounted size (Width, Length, Height) | All similar: 4.9mm x 12mm x 3.1mm | |
| Reflectivity (450 to 700 nm) | > 90% | > 90% |
| Shock resistance | >4'000g | >4'000g |
| Input impedance (+/- 5%) | ~450Ω | ~400Ω |
| Power consumption (instantaneous) | 35mW (at 3.7V) | 35mW (at 3.7V) |
| Mirror flatness | < 100nm | < 100nm |
| Reliability testing | > 10 ¹¹ cycles | > 10 ¹¹ cycles |
| Product part number | 1D1-DC2 | 1D1-DC3 |

- These standard available micromirror are delivered on rigid PCB without glass packaging

Lemoptix

Your partner for innovative and reliable optical scanning solutions