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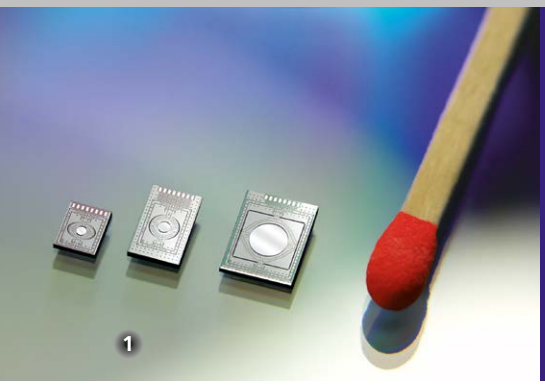
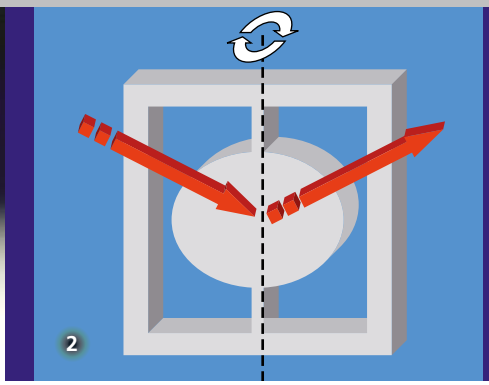
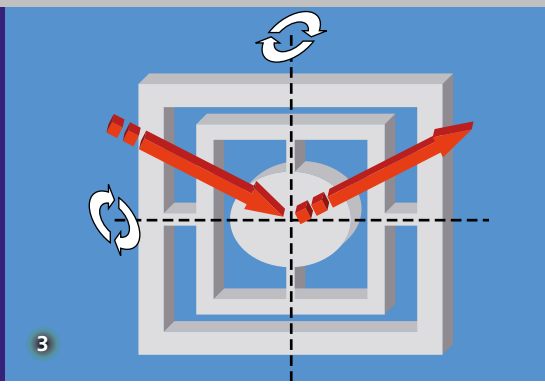
FRAUNHOFER INSTITUTE FOR PHOTONIC MICROSYSTEMS IPMS







1 *Comparison of the sizes of microscanners.*
2 *Operation principle of 1D microscanner mirror.*
3 *Operation principle of 2D microscanner mirror.*

RESONANT MICROSCANNERS

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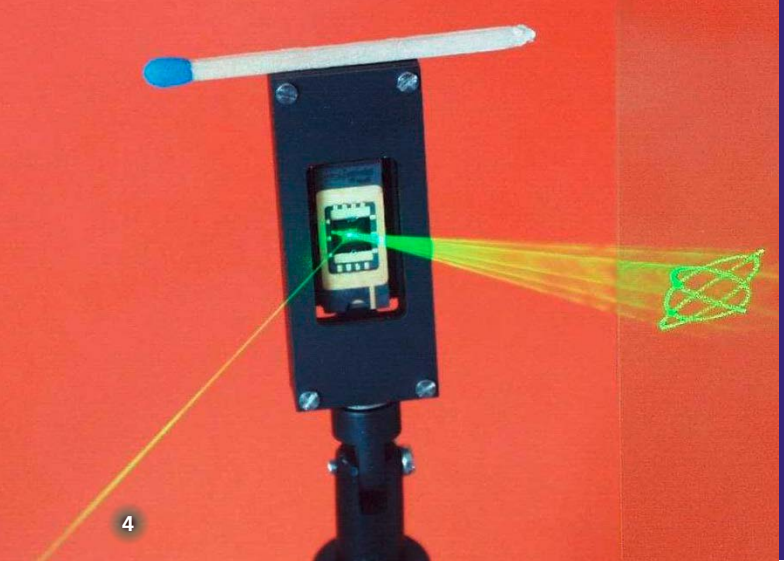
Introduction

Fraunhofer IPMS has a long and successful track record in developing and fabricating customized highly miniaturized resonantly operated MEMS scanners. The devices feature large scan angles, high scan frequencies and show excellent long-term stability. A qualified CMOS compatible bulk micromachining process is used to fabricate 1D and 2D microscanners in small and medium volumes. The scope of application is continuously increased by means of novel and patented design solutions as well as application-specific process modules. Up to now more than 150 designs were fabricated in the 1500 m² class 10 clean room facilities of the institute.

Standard fabrication process and options

A standard MEMS process is available using BSOI wafers. Application-specific process modules provide high flexibility and enable meeting the requirements of a huge variety of applications.

All the mechanically loaded elements like springs and mirror plates are made from monocrystalline silicon. This material is characterized by excellent elastic and fracture mechanical properties. In particular, due to the lack of grain boundaries, no fatigue is observed during operation.



Properties of Microscanners

Mirror form	Square, elliptical or circular
Scan frequencies	Depending on configuration 0.1 - 100 kHz
Optical scan range	Up to 120°
Mirror diameter	Typical: up to 5 mm (1D), up to 2 mm (2D)
Reflection coefficient	App. 90% (standard coating)

Our standard mirror coating provides a reflection coefficient of approximately 90% in the visible range. For higher demands, a customized dielectric high-reflecting coating can be deposited. Another option is the integration of a piezoresistive sensor to determine the angular position of the mirror plate.

Technical Properties

The mirror plate of the microscanner device performs a continuous, harmonic oscillation. The driving utilizes in-plane electrostatic combs. Adjusting the driving voltage or the driving frequency allows setting and controlling the oscillation amplitude. For 2D devices, the mirror plate is gimbal-mounted. The resonance frequency of each axis is determined by design independently. Each axis is excited individually. Thus, the ratio of the oscillation amplitudes and the phase difference can be set and controlled arbitrarily. Depending on design and parameter combination, the microscanner devices have the following technical properties:

- Large optical scan range up to 120°
- Scan frequency: 100 Hz - 100 kHz
- Mirror diameter up to 5 mm
- High shock resistance of at least 2500 g
- Driving voltage typically 15 - 200 V
- High static planarity (radius of curvature > 5 m)
- High dynamic planarity (typically better than λ/20)
- Position detection: integrated or at package level
- Generation of trigger signal and amplitude-proportional signal (requires control circuit)

Operation

The resonant microscanners are operated with a square-wave voltage, which e.g. can be supplied by a commercial function generator (plus amplifier if required). Alternatively, Fraunhofer IPMS offers development of scanner-specific control circuitry comprising trigger generation and amplitude control.

Applications

- Projection displays
- Imaging, e.g. for technical and medical endoscopy
- Barcode / datacode scanning
- Spectroscopy
- Laser marking and material processing
- 3D metrology / triangulation
- 3D cameras
- Object detection / 1D and 2D light curtains
- Confocal microscopy / OCT
- Scanning fluorescence microscopy
- Laser wavelength modulation

4 2D microscanning mirror. The oscillation frequency ratio is 5:6.