

- 1 Ceramic-packaged $48\mu\text{m}$, 512×320 Tip-Tilt Micro Mirror Array
- 2 SEM photograph of single pixels (mirrors partly removed)

512 x 320 TIP-TILT MICRO MIRROR ARRAY FOR OPTICAL BEAM STEERING

The Device

The Fraunhofer IPMS has developed a novel Tip-Tilt Micro Mirror Array (MMA) for applications in optical beam steering.

The device consists of 512×320 individually addressable mirrors at $48\mu\text{m}$ pixel size. The actuators are designed to provide a 2-axis-tip-tilt motion, allowing a continuous, analog deflection of up to 3.5° in arbitrary directions, fully calibratable at standard deviations of better than 0.025° .

They are realized within a 2-level architecture with 4 suspending flexure beams underneath and the mirror on top. Fabrication is done by surface-micromachining in a fully CMOS compatible process.

The mirrors are electrostatically activated by 4 underlying address electrodes. The required drive voltages are fed in via an integrated CMOS backplane supporting re-programming rates of up to 3.6 kHz.

For data transfer and control also an external drive electronics has been developed comprising a main unit and a satellite board hosting the MMA chip.

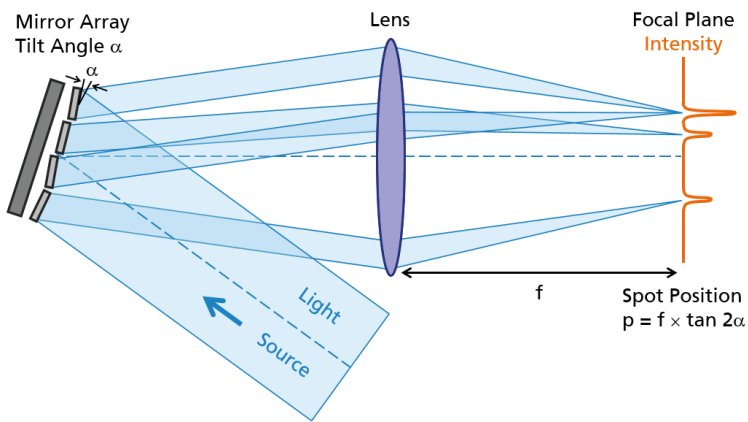
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3 Optical principle: pixelwise redirecting of light

4 Examples of generated 2D intensity patterns

Working Principle

The optical working principle relies on a pixel-wise re-distribution of light. Each mirror creates a beamlet that can be positioned arbitrarily within the focal plane of a subsequent lens. This might be used for a simple redirection of light beams or for the formation & control of variable 2D intensity profiles, patterns or shapes. Since there are no blocking or filtering elements involved, a higher light efficiency (higher brightness using lower powers) is facilitated.

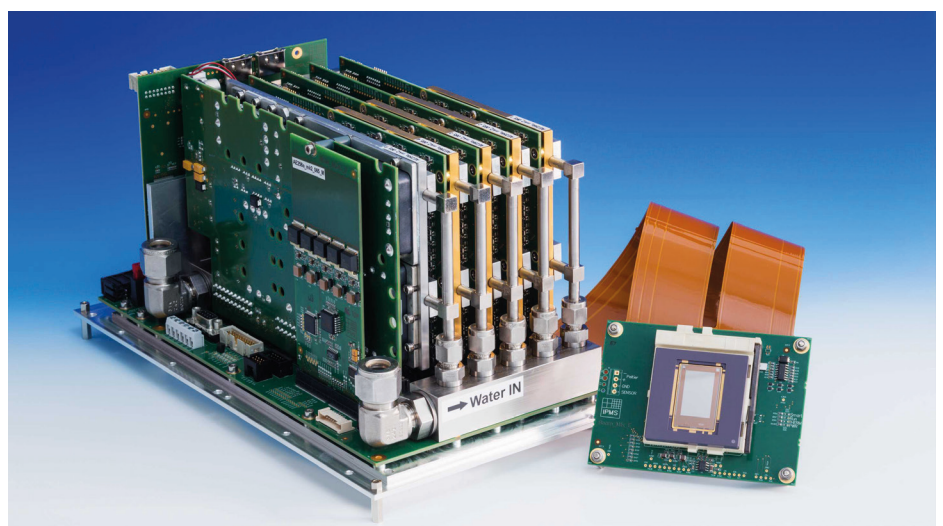
Possible Applications

- Laser Beam Shaping
- Laser Spot Tracking
- Programmable Illumination
- Laser Material Processing: Laser Ablation, Engraving or Cutting

Key Parameter

Parameter	Value	Remark
Array Format	512 x 320	optional: 342 x 213
Pixel Size	48 μm	optional: 72 μm
Array Area	$2.5 \times 1.5 = 3.8 \text{ cm}^2$	
Deflection Range	3.5° in any direction	
Accuracy (1σ)	$< 0.025^\circ$	
Fill Factor	$> 92\%$	
Reflectance	$> 85\%$ (DUV – IR)	wavelength-tuning possible
Light Power Density	$< 50 \text{ W/cm}^2$	typical range*
Chip Frame Rate	3.6 kHz	
Chip Power Dissipation	10 W	
Ext. I/F Data Rate	20 Hz	upgrade option to 3.6 kHz

*: actual value may differ depending on specific irradiation conditions



Complete system: micro mirror chip with external drive electronics