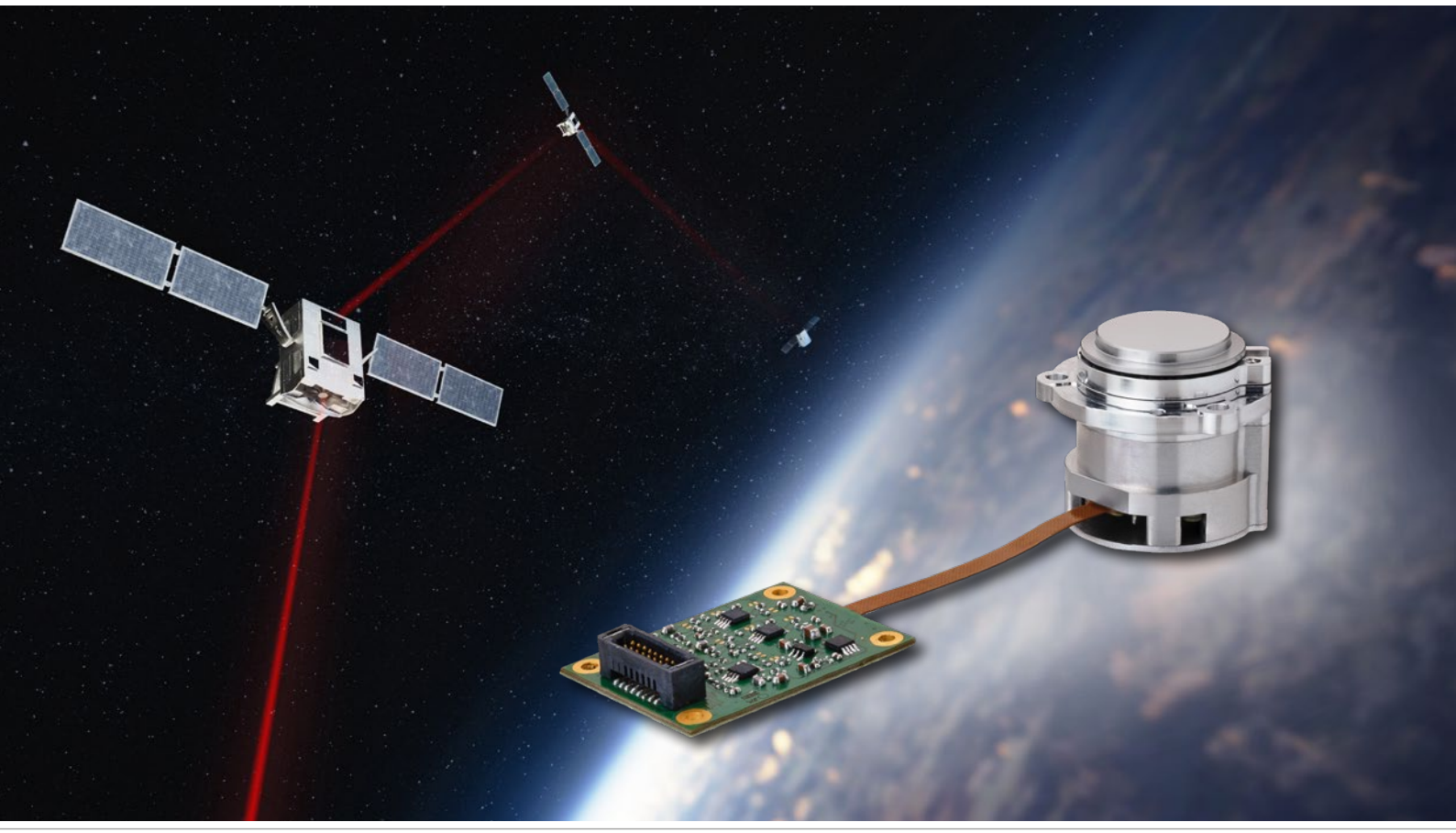
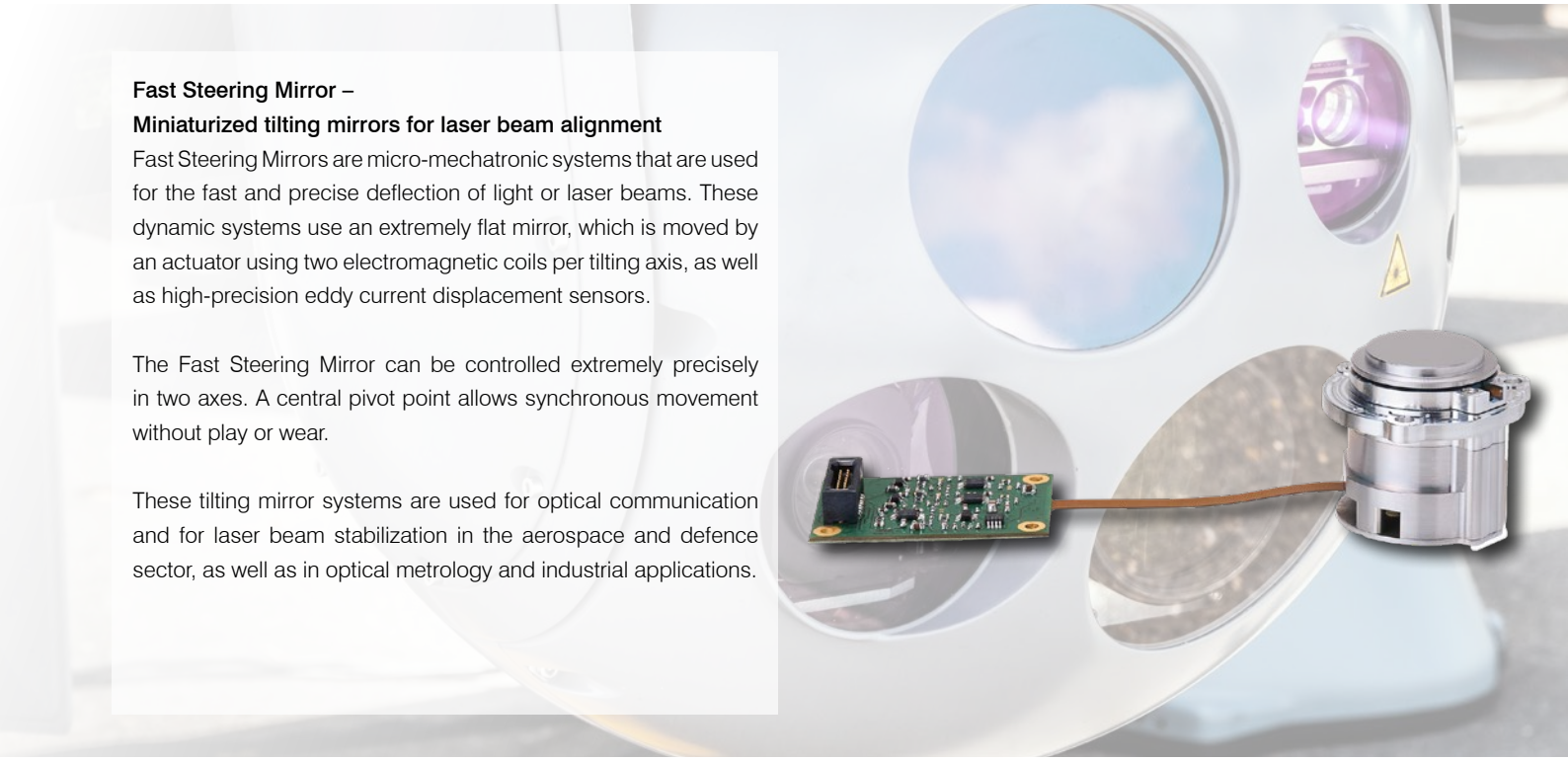
MICRO-EPSILON

More Precision

FSM3000 // Fast Steering Mirrors for precise laser beam steering



Highly dynamic and robust tilting mirror systems
FSM3000



Fast Steering Mirror –
Miniaturized tilting mirrors for laser beam alignment

Fast Steering Mirrors are micro-mechatronic systems that are used for the fast and precise deflection of light or laser beams. These dynamic systems use an extremely flat mirror, which is moved by an actuator using two electromagnetic coils per tilting axis, as well as high-precision eddy current displacement sensors.

The Fast Steering Mirror can be controlled extremely precisely in two axes. A central pivot point allows synchronous movement without play or wear.

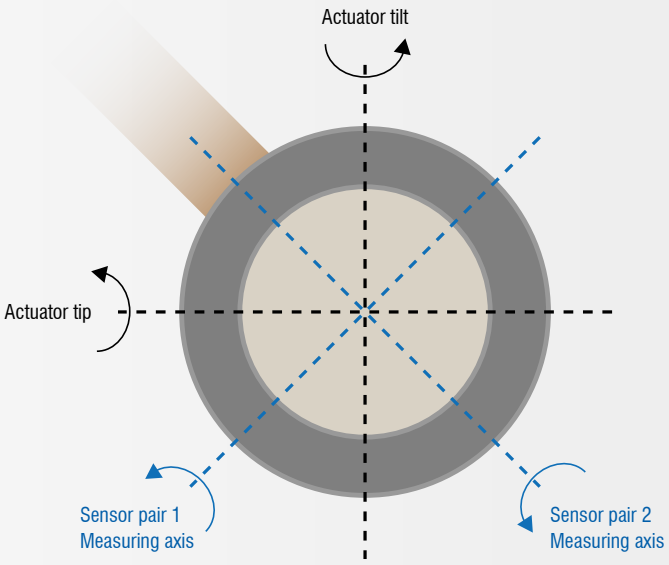
These tilting mirror systems are used for optical communication and for laser beam stabilization in the aerospace and defence sector, as well as in optical metrology and industrial applications.

Functional principle

Fast Steering Mirrors from Micro-Epsilon are based on the voice coil principle. The mirror is moved by four actuator coils, two of which form an axis of rotation. Feeding the coils with current creates a magnetic field around the coil, which generates a torque and tilts the mirror around the axis of rotation (tip/tilt). This is done wear-free and via a central pivot point.

Four temperature-stable, integrated eddy current sensors determine the position of the mirror. Two opposing sensors define a measuring axis and are offset against each other in order to obtain the tilt component of the signal and output it in analog form. In addition, another sensor monitors the temperature in the FSM and outputs them. The actual mirror position is determined very precisely using a linearization polynomial, which also takes the temperature signal into account.

In closed-loop operation, for example, this result can be offset by the customer as an actual angle value against a set point in the controller, and the current provided by the power electronics can be controlled by the actuator coil.

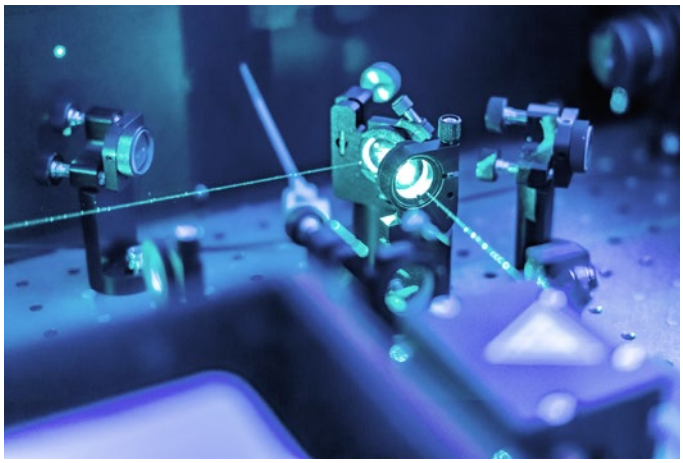


Fields of applications

Industries
- Aviation
- Defense
- Optical measurement technology
- Semiconductors

Applications
- Laser communication
- Laser-based processing
- Optical imaging
- Tracking

Satellite communication
The Fast Steering Mirror is used to guide laser beams in a low-earth orbit over thousands of kilometers and at speeds of 25,000 km/h in order to establish secure satellite communication. Based on an extremely robust design, the FSM3000 operates very precisely and reliably even in orbit.



Laser micromachining
Fast Steering Mirrors enable fast, high-resolution control and are therefore used for inline alignment of lasers, e.g., in the manufacture of gratings and waveguides or in dicing and laser etching applications. Crucial factors are the high tilt frequency and precision, which remain stable over the long term due to excellent control performance.

Tracking
For the optical tracking of objects or vehicles, e.g. by drones, Fast Steering Mirrors take over the laser-based communication between the drone and a ground station.

Image stabilization
For fast imaging, lenses must remain as stable as possible during movement in order to produce sharp images. The Fast Steering Mirrors support the compensation of the lens movements so that each individual shot can be taken in quasi-still. The fine alignment and fast response of the FSM are particularly advantageous here.

Highly dynamic and robust tilting mirror systems
FSM3000

- High dynamic range with excellent control behavior up to 1.5 kHz
- Large tilt angle of ±1.5° (26 mrad)
- High-resolution position measurement <0.3 µrad (RMS, 0 - 10 kH)
- Compact design, large mirror (Ø20 mm)
- Robust and stable for aerospace & defense, optics and industry
- Optimized for series applications

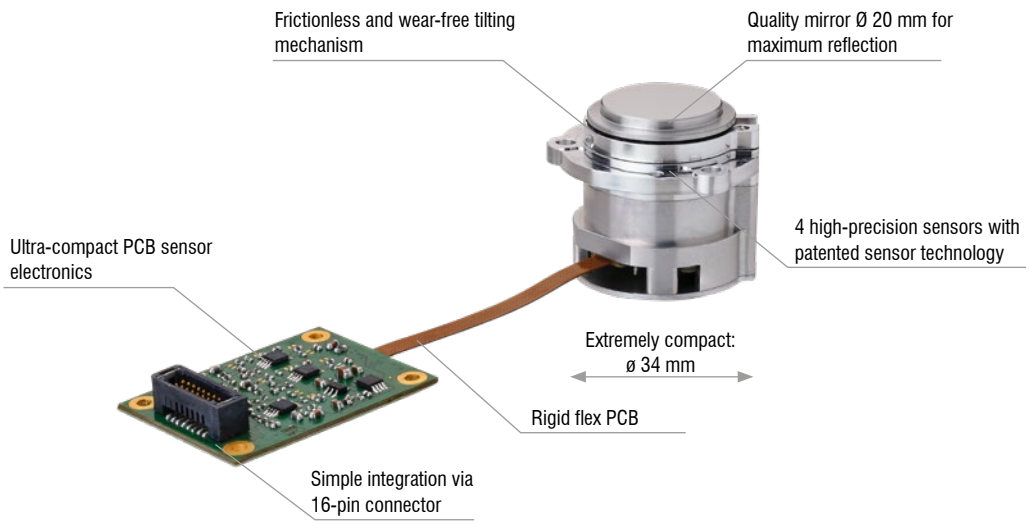
Outstanding combination of dynamics & tilt angle

The Fast Steering Mirrors FSM3000 are compact, miniaturized tilting mirrors that are used for precise steering or targeted positioning of laser light. The FSM3000 is characterized by a large movement range of ±1.5° per tilting axis combined with a short response time, allowing dynamic applications to be solved with high precision.

High-precision mirrors with excellent surface quality and high reflectivity also ensure virtually loss-free deflection of the light with low heating.

Robust and stable in the open field right into space

The FSM3000 tilting mirror systems impress with their robustness, compact design and low weight. This makes them not only easy to integrate, but also extremely resilient, e.g. to withstand strong shocks and vibrations during rocket launches, even without a launch lock. The systems also operate extremely reliably in space or in a vacuum.



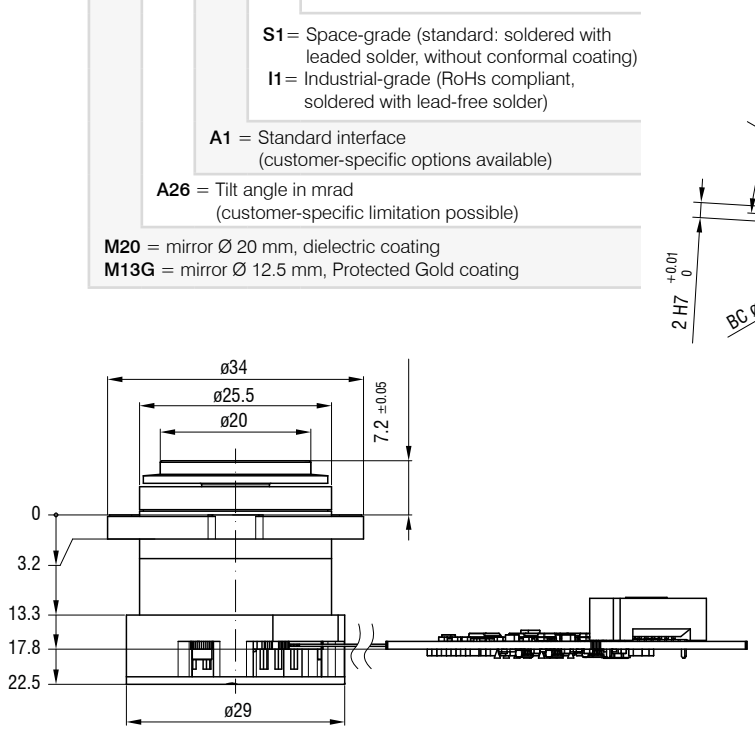
Model		FSM3000-M20-A26/A1/S1
Number of axes		2 (tip-tilt)
Tilt angle [1]		nominal ±1.5° (26 mrad)
Resolution		< 0.3 µrad (RMS, 0 - 10 kHz)
Linearity [2]		< 0.15 % FSO
Tilt frequency		up to 2 kHz
Supply voltage		Sensor: +5 V (±2 %), optionally +8 V (±10 %)
Power consumption		Sensor: < 0.5 W Actuator: static 115 mW at 1.5° (nominal)
Max. current consumption		Actuator: approx. 7 mA/mrad
Coil resistance		4.2 Ω ±0.5 Ω
Inductivity		540 µH ±40 µH
Analog output		Angle: -4 ... +4 V (per axis) Temperature: 0 ... +4.5 V (115 ... -50 °C, non-linear)
Connection		16-pin connector type Samtec TFM-108-02
Mounting		Mirror: Screw connection via 3 mounting holes (through-hole Ø 3.2 mm) Sensor electronics: Screw connection via 4 mounting holes (through-hole Ø 2.2 mm)
Temperature range	Storage	-40 … +80 °C
	Operation [3]	-10 ... + 65 °C (-40 ... +80 °C)
Shock (DIN EN 60068-2-27)		approx. 220 g / 100 Hz > 400 g (x/y), 600 g (z) / 2 kHz
Vibration (DIN EN 60068-2-6)		up to 55 g RMS
Material		Aluminum housing; soldering process: leaded (for Space FSM3000... /S1), optionally lead-free (Industry FSM3000... /I1)
Weight		approx. 55 g
Protocol format		JSON (optional XML) Contains polynomial coefficients, temperature coefficients and other information
Mirror parameters		
Substrate		Aluminum
Coating		Dielectric (optionally Protected Gold)
Mirror size		Ø 20 mm (optionally Ø 12.5 mm with FSM3000-M13)
Free aperture		> Ø 18.5 mm (optional 11.3 mm)
Reflectivity		> 99.3 % (@1550 nm)
Surface deviation [4]		26 nm RMSt

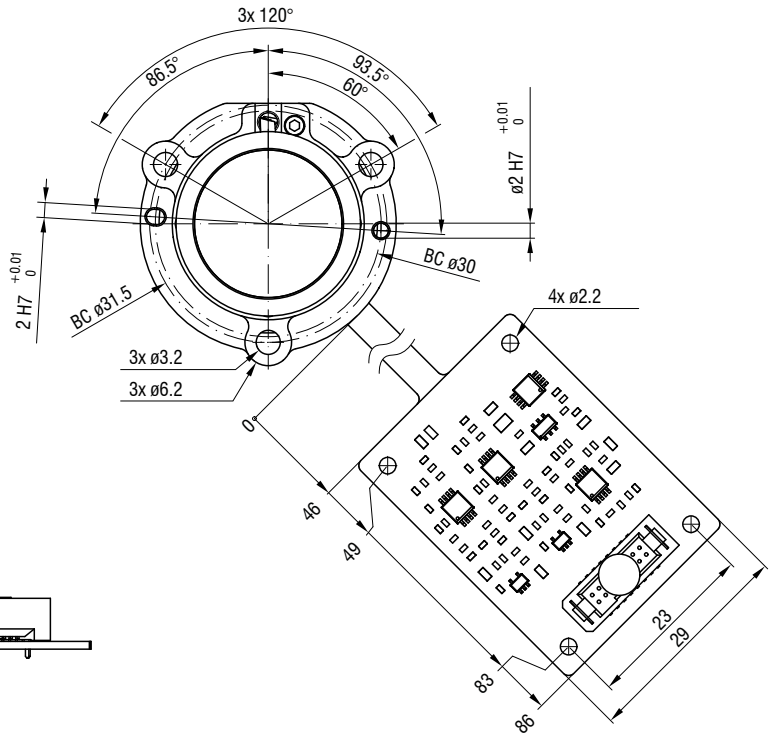
[1] from ~ 200 Hz with reduced tilt angle
[2] FSO = Full Scale Output; value after applying the linearization polynomial
[3] -40 … +80 °C with reduced performance in terms of local temperature sensitivity and wavefront error
[4] Room temperature, 20 mm mirror

Article designation

FSM3000 -M20 -A26 /A1 /S1

- **S1** = Space-grade (standard: soldered with leaded solder, without conformal coating)
  I1 = Industrial-grade (RoHs compliant, soldered with lead-free solder)
- **A1** = Standard interface (customer-specific options available)
- **A26** = Tilt angle in mrad (customer-specific limitation possible)
- **M20** = mirror Ø 20 mm, dielectric coating
  M13G = mirror Ø 12.5 mm, Protected Gold coating

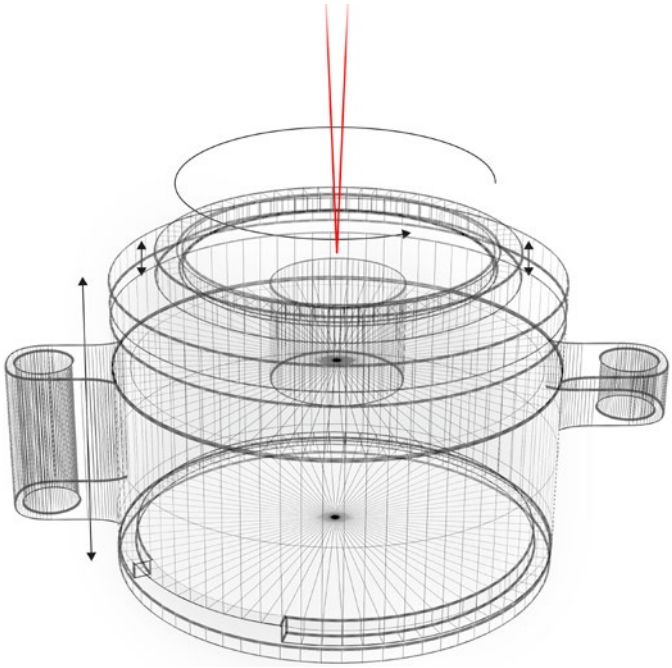




Fast Steering Mirror – Customer-specific development and modification

From catalog products to OEM:
optimized tilting mirror systems for series use

With the FSM3000 series, Micro-Epsilon offers a versatile portfolio: systems with standard mirrors (COTS), customer-specific modifications (MOTS) and OEM developments for series applications. Based on state-of-the-art technologies and specialized manufacturing processes, we implement cost-effective complete solutions – even for the most demanding requirements.

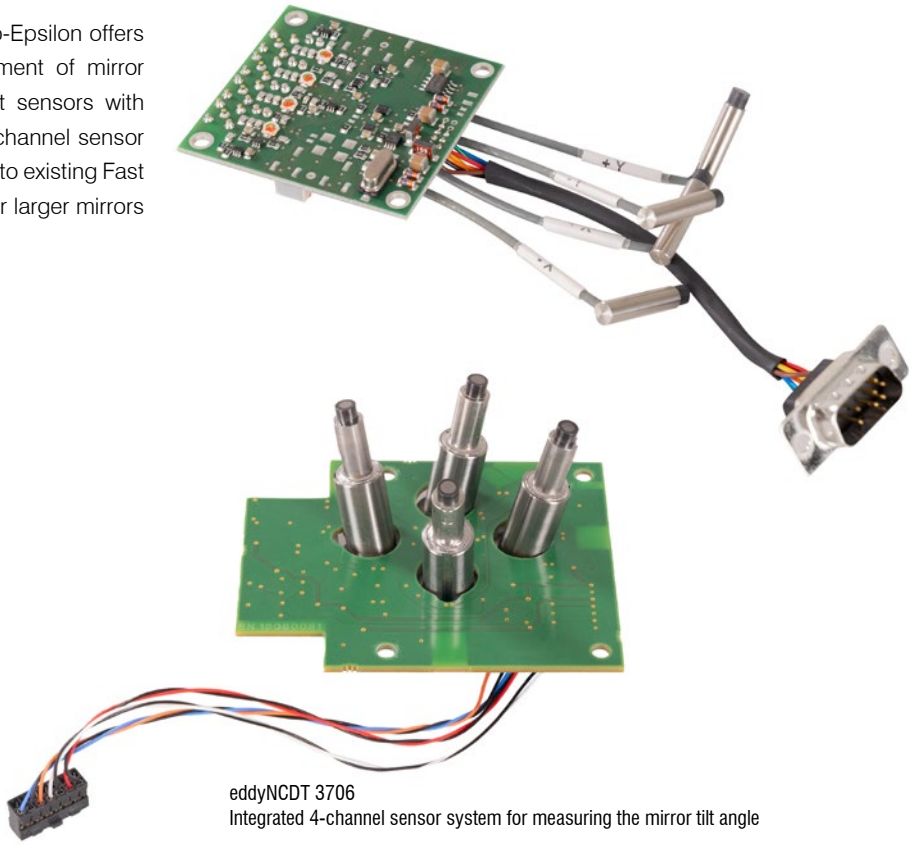


Typical modifications for OEM applications:

- Mirror diameter
- Coating (depending on the required laser power)
- Sensor electronics (form factor)
- Leaded for space / lead-free for industrial applications
- Length of flex PCB
- Mounting interface

Sensor solutions for high-precision measurement of mirror tilt angles

In addition to the complete tilting mirror systems, Micro-Epsilon offers special sensor systems for high-precision measurement of mirror tilting angles. These systems use four eddy current sensors with optimized resolution and frequency response. The 4-channel sensor systems are integrated directly – either standalone or into existing Fast Steering Mirror systems – and are used in particular for larger mirrors or special positioning requirements.



eddyNCDT 3706
Integrated 4-channel sensor system for measuring the mirror tilt angle

Modern manufacturing processes for high-precision systems

Micro-Epsilon is a leading global supplier of displacement sensors and measurement technology with decades of experience in development, production and application. In-depth technology, application and industry knowledge enable efficient and targeted development of catalog solutions and OEM series products. State-of-the-art production facilities and automated processes help to realize large production batches with high demands and quality requirements from the "New Space".

Sensor expertise

Our sensor products are developed with foresight: they are compact, very robust, easy to integrate, and operate reliably and precisely in almost all environments.

More precision

The FSM3000 systems use the world's leading eddy current sensor technology: extremely robust, accurate and highly dynamic for high-precision position monitoring.

Highest quality

High-quality mirrors with excellent reflectivity and surface quality reduce optical losses to a minimum.

Flexibility

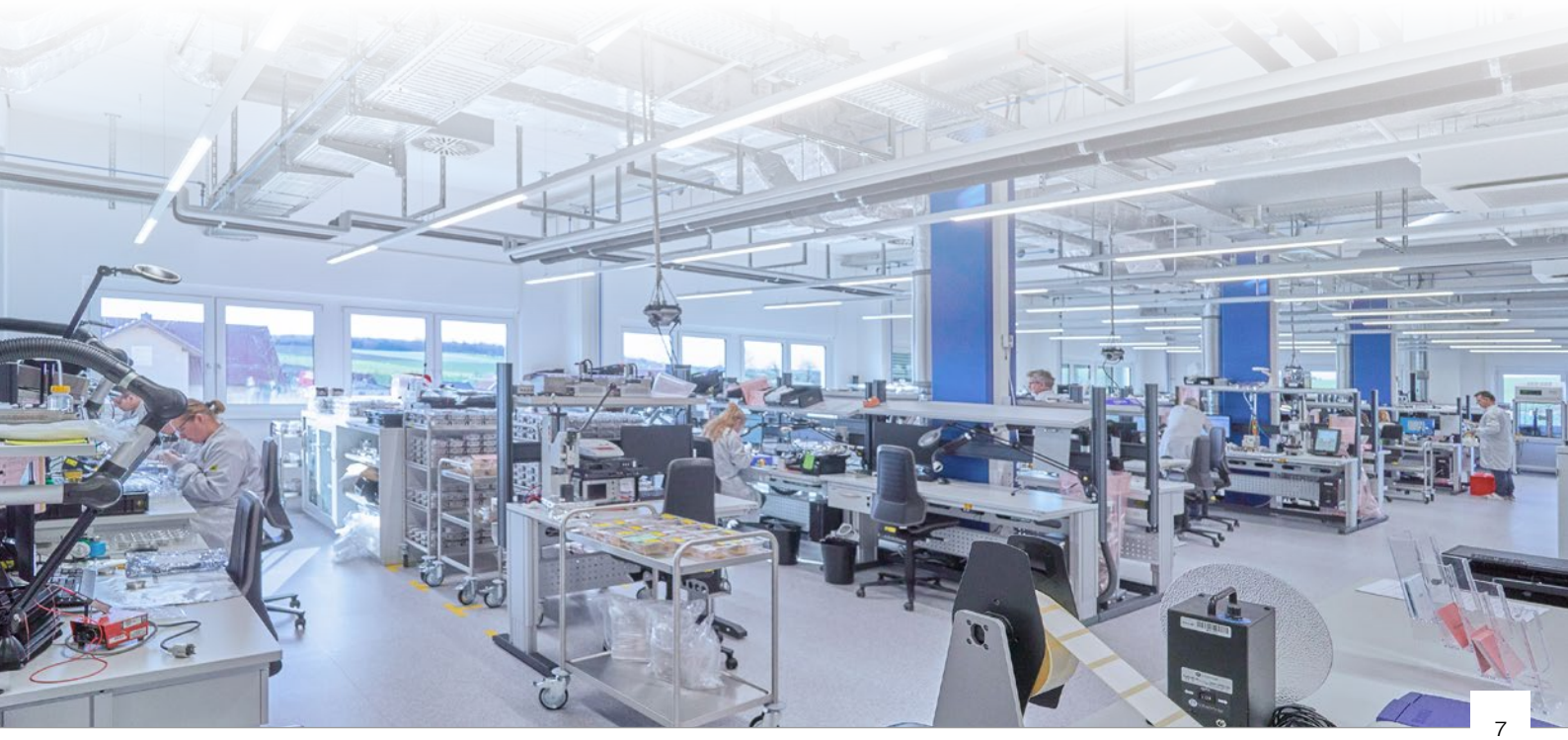
The sensor systems can be customized or developed specifically for large series.

Industry and application experience

Decades of experience in the aviation, semiconductor and industrial sectors flow into our products – creating sustainable added value for our business partners.

Highly specialized in-house production

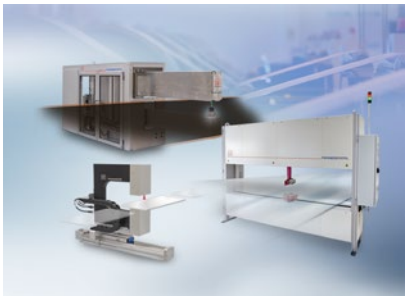
With the combined expertise and vertical integration of the Micro-Epsilon Group, we supply high-performance sensor products from a single source – even in large series.



Sensors and Systems from Micro-Epsilon

Sensors and systems for displacement, distance and position

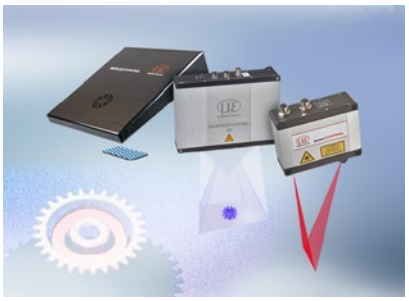
Sensors and measurement devices for non-contact temperature measurement



Measuring and inspection systems for metal strips, plastics and rubber

Optical micrometers and fiber optics, measuring and test amplifiers

Color recognition sensors, LED analyzers and inline color spectrometers



3D measurement technology for dimensional testing and surface inspection

MICRO-EPSILON

MICRO-EPSILON Headquarters
Koenigbacher Str. 15 · 94496 Ortenburg / Germany
Tel. +49 (0) 8542 / 168-0 · Fax +49 (0) 8542 / 168-90
info@micro-epsilon.com · **www.micro-epsilon.com**