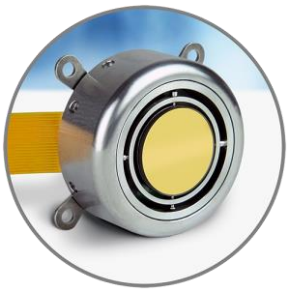

Dual axis fast steering mirror with position feedback

MR-15-30

Optotune's dual axis fast steering mirror series MR-15-30 is the ideal choice for applications that require large deflections in a compact form factor. With a mirror size of 15 mm the MR-15-30 achieves up to ±25° mechanical tilt, which results in up to ±50° optical deflection. The mirror includes a position feedback system which allows it to be accurately controlled with a standard PID controller.

The actuator is based on proven technologies. In contrast to galvo mirror systems, the virtual rotation point is very close to the mirror surface. The mirror can be fabricated with various coatings such as protected gold or protected silver.

Advantages

- Large scan angle
- Compact
- Precise
- Reliable

Applications

- Automotive (LiDAR, dynamic headlights, ADAS)
- Vision (field of view (FOV) expansion, zoom)
- Biometric (eye-tracking) & diagnostic equipment
- 3D printing

The following table outlines the specifications of our standard MR-15-30. Custom mirror substrates and coatings are possible.

Mechanical specifications[1]

Actuator Type	4-Quadrant (2 axis, bi-directional)	
Mechanical tilt angle DC	±25 X axis; ±25 Y axis (circular FOV)	°
Mechanical tilt angle dynamic	±25 X axis; ±25 Y axis (circular FOV)	°
Mirror diameter	15	mm
Center of rotation to mirror surface	1.3	mm
Housing diameter	30.0	mm
Height	14.5	mm
Weight	29.3	g
Mechanical clamping	4x M2 screws	
Magnetic shielding	yes	
Zero drift (typical)	100	µrad /K RMS value over entire FOV
Sensor resolution (with 14bit ADC)	22	µrad
Repeatability	40	µrad (RMS value over entire FOV, at room temperature)
Calibration accuracy	0.25	° RMS value over entire FOV, factory calibration may degrade to 0.5° (typ.

[1] All angle values are with respect to mechanical angle.

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		0.3°) long-term, MR-E-2 interpolates from 50 points
Static displacement constant	3	rad/A Linearized full range
Angular acceleration constant	1.4 * 10^4	rad/(A s^2) Linearized full range
Full scale bandwidth Sine wave (±25°)	20	Hz
Small signal bandwidth (< ±0.1°)	350	Hz
Large angle step settling time (20° step)	13	ms Measured with MR-E-2 driver board with 700mA peak current
Small angle step settling time (0.1° step)	3	ms Measured with MR-E-2 driver board with 700mA peak current

Optical specifications

Surface finish	Protected gold, protected silver and dielectric (VIS), other custom coatings available	
Reflectivity	Average	
Protected Gold	>95% (800 nm < λ < 2 µm)	45° AOI
Protected Silver	>96% (450 nm < λ < 2 µm)	45° AOI
Dielectric VIS	>97% (450 nm < λ < 650 nm)	45° ± 25° AOI
Surface quality	5/ 5x0.4; L1x0.06; C3x0.25; E 0.25	ISO 10110 (60-40 Scratch-Dig)
Mirror flatness	λ/2	P-V @549nm (ISO Norm 10110)

Electrical specifications

Control interface	Analog interface for driver coils and for feedback readout	
Max continuous current (RMS)	0.3	A Per coil. See thermal management.
Peak current (10 ms duration)	2	A
Max mean actuation power	1.5	W both coils together
Coil resistance (typical)	11	Ω
Coil inductivity (typical)	6	mH
Position sensor supply current (@1.5V)	40	mA
Position sensor output current (typical)	0.1	mA 4 channels
Temperature sensor	LM75B or equivalent	I2C-Address: 0x48 (+R/W bit)
EEPROM[2]	M24C08 or equivalent	I2C-Addresses: 0x50 to 0x53 (+R/W bit)

Environmental specifications

Operating temperature[3]	-20 to +85	°C
Storage temperature[3]	-40 to +85	°C
Shock	105 *g*, 15 ms	DIN EN 60068-2-27
Vibration	2 *g*, 10-150 Hz	ISO 9022-3-36
Cycle life	>10^9	cycles

[2] EEPROM content definition is available upon request.

[3] For larger temperature ranges contact Optotune.

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Overview of available standard products

Standard Product	Coating	Typical wavelength range
MR-15-30-G-25x25D	Protected gold	800 nm - 2 µm
MR-15-30-PS-25x25D	Protected silver[4]	400 nm - 2 µm (low humidity)
MR-15-30-DVIS-25x25D	Dielectric VIS	450 nm - 650 nm

[4] DISCLAIMER: Despite the protective coating layer, it is best to avoid exposing silver mirrors to high humidity environments due to the associated tarnishing risk. For applications in the visible spectrum we strongly recommend the dielectric coating. Optotune declines the warranty due to humidity induced corrosion of the mirror coating.

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Mechanical Layout

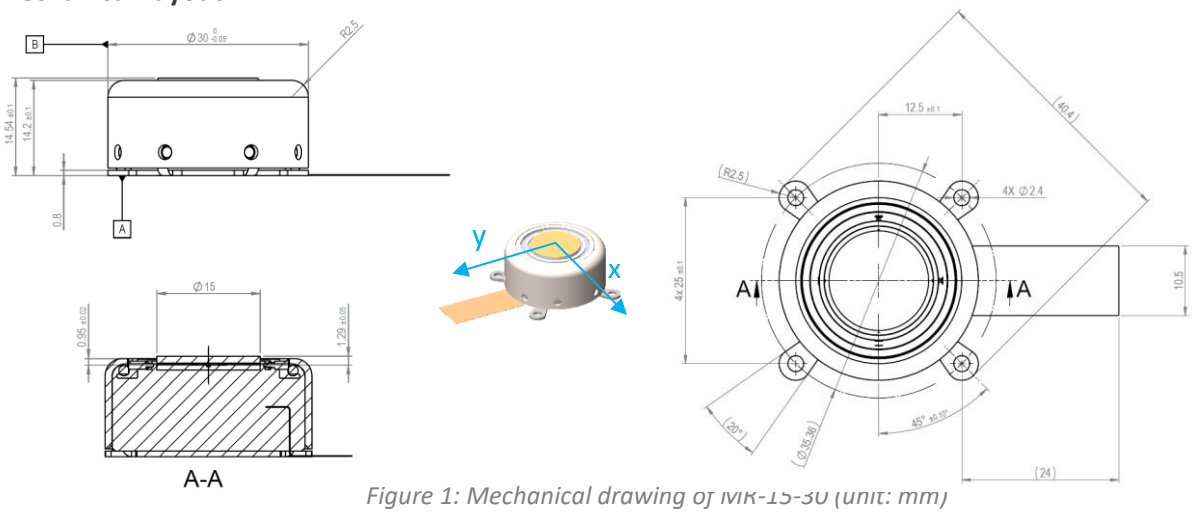

Figure 1: Mechanical drawing of MR-15-30 (unit: mm)

When screwed in place, make sure the mirror is in firm contact with the heat sink. It is recommended that the heatsink dissipates about 2-5 W.

In terms of lateral alignment, it is recommended to use the outer diameter of the housing as an alignment feature.

Thermal Management

- Heat is generated as a function of actuation current and conducted away through the backside.
- Mount mirror firmly on a heat-conductive plate (copper or aluminum)
- Maximum dissipated power at max. static deflection is 0.25 W/channel (0.5 W total)
- For fast oscillations with high duty cycle the dissipated power is 4-5 W for the two axes combined.
- Max. operating temperature is 85°C

Packaging

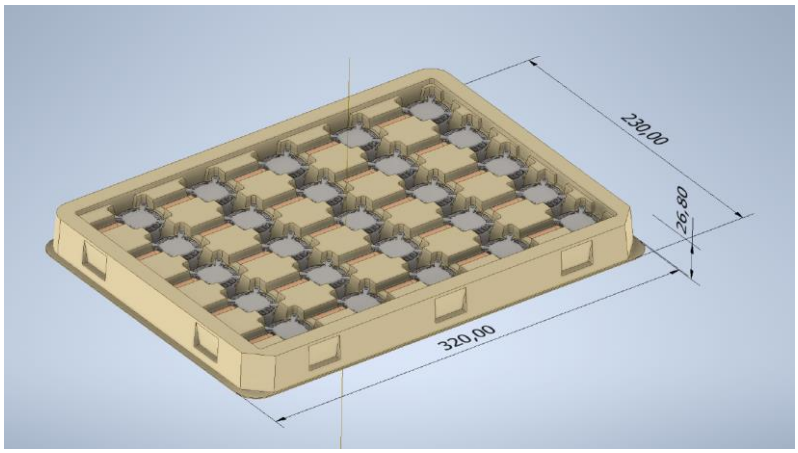

Figure 2: MR-15-30 tray design

Single units ship in cardboard boxes. Larger volumes ship in ESD-safe and stackable PET trays of 25 MR-15-30 units each, sealed in a vacuum bag.

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Static response

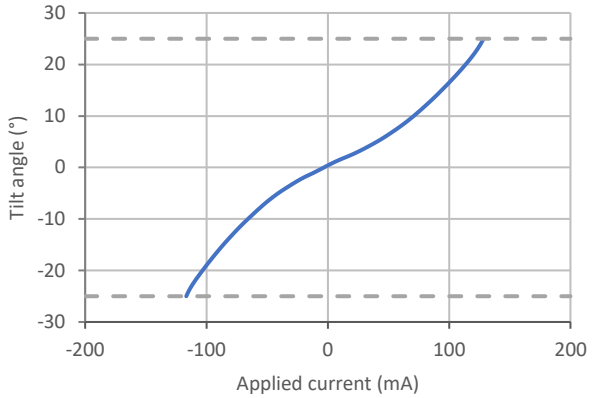

Figure 3: Mechanical tilt angle (limited to ± 25°) versus applied current for single axis.

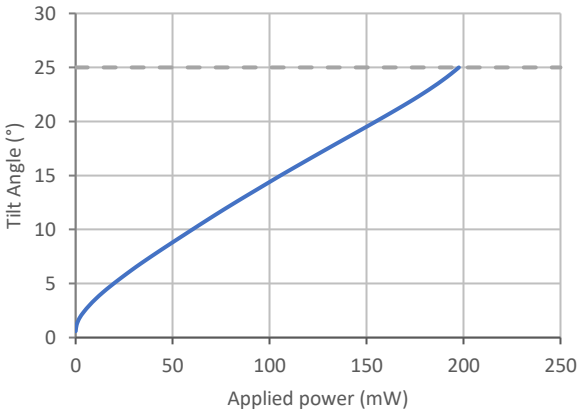

Figure 4: Tilt angle (mechanical) versus applied power (~8.6 mW/°)

Magnitude response

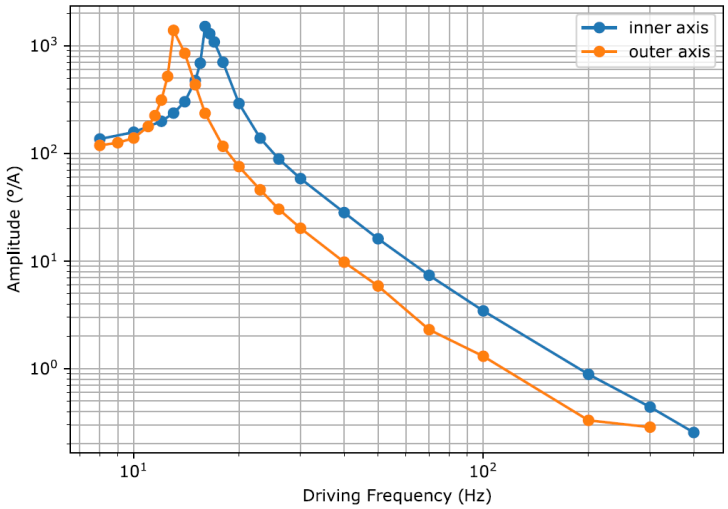

Figure 5: Magnitude response of outer axis (x) and inner axis (y) with sinusoidal excitation (15 mA amplitude).

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Small step response

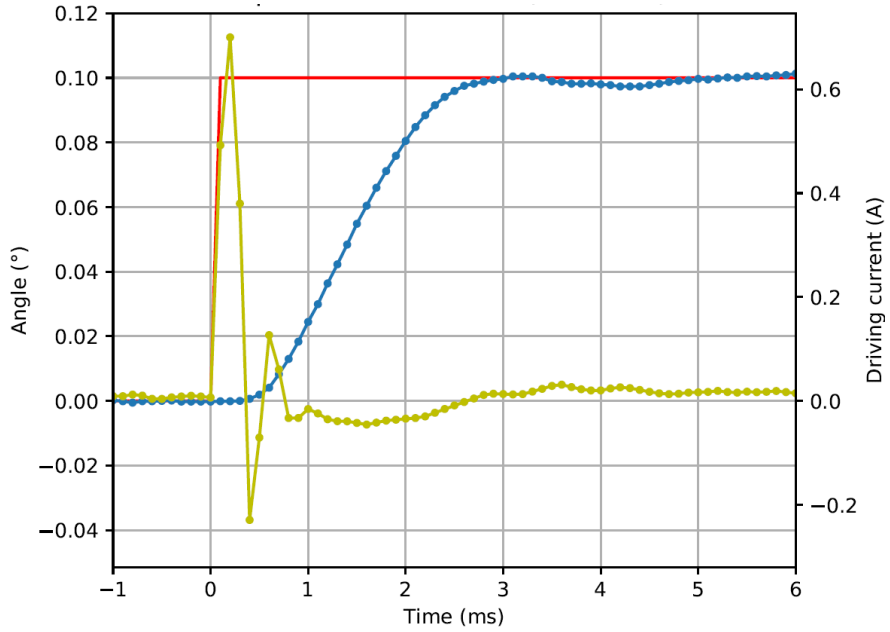

Figure 6: Small step settling time (blue curve) of outer axis for a 0.1° (mech.) step is 3 ms. Mirror operated with MR-E-2 PID controller. The yellow curve shows the corresponding driving current.

Large step response

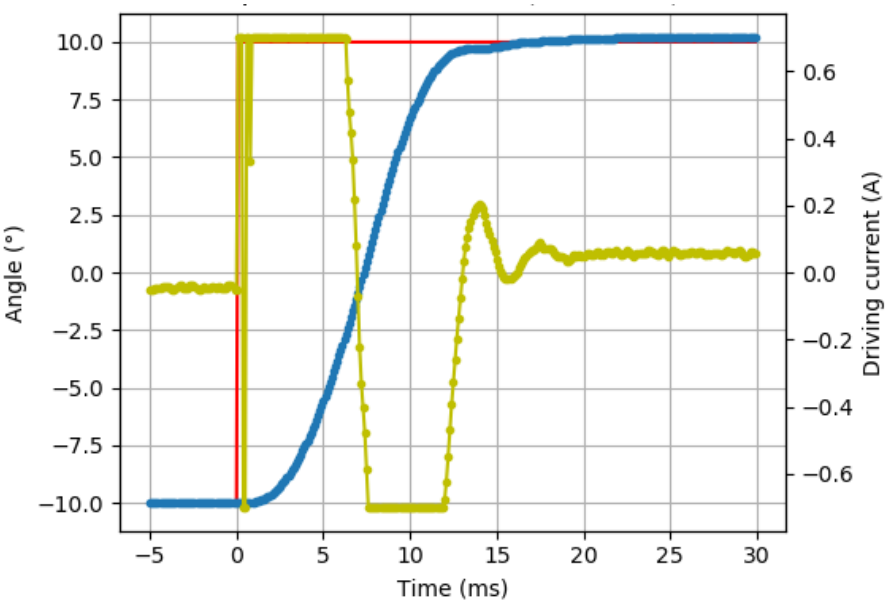

Figure 7: Large step settling time (blue curve) of outer axis for a 20° (mech.) step is 13 ms. Mirror operated with MR-E-2 PID controller. The yellow curve shows the corresponding driving current.

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Maximum oscillation frequency

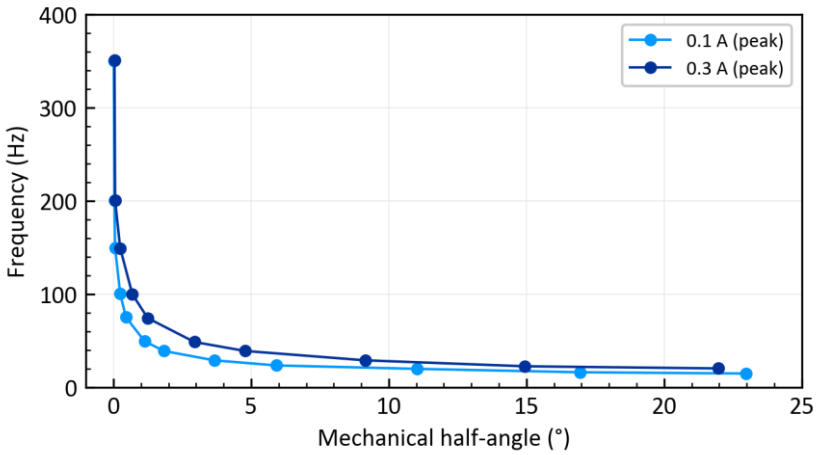

Figure 8: Max. oscillation speed (sinusoidal) of the outer axis as a function of the mechanical half-angle and driving current. The total optical FOV is 4 times the mechanical half-angle.

Reflectivity

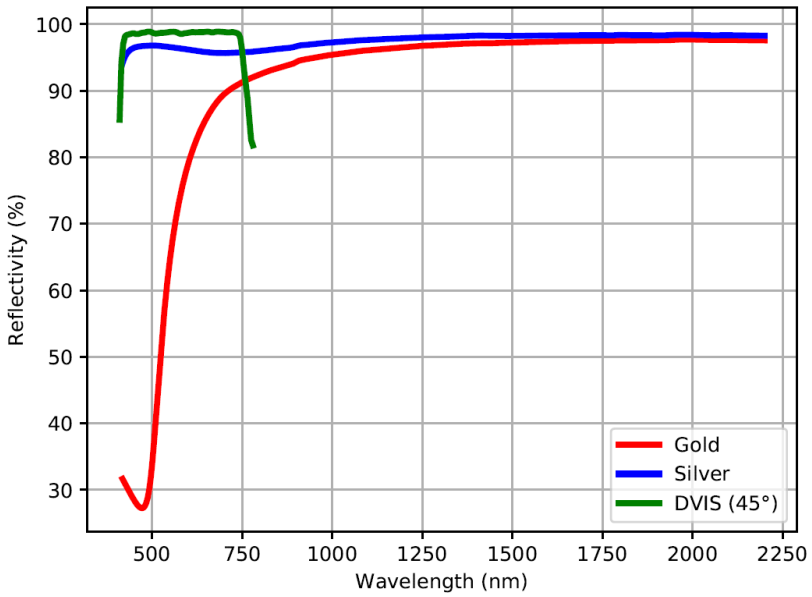

Figure 9: Reflectance spectra of our standard coatings.

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Electrical connection and block diagram

Pin	Function	Value	Pin	Function	Value
1	Position feedback supply Cathode	40 mA 1.5 V	11	VDD	3.3V
2	Position feedback supply Anode		12	SCL	Digital 3.3 V
3	Y Coil +	± 1 A ± 15 V	13	SDA	Digital 3.3 V
4			14	GND	
5	Y Coil -		15	Position feedback Anode	currents (µA range)
6			16	Position feedback Y2 Cathode	
7	X Coil +		17	Position feedback Y1 Cathode	
8			18	Position feedback X2 Cathode	
9	X Coil -		19	Position feedback X1 Cathode	
10			20	Position feedback Anode	

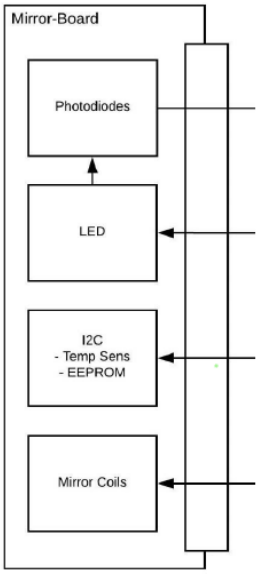

Table 1: Electrical pinout of the FPC cable (20 pins, 0.5 mm pitch) and block diagram of the MR-15-30

Beam clipping

Clipping of beam depends on beam diameter and tilt angle. For a beam incident at 0° beam sizes up to 10 mm can be used without clipping.

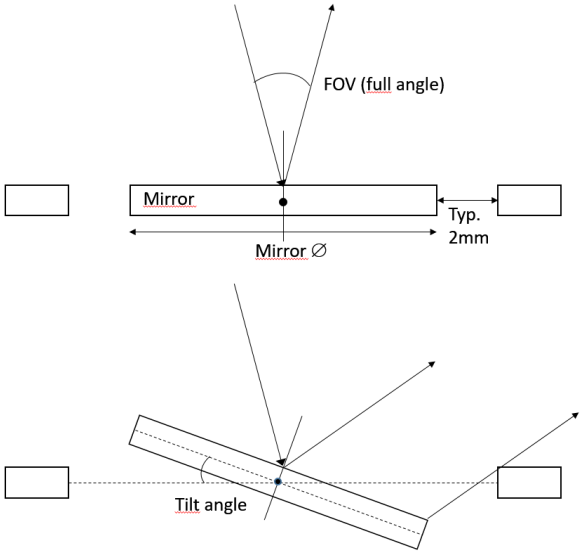

Figure 10: The maximum allowed beam diameter depends on input angle and mirror tilt angle.

Optotune can supply by request an EXCEL based calculation tool to evaluate beam clipping.

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Environmental testing

The MR-15-30 is going through environmental and accelerated aging tests as outline in the table below.

Test	Norm	Status
Mechanical cycling 5-point star pattern running at 5 Hz, 2 billion cycles reached with no signs of fatigue, tested with MR-E-2 at room temperature	-	Ongoing
Accelerated gimbal test: Gimbal subassembly tested at 8000 rpm for 800 million full rotations without significant degradation.	-	Pass
Temperature & Humidity 85±2 °C, rel. hum. 45%, 1 week	-	Pass
Shock test 15 ms deceleration, three drops per axis. Mirror is not affected by shocks up to 105 *g*.	DIN EN 60068-2-27	Pass
Vibration test According to ISO 9022-3-36-03-01, 2 *g*, 10-150 Hz	ISO 9022-3-36-03-01	Pass
Temperature Shock -40 to 55 °C, 2.5h/cycle, <20s transition time, 5 cycles	9022-15-03-1	Pass

Table 2: Environmental tests performed on the MR-15-30

Custom Products

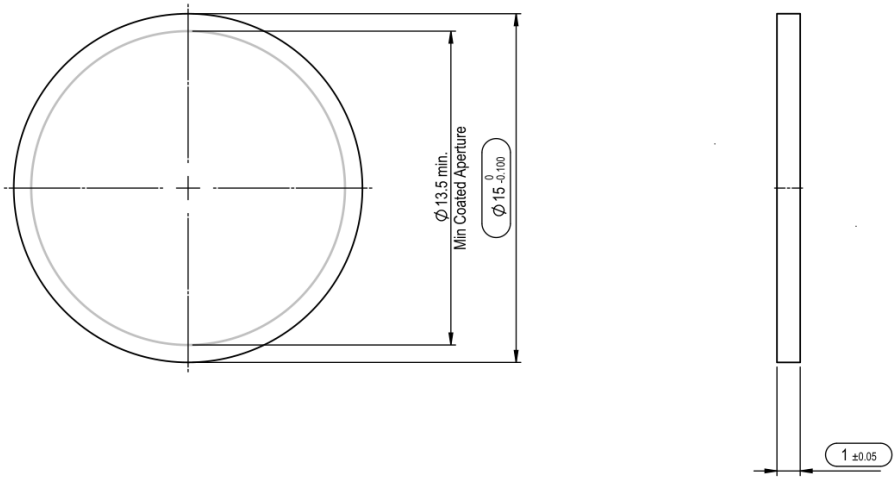

Figure 11: Dimensions of standard mirror substrate

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Optotune offers customizations of mirror substrates and coatings upon request. Substrates with a thickness of more than the standard 1 mm need to have a smaller diameter to maintain the full FOV. For a diameter of 12.7 mm the thickness can be as large as 3.5 mm. A change in inertia will influence mirror dynamics.

Safety and compliance

The product fulfills the RoHS, REACH, CE and flammability UV94 V-0 compliance standards. The customer is solely responsible to comply with all relevant safety regulations for integration and operation, including EMC compliance.

For more information on optical, mechanical and electrical parameters, please contact sales@optotune.com.

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