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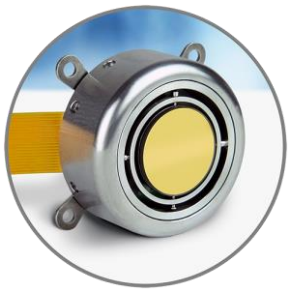

Dual axis fast steering mirror with position feedback MR-15-30

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.

Specifications

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	
Mechanical clamping	4x M2 screws		
Height	14.5	mm	
Weight	29.3	g	
Magnetic shielding	yes		
Zero drift	100	µrad/K	RMS value over entire FOV, typical
Sensor resolution	22	µrad	with 14bit ADC
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. 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
Control specs:			
Full scale bandwidth Sine wave (±25°)	20	Hz	

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

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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 Protected Gold Protected Silver Dielectric VIS	Average >95% (800 nm < λ < 2 µm) >96% (450 nm < λ < 2 µm) >97% (450 nm < λ < 650 nm)		 45° AOI 45° AOI 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	2	A	For 10 ms duration
Max mean actuation power	1.5	W	Both coils together
Coil resistance	11	Ohm	Typical
Coil inductivity	6	mH	Typical
Position sensor supply current (@1.5V)	40	mA	
Position sensor output current	0.1	mA	4 channels, typical
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	-20 to +85	°C	for higher temp. ranges contact Optotune
Storage temperature	-40 to +85	°C	for higher temp. ranges contact Optotune
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	

Overview of configurations

Configuration	Coating	Typical wavelength range
MR-15-30-G-25x25D	Protected gold	800 nm - 2 µm
MR-15-30-PS-25x25D	Protected silver[3]	400 nm - 2 µm (low humidity)
MR-15-30-DVIS-25x25D	Dielectric VIS	400 nm - 700 nm
MR-C-15-30	Custom	to be defined

[2] EEPROM content definition is available upon request.
[3] 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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Static response

Current vs angle

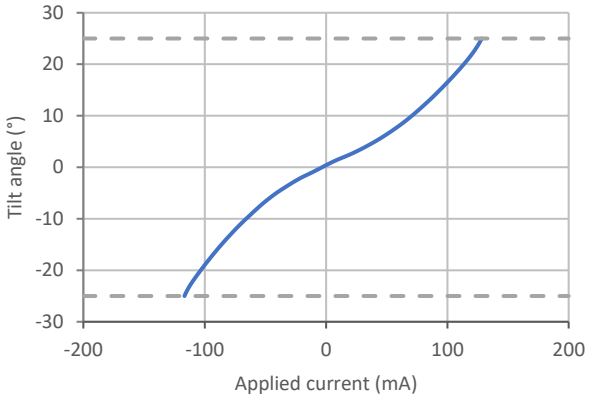

Figure 1: Mechanical tilt angle (limited to ± 25°) versus applied current for single axis.

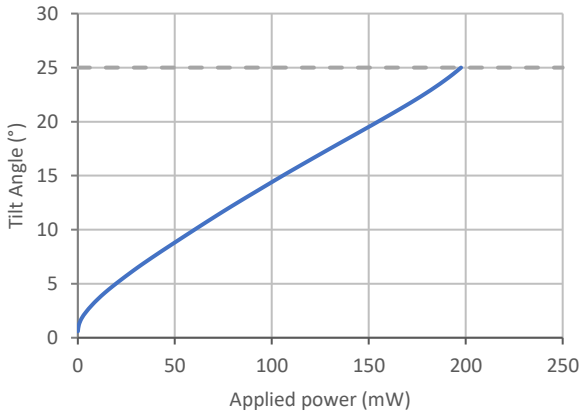

Figure 2: Tilt angle (mechanical) versus applied power (~8.6 mW/°)

Dynamic response

Magnitude response

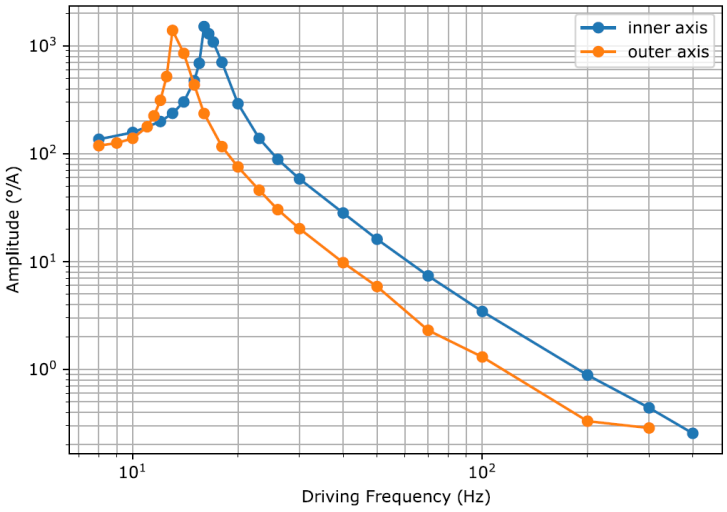

Figure 3: Magnitude response of outer axis (x) and inner axis (y) with sinusoidal excitation (15 mA amplitude).

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Small step response

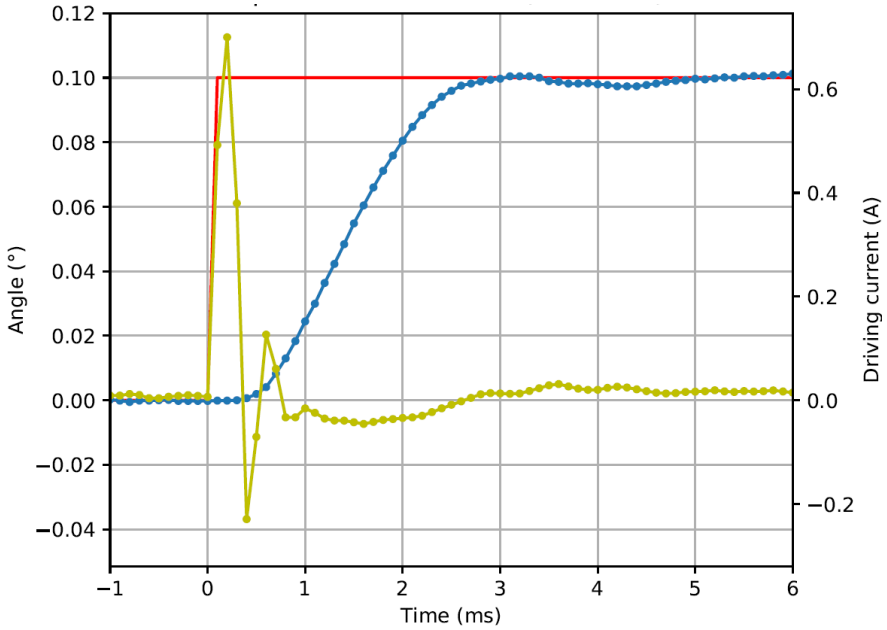

Figure 4: Small step settling time (blue curve) of outer axis for a 0.1° (mech.) step is 3 ms. Mirror operated with MR-E-2 PID controller. The yellow curve shows the corresponding driving current.

Large step response

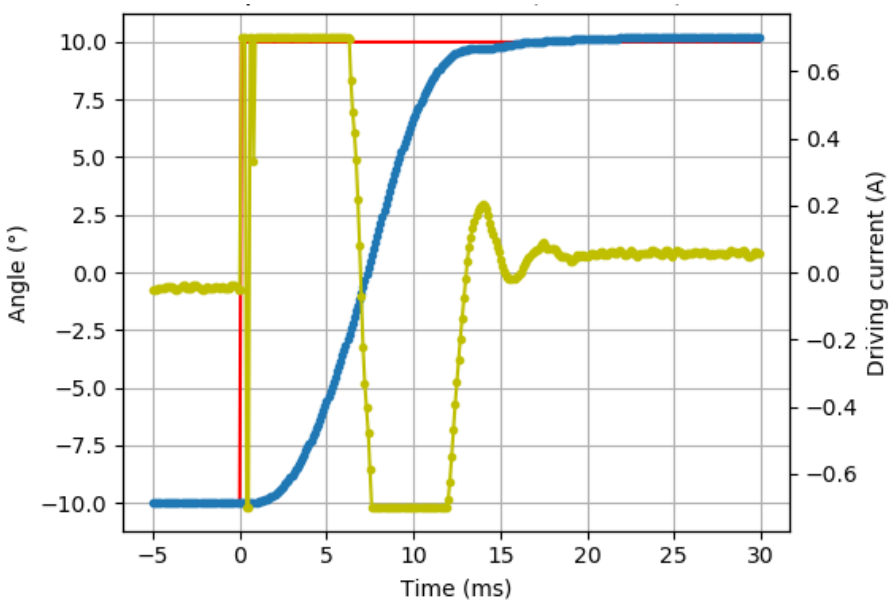

Figure 5: Large step settling time (blue curve) of outer axis for a 20° (mech.) step is 13 ms. Mirror operated with MR-E-2 PID controller. The yellow curve shows the corresponding driving current.

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Maximum oscillation frequency

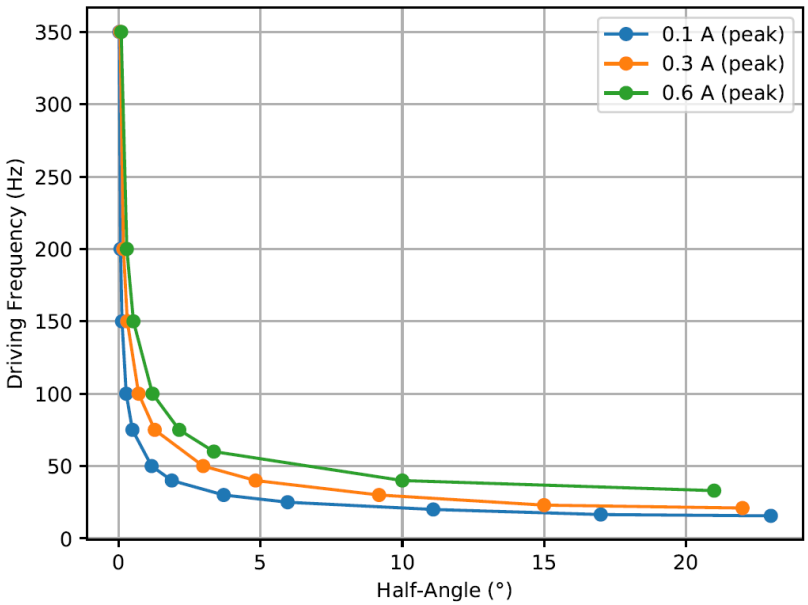

Figure 6: Max. oscillation speed (sinus) of outer axis as a function of mechanical half-angle and driving current. The total optical FOV is 4 times the mechanical half-angle.

Reflectivity

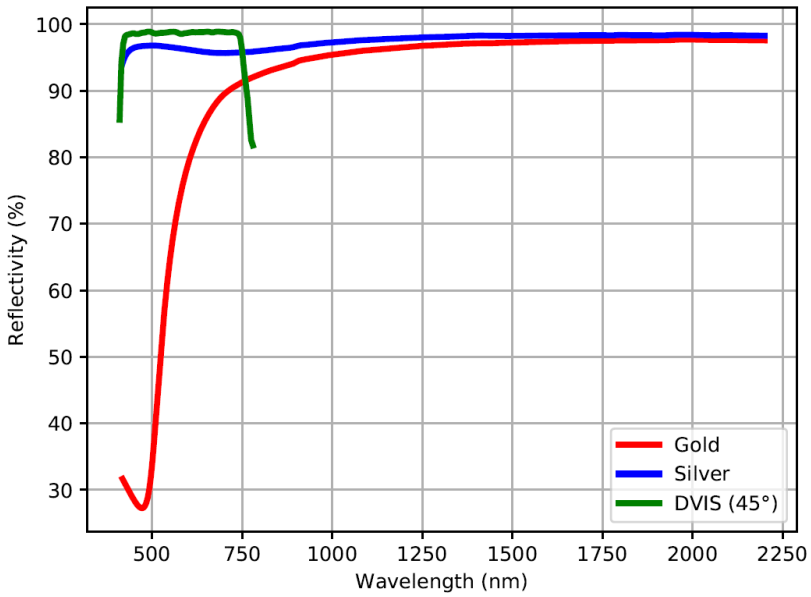

Figure 7: Reflectance spectra of our standard coatings.

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Mounting

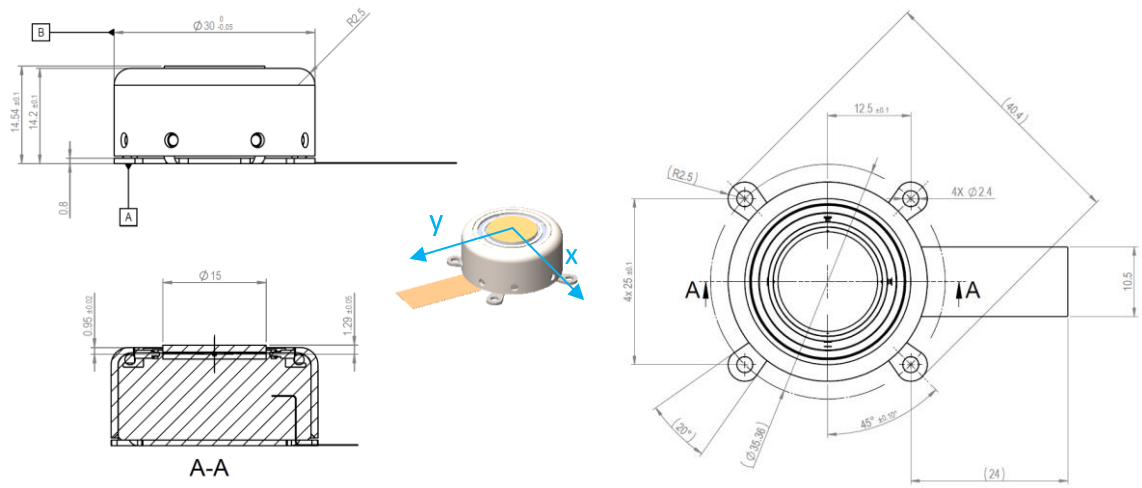

Figure 8: Mechanical drawing of MR-15-30 (unit: mm)

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

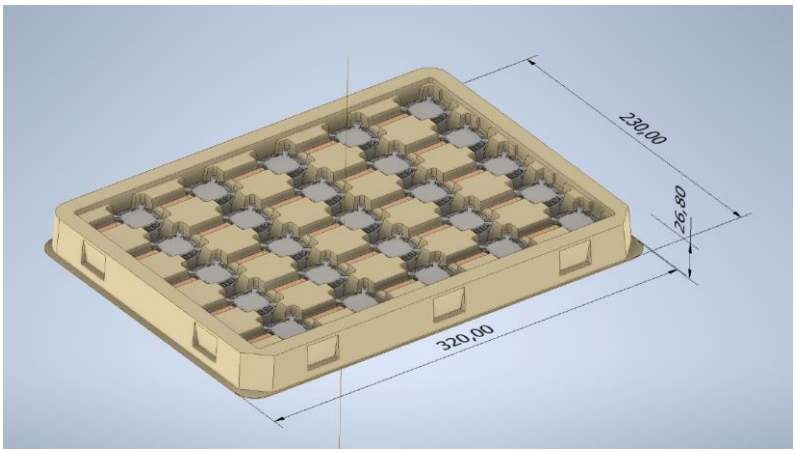

Figure 9: MR-15-30 tray design

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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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	

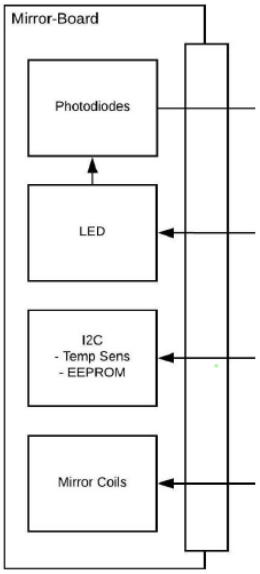

Table 1: Electrical pinout of the FPC cable (20 pins, 0.5 mm pitch) and block diagram of the MR-15-30

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.

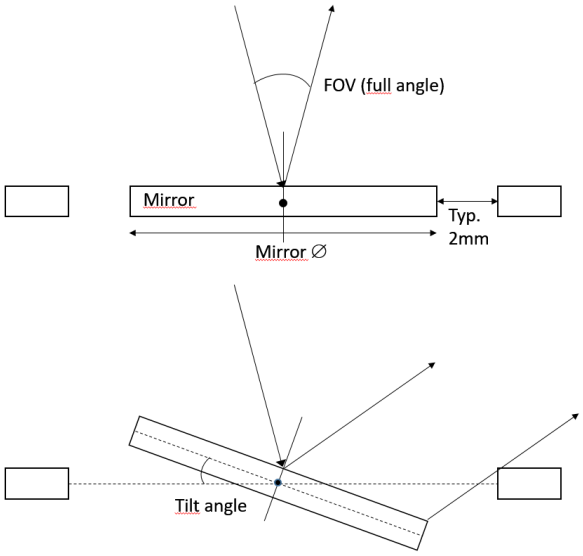

Figure 10: The maximum allowed beam diameter depends on input angle and mirror tilt angle.

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	MR-15-30
Mechanical cycling 5-point star pattern running at 5 Hz, 200 million 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.	Passed
Temperature & Humidity 85°C / 45% (duration: 1 week)	Passed
Shock test According to DIN EN 60068-2-27, 15 ms deceleration, three drops per axis. Mirror is not affected by shocks up to 105 *g*.	Passed
Vibration test According to ISO 9022-3-36-03-01, 2 *g*, 10-150 Hz	Passed

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

Safety and compliance

The product is intrinsically safe and fulfills the RoHS and REACH compliance standards. The customer is solely responsible to comply with all relevant safety regulations for integration and operation, including EMC compliance.

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Custom Products:

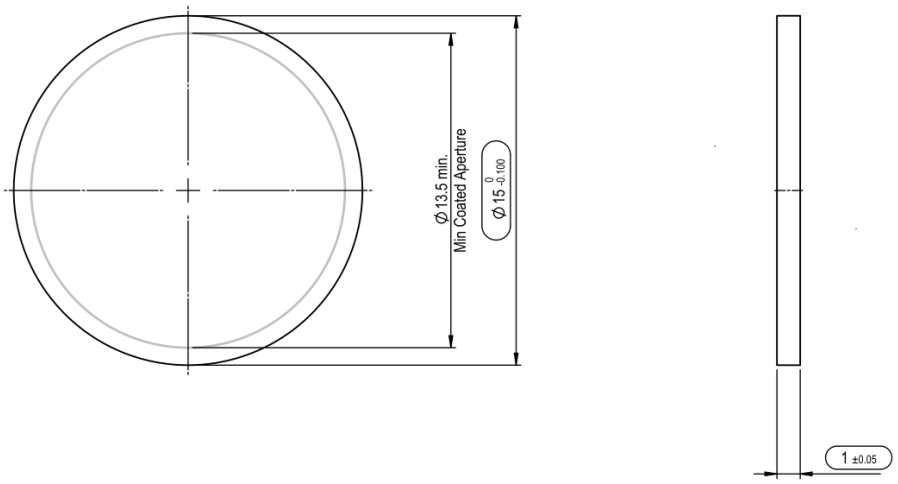

Figure 11: Dimensions of standard mirror substrate

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.

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

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