

ALPAO



Leading the light



Deformable Mirrors



Our Company

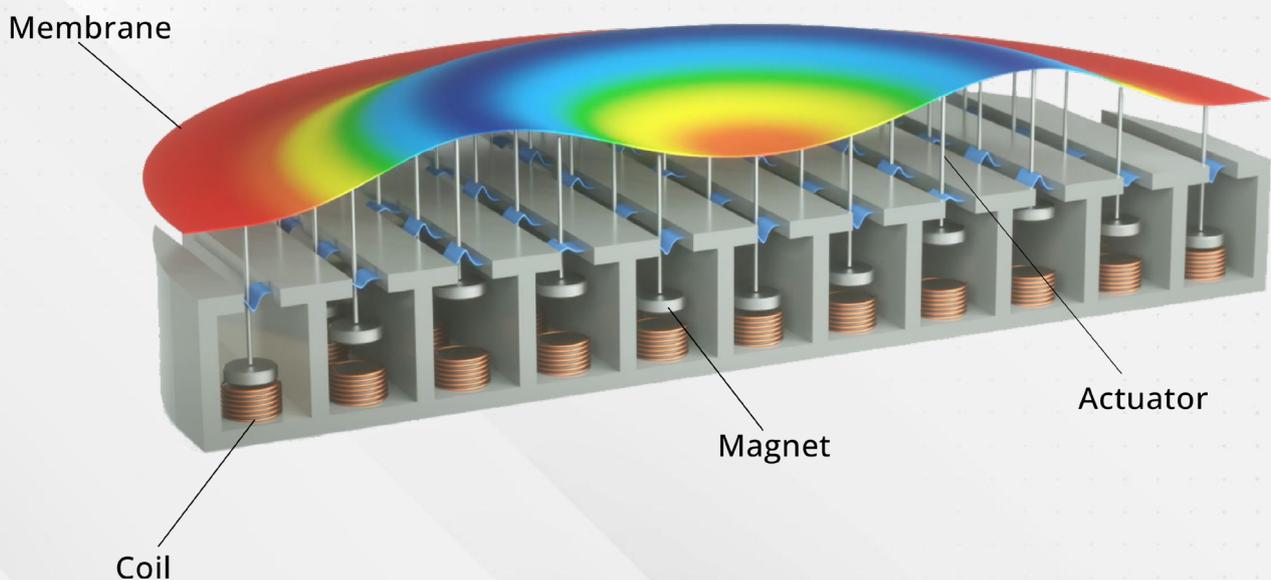
Experience the cutting edge of Adaptive Optics technology with the industry standard in design and manufacture of high-performance components for Adaptive Optics systems.

Since its inception in 2007, ALPAO has been consistently revolutionizing the field, offering innovative solutions tailored to a wide range of applications. With a strong commitment to research and development, ALPAO is at the forefront of optical technology, delivering unparalleled performance, reliability, and precision to its customers around the world.

Our Technology

ALPAO's Deformable Mirrors are powered by state-of-the-art electromagnetic actuators, which offer unparalleled precision, speed, and reliability.

These advanced actuators employ the magnetic force generated by the interaction between a coil and a magnet to accurately control the movement of the mirror surface. Electromagnetic actuators also boast rapid response times, enabling real-time adjustments to account for dynamic changes in the optical environment.





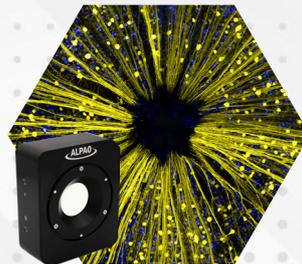
Key Features and Benefits

- Superior best flat
- Excellent linearity
- Low hysteresis
- Vacuum compatibility
- Large variety of options
- Proven electromagnetic technology
- Wide range of accessories
- High dynamic motion
- High number of actuators
- Low power consumption
- Large deformation capacities
- SDK available for C++, Python, Matlab

Applications



Astronomy



Vision Science



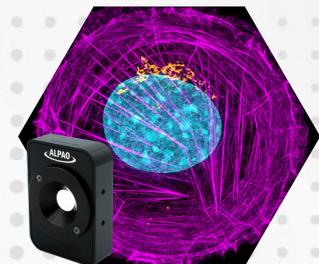
FSO - QKD - SSA



Space



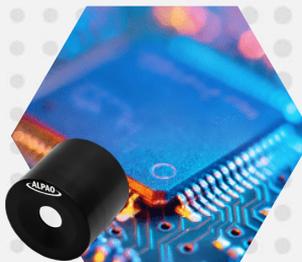
Laser



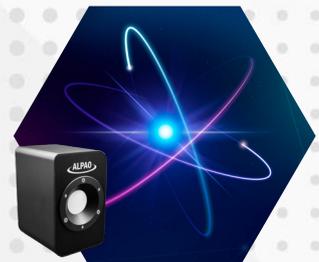
Microscopy



Defense



Microelectronics



Physics



Small Deformable Mirrors (DM) < 100 actuators

ALPAO defines small Deformable Mirrors as mirrors who have less than 100 actuators. The company's mirrors offer high stroke and resolution, allowing for the correction of large wavefront errors with nanometer-level precision. Furthermore, ALPAO's mirrors boast high optical quality, low hysteresis, and minimal creep, enabling accurate and stable operation in demanding applications.

Small Deformable Mirrors are ideal for applications where low-order optical aberrations need to be corrected, or where the system size and complexity needs to be minimized.



Each Deformable Mirror is designed to fulfill specific needs and applications, with varying levels of actuator counts, aperture sizes, and strokes. Additionally, ALPAO provides custom Deformable Mirror solutions, allowing clients to tailor their mirrors according to their unique requirements.

ALPAO's Deformable Mirrors are compatible with a variety of software platforms, including MATLAB, LabVIEW, and Python. This compatibility ensures seamless integration into existing systems and facilitates communication with various wavefront sensors and control algorithms.

Furthermore, ALPAO provides comprehensive customer support, offering technical assistance, training, and workshops to help clients maximize the potential of their Deformable Mirrors.



DM 57-15 Technical Specifications

	DM 57-15
Number of actuators	57
Actuator matrix size	9x9
Pupil diameter (mm)	9.0
Pitch (mm)	1.5
Number of actuators across a diameter	9
Active best flat (nm RMS, mechanical) _{max}	7
Tip/Tilt stroke (μm PV, wavefront) _{min}	± 60
Defocus/Astig stroke (μm PV, wavefront) _{min}	± 40
3x3 stroke (μm PV, wavefront) _{min}	± 25
Settling time (ms at $\pm 10\%$, any stroke) _{max}	0.8
First resonance of the membrane (Hz) _{min}	800
Frequency at phase lag of 45° (Hz) _{min}	700
Mechanical W x H x D (mm)	51.5x74x22
Weight (g)	180
Non-linearity (%) _{max}	3
Hysteresis (%) _{max}	2
Standard face sheet coating type	Protected Silver
Optional face sheet coatings	Gold, Aluminium, Copper and Dielectric
Functional temperature ($^\circ\text{C}$)	-50 to 50
LIDT	On request
Floating actuator count _{max}	0



DM 69-xx Technical Specifications

	DM 69-08	DM 69-15	DM 69-25	DM 69-50
Number of actuators	69			
Actuator matrix size	9x9			
Pupil diameter (mm)	5.6	10.5	17.5	35
Pitch (mm)	0.8	1.5	2.5	5.0
Number of actuators across a diameter	9			
Active best flat (nm RMS, mechanical) _{max}	7			25

Tip/Tilt stroke (μm PV, wavefront) _{min}	± 80	± 60	± 40	
Defocus/Astig stroke (μm PV, wavefront) _{min}	± 40		± 30	
3x3 stroke (μm PV, wavefront) _{min}	± 25			

Settling time (ms at $\pm 10\%$, any stroke) _{max}	1.5	0.8	1.5	
First resonance of the membrane (Hz) _{min}	400	800	600	600
Frequency at phase lag of 45° (Hz) _{min}	300	700	500	500

Mechanical W x H x D (mm)	51.5x74x35	51.5x74x22	62x84x23	100x120x40
Weight (g)	230	180	200	1000

Non-linearity (%) _{max}	3			
Hysteresis (%) _{max}	2			

Standard face sheet coating type	Protected Silver			
Optional face sheet coatings	Gold, Aluminium, Copper and Dielectric			

Functional temperature ($^\circ\text{C}$)	-50 to 50			
LIDT	On request			
Floating actuator count _{max}	0			



DM 97-xx Technical Specifications

	DM 97-08	DM 97-15	DM 97-25	DM 97-50
Number of actuators	97			
Actuator matrix size	11x11			
Pupil diameter (mm)	7.2	13.5	22.5	45
Pitch (mm)	0.8	1.5	2.5	5.0
Number of actuators across a diameter	11			
Active best flat (nm RMS, mechanical) _{max}	7			25

Tip/Tilt stroke (μm PV, wavefront) _{min}	± 80	± 60	± 40	
Defocus/Astig stroke (μm PV, wavefront) _{min}	± 40		± 30	
3x3 stroke (μm PV, wavefront) _{min}	± 25			

Settling time (ms at $\pm 10\%$, any stroke) _{max}	1.5	0.8	1.5	
First resonance of the membrane (Hz) _{min}	400	800	600	
Frequency at phase lag of 45° (Hz) _{min}	300	700	500	

Mechanical W x H x D (mm)	51.5x74x35	51.5x74x22	62x84x23	100x120x40
Weight (g)	230	180	200	1000

Non-linearity (%) _{max}	3			
Hysteresis (%) _{max}	2			

Standard face sheet coating type	Protected Silver			
Optional face sheet coatings	Gold, Aluminium, Copper and Dielectric			

Functional temperature ($^\circ\text{C}$)	- 50 to 50			
LIDT	On request			
Floating actuator count _{max}	0			



Large Deformable Mirrors (DM) > 100 actuators

ALPAO large Deformable Mirrors are mirrors who have 100 or more actuators. The company's mirrors offer high stroke and resolution, allowing for the correction of large wavefront errors with nanometer-level precision. Furthermore, ALPAO's mirrors boast high optical quality, low hysteresis, and minimal creep, enabling accurate and stable operation in demanding applications.

Large Deformable Mirrors provide finer control of the mirror surface, this enables the correction of higher-order aberrations and better performance in various applications.



Each Deformable Mirror is designed to fulfill specific needs and applications, with varying levels of actuator counts, aperture sizes, and strokes. Additionally, ALPAO provides custom Deformable Mirror solutions, allowing clients to tailor their mirrors according to their unique requirements.

ALPAO's Deformable Mirrors are compatible with a variety of software platforms, including MATLAB, LabVIEW, and Python. This compatibility ensures seamless integration into existing systems and facilitates communication with various wavefront sensors and control algorithms.

Furthermore, ALPAO provides comprehensive customer support, offering technical assistance, training, and workshops to help clients maximize the potential of their Deformable Mirrors.



Large DM Technical Specifications

	DM 192-15	DM 256-15	DM 277-30	DM 292-15
Number of actuators	192	256	277	292
Actuator matrix size	16x16	18x18	19x19	20x20
Pupil diameter (mm)	21	24	50	26.5
Pitch (mm)	1.5		3.1	1.5
Number of actuators across a diameter	16	18	19	20
Active best flat (nm RMS, mechanical) _{max}	7		15	7

Tip/Tilt stroke (μm PV, wavefront) _{min}	± 15	± 10	± 15
Defocus/Astig stroke (μm PV, wavefront) _{min}	± 10		
3x3 stroke (μm PV, wavefront) _{min}	± 10		

Settling time (ms at $\pm 10\%$, any stroke) _{max}	0.5	1	0.5
First resonance of the membrane (Hz) _{min}	2000	1100	2000
Frequency at phase lag of 45° (Hz) _{min}	1500	1000	1500

Mechanical W x H x D (mm)	70x110x82	100x120x60	70x110x82
Weight (g)	1000		

Non-linearity (%) _{max}	3
Hysteresis (%) _{max}	2

Standard face sheet coating type	Protected Silver
Optional face sheet coatings	Gold, Aluminium, Copper and Dielectric

Functional temperature ($^\circ\text{C}$)	-50 to 50
LIDT	On request
Floating actuator count _{max}	1%



Large DM Technical Specifications

	DM 308-15	DM 468-15	DM820-15	DM 1433-26
Number of actuators	308	468	820	1433
Actuator matrix size	20x20	24x24	32x32	43x43
Pupil diameter (mm)	27	33	45	102
Pitch (mm)	1.5			2.6
Number of actuators across a diameter	20	24	32	43
Active best flat (nm RMS, mechanical) _{max}	7	7	7	15

Tip/Tilt stroke (μm PV, wavefront) _{min}	± 15	± 12		± 15
Defocus/Astig stroke (μm PV, wavefront) _{min}	± 10			± 15
3x3 stroke (μm PV, wavefront) _{min}	± 10			± 15

Settling time (ms at $\pm 10\%$, any stroke) _{max}	0.5		1.2	
First resonance of the membrane (Hz) _{min}	1800	1600		800
Frequency at phase lag of 45° (Hz) _{min}	1400	1500		600

Mechanical W x H x D (mm)	70x110x82	90x110x124	100x120x120	153x180x180
Weight (g)	1000	1800	1700	5200

Non-linearity (%) _{max}	3			
Hysteresis (%) _{max}	2		3	

Standard face sheet coating type	Protected Silver			
Optional face sheet coatings	Gold, Aluminium, Copper and Dielectric			

Functional temperature ($^\circ\text{C}$)	-50 to 50			
LIDT	On request			
Floating actuator count _{max}	0%			0.5



Large DM Technical Specifications

	DM 2844-25	DM 3228-15	DM 13107-15
Number of actuators	2844	3228	13107
Actuator matrix size	60x60	64x64	128x128
Pupil diameter (mm)	142.5	93	190
Pitch (mm)	2.5	1.5	1.5
Number of actuators across a diameter	60	64	128
Active best flat (nm RMS, mechanical) _{max}	15	7	7

Tip/Tilt stroke (μm PV, wavefront) _{min}	± 10	± 10	-
Defocus/Astig stroke (μm PV, wavefront) _{min}	± 10	± 8	-
3x3 stroke (μm PV, wavefront) _{min}	± 10	± 8	-

Settling time (ms at $\pm 10\%$, any stroke) _{max}	1	0.5	-
First resonance of the membrane (Hz) _{min}	1000	1200	-
Frequency at phase lag of 45° (Hz) _{min}	800	1000	-

Mechanical W x H x D (mm)	220x280x200	140x180x180	-
Weight (g)	12000	4800	-

Non-linearity (%) _{max}	3		
Hysteresis (%) _{max}	3	2	-

Standard face sheet coating type	Protected Silver		
Optional face sheet coatings	Gold, Aluminium, Copper and Dielectric		

Functional temperature ($^\circ\text{C}$)	-50 to 50		
LIDT	On request		
Floating actuator count _{max}	0.5%		



Large Aperture Deformable Mirrors (DMX)

The company's mirrors offer high stroke and resolution, allowing for the correction of large wavefront errors with nanometer-level precision. Furthermore, ALPAO's mirrors boast high optical quality, low hysteresis, and minimal creep, enabling accurate and stable operation in demanding applications.

Large Aperture Deformable Mirrors boast a larger pupil diameter than other Deformable Mirrors. This larger pupil captures more light from the source, which can be particularly beneficial when low-light conditions or when observing faint objects.



Each Deformable Mirror is designed to fulfill specific needs and applications, with varying levels of actuator counts, aperture sizes, and strokes. Additionally, ALPAO provides custom Deformable Mirror solutions, allowing clients to tailor their mirrors according to their unique requirements.

ALPAO's Deformable Mirrors are compatible with a variety of software platforms, including MATLAB, LabVIEW, and Python. This compatibility ensures seamless integration into existing systems and facilitates communication with various wavefront sensors and control algorithms.

Furthermore, ALPAO provides comprehensive customer support, offering technical assistance, training, and workshops to help clients maximize the potential of their Deformable Mirrors.



DMX Technical Specifications

	DMX 37	DMX 61	DMX 85
Number of actuators	37	61	85
Actuator matrix size	7x7	9x9	11x11
Pupil diameter (mm)	100	130	170
Pitch (mm)	20.6		
Number of actuators across a diameter	7	9	11
Active best flat (nm RMS, mechanical) _{max}	25	25	25

Tip/Tilt stroke (μm PV, wavefront) _{min}	± 30	± 50	± 50
Defocus/Astig stroke (μm PV, wavefront) _{min}	± 25	± 40	± 40
3x3 stroke (μm PV, wavefront) _{min}	± 25		

Settling time (ms at $\pm 10\%$, any stroke) _{max}	2		
First resonance of the membrane (Hz) _{min}	400		
Frequency at phase lag of 45° (Hz) _{min}	400		

Mechanical W x H x D (mm)	244x290x78	244x290x78	244x290x78
Weight (kg)	8.5	8.5	8.5

Non-linearity (%) _{max}	3		
Hysteresis (%) _{max}	2		

Standard face sheet coating type	Protected Silver		
Optional face sheet coatings	Gold, Aluminum, Copper and Dielectric		

Functional temperature ($^\circ\text{C}$)	-50 to 50		
LIDT	On request		
Floating actuator count _{max}	0%		



Deformable Modal Mirror (DMM)

Deformable Modal Mirrors are a distinct class of Adaptive Optics components that correct optical aberrations by adjusting the reflective surface of the mirror in a modal approach. Unlike traditional Deformable Mirrors with individual actuators, deformable modal mirrors utilize a limited number of actuators to generate a set of predefined modes, such as Zernike polynomials, that describe the shape of the mirror. This approach offers various advantages, including reduced complexity, lower cost, and improved reliability.

ALPAO's DMM is designed to provide exceptional performance in correcting low-order aberrations. This mirror offers high optical quality and large strokes, allowing for accurate and efficient correction of wavefront errors. Additionally, the DMM technology enables rapid response times, ensuring real-time correction of optical aberrations in dynamic environments.



To further meet the unique requirements of various industries, ALPAO also offers custom DMM solutions, providing clients with tailored mirrors to best suit their optical systems.

ALPAO Deformable Modal Mirrors are compatible with a variety of software platforms, including MATLAB, LabVIEW, and Python. This compatibility ensures seamless integration into existing systems and facilitates communication with various wavefront sensors and control algorithms.

Furthermore, ALPAO provides comprehensive customer support, offering technical assistance, training, and workshops to help clients maximize the potential of their Deformable Modal Mirrors.



DMM Technical Specifications

	DMM
Number of controls channels	8
Pupil diameter (mm)	13.5
Active best flat (nm RMS, mechanical) _{max}	$\lambda/10$
Tip-tilt correction stroke _{min}	± 100
Fitting error (%) _{max}	3
Defocus/Astig correction stroke _{min}	± 20
Fitting error (%) _{max}	3
Spherical correction stroke _{min}	± 1
Fitting error (%) _{max}	30
First resonance of the membrane (Hz) _{min}	120
Settling time (ms at $\pm 10\%$, any stroke) _{max}	10
Non-linearity (%) _{max}	5
Hysteresis (%) _{max}	5
Cylinder diameter (mm)	50
Cylinder length (mm)	50
Standard face sheet coating type	Protected Silver
Optional face sheet coatings	Gold, Aluminium, Copper and Dielectric
Functional temperature (°C)	-50 to 50



Deformable Mirror Electronics



The **Standard Electronics** are the default drivers for small Deformable Mirrors. Powered manually via a on/off button, It ensures fast and efficient communication with Deformable Mirrors, enabling users to fully harness the capabilities of their Adaptive Optics Systems. The default connection is USB 3.0 / Ethernet. For clients requiring even higher-speed communication, a PCIe card can be integrated, providing the flexibility needed to meet the most demanding requirements.

The **OEM Electronics** are available as an option for small Deformable Mirrors. They offer a compact form factor for systems in which space is crucial. The default connection is USB 3.0 / Ethernet. For clients requiring even higher-speed communication, a PCIe card can be integrated, providing the flexibility needed to meet the most demanding requirements.



The **Large Electronics** are the default drivers for large Deformable Mirrors. Powered manually via a on/off button, it allows the most precise control in order to correct high order complex aberrations. The default connection is an integrated PCIe card. The number of PCIe cards changes in accordance to the mirror purchased (a higher actuator count requires more connections).

Deformable Mirror Options

Variations of our mirrors are available under request:

- High Speed reduces the response time of the DM by a factor 2.
- Large Stroke increases the stroke of the DM by a factor 2.
- High Stability is recommended for open loop applications, enhancing the stability of the DM. It is compatible with the Large Stroke option.

	Stroke	Settling Time	1 st resonance freq.	Freq. phase lag 45°
Large Stroke	x1.5	x2	/2	/2
High Speed	/2	/2	x2	x2

Accessories



The **Rotation Stage** is available for our Deformable Mirrors depending on the model. It allows for precise tip-tilt correction and alignment of the mirror. A **Motorized Rotation Stage** is also available under request.



The **Alignment Static Mirror** is available for every Deformable Mirror. It uses the same housing as your mirror. It replaces your ALPAO DM for alignment tests or when you must move your DM to another optical bench.



The **Trigger-IN and Trigger-OUT** cable allows you to synchronise sharply your DM with external hardware or vice-versa. This requires your Electronic Drive to have a PCIe card.



The **Ledbox** allows you to verify that the expected signals are arriving from your control computer to the deformable mirror.

The ALPAO logo is printed in white on the top surface of a black, rounded rectangular device. The logo consists of the word "ALPAO" in a bold, sans-serif font, enclosed within a white oval shape that has a slight 3D effect.

ALPAO

The ALPAO logo is displayed in white on a dark background. It features the word "ALPAO" in a bold, sans-serif font, surrounded by a white oval with a subtle shadow effect.

ALPAO

727, rue Aristide Berges
38330 Montbonnot - France

www.alpao.com
marketing@alpao.fr

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