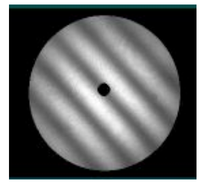
Aperture Optical Sciences

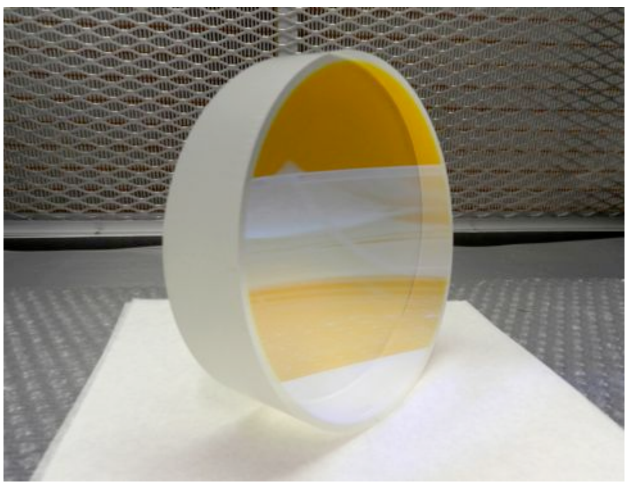
Off-Axis Parabolic Mirrors



Aperture Optical Sciences Inc. provides some of the most unique custom precision optics and systems made in the world today. We develop and employ advanced technology for making aspheric mirrors and lenses, SiC optics, optics for high energy lasers and engage in developmental processes of advanced materials. AOS optics are deployed in aircraft vision systems, industrial scanners, research facilities using advanced lasers, and remote sensing applications.

Off-Axis Parabolas

Off-Axis Parabolic (OAP) Mirrors are used throughout sophisticated reflective optical systems today. Our customers use OAP's in beam expanders, collimators, airborne imaging systems, telescopes, and as focusing elements for high-energy lasers. OAPs offer the advantages of compact geometry, simplification in optical design over refractive optics, and very high accuracy imaging over a broad spectral range.

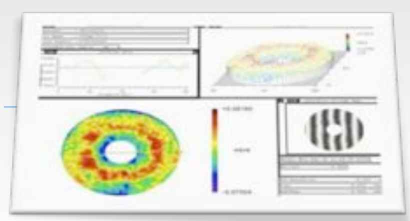


AOS Technology

Precision contouring of off-axis aspheric surfaces is accomplished by means of fixed abrasive diamond grinding using a 7-axis robotic machine platform. AOS first models the desired mathematical description of the asphere using in-house developed software and then programs the fine grinding operation using a combination of 3D mechanical probing and robotic small tool grinding. This operation is extended into the polishing regime using interferometric surface characterization and polishing using robotic polishing. Surfaces Roughness is characterized using white light scanning interferometric profilometry. Finished mirrors are available in multiple configurable options. Our applications engineers can work with you to determine the specifications you need.

AOS Manufacturing Capabilities

- **Size:** 25-mm – 945-mm
- **Materials:** Fused Silica, Zerodur / Clearceram, and Silicon Carbide, Single Crystal Silicon. Other materials may also be available
- **Off-Axis Angle**: 0-90 deg.
- **F/#:** f/0.65 – F/50
- Lightweighting available
- High Damage Threshold Coatings
- Design Services
- Custom Opto-Mechanical components / mounts
- Custom reflective beam expanders



Aperture Optical Sciences, Inc.
27 Parson Lane, Unit G   Durham, Connecticut 06422
T: (860) 316-2589 F: (860) 760-6564
www.apertureos.com

Off-Axis Parabolic Mirrors Definitions:

(* denotes essential information to specify an OAP)

Parent Axis: The optical axis normal to the center of the parent parabola.

Segment Axis: The axis of the off-axis parabola segment drawn parallel to the parent axis and corresponding to the geometric center of the off-axis segment surface.

***Parent Focal Length (fp):** The distance from the vertex to the focus along the parent axis. This spec is fundamental to all parabolas – even those off-axis.

Segment Focal Length (fs): The distance from the geometric center of the surface of the off-axis segment to the focal point.

***Off-Axis Angle (OAA):** The angle subtended between the segment axis and the segment focal length.

***Off-Axis Distance (OAD):** The distance between the parent axis and the segment axis. *Some manufacturers define this as the distance from the parent axis to the inner edge of the segment – we do not because measuring this quantity is less reliable and prone to higher errors. The center of the parabola is a more reliable datum point.*

Sag (Z) : The displacement of surface from the vertex, at the radial distance (r) from the parent axis.

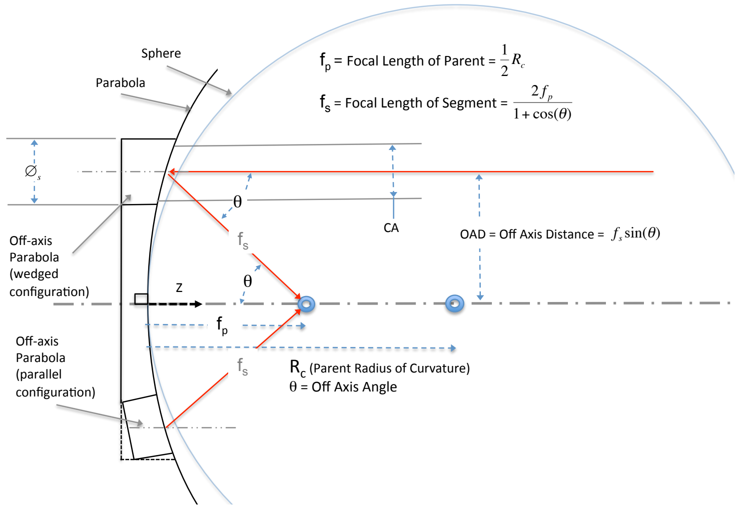
$$z(r) = \frac{r^2}{R\left(1+\sqrt{1-(1+K)\frac{r^2}{R^2}}\right)} + \alpha_1 r^2 + \alpha_2 r^4 + \alpha_3 r^6 + \cdots,$$

Departure from Sphere (δ): It is often useful to determine the difference in sag between the parabola surface and the sag of the best-fit sphere. This quantity is known as the "departure from sphere" and determines the degree of apherization. This often has a bearing on the level of difficulty in manufacturing.

Form Error: Also called "Figure Error" or "Surface Irregularity". This is the departure from the perfect intended surface contour. For optics of size > 100 mm form error applies to errors of spatial scale length greater than 10mm. See also ISO 10110 for general definitions.

Mid-Spatial Frequency (MSF) Error: Periodic surface ripples of spatial scale length between 1 mm and 10 mm (some definitions extend this to 33 mm). See AOS Technical Note on MSF Error for a more detailed description. See also ISO 10110 for general definitions.

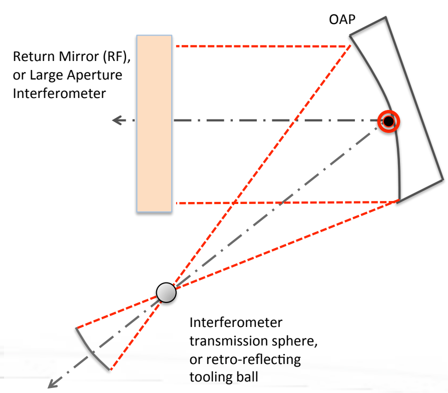
Roughness: Surface errors of scale length 0.0025 mm to 0.080 mm. See also ISO 10110-8-2010 for more general definitions.



Interferometric Test Methods:

AOS tests parabolic mirrors a number of ways – but almost always attempts to test the parabola in the same way it is used in its application. This includes the following common configurations:

1. Collimated reference wavefront from a large aperture interferometer is incident on the OAP and retro-reflected off a spherical reference or calibrated tooling ball.
2. Spherical wavefront incident on the OAP and retro-reflected off a reference flat
3. A Computer Generated Holographic (CGH) null lens may be used in conjunction with a plano or spherical reference beam from a large aperture interferometer



Aperture Optical Sciences Inc.'s mission is to provide its customers with optical components, systems and optically driven technologies that will fuel the growth of their businesses in the US, Japan, Europe and Asia. We are a privately owned US company and ITAR registered.

Our principal products are Silicon Carbide optics, Aspheric mirrors and lenses, laser optics, and opto-mechanical systems including precision beam steering systems, telescopes, and laser focusing systems. Our customers use our optics in high-energy lasers, airborne vision systems, remote sensing, optical lithography, and a variety of scientific research applications.

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