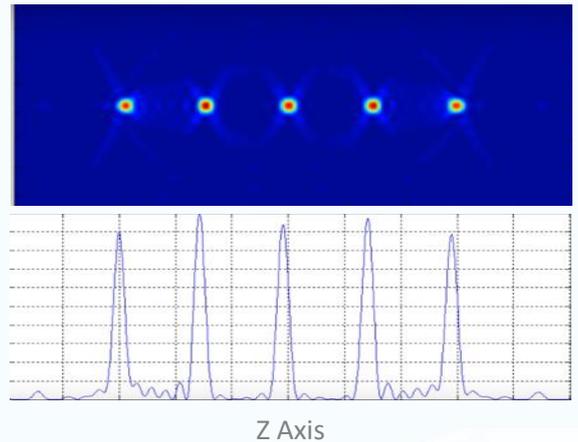


Multi Focal Lens

Multi-focal Diffractive Optical Elements (DOE's) allow a single incident beam to focus simultaneously at several focal lengths along the propagation axis.

From a collimated input beam (single mode or multi-mode), the output beams focus at a fixed number of focal lengths, predetermined during the design of the DOE based on the customer's system requirements.



FEATURES

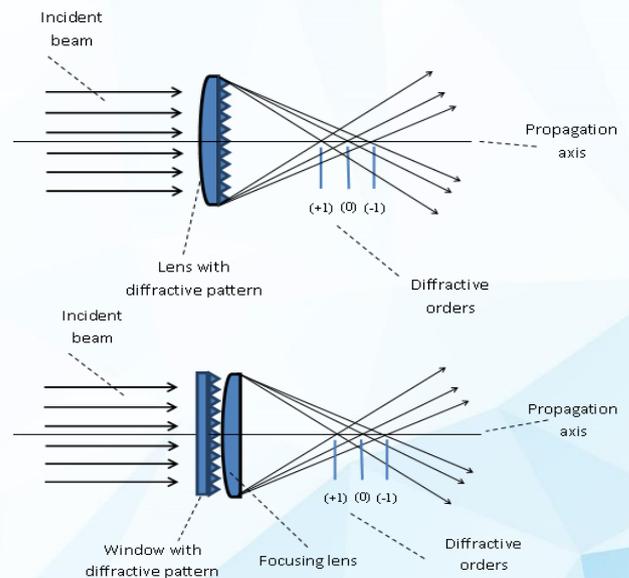
- Arbitrary number of foci
- Control in the distance between foci
- High power threshold

APPLICATIONS

- Ophthalmic application
- Optical sensors
- Parallel zoom systems
- Material processing (Laser cutting)

Multi-focal DOE come in two configurations:

1. A DOE consisting of a Plano convex lens with predetermined focal length, and a diffractive pattern, etched on its Plano side.
2. For more flexibility, a window DOE, thus, to get the foci spots at certain distances, the user adds a regular focusing lens after the DOE. The lens focal length determines the working distance (WD).



THEORY & DESIGN CONSIDERATIONS

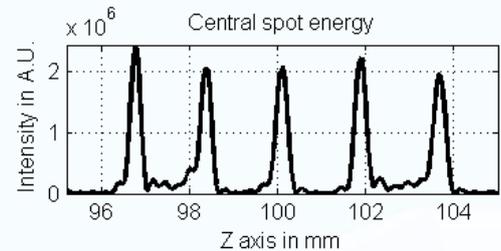
The multi-focal spots location is a function of the refractive focal length, $f_{\text{Refractive}}$, and predetermined diffractive focal length, $f_{\text{Diffractive}}$. The foci spot at the “zero” order refers to the refractive FL of the used lens. The other diffractive foci spots, orders $\pm 1, 2, 3, \dots$, appear symmetrically around the refractive “zero” order. The distances between the foci spots are described by the equation below:

$$\frac{1}{f_{m\text{Diffractive}}} = \frac{1}{f_{\text{Refractive}}} + \frac{1 \cdot m}{f_{\text{Diffractive}}} \quad m = \pm 1, \pm 2, \pm 3, \dots$$

Where:

$f_{m\text{Diffractive}}$: FL for “m” diffractive order ; $f_{\text{Refractive}}$: FL of a refractive lens ; m : order of multi-focal spot

The Multi-focal spots location can also be calculated by using **HOLO/OR**'s online optical calculator: <https://www.holor.co.il/optical-calculator/multifocal-lenses/>



In the case of a multi-focal DOE with an even number of foci spots, the removal of the Zero-Order spot is achieved by special design and processing.

For binary designs (2 levels pattern structure), power efficiency varies between 75% (for Bi-focal and multi-focal) to 85% (Tri focal).

Each focal spot contains a fraction of the input beam power. In example, for a tri-focal DOE (~85% efficiency), first focal spot will have ~28% of the input beam power at precise diffractive FL, “+1” order. Forward on the propagation axis a focus will appear at the nominal FL of the lens. Here the focus spot will have ~28% of the input beam power. The last focus appears at the “-1” order (diffractive order) and will have the same power. At each order the rest of the power (~56%) will be spread around the focus in the form of a halo.

Multi-focal can also be used as quasi-elongated focus elements, effectively creating a larger depth of focus in material processing operations.

SPECIFICATIONS RANGE

Materials	Fused Silica, ZnSe, Plastic
Wavelength range	193nm to 10.6um
Number of Foci	Custom specific (2-11)
Doe design	Binary, 8-level, 16-level
Diffraction efficiency	75%-98%
Element size	5mm to 38.1mm
Coating (optional)	AR/AR
Custom design	Tailored power distribution, Foci spacing

