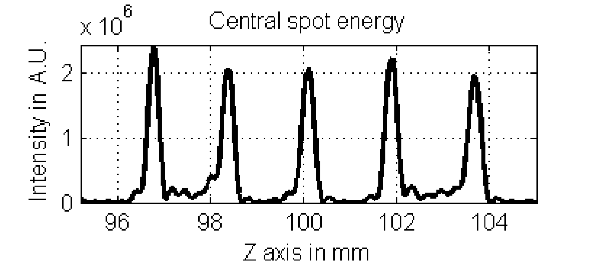
The Early Pioneer of Diffractive Optics

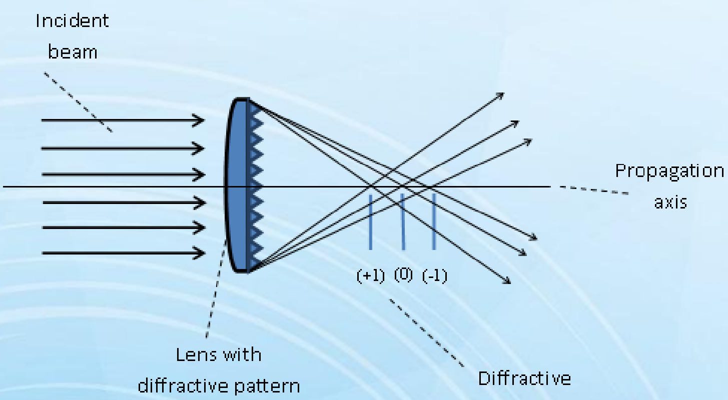
Multi Focal Lens



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

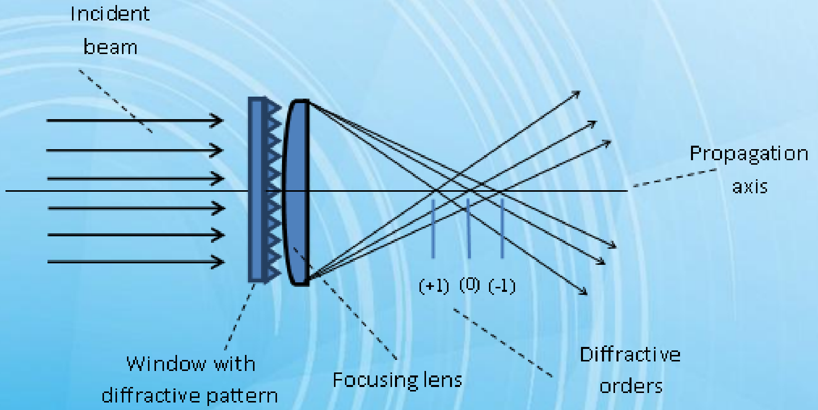
Features:	Applications:
• High power threshold • Arbitrary number of foci • Control in the distance between foci	• Ophthalmic application • Optical sensors • Parallel zoom systems • Material processing (Laser cutting)

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



The Multi-focal DOE comes 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, $f_{Refractive}$, and predetermined diffractive focal length, $f_{Diffractive}$. The foci spot at the "zero" order refers to the refractive FL of the used lens. The other diffractive foci spots, orders +/-1,2,3…, appear symmetrically around the refractive "zero" order. The distances between the foci spots are described by the equation below:

$$\frac{1}{f_{"m"\text{Diffractive}}} = \frac{1}{f_{\text{Refractive}}} + \frac{1 \cdot m}{f_{\text{Diffractive}}} \quad m = \pm1, \pm2, \pm3...$$

$f_{"m"\text{Diffractive}}$: 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 HoloOr's online optical calculator: http://holoor.com/Diffractive_Optics_Products/Calculators.htm
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:

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