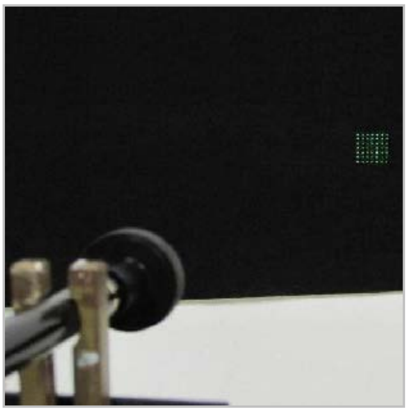
Optics

Beam Splitting / Multispot - Diffractive Optics

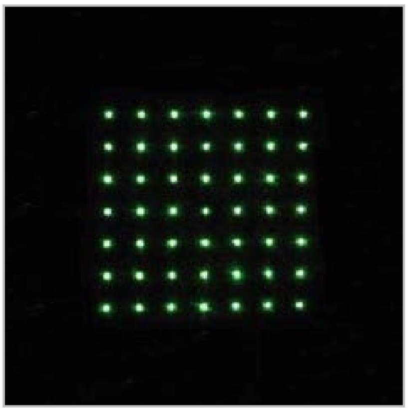
Introduction



A common variation of the beam splitting / multispot DOE is a multi-line array, where instead of a 1xN array of spots, the user will get a 1xN array of lines, whose length is determined during the design according to the customer's application requirements.

Our beam splitters are used in a wide variety of research and industrial applications. Some typical areas include:

- Laser scribing such as in solar cells or panels
- Laser dicing
- Laser displays
- Filters for cigarettes
- Medical/aesthetic applications such as skin treatment
- 3-D sensors
- Fiber optics



This application note is meant to aid the user's understanding of the functionality and considerations when using a diffractive beam-splitting element.

Principle of Operation

The operational principle is quite straightforward. From a collimated input beam, the output beams exit from Diffractive Optical Element (DOE) with a separation angle that is determined during the design of the DOE based on the customer's system requirements (See figure 1 below). The separation angle is highly accurate (<0.03 mR error). The beams' separation is designed for far-field so that as the beams continue to propagate after DOE, they become more well-defined.

Normally, the customer wishes to get well-focused spots at a certain distance. This is easily achieved by the addition of a simple focusing lens after the DOE, whose BFL (back focal length) determines the working distance (WD) to the multi-spot focal plane. See figure 2 below.

01/20 / V07 / IF / holo-or/diffractive_beam-splitters

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Figure 1: 1x2 DOE basic set-up

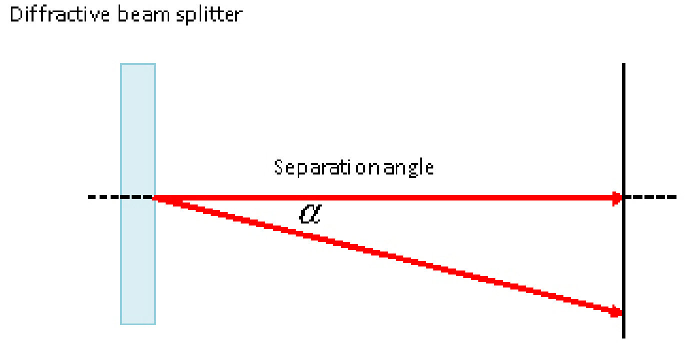
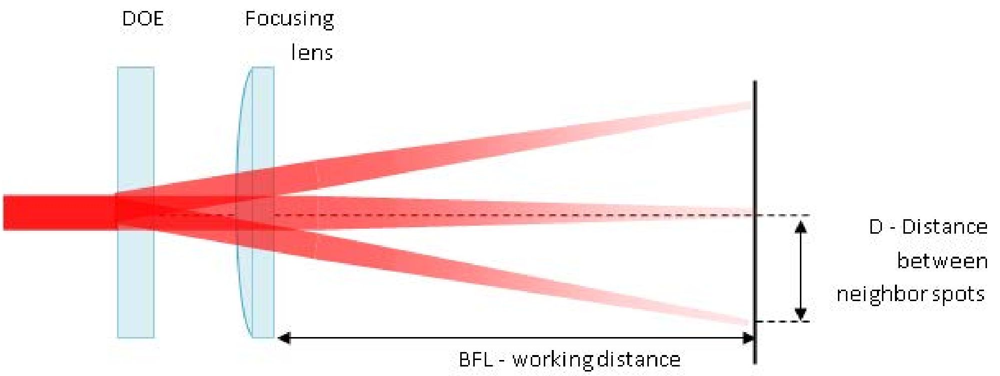


Figure 2: DOE with focusing lens



Choosing the Right Lens

Choosing the right lens for the application is quite easy using the following mathematical relationship between the Working distance WD, separation angle and D (inter-spot distance):

$$D = WD \times \tan(S.A.)$$

D: Inter-spot distance (measured between centers of spots)
WD: Working distance
S.A.: Separation angle

The spot size at the focal plane is given by the formula:

$$\frac{4 \times WD \times \lambda}{\pi \times B.S.} \times M^2 = spotsize$$

WD: Working Distance
λ: Wavelength
B.S.: Input Beam Size ($1/e^2$)
M2: M2 value of input laser beam

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Design Considerations and Limitations

In double-spot configuration, **power efficiency** can reach nearly 80% due to physical constraints, while the multi-spot (>2) configurations can reach nearly 85% in binary etching process, and nearly 95% in multi-level etching. The remaining power is distributed among the other (parasitic) orders.

Multi-level etching is worthwhile only in cases where the minimum feature of the diffractive pattern is not so small. If too small, then manufacturing tolerances will likely reduce efficiency level to near binary level. The minimum feature size is a function of the total angular divergence of the generator array and the wavelength.

Energy distribution can be designed for either **spot uniformity** or for any non-uniform distribution meeting the application's requirements.

Often, for initial testing purposes, a user may want to use a standard product whose design wavelength is not exactly the wavelength in the user's application. Holo-Or can provide in such cases the expected performance (power distribution among orders) with the user's alternative wavelength.

The **minimum input beam size** is determined by various design parameters specific to the application at hand, and is given as at least 3 times the size of the Period in the DOE. The Period in turn is given by the equation:

$$\frac{m\lambda}{\sin\theta} = \Lambda$$

Λ = Period of DOE
m = diffraction order
λ = wavelength
θ = Separation Angle between beams

In cases where the Period is very large, and the laser beam is very small, the user can widen the input beam using a beam expander that matches his/her wavelength and required magnification.

Tolerances

In configurations involving an even number multi-spot, the zero-order spot is undesired. Tolerances in the manufacturing process may result in a zero-order intensity differing slightly from the theoretical simulations; likewise, for uniformity and efficiency. For any particular design, the expected values can be supplied to the customer upon his/her inquiry.

Normally, due to standard tolerances in etching, the zero-order intensity can vary by about 1% of input beam in IR applications, and is typically more in the UV.

Intensity distribution Vs. working distance (near focal plan of lens):

http://www.youtube.com/watch?v=QHrzIcZ7Pw8&feature=player_embedded

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