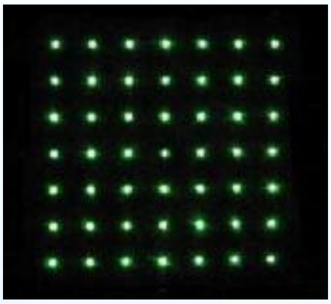
# Beam Splitting



Beam Splitting elements are diffractive optical elements (DOE) used to split a single laser beam into several beams, each with the characteristics of the original beam.

**Features:**

- Accurate angle separation
- Insensitive to X-Y-Z displacements
- Custom separation angle and shape
- Any input beam shape
- High power threshold
- Wavelengths from UV to IR
- Optional AR/AR coating

**Applications:**

- Parallel material processing
- Medical/aesthetic treatment
- Laser scribing (solar cells)
- Glass dicing (LCD displays)
- Laser display & illumination
- Machine vision & 3D sensors
- Fiber optics

DOEs can generate unique optical functions that are not possible by conventional reflective or refractive optical elements, providing greater flexibility in system configuration. Among the few advantages are: small footprint, fast/high throughput thanks to simultaneous processing, tailored energy distribution, etc. The operational principle is quite straightforward; from a collimated input beam, the output beams exit the DOE with a predesigned separation angle and intensity. Several examples are presented in Fig.1.

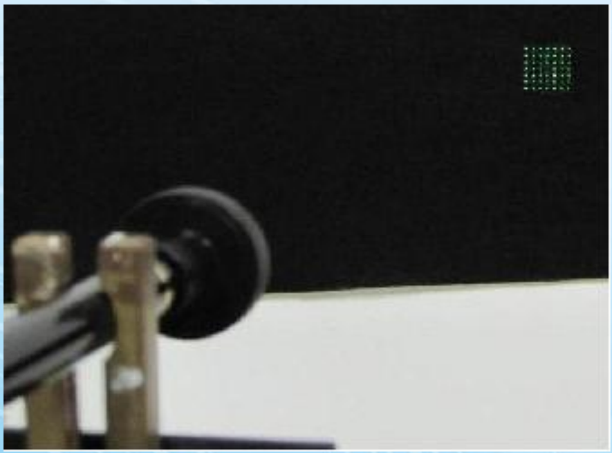
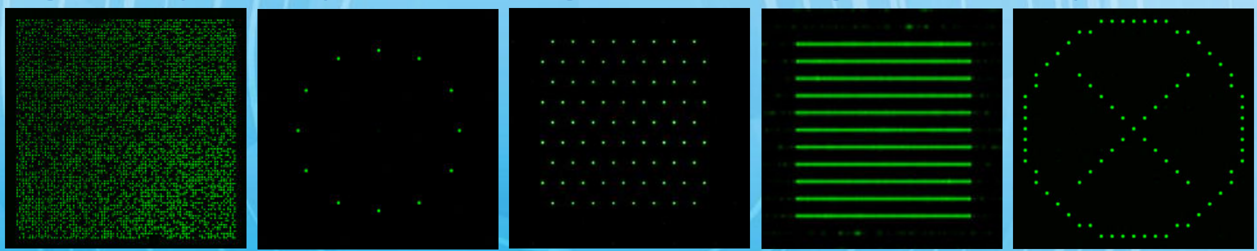
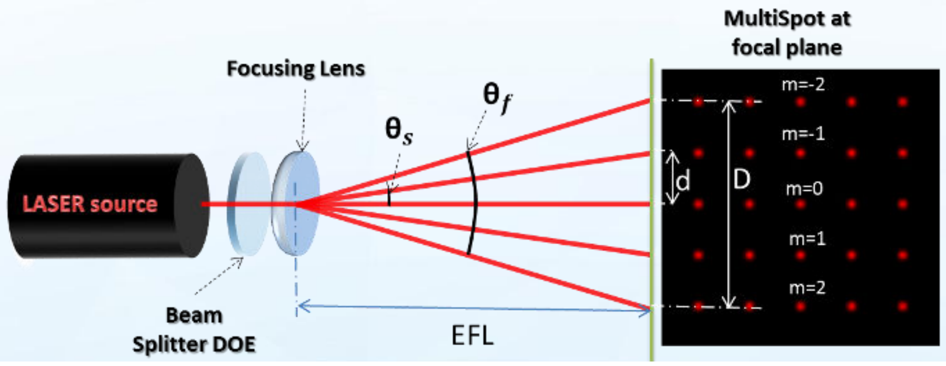


Figure 1 - Examples of Multi-spot DOEs. From left to right: Random, Round, Hexagonal, Viewfinder, Multiple lines



## Design Considerations

1. In order to achieve well-focused spots at a certain distance, one needs to add a focusing lens after the DOE, as shown in figure 2 below.




| | |
|---|---|
| EFL | Effective focal length |
| m | Orders (spot) of the MultiSpot |
| $\theta_s$ | Separation angle between 2 focal spots |
| d | Distance between 2 focal spots |
| $\theta_f$ | Full angle |
| D | Length of the spots array |

Figure 2 - Schematic set-up

2. In order to obtain the right lens, use the following mathematical relationship between the effective focal length (**EFL**), separation angle (**$\theta_s$**), and inter-spot distance/ pitch (**d**):

$$\mathrm{d} = \mathrm{EFL} \times \tan(\theta_s)$$

3. In double-spot configuration, **power efficiency** can reach ~80%, and for multi-spot (>2) 85% is achivable, for a **binary (2 level)** etching process. In **multi-level** etching, efficiency can reach up to 95%. The remaining power is distributed among the other (parasitic) orders.
4. Energy distribution can be designed for either **spot uniformity** or for any non-uniform distribution meeting the application's requirements.
5. The **minimum input beam size** should generally be at least 3 times the size of the **period** in the DOE. The **period** is given by the grating equation:

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

Where, **Λ** = period of DOE, **m** = diffraction order, **λ** = wavelength, **θ**= Separation angle between beams.

## Specifications:

| | |
|---|---|
| **Materials:** | Fused Silica, ZnSe, Plastics |
| **Wavelength range:** | 193nm to 10.6um |
| **Separation angle:** | 0.001° to 60° (larger angles require additional optics) |
| **DOE design:** | Binary, 8-level, 16-level, and more |
| **Diffraction efficiency:** | 64%-98% |
| **Element size:** | 2mm to 100mm |
| **Coating (optional):** | AR/AR V-Coating |
| **Custom Design:** | Almost any symmetry or arbitrary shape |