

## 7. Beam splitters

The tasks of optical dividers are to combine or to distribute light beams of determined properties in some special way, depending of application. Such an effect is obtained due to the use of optically active materials or interference coatings. On the basis of application one can choose kind of divider, its shape and material .

Kinds of dividers depending on their function:

1. energetic (divides power of light beam)
  - metallic
  - dielectric
2. selective separators (filters)
  - edge filters :
    - short-pas filters
    - long-pass filters
  - narrow-band-pass filters
3. polarizing dividers (polarizers)
4. non-polarizing dividers

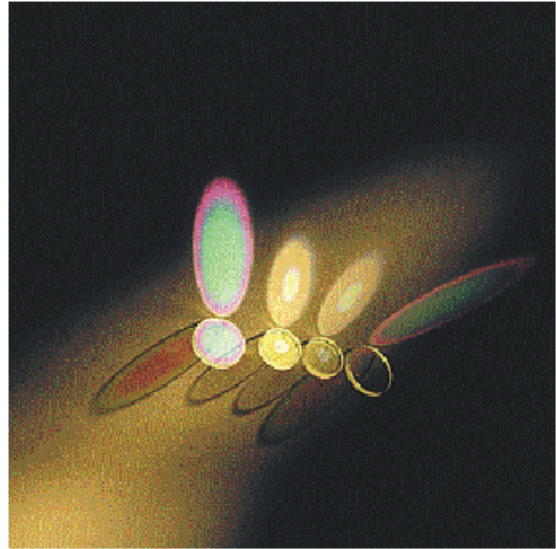
Kinds of dividers depending on their shape:

1. plate dividers
2. prismatic dividers
  - cubic
  - special

**Energetic dividers** are used for energetic separation of beam intensity in denominated ratio. They may serve to divide the beam of white light or another band of light spectrum as well as monochromatic light. The incident beam can be divided into transmitted and reflected beams with various ratios, e.g. R:T= 20:80, 30:70, 50:50, 70:30. The parameters of a light beam influence the choice of the kind of splitter.

**Metallic coating beam divider** is characterized by significant absorption lowering the intensity of reflected and transmitted beams after splitting, but has no influence on the state of light polarization and thus, may be used in wide range of band spectrum (has flat spectral characteristic).

**Dielectric coating beam divider** has no absorption qualities so it can be applied to high-power laser systems but as it has great influence on the state of outgoing beams polarization and can be used only in narrow spectrum band or line of monochromatic light.



**Selective separators ( filters )** divide the beam with two wavelengths into two beams. ( see "Filters" )

**Polarizing dividers** separate the beam with mixed polarization states into two beams of one state of polarization. The reflected beam is "s" polarized and the transmitted beam is "p" polarized. (see "Polarizers")

**Non-polarizing dividers** are a special kind of interference dielectric coating dividers for energetic splitting of the beam without influencing the state of splitted beams polarization. It can be developed only for one wavelength of light. The splitting ratio can be 20:80 or 50:50 and differences between states of polarization are less than 5%.

Additionally to classification of dividers under their kind of coating, they can be listed under the kind of substrate and construction used:

## 7.1. Beam splitter plates

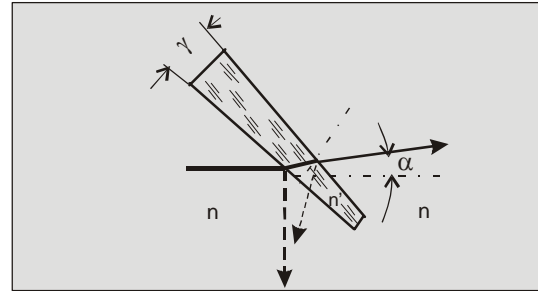
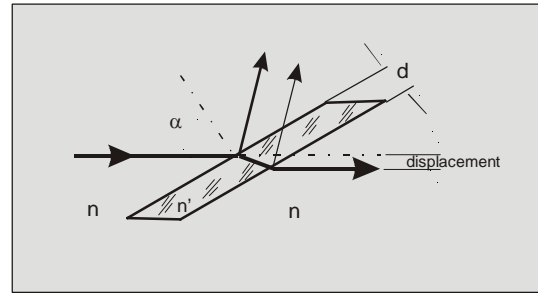
**Plate dividers** are thin plane-parallel or edge plates made of optical glass, quartz or single-axis crystals (e.g. CaF<sub>2</sub>) coated with thin-film layers system. Depending on application it can be either metallic layer or dielectric coating. However one should remember that such an element introduces a shift or deviation into the light beam due to the thickness of optical element. In order to get the normal deviation between transmitted and reflected beams the working angle of incidence should mainly be 45°. The second surface of optical element is often coated with antireflection coating to avoid unwanted additional reflections. Such a divider can be applied in optical systems with high power of light beam.

Parallel displacement on a plane plate:

$$v = d \frac{\sin(\alpha - \alpha')}{\cos \alpha'}$$

Beam deflection with wedge angle  $\gamma$  at 45° angle of incidence:

$$\alpha = \gamma(n' - 1)$$

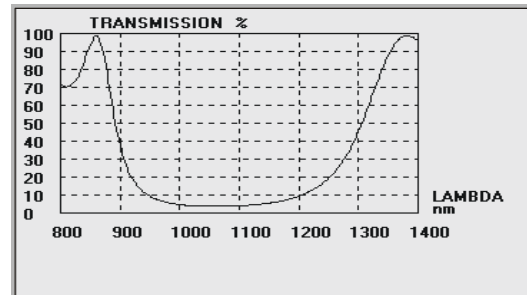


| Technical specification-beam splitter plates |                     |                       |        |
|--|---------------------|-----------------------|--------|
|  | Standard            |                       |        |
| Substrate material                           | on request          |                       |        |
| Size   | 5 – 100 mm          |                       |        |
| Size tolerance                               | -0,1 mm             |                       |        |
| Clear aperture                               | 90 %                |                       |        |
| Thickness tolerance                          | ± 0,1 mm            |                       |        |
| Flatness (633 nm)                            | 1 λ per inch        |                       |        |
| Surface finish (Digs - Scratches)            | 60 – 40             |                       |        |
| Dividing ratio R:T / % /                     | metallic            | 10:90 up to 90:10     |        |
|  | dielectric          | 30:70 ; 50:50 ; 70:30 | BB     |
|  |                     | 10:90 up to 90:10     | V-type |
| Dividing ratio tolerance                     | +/- 5% (for 50:50)% |                       |        |
| Wedge substrate                              | on request          |                       |        |
| Spectral range                               | metallic            | 400nm – 7000 nm       |        |
|  | dielectric          | 300 nm – 16 000nm     |        |
| AR Coatings                                  | on request          |                       |        |

According to customer specification, we can deliver non-standard beam splitters with significantly higher optical parameters: 20-40;  $\lambda/20$  (633nm)+/- 2%, for example. Beam splitters in mountings – also if requested.

## 7.2. Output laser mirrors

Output laser mirrors are a kind of plate dividers. They are used inside the laser generator. The shape of active area could be flat, concave or convex and coated with multi-layer dielectric system. High-quality quartz glass, BK 7 ZnSe, etc. are used as a substrate material.

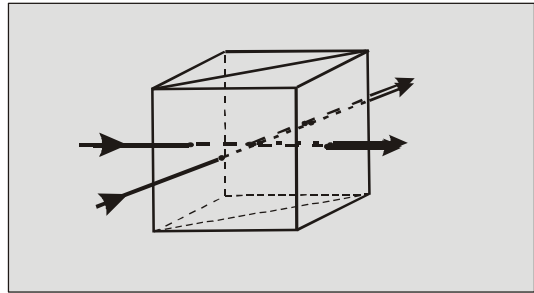


| Technical specification- output laser mirrors |                                      |
|---|--------------------------------------|
|   | Standard                             |
| Substrate material                            | on request                           |
| Size  | 5 – 100 mm                           |
| Size tolerance                                | -0,1 mm                              |
| Clear aperture                                | 90 %                                 |
| Thickness tolerance                           | ± 0,1 mm                             |
| Surface accuracy (633 nm)                     | $\lambda/10$ per inch                |
| Surface finish (Digs - Scratches)             | 10-5                                 |
| Damage threshold                              | 1 GW/cm <sup>2</sup> for 10 ns pulse |
| Spectral range:                               | 300nm – 7000nm                       |
| AR Coatings                                   | on request                           |

According to customer specification, we can deliver non-output mirrors with higher optical parameters:  $\lambda/20$  (633nm), for example. Mirrors in mountings – also if requested.

### 7.3. Beam splitter cubes

Prismatic or cube dividers are optical elements where the working splitting coating surface works at the incidence angle of incidence  $45^\circ$  being glued inside the glass cube. In such an element there is no shift or deviation in the transmitted beam and the optical paths in transmission and reflection are equal. However, the layer of glue inside the cube is lowers thermal durability of the element. Such elements work in medium and low light power optical systems.

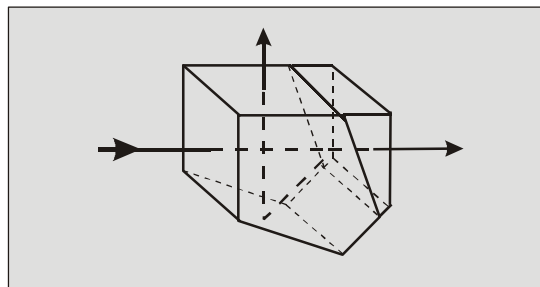


| Technical specification- beam splitter cubes |                       |                   |
|--|-----------------------|-------------------|
|  | Standard              |                   |
| Material                                     | on request            |                   |
| Size   | (5x5)mm.....(50x50)mm |                   |
| Size tolerance                               | +/-0,1 mm             |                   |
| Clear aperture                               | 80 %                  |                   |
| Angle tolerance                              | $\pm 3$ arc min       |                   |
| Flatness (633 nm)                            | $1 \lambda$ per inch  |                   |
| Surface finish (Digs - Scratches)            | 60 – 40               |                   |
| Dividing ratio R:T / % /                     | metallic              | 10:90 up to 90:10 |
|  | dielectric            | 10:90 up to 90:10 |
| Dividing ratio tolerance                     | +/- 5%(for 50:50)%    |                   |
| Cut corners                                  | on request            |                   |
| Spectral range                               | metallic              | 350nm – 1500nm    |
|  | dielectric            | 400 nm – 1500nm   |
| AR Coatings                                  | on request            |                   |

According to customer specification, we can deliver non-standard beam splitter cubes with significantly higher optical parameters: 20-10;  $\lambda/20$  (633nm), for example. Beam splitters in mountings – also if requested.

### 7.4. Penta beam divider

Application of pentagonal prism divider is similar to that of cube divider, but in wide range of angles the image is not reverted and the deviation angle of reflected beam does not depend on the incidence angle. It may be applied in optical systems where precise positioning is either difficult or impossible. The prism is coated with metal reflection coatings and dielectric dividing coatings.



| Technical specification- penta beam splitters |                       |                   |
|---|-----------------------|-------------------|
|   | Standard              |                   |
| Material                                      | on request            |                   |
| Size  | (5x5)mm.....(30x30)mm |                   |
| Size tolerance                                | +/-0,1 mm             |                   |
| Clear aperture                                | 90 %                  |                   |
| 90° degree tolerance                          | ± 2 arc min           |                   |
| Beam deviation tolerance                      | 1 arc min             |                   |
| Flatness (633 nm)                             | 1 λ per inch          |                   |
| Surface finish (Digs - Scratches)             | 60 – 40               |                   |
| Spectral range                                | metallic              | 350nm – 1500nm    |
|   | dielectric            | 400 nm – 1500nm   |
| Dividing ratio R:T / % /                      | metallic              | 10:90 up to 90:10 |
|   | dielectric            | 10:90 up to 90:10 |
| Dividing ratio tolerance                      | +/- 5%(for 50:50)%    |                   |
| AR Coatings                                   | on request            |                   |

According to customer specification, we can deliver non-standard penta beam splitters with significantly higher optical parameters

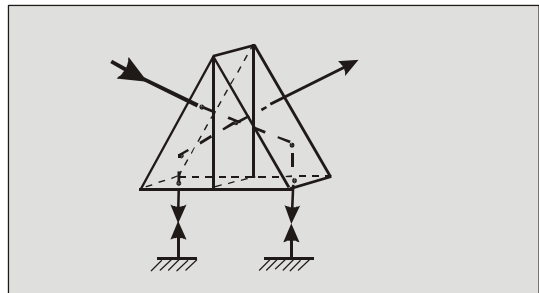
Three groups of penta beam splitters with different deviation tolerance are offered:

- up to 1 arc min,
- up to 30 arc sec
- up to 15 arc sec

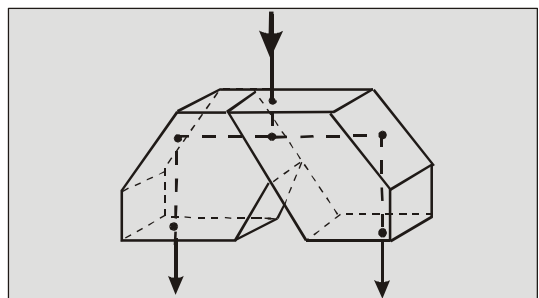
Beam splitters in mountings – also if requested.

## 7.5. Special prismatic beam splitters

KÖSTER prism made with two identical prisms (90°-60°-30°). Longer short faces, with beam dividing coating on one of them, are cemented. With this prism, the light beam can be divided into two parallel beams. The distance between beams can be adjusted.



This special beam divider also enables splitting beam of light per two beams parallel each to the other, and parallel to the input beam with accuracy of tolerance.



| Technical specification- prismatic beam dividers |                       |                   |
|--|-----------------------|-------------------|
|  | Standard              |                   |
| Material   | on request            |                   |
| Size   | (5x5)mm.....(30x30)mm |                   |
| Size tolerance                                   | ± 0,1 mm              |                   |
| Clear aperture                                   | 90 %                  |                   |
| Thickness tolerance                              | ± 0.1 mm              |                   |
| Beam deviation tolerance                         | ± 2 arc min           |                   |
| Flatness (633 nm)                                | 1 λ per inch          |                   |
| Surface finish (Digs - Scratches)                | 60 – 40               |                   |
| Spectral range                                   | metallic              | 350nm – 1500nm    |
|  | dielectric            | 400 nm – 1500nm   |
| Dividing ratio R:T / % /                         | metallic              | 10:90 up to 90:10 |
|  | dielectric            | 10:90 up to 90:10 |
| Dividing ratio tolerance                         | +/- 5%(for 50:50)%    |                   |
| AR Coatings                                      | on request            |                   |

According to customer specification, we can deliver prismatic dividers with significantly higher optical parameters: beam divergence- up to 30 arc sec, 40-20;  $\lambda/10$  (633nm). Beam splitters in mountings – also if requested.