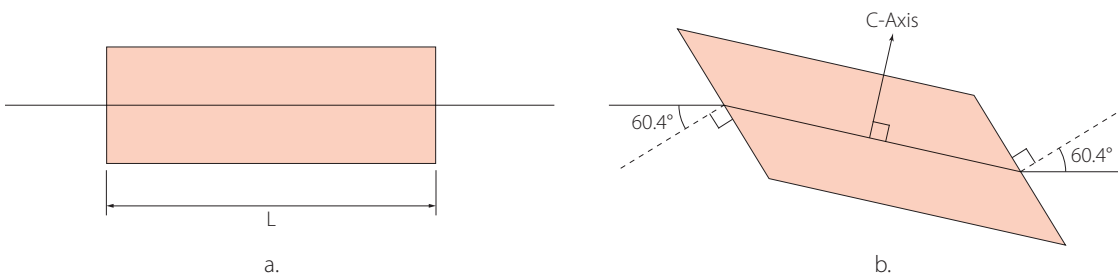


# A Quick Guide on choosing laser crystal cut

## Difference between right-angle and Brewster-angle cut laser crystals

When choosing laser crystals, one has to decide which cut to use, i.e. how the end faces of the crystal will be cut. Generally, two different cuts are used in laser crystals: right-angle cut and Brewster-angle cut.

Figure 1 shows the visual difference between the two cuts in Titanium doped Sapphire crystals: right-angle cut has the polished ends perpendicular to the axis of propagation of light; whereas Brewster-angle cut crystals are at Brewster's angle between the normal vector of the polished face and axis of light input. For laser beam propagation from air to laser crystal (with refractive index  $n$ ), Brewster's angle is defined as  $\theta_B = \arctan(n)$ . At Brewster's angle, the surface reflectance is zero for the light with polarization inside the plane defined by the direction of light propagation and the normal to the surface (also defined as p-polarized light).



**Fig. 1.** Right-angle cut (a.) and Brewster-angle cut (b.) of Ti:Sapphire laser crystal. L stands for crystal length.

**Right-angle cut** is easier to manufacture than Brewster-angle cut, however, it leads to higher resonator losses. It is convenient for application of anti-reflective, high reflection or partial reflecting coatings, but not very useful in high power, especially short-pulse, applications. Coatings applied to the crystal usually have lower damage threshold than uncoated Brewster-angle cut crystal faces.

**Brewster-angle cut** is used to eliminate reflection losses, increase polarization contrast, avoid formation of parasitic pulses in ultra-short pulse oscillators or even induce negative dispersion. Brewster cut faces are left uncoated in order to increase damage threshold of the surface. Reflection losses for p-polarization is zero at Brewster angle.

Brewster-angle cut crystals are more expensive than right-angle cut crystals because the former require more raw material to get the same crystal length L.

Table below summarizes the differences between the two cuts

	Right-angle cut	Brewster-angle cut
<b>Price</b>	Lower	Higher
<b>Laser induced damage threshold</b>	Lower, if dielectric coatings are applied	Higher
<b>Reflection losses</b>	Higher, if no AR coatings are applied	Zero reflection losses for p-polarized light
<b>Aligning</b>	Convenient	Inconvenient
<b>Other</b>	Additional recurring repolishing/ recoating costs due to damaged coatings over time	Astigmatism induced under high average power

To sum up, Right-angle cut crystals are often chosen as cost effective solution, while Brewster cut allows getting maximum power out of a crystal.