DIFFERENCE BETWEEN RIGHT-ANGLE AND BREWSTER-ANGLE CUT LASER CRYSTALS

A QUICK GUIDE ON HOW TO CHOOSE LASER CRYSTAL CUT

When choosing laser crystals one has to decide which crystal cut to use, i.e. how the end faces of the crystal will be cut. Generally, there 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. In the figure this angle is 60.4°. For laser beam propagation from air to laser crystal (with refractive index n), Brewster's angle is defined as θ_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).

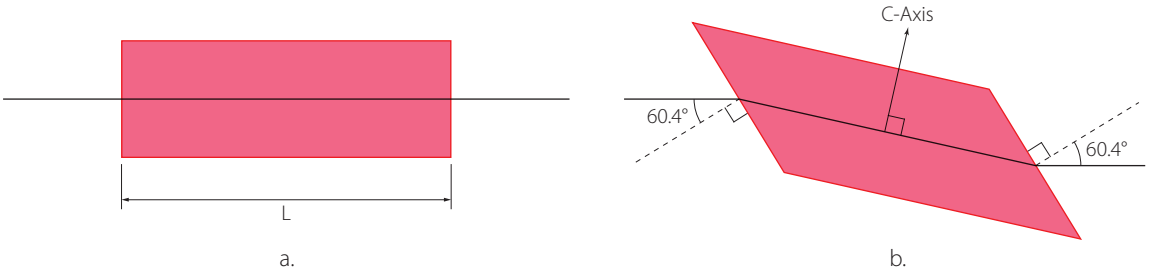

Fig. 1. Right-angle cut (a.) and Brewster-angle cut (b.) of Ti:Sapphire laser crystal. L stands for crystal length.

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 is 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 loss of p-polarization is Brewster-angle cut crystals is zero.

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

As a rule of thumb, right-angle cut crystals are often chosen when the applications require cost effective solution and when the aim of application isn't to get the maximum output of lasing power, whereas Brewster-angle cut crystals are chosen when the application is to get maximum power output keeping in mind that the polarization of pumping laser has to be parallel to the plane of incidence of the laser crystal for best results.