RAICOL CRYSTALS

LBO

Super Polished Crystals

The key to LBO crystal performance: Minimizing surface and bulk absorption

Abstract

When it comes to manufacturing LBO crystals for wavelength conversion, there are a number of important factors to consider. Crystals must have high efficiency and a long life expectancy, which is especially challenging when the crystals are for use in high power laser applications. The key to meeting these requirements is minimizing both surface and bulk crystal absorption. Through cutting-edge technologies and advanced methodologies, Raicol have succeeded in the manufacture of LBO crystals with unparalleled performance. The bulk absorption of these crystals is so minimal that they require a sophisticated measuring technology, IPHT's LID technique, for accurate measurements.

Introduction: What are LBO crystals?

Lithium triborate (LBO) crystals are nonlinear crystals used for wavelength conversion, including second harmonic generation (SHG) and third harmonic generation (THG). LBO crystals have a number of unique features that make them particularly suited to a range of nonlinear optical applications. As well as good mechanical and chemical properties, LBO crystals have a wide transparency range, moderately high nonlinear coupling, and a high damage threshold.

The challenges of manufacturing LBO crystals

For the customer - desirable LBO crystal properties include high efficiency and a long life expectancy. In addition, LBO crystals must be able to withstand the ever-increasing power levels of high power lasers. However, manufacturing such a crystal presents multiple challenges.

When subject to a laser beam, any crystal will absorb some of the laser's power, causing it to heat up - this is known as thermal lensing. Thermal lensing effects include distorting the crystal and causing damage, which reduces both its current performance and its overall lifespan. The higher the absorption level of the crystal, the more heat it will absorb, and the higher the levels of damage that will occur. In tandem with this, the higher the power of the laser beam, the more significant the effects of thermal lensing on the crystal. In order to reduce thermal lensing, the crystal's absorption must be minimized. There are a number of steps that crystal manufacturers can take to ensure that every crystal produced has minimal absorption levels.

Achieving minimal absorption

To manufacture crystals with high performance across a range of wavelengths and laser power levels, crystal manufacturers must ensure that both surface and bulk absorption is minimal.

Surface absorption

The surface absorption of a crystal is directly related to the roughness of the crystal's surface. Any surface roughness creates pockets which lead to increased absorption. A perfectly smooth surface, with minimal roughness, is highly desirable.

To achieve minimal roughness, Raicol employs a number of cutting-edge technologies, such as proprietary machining techniques, to smooth and polish crystal surfaces, leading to an unparalleled surface roughness of less than 3Å RMS.

In order to measure the surface absorption of a crystal, a Common Path Interferometer (CPI) is often used. This allows for highly sensitive measurements of absorption losses on the surface and in the coating layers. Measurements are taken over a short period of time in order to calculate optical degradation levels, and thus predict the life time of the crystal.

Bulk absorption

The bulk absorption of a crystal focuses on the purity of the crystal itself, and increases if there are irregularities in the crystal's structure.

For bulk absorption to be minimized, the crystal itself must be of very high quality. Raicol's LBO crystals are grown using superior materials, in an extremely controlled environment, using the latest growth chambers. This ensures that every crystal manufactured has the most favorable characteristics, including low bulk absorption.

Measuring low bulk absorption rates is particularly challenging. For example, as Raicol's LBO crystals have such low bulk absorption rates, a cutting-edge measurement technique, laser induced deflection (LID), developed by IPHT, was required to achieve accurate and consistent measurements. This method records precise absorption measurements of the bulk crystal, using pulsed laser irrigation in a compact experimental setup. Analysis focuses on the influence of both pure bulk and pure surface absorption on temperature and refractive index, and the consequential probe beam deflection.

Conclusion

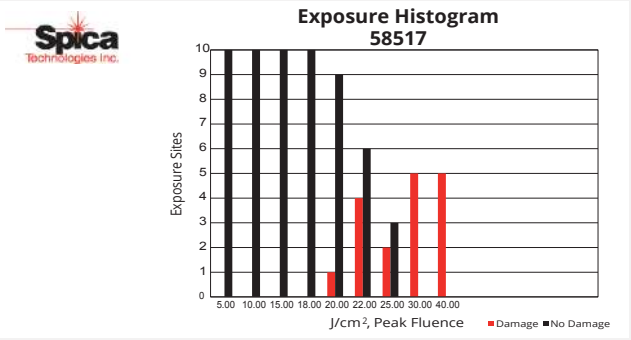
Measurements of Raicol's LBO crystals, for both surface and bulk absorption, show a promising future for a variety of applications, including for use with lower wavelengths and higher intensities, due to unparalleled low bulk and surface absorption rates. Bulk absorption measurements for Raicol's LBO crystals have been made possible through IPHT's laser induced deflection (LID) technique, allowing accurate measurements where other standard methodologies have failed, highlighting the extent to which Raicol's LBO crystals surpass the performance of other crystals in the same. These minimal absorption rates are achieved through state-of-the-art equipment and methodologies.

Higher Damage Threshold -
Test Results of independent measurements of SPICA and Lumibird:

"Raicol's Super Polished LBO crystals show extremely high LIDT @ 355 nm and 532 nm."

SPICA test results:

LBO testing results @ 355 nm:
* Laser damage threshold measured as **18.00 J/cm²**, peak fluence.
* Part irradiated at **18.00 J/cm²** with no damage in 10 sites.



Lumibird test results:

LBO Testing Results @ 532 nm:
* Root T scaled: 17 J/cm² @ 8 ns is equivalent to **19 J/cm²** @ 10 ns.
* Root T scaled: 2124.41 MW/cm² @ 8 ns is equivalent to **1900.13 MW/cm²** @ 10 ns.

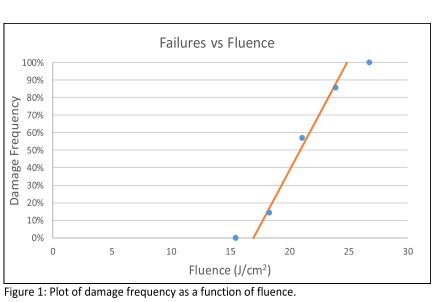
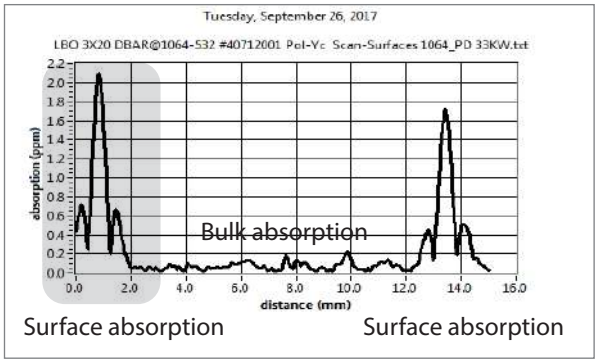


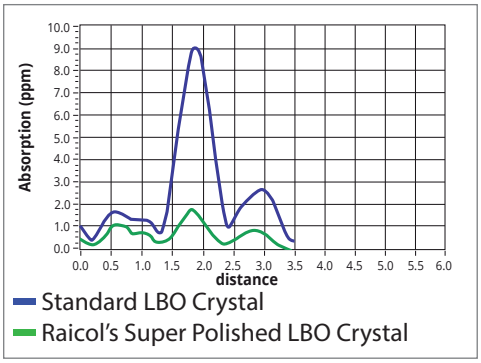
Figure 1: Plot of damage frequency as a function of fluence.

Unmatched surface absorption

Raicol has developed the Super Polished LBO to minimize roughness which lowers surface absorption.



* A screen shot of actual bulk absorption test.
* Surface Absorption Graph for Uncoated Standard LBO @ 532 nm.
* **Over 70% of total LBO crystal absorption occurs on the surfce of the crystal.**



* Comparison of surface absorption performed @ 532 nm on LBO crystal AR coated @1064/532 nm.
* **Super polished LBO by Raicol (3Å as a standard) reduces surface absorption by 80%!**

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