Inradoptics

Custom Crystals for Doubling Ultrafast Ti:Sapphire Pulses

In the years since their first demonstration at MIT Lincoln Labs in 1982, mode-locked Ti:Sapphire oscillators have become almost ubiquitous. The ultrashort, tunable output pulses from these lasers permit investigation of previously extremely difficult to study phenomena. Typical output from these lasers ranges from red to near infrared, yet for many applications which require high peak powers and ultrashort pulses, shorter wavelengths are desirable. Harmonic generation using nonlinear optical crystals has become one of the most popular methods of reaching these wavelengths.

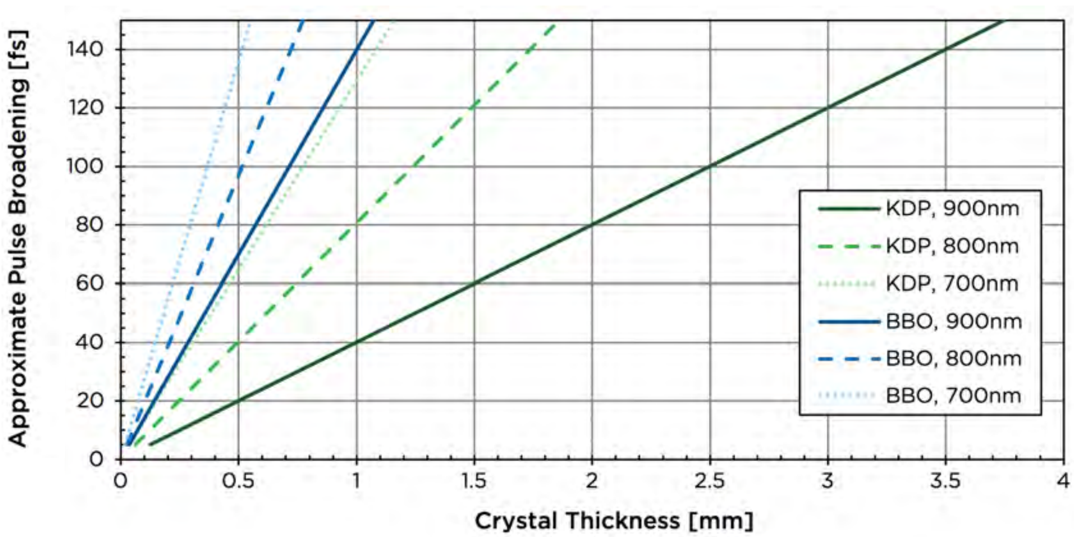
Commercial Tunable Femtosecond Ti:Sapphire Oscillators		
Model	**Pulse Width**	**Tuning Range**
Chameleon Ultra (Coherent)	< 140 fs	690 - 1020 nm
Mira HP-F (Coherent)	< 150 fs	700 - 980 nm
Mira Optima 900-F (Coherent)	< 200 fs	700 - 980 nm
Mai Tai HP (Spectra-Physics)	< 100 fs	690 - 1040 nm
Mai Tai XF-1 (Spectra-Physics)	< 70 fs	710 - 920 nm
Spitfire Ace 35F (Spectra-Physics)	< 35 fs	795 - 805 nm
Tiberius (Thorlabs)	< 120 fs	720 - 1020 nm

APPLICATIONS

- **Biology:** Multiphoton Fluorescence Microscopy (MFM) – ultrafast Ti:Sapphire lasers offer high peak powers with low average powers, permitting high signal strength without damaging samples.
- **Chemistry:** Femtosecond spectroscopy – examination of chemical reactions on ultrashort time scales and over a wide range of wavelengths is made possible by tunable femtosecond Ti:Sapphire lasers.
- **Physics:** Advancing nonlinear optics research, THz generation, and plasma physics.

CHALLENGES IN ULTRAFAST NONLINEAR OPTICS

Group velocity delay varies with wavelength and crystal material, and typically has a magnitude of 10's to 100's of fs/mm. Hence, when working with femtosecond pulses, it is critical to consider possible pulse broadening when choosing an appropriate crystal thickness. Plotted below are approximate values for pulse broadening in KDP and BBO crystals for type I second harmonic generation of femtosecond pulses over the typical output range of Ti:Sapphire oscillators.



INRAD OPTICS NONLINEAR CRYSTALS

BBO and KDP crystals are grown and fabricated at the Inrad Optics facility in Northvale, NJ by experienced professionals with decades of experience in working with nonlinear optical crystals. Large aperture crystals are available and standard thicknesses for ultrashort pulses range from 5 mm to 0.1 mm. Custom dimensions are available upon request.

Angular accuracy is critical to achieve optimum performance. At Inrad Optics, the optic axis is identified by laser testing and the orientation is corrected. For high precision applications, the crystal orientation accuracy can be enhanced by x-ray methods: by aligning to the Bragg angle for the appropriate crystalline plane, fine adjustments can be made to reach sub-arcminute accuracy.

CUSTOMIZE A CRYSTAL FOR YOUR APPLICATION

Typical Specifications			
	Standard	**Precision**	**High Precision**
TWD (@633nm)	<λ/4	<λ/8	<λ/10
Scratch Dig	20 - 10	10 - 5	10 - 5
Theta Tolerance	<30 arcmin	<6 arcmin	<1 arcmin
Parallelism	<5 arcmin	<30 arcsec	<10 arcsec
Typical Dimensions			
BBO	Aperture: 25x25 mm maximum, <10x10 mm typical Thickness: 0.1 mm - 15 mm		
KDP	Aperture: Ø125 mm maximum, < Ø60 mm typical Thickness: 0.1 mm - 30 mm		

For help optimizing specifications for a crystal for your application, call Inrad Optics to speak with a sales engineer or send a description of your system requirements to sales@inradoptics.com

References:

K.F. Wall and A. Sanchez, “Titanium Sapphire Lasers”, The Lincoln Laboratory Journal, 3 447-462 (1990).

H. Wang and A.M. Weiner, “Efficiency of Short-Pulse Type-I Second-Harmonic Generation With Simultaneous Spatial Walk-Off, Temporal Walk-Off, and Pump Depletion”, IEEE J. Quant. Elec. 39 1600-1618 (2003).

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