Inradoptics

Walk-off Compensated Crystals

The term “walk-off” refers to the separation in time and space which develops between beams of differing polarization and frequency as they pass through a birefringent crystal. Because critical phase-matching is sensitive to the alignment of the beams in any given interaction, evaluating spatial walk-off is important for estimating conversion efficiency and optimizing crystal parameters.

CONVERSION EFFICIENCY

Nonlinear optical conversion efficiency typically scales with the interaction length, but increasing the length of a crystal is not a fool-proof approach to increasing efficiency. Narrow angular acceptance, spatial and temporal walk-off and a variety of other factors limit the useful interaction length and degrade the quality of the beam(s). To combat these effects, the technique of using multiple shorter crystals with alternating walk-off directions was developed, as illustrated in figure 1. This method maximizes the useful interaction length and enables enhanced conversion efficiency and beam quality, but requires careful alignment and very well matched crystals, hence the actual enhancement of efficiency depends on the precision of manufacturing and alignment of the crystals.

WALK-OFF COMPENSATED ASSEMBLIES

Inrad Optics produces optically bonded crystals including a four-crystal, walk-off compensated BBO stack. This high precision crystal assembly uses no adhesive and requires no additional mounts or alignment procedures beyond those used for a single crystal. The assembly consists of two sets of paired crystals, each crystal cut to the precise phasematching angle to within 2 arcminutes. Paired crystals are matched in thickness to within ±10μm in order to optimize walk-off compensation.

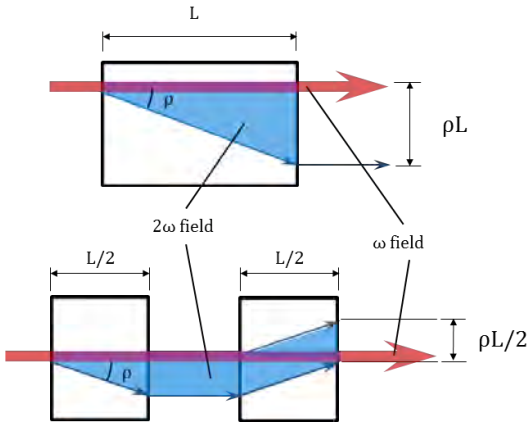

Figure 1:

Top: *Spatial walk-off in a type I SHG interaction in a single negative uniaxial crystal of length, L. The fundamental, ω, is o-polarized. The second harmonic, 2ω, is e-polarized and propagates along the birefringence (walk-off) angle, ρ. Note that ρ is on the order of mrad, and sufficiently small with respect to the crystal length that the small angle approximation is applicable.*

Bottom: *The same interaction in two shorter crystals of opposing birefringence angles. The total interaction length, L, is unchanged, but the spatial walk-off of the second harmonic is cut in half.*

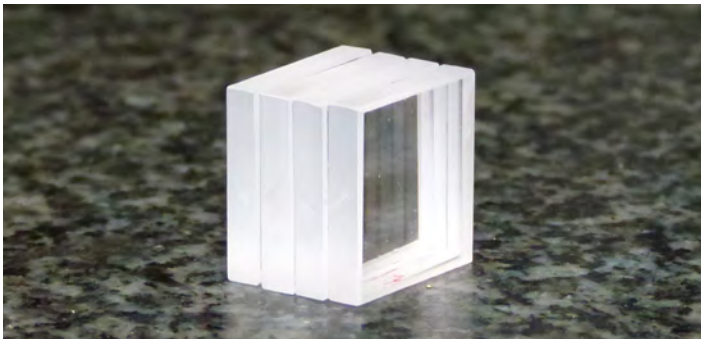

Figure 2: *Contacted walk-off compensated ß-BBO assembly produced at Inrad Optics, Inc.*

References:

A. V. Smith et al., “Increased acceptance bandwidths in optical frequency conversion by use of multiple walk-off-compensating nonlinear crystals”, J. Opt. Soc. Am. B 15 (1), 122 (1998).

R. J. Gehr et al., “Simultaneous spatial and temporal walk-off compensation in frequency-doubling femtosecond pulses in β-BaB2O4”, Opt. Lett. 23 (16), 1298 (1998).