Abstract

A laser frequency tripler intended to change 800nm light into 266.6nm light is modelled in Labview and designed according to ideal specifications. The tripler consists of birefringent crystal elements whose properties vary as certain parameters are changed, such as: crystal thickness, angle of incidence, optical axis angle, and crystal type. The final design is made up of four crystals; β-BBO for SHG(second harmonic generation), calcite for time delay compensation, quartz for polarization rotation, and another β-BBO for THG(third harmonic generation).

Objective: Start with 800nm light to produce 267nm UV light with proper polarization.

Aim: Cost effective, efficient, versatile arrangement.

Sum Frequency Generation

Second Harmonic Phase Matching:

\[ 2\vec{k}_1 = \vec{k}_2 \rightarrow 2n_1\omega/c = n_2\beta\omega/c \rightarrow n_1 = n_2 \]

Third Harmonic Phase Matching:

\[ \vec{k}_1 + 2\vec{k}_2 = 3\vec{k}_3 \rightarrow n_1\omega/c + n_2\beta\omega/c = n_3\beta\omega/c \rightarrow n_1 + 2n_2 = 3n_3 \]

Indices of refraction β-BBO

\[ n_{β-BBO} @800nm = 1.66055, \quad n_{β-BBO} @400nm = 1.56442 \]

\[ n_{β-BBO} @400nm = 1.639, \quad n_{β-BBO} @400nm = 1.56789 \]

Compute indices of refraction using Sellmeier relation.

Graphs and Final Values

Graph 1

Index vs. wavelength for the ordinary and extraordinary waves in β-BBO at 800nm

Graph 2

At 0º compensator is able to correct for a delay of approx. 137º, 50º cutting angle with 50µm thickness

References and Acknowledgments

References:


Acknowledgments:

1. National Science Foundation
2. Florida State University: Jose Sanchez, Stephen McGill
3. Georgia State University

High Intensity Ultrashort Pulses

Chirped pulse amplification

- Low intensity light enters
- Light pulse bandwidth is stretched
- Stretched pulse is amplified
- Amplified pulse is recompressed
- High intensity ultrashort pulse is emitted

Eximer lasers:

- “Excited dimer” (Halide molecule, ex. ArF)
- Emits powerful pulses that last for nanoseconds or tens of nanoseconds at UV wavelengths
- Lasing medium is diatomic molecule (dimer)
- As pulse repetition rate increases power per pulse decreases.
- Difficult to build due to toxic gases and high voltages needed for population inversion.

Tripler Design

A frequency tripling arrangement consists of four crystals:

- SHG: β-BBO, low temperature phase BaB2O4 produces second harmonic generation from an incident 800nm E-M wave by exploiting non-linear behaviors.
- Compensator: Calcite(CaCO3) is used to compensate for the group velocity mismatch among outgoing light rays so that they may be aligned in-phase once THG has been produced.
- A/2: Quartz(SIO2) half wave plate rotates the polarization of the wave fundamental 90° in the same direction as the extraordinary wave.
- THG: β-BBO is used for the THG crystal as well to produce the third harmonic (λ=266.6nm) with electric field polarization aligned orthogonal to the 800nm and 400nm outgoing waves.

Indices of refraction birefringence:

- Ordinary waves index: \( n_1 \)
- Extraordinary waves index: \( n_2 \)
- Optical axis parallel to OA is the e-wave

Compensation Plate

- Group velocity: \( v_p = v_e \left(1 + \frac{\lambda}{n_2 d\lambda} \right) \)
- Relative time delay: \( \Delta t = t_e - t_o = \frac{AC}{v_p/c - \frac{AB}{v_p/f_p}} \)

Compensation parameters:

- GVM(group velocity mismatch) must be considered for phase matching extraordinary and ordinary waves
- Extraordinary index is dependent upon optical axis (8) and crystal tuning angle (4).

Graph 3

Index Ellipsoid

Graph 4

Compensator:

- Calcite crystal
- Size 12.7x12.7x2mm0
- 40º cutting angle
- AR@800/400nm
- mounted in OD 1” holder

Graph 5

Compensator:

- Quartz crystal
- Size 12.7x12.7x2mm0
- 50º cutting angle
- AR@800/400nm
- mounted in OD 1” holder

Graph 6

THG:

- λ = 800nm
- λ = 400nm
- λ = 266.6nm
- λ = 532nm
- λ = 355nm
- λ = 222nm
- AR@800/400nm