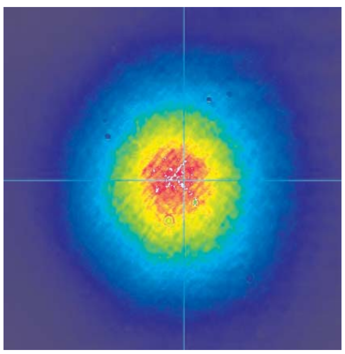
IMRA technical note

T-0701

Second-harmonic Generation with IMRA's FCPA µJewel™

This note describes a simple set-up for second-harmonic generation (also known as "frequency-doubling") of an FCPA µJewel to obtain green, pulsed light using off-the-shelf components.



522 nm beam profile obtained by frequency doubling an IMRA FCPA µJewel laser

Among the various nonlinear crystals available (BBO, KTP, BiBO, $KNbO_3$, PPLN, etc.), we recommend the use of LBO for the following reasons:

a. Non-Critical Phase Matching (NCPM) condition
  - No walk-off
  - Large acceptance angle → ease of alignment

  Since the energy per pulse from the FCPA µJewel changes for different repetition rates, different focusing conditions are required for optimal conversion.

b. Small Group Velocity Mismatch (GVM) allows longer crystal to be used → greater SHG output

c. High damage threshold

  Intensity = 45 GW/cm², τ = 100 ps @ λ = 532 nm (ref. Newlight Photonics)

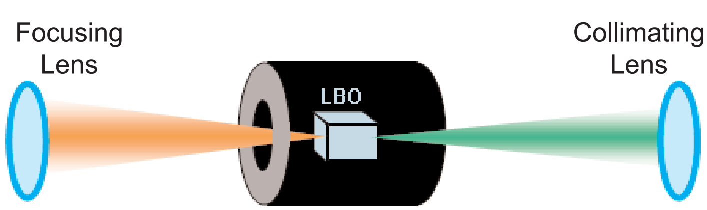


Figure 1. LBO SHG conversion with singlet lenses

Set-Up

Focus the laser output beam into the LBO crystal (See Figure 1). It is not critical that the focus be perfectly centered in the crystal. Recommended optics are given in the next section. The beam should be incident nearly perpendicular to the crystal front surface. However, a minor tilt adjustment may be necessary to get the best conversion efficiency. While there are other suppliers for LBO mounted in an oven for temperature control, a product from Newlight Photonics is described in the table below for your convenience. See Table 1 and Figure 2 for more information.

LBO temperature setting: 174.4°C (SNLO- see reference), adjusted for the best conversion

LBO Crystal 3-mm thick, 6 mm x 6 mm face cut angles: theta=90°, phi=0° 1045 nm to 522 nm conversion (NCPM) AR coating: 1045 & 522 nm	Newlight Photonics
Oven & Precision Temperature Controller	Newlight Photonics
2" Kinematic Mirror Mount (for oven)	Thorlabs KM200

www.newlightphotonics.com , www.thorlabs.com

Table 1. Crystal Assembly

Oven & Temperature Controller (Newlight Photonics)

Kinematic Mount (Thorlabs)

Figure 2. Photos of Equipment

Optics Selection

a. Focusing Lens

The FCPA µJewel pulse energy varies for different repetition rates, so different focusing optics will produce the optimum conversion efficiency. The lenses in Table 2 are based on typical values of pulse energy at different repetition rates.

repetition rate	focusing lens
100 kHz	f = 400-500 mm
200 kHz	f = 300-500 mm
500 kHz	f = 200-300 mm
1 MHz	f = 150-250 mm
5 MHz	f = 100 mm

Table 2, Focusing lens for different repetition rates

b. Collimating lens - selected for the desired beam size

Note: The focusing lens should be anti-reflection coated for 1 μm light and the collimating lens should be anti-reflection coated for ~520 nm to obtain optimal results.

Conversion Efficiency

The conversion peaks at a certain crystal temperature (Figure 3). The conversion efficiency can be up to 50%. It is recommended that maximum input laser power is used to generate SHG. If less power at ~520 nm is required, attenuate the converted beam.

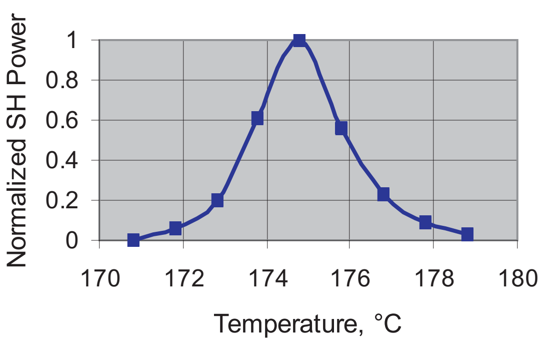


Figure 3. SHG power vs. temperature efficiency @ 200 kHz Optimized at 174.8°C

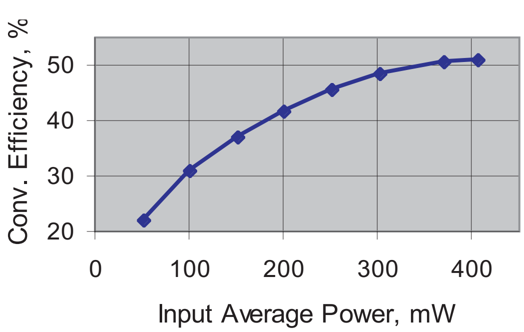
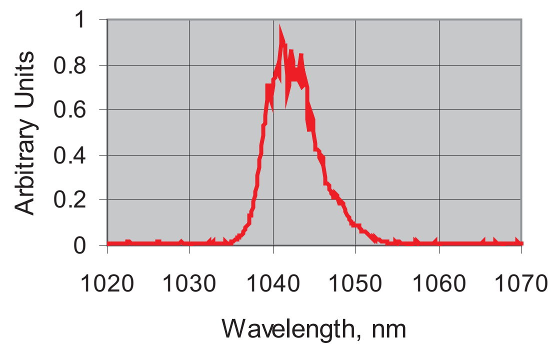


Figure 4. SHG efficiency @ 200 kHz f = 200 mm

Spectra

The spectra for the input fundamental and the generated second harmonic are shown below.



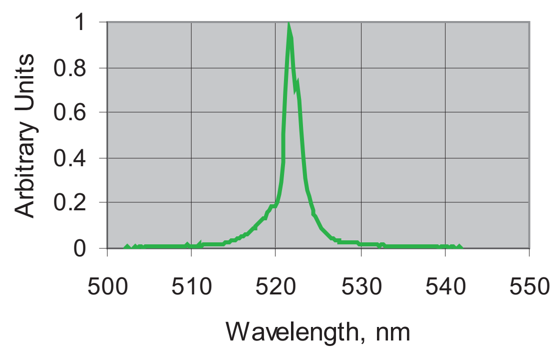


Figure 5. Spectra of fundamental and second harmonic wavelengths

Summary

Using off-the-shelf optics and a simple set-up, conversion of the 1 μm output of the FCPA μJewel laser to green output of ~ 520 nm with conversion efficiency of up to 50%.

References

SNLO nonlinear optics code available from A. V. Smith, Sandia National Laboratories, Albuquerque, NM
www.sandia.gov/imrl/XWEB1128/xxtal.htm

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