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ABSTRACT

Significant progress has been achieved recently in the growth of Yttrium Calcium Oxyborate (YCOB) crystals. Boules have been grown capable of producing large aperture nonlinear crystal plates suitable for high average power frequency conversion or optical parametric chirped pulse amplification (OPCPA). With a large aperture (5.5 cm x 8.5 cm) YCOB crystal we have demonstrated a record 227 W of 523.5nm light (22.7 J/pulse, 10 Hz, 14 ns). We have also demonstrated the applicability of YCOB for 1053 nm OPCPA.

YCOB is a high-energy-class, high-average-power nonlinear crystal that boasts good optical (i.e. absorption and transparency) and thermal properties (i.e. thermal conductivity and thermal sensitivity) [1]. Rare-earth calcium oxyborates were first grown as an nonlinear optic crystal in 1996 [2]. Initial boules grown were quite small, and, as a result, were ill suited for high-power applications. Recent improvements in YCOB growth have resulted in the increase of the quality and size of the YCOB boules. Using crystals cut from those new boules, we have already demonstrated record average power handling capabilities in generation of 227 W of 523.5 nm light using a 5.5 cm x 8.5 cm YCOB second harmonic generation plate [3]. The input beam consisted of a high repetition rate pulse (10 Hz in 14 ns) with 46 J of energy at 1047 nm. It is now possible to obtain 8 cm x 20 cm aperture YCOB plates. Traditionally, such sizes have been available only with KDP crystals. The large aperture scaling, along with unique optical and thermal properties, enable YCOB to be the only single crystal solution capable of producing pulses at 100-J energy level, while handing kW-level average power levels [1].

One of the possible uses of YCOB is in high average power optical parametric chirped-pulse amplification (OPCPA). To test the YCOB gain media for OPCPA, we used an existing OPCPA setup [4] that utilizes BBO as the parametric amplifier crystal (Fig. 1). The system is comprised of a femtosecond oscillator, stretcher, compressor, pump laser, and OPCPA preamplifier and amplifier. We obtained 40 mJ of amplified signal energy with peak on-axis pump irradiance of 170 MW/cm^2. The energy and beam profile obtained from the YCOB OPCPA is identical to the one produced by the BBO OPCPA (Fig. 2) [4]. The measured intensity autocorrelation of the output pulse is 1.3 times greater than the calculated transform-limited autocorrelation width based on the measured pulse spectrum (primarily due to aberrations in the stretcher-compressor pair). We will present additional scaling arguments for using YCOB for production of high average power ultrashort pulses using OPCPA.

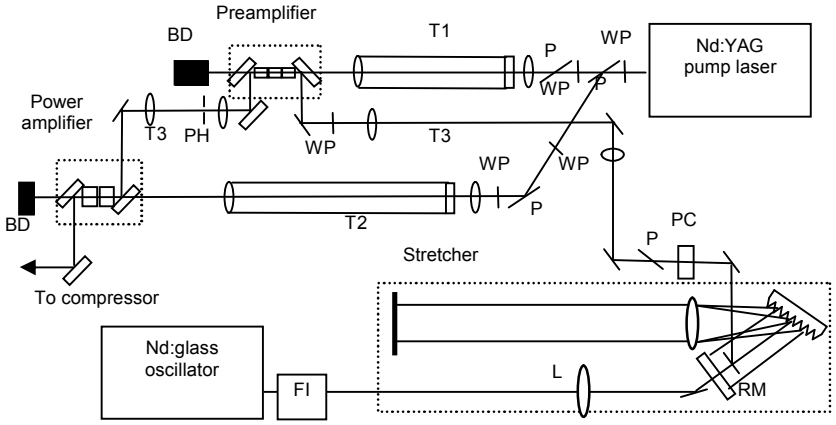

Figure 1: 1053nm OPCPA system with YCOB as the power amplifier (P=polarizer, L=lens,WP=λ/2 wave plate, BD=beam dump, T=telescope, PH=pinhole, FI=Faraday isolator, RM=roof mirror, PC=Pockels cell).

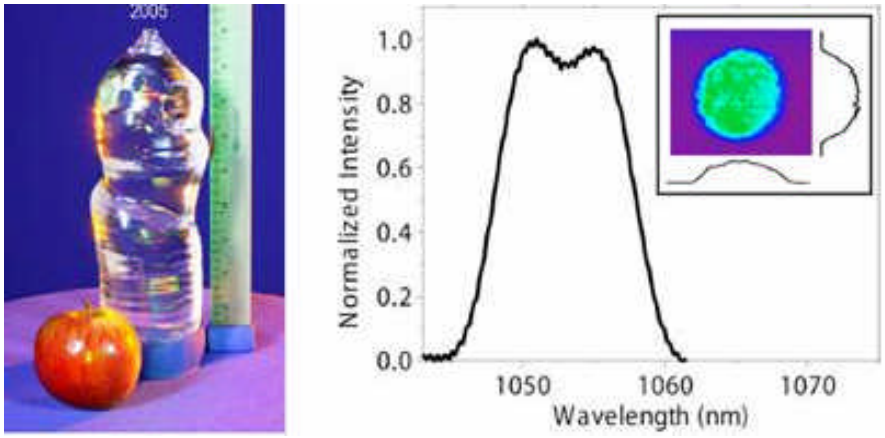

Figure 2: Record size YCOB boule (7.5 cm diameter by 24 cm in length). Showing is the amplified pulse spectrum produced at the output of YCOB OPCPA power amplifier at 1μm. The insert also shows near-field amplifier beam profile at the output. The output profile matches the pump laser profile

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