TPA coefficients $\beta = (6 \pm 1.2) \times 10^{-9}$ cm/W for GaSe and $\beta = (2.5 \pm 0.5) \times 10^{-7}$ cm/W for CdGeAs$_2$.

The practical implication of the results in this work is that TPA may impose significant losses induced by pump laser frequencies in the range $E_g/2 < \hbar\omega < E_g$. For instance the pump laser intensity of 40 MW/cm^2 will create 25% TPA losses in GaSe at 1 cm crystal length. In the case of CdGeAs$_2$ of the same length similar losses will be created by the intensity of as small as 1 MW/cm^2.

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CThT 4:30 pm–6:30 pm Rooms 318/320

Laser Sources and Techniques

Dirk Basting, *Lambda Physik Co., USA, Presider*

CThT1 4:30 pm

980 nm diode pumped laser action in Yb^{3+}:YCOB

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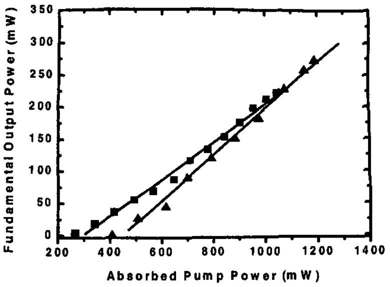
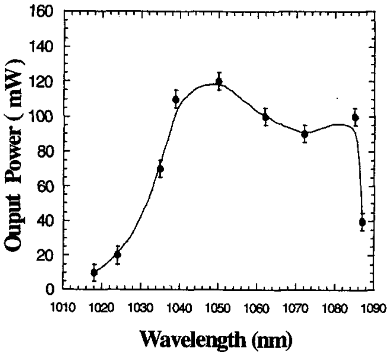
Ytterbium doped laser media are well suited for diode pumping and have favorable spectroscopic properties for compact high average power lasers emitting either tunable or ultrashort infrared radiation.[1–3] In our previous work,[4–7] we have demonstrated YCa$_4$O(BO$_3$)$_3$ (YCOB), to have some advantages such as broad wavelength tunability and the capability of self-frequency doubling. We have investigated the potential of Yb:YCOB under diode-pumping utilizing widely available 980 nm diodes. Additional experiments were performed to show laser operation of Yb:YCOB under 900 nm pumping using a tunable cw Ti-Sapphire.

Laser experiments were performed with a 1.5 W Ti:Sapphire laser pump tuned to 900 nm with both 10% and 20% doped Yb:YCOB laser crystals (5 × 5 × 13 mm).[7] The pump source was used to end-pump a hemispherical linear cavity consisting of a 5-meter radius of curvature (ROC) high reflector and a 10-cm ROC output coupler. The uncoated Yb:YCOB crystal was placed next to the high reflector. The pump beam was focused with an 8.8-cm focal length plano/convex lens to a ~70 μm (FWHM) spot size. Figure 1 shows the observed cw oscillator output power as a function of absorbed pump power for both the 10% and 20% doped crystals. The laser emission was observed for the 10% doped crystal at 1050 nm, while the 20% doped crystal lased at 1090 nm. We attribute the laser action at 1090 nm to a consequence of self-absorption on the short-wavelength side of the emission band. Slope efficiencies of 29% and 36% were achieved with a nominal output coupling of 20% with 10% and 20% doped crystals, respectively. With a separate X-cavity configuration utilizing a 10 mm long, Brewster/Brewster 10% Yb:YCOB crystal, tunable laser emission was observed a broad region, (Fig. 2).

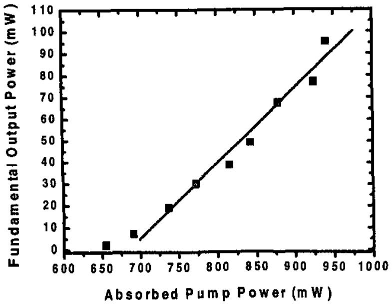


CThT1 **Fig. 1.** Laser output power of 10% and 20% doped Yb^{3+}:YCOB as a function of absorbed 900 nm pump power.



CThT1 **Fig. 2.** X-Cavity Laser output power versus laser wavelength.

Diode-pumped experiments were performed with a similar hemispherical laser resonator. A high brightness, InGaAs/AlGaAs laser diode (Polaroid POL-5300 BW) with a maximum output power of 1.6 W from a 100 μm stripe at 980 nm was used to pump an uncoated 10% doped Yb:YCOB laser rod (5 × 5 × 13 mm). The diode was temperature tuned to match the 977 nm absorption line in Yb^{3+}:YCOB, and the collimated pump beam was focused with a 60 mm focal length lens to a spot size ~65 μm (FWHM) at the crystal. The Quality Thin Films rear mirror was highly reflecting from 1050–1150 nm and over 95% transparent at 977 nm. The diode-pumped output power versus the absorbed pump power with 1% OC is shown in Fig. 3. Output powers exceeding 100 mW for 950 mW of absorbed pump power were obtained with 1% output coupling. The decrease in reflectivity at wavelengths below 1050 nm caused the laser to operate at 1085 nm. A high slope efficiency of 34% was achieved under diode-pumping with the 980 source as compared to 36% with the Ti:Sapphire laser pumping at 900 nm. Since the diode wavelength is closer to the laser wavelength, the reduced quantum defect should lead to less thermal loading and higher slope efficiencies. Experiments are currently ongoing to achieve high power diode pump operation for tunability, ultra-short pulse generation and self-frequency doubling.



CThT1 **Fig. 3.** Laser output power at 1085 nm as a function of absorbed 977 nm pump power in 10% doped Yb^{3+}:YCOB.

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CThT2 **4:45 pm**

A new femtosecond UV source based on Nd:YAG

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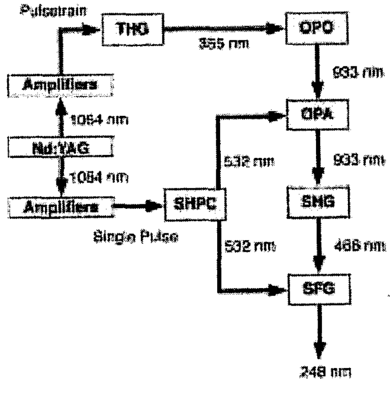
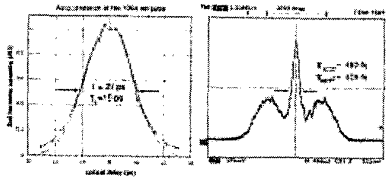
Current techniques to generate millijoules of femtosecond radiation are rather complex and expensive. The most common system consists of a femtosecond Ti:Sapphire oscillator, stretcher, amplifier and compressor elements together with Argon ion (high power systems) and YAG or YLF pump sources. Aside from the terribly low wall-plug efficiency, it is clear that there is a need for simpler and more efficient high-power femtosecond sources.

We report on a new system which is based on a single flashlamp pumped active/passive modelocked Nd:YAG laser stabilized by passive negative feedback.[1] The picosecond output from this laser is compressed in the second harmonic (SHG) down to the femtosecond regime[2] leading to an ideal source for pumping of amplifier stages of synchronously pumped (femtosecond) parametric oscillators.

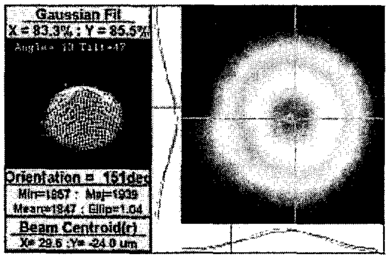
The pump source for the system sketched in Fig. 1 is a Nd:YAG laser providing two outputs: A single pulse at an energy of 200 μJ and pulse duration of 10–15 ps and a train of 60 pulses with total energy of 2 mJ and an amplitude stability of better that 1%. The single pulse enters the second harmonic pulse compressor (SHPC) after being amplified to 10 mJ. In the SHPC, the beam is split into two components (o and e-wave) by a polarizing beamsplitter, one component is given an appropriate predelay, and then recombined by a second polarizing beamsplitter before it is sent into a 6 cm long Potassium Dihydrogen Phosphate (KDP) crystal cut for type II second harmonic generation (SHG). The pulse compressor yields pulses with duration as short as 310 fs[3] (see Fig. 2) at an energy conversion rate of 10%.



CThT2 **Fig. 1.** Femtosecond UV source based on a single Nd:YAG laser.



CThT2 **Fig. 2.** Temporal profiles before and after the second harmonic pulse compressor.



CThT2 **Fig. 3.** Spatial profile of the 248.6 nm beam. The picture is a grayscale version of a color coded beam profile.

The pulse train is amplified to 34 mJ, then frequency tripled to a wavelength of 355 nm, to synchronously pump an optical parametric oscillator (OPO) with β-Barium Borate (BBO) crystal as active element. The same mechanism that leads to pulse compression in SHG is exploited to get compression for the singly resonant idler wavelength of 933 nm.[4] The non-simultaneity of the satellites seen in Fig. 2 and from the OPO can be exploited to eliminate them in the amplification process.[5] For the latter, one pulse out of the train of 20 pulses (10 μJ total energy) is amplified 1000 times in a noncritically phasematched Lithium Triborate (LBO) optical parametric amplifier (OPA), pumped by the single femtosecond green (532 nm, 0.5 mJ) pulse from the SHPC. The amplified single pulse at 933 nm is then frequency doubled in a BBO crystal before being frequency mixed in the last BBO crystal with a second short green (532 nm, 0.5 mJ, fs) pulse. The resulting 248.6 nm output was then successfully amplified in a triple pass Krypton Fluoride (KrF) amplifier to the final output energy of 10 mJ. The excellent spatial distribution obtained from this new source is shown in Fig. 3.

The source is versatile, a nearly identical setup is used to generate a pair of wavelengths near 589 nm and 1.14 μm to excite the two-photon 3s-4p resonance of sodium, with application to excite a bichromatic guide star.

In conclusion, we have shown that the application of several nonlinear frequency mixing techniques leads to a new high-power femtosecond source tunable in the UV, based on a single flashlamp pumped Nd:YAG laser. This source is suitable to replace the common Ti: Sapphire oscillator, stretcher, amplifier, compressor system followed by a frequency tripler. Advantages over the Ti:Sapphire systems are simplicity, ruggedness, wall-plug efficiency, RF-insensitivity and portability.

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CThT3 **5:00 pm**

Programmable pulse shaping for optimized laser interactions

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We have developed Q-switched lasers which function as arbitrary pulse shapers. We apply the effect of "dynamic mirrors" by temporally varying the cavity Q as the laser rod is pumped (i.e. effectively varying the output coupling). Hence, the energy storage in the rod and the intracavity intensity can be controlled. This allows temporal shaping of the laser pulses with intracavity elements. We have built and tested both acousto-optic and electro-optic pulse shapers.

Both systems are based around quasi-CW diode-pumped Nd:YLF systems. The first system actively employs an acousto-optic Bragg device. The cavity configuration is a folded three mirror cavity in which the Bragg deflector is used to variably modulate the Q of the cavity. By balancing the Q and the loss modulation it is possible to efficiently shape the output pulse using programmable input waveforms. The cavity dimensions have been optimized to compensate for the thermal lens in