Cavity-dumped near-IR femtosecond optical parametric oscillator

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Synchronous pumped optical parametric oscillator (OPO) pumped by a Ti:sapphire laser is a stable and simple femtosecond light source tunable from ultraviolet to mid-infrared region without costly amplifier and optical parametric amplifier system. Utilizing quasi-phase-matching and large nonlinear coefficient d_{33}, periodically poled lithium niobate (PPLN) gain medium allows OPO have large conversion efficiency and tunability in its transparent range beyond 5 μm.[1] For nonlinear experiments in the condensed phase related with some chemical and biological applications, however, its pulse energy is small to make a measurable nonlinear signal, and its high repetition rates around 100 MHz causes pulse accumulation and heating effect in the sample. Cavity dumping can enhance the pulse energy by an order of magnitude, and reduce pulse repetition rate from a few MHz to a single shot. In visible region, Wiersma group reported 13 nJ, 30 fs pulses up to 400 KHz repetition rates using a BBO crystal as an OPO gain medium and second harmonic of a Ti:sapphire laser as a pump.[2] A near infrared cavity dumped PPLN OPO may have several advantages compared with the visible one. The visible OPO is less efficient because second harmonic of a Ti:sapphire laser is used to pump the OPO. A near infrared OPO can have wider tuning range for the signal pulses from near infrared to ultraviolet, visible region by doubling or tripling fundamental pulses.

In this work, we report high power near infrared cavity dumped OPO.

The PPLN OPO operated on high intracavity pulse energy, however, show a severe oscillation in the blue region of the spectrum, and become unstable when the oscillator operates at small negative

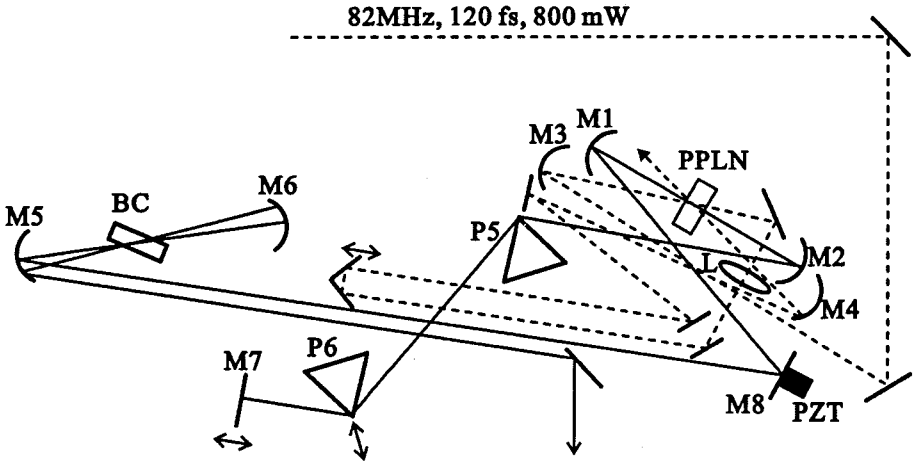

Figure 1. Schematic of cavity dumped near infrared OPO using synchronous double pumping.

intracavity group velocity dispersion (GVD) region, where the pulse is free of chirp with Gaussian-like spectrum at low intracavity power. Recently, it has been reported that a Kerr-lens mode-locked Ti:sapphire laser can produce stable and compressible highly positively chirped a few hundred nJ pulses when operated at small positive intracavity GVD.[3] We also operate the OPO in the small positive intracavity region. However, the output pulse shows a hole in the spectrum at high power due to self phase modulation effect, which results in a wing in the pulse time profile.[4] To reduce this effect, we made the pump pulse positively chirped.

We can control the pulse duration and spectrum by adjusting the intracavity GVD through material path length. Cavity dumping was achieved by a TeO_2 Bragg cell. The cavity dumped output is highly chirped with pulse duration of ~600 fs. The positive GVD was compensated by an external SF11 prism pair to give 55 fs. The transform limited pulse duration is 52 fs from direct Fourier transformation of the signal spectrum.

In conclusion, we have demonstrated near infrared cavity dumped OPO that gives 55 fs, 90 nJ pulses tunable from 1.0 to 1.5 μm at variable repetition rates. By positively chirping the pump and operating in a small positive intracavity GVD, we can get stable transform-limited pulses. This laser can be an ideal light source in fluorescence upconversion and multi-photon microscopy.

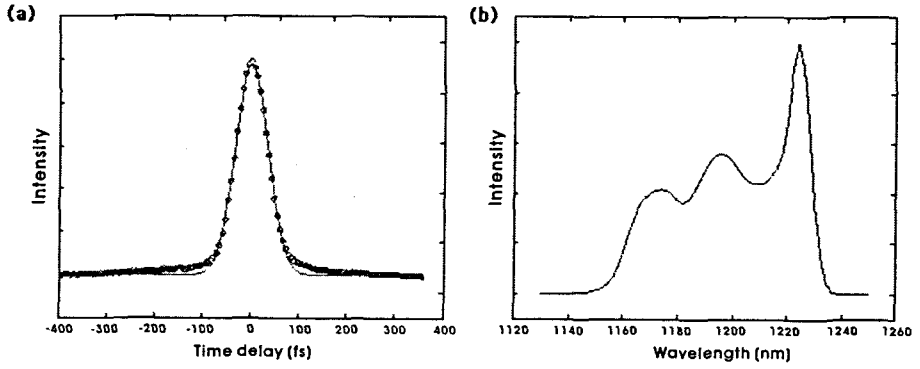

Figure 2. (a) Noncollinear intensity autocorrelation and (b) spectrum of cavity dumped signal pulses.

References

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