

High-energy Mid-Infrared Cr:ZnS Chirped-pulse Oscillator

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Femtosecond coherent light sources emitting in the mid-infrared are of particular interest for a number of applications like environmental sensing, medicine, metrology, material processing and telecommunications. Among the alternatives, Cr-doped chalcogenide-based crystalline lasers are the most compact, robust and cheap.

For decade pulse energy of these lasers were limited at the level of 1-2 nJ. Finally Cr:ZnS laser with 3.8 nJ pulse energy and 550 mW average output power producing 69-fs pulses was demonstrated very recently [1].

Power scaling of femtosecond crystalline oscillators is not a simple task. The pulse energy of these systems is limited by the pulse breakup due to high third-order optical nonlinearity of the active medium. Increasing the output power over the certain limit result in either multiple-pulsing or harmonic mode-locking regimes. In order to overcome that, the intracavity power density inside the active medium should be reduced. That could be done by using the technique of chirped-pulse-oscillator (CPO). This technique is well-established in fiber and Ti:sapphire lasers, and has recently been demonstrated with the Cr:YAG and Yb-doped thin-disk lasers. For Cr:ZnSe the analytical theory [2] predicts pulse energies up to 0.5 μ J [3] and initial demonstration of CPO technique has already been performed for Cr:ZnSe as well as Cr:ZnS lasers [4].

We report the successful demonstration of Cr:ZnS CPO pulse energy over 8 nJ. The laser was build on the basis of a classic 4-mirror astigmatically-compensated cavity and was pumped by 1.61 μ m cw polarized 5-W Er: fiber laser. The mode-locking was achieved using soft-aperture Kerr lens effect. The compensation of the group-delay dispersion was performed by the chirped mirror. The pulses having the duration ranging from 0.8 to 2 picoseconds were obtained at the pulse repetition rate of 105 MHz. The laser average output power reached 0.88 W with 26% slope efficiency. At output powers over 750 mW we observe leakage of 3-5 % of energy into higher-order modes, visible as the narrow spectral lines. The input-output curve, typical autocorrelation trace, and laser emission spectra for different output pulse energies are shown in the Figure 1.

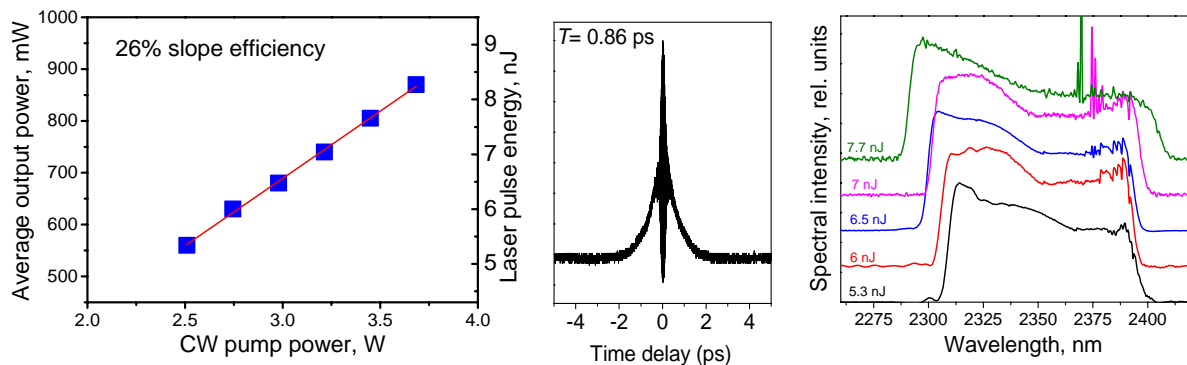


Fig. 1 The input-output curve, typical autocorrelation trace and pulse spectra of Cr:ZnS CPO

The reached energy level already exceeds the needs for a number of applications, for example high-sensitive spectroscopy [5] and mid-IR OPO pumping [6]. The increased energy will result in the generation of a broader supercontinuum in the step-index chalcogenide fiber [7].

References

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