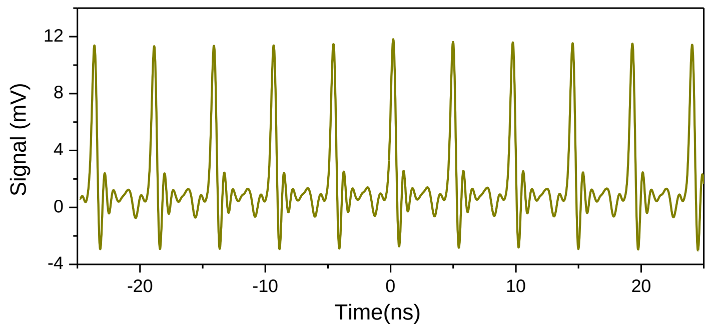


Fig. 4. The pulse train at the TPA photodiode from the mode-locked Cr:ZnS laser, operating in the anomalous (soliton) dispersion regime.

Removing the YAG plate brings the net GDD to nearly zero and resulted in a chirped-pulse regime with about 630-fs pulse duration. The output power could be scaled up to 205 mW at 1.9 W of absorbed pump (Fig. 3(b)). At this power level we observe leakage of 5-10% of energy into higher-order modes, visible as the narrow spectral lines in (Fig. 3(b)). This leakage was practically unavoidable at high pump power, reproduced itself in the chirped-pulse spectra of Cr:ZnSe sample as well (Fig. 3(d)), and was caused by the thermally-induced aberrations in the SESAM [22], where we could estimate the temperature raise to reach 50-70°C in the beam center. Further increasing the pump power resulted in more deterioration of the beam quality and loss of mode-locking stability, eventually followed by the SESAM damage.

In order to assess the prospects of the system let us revisit the loss, bandwidth and dispersion budgets (Fig. 2). It can be clearly seen that the SESAM has the narrowest bandwidth despite the quite high (for semiconductors) index contrast of 3.77 to 3.10 for the lattice-matched CaSb/AlAsSb stack. Moreover, the SESAM provides the main loss mechanism, and a major contribution to the higher-order dispersion. While it is relatively straightforward to decrease the losses of the SESAM and thus improve the efficiency of the system, any significant shortening of the pulse will be limited by the bottom mirror bandwidth. Moving further to few-cycle pulses with a SESAM will require special designs, such as e.g. hybrid semiconductor-metal [23], hybrid semiconductor-dielectric [3], or oxidized semiconductor stack [24]. The recently demonstrated Kerr-lens modelocked Cr:ZnS laser [25] is also free of the bandwidth limitation and allows increasing the pump power, but this comes at the expense of self-starting.

## 4. Conclusion

Summarizing, we have demonstrated the first SESAM-controlled femtosecond Cr:ZnS laser, generating high power 130 (205) mW stable 130 fs (630 fs) pulses at 180 MHz repetition rate in the soliton (chirped-pulse) regime. The Cr:ZnS crystal produced about 30-50% higher average power than a comparable Cr:ZnSe sample, but the overall system performance and limitations are defined by the SESAM device, rather than by the active medium choice. Taking full advantage of the Cr:ZnS bandwidth and high-power capability would require a saturable absorber with lower initial absorption, significantly broader reflection band and well-controlled dispersion.

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