Simple repetition rate upgrade scheme for passively mode-locked solid-state lasers

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Abstract: We propose a technique for increasing the repetition rate of solid-state lasers potentially solving the limitation of cavity length reduction. Based on spectral selection we achieved high quality multiplication with relatively broad detuning range.

OCIS codes: (140.3580) Lasers, solid-state; (140.4050) Mode-locked lasers; (230.6080) Sources

1. Introduction

Passively mode-locked solid-state lasers are ideal for generating high power, short, transform limited pulses. However, increasing the pulse repetition rate to 40 GHz, 80 GHz or 160 GHz becomes increasingly difficult due to mechanical and physical constraints [1]. Mode-locked semiconductor lasers may produce high repetition rates [2] yet in expense of output power. We propose a technique for increasing the repetition rate of fundamentally mode-locked solid-state lasers. The technique is based on a low finesse Fabry-Perot filter (FPF) and achieves rate multiplication with relatively broad detuning range [3]. In this way, high repetition rates are simply achieved without the need for laser cavity re-designing, energy management during the mode-locking process or very short cavity lengths.

2. Experiment

We have used a diode pumped Er:Yb:glass plate in a three–mirror cavity, consisting of two curved mirrors, with an externally synchronized semiconductor saturable absorber mirror (SESAM) forming one end of the laser cavity as shown in figure 1 [1]. The wavelength of the produced pulse train was at 1535 nm, while the cavity length corresponded to a repetition rate of 10.05 GHz.

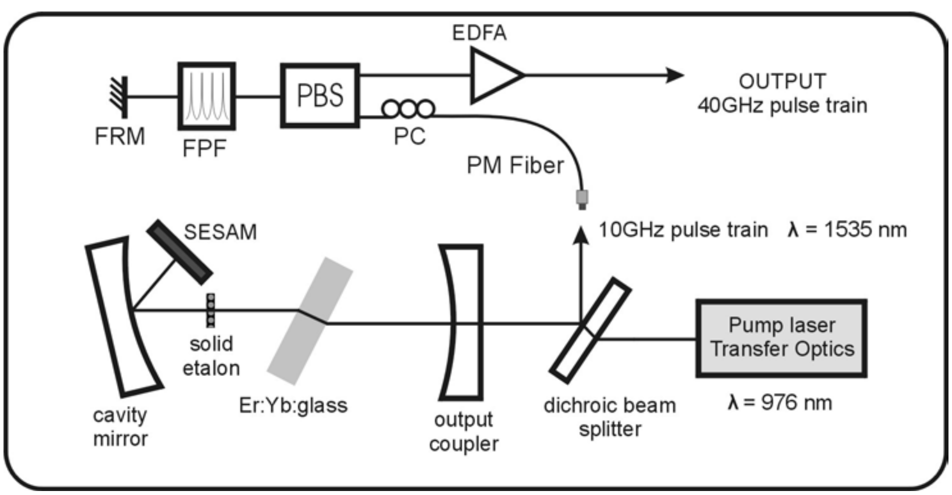

Fig.1 Schematic diagram of the experimental layout.

This pulse train was then fed into the FPF through the ordinary axis of a polarization beam splitter (PBS), so that a single state of polarization entered the double-pass arm. The FPF was an antireflection-coated fused quartz substrate with an FSR equal to 40.2 GHz and a finesse of 50. At its output, a Faraday rotator mirror (FRM) was used to reflect the rate-multiplied pulse train back into the FPF so that the final 40 GHz output was obtained at the extraordinary axis of the PBS. By passing the pulse train through the FPF twice, the effective finesse of the filter is

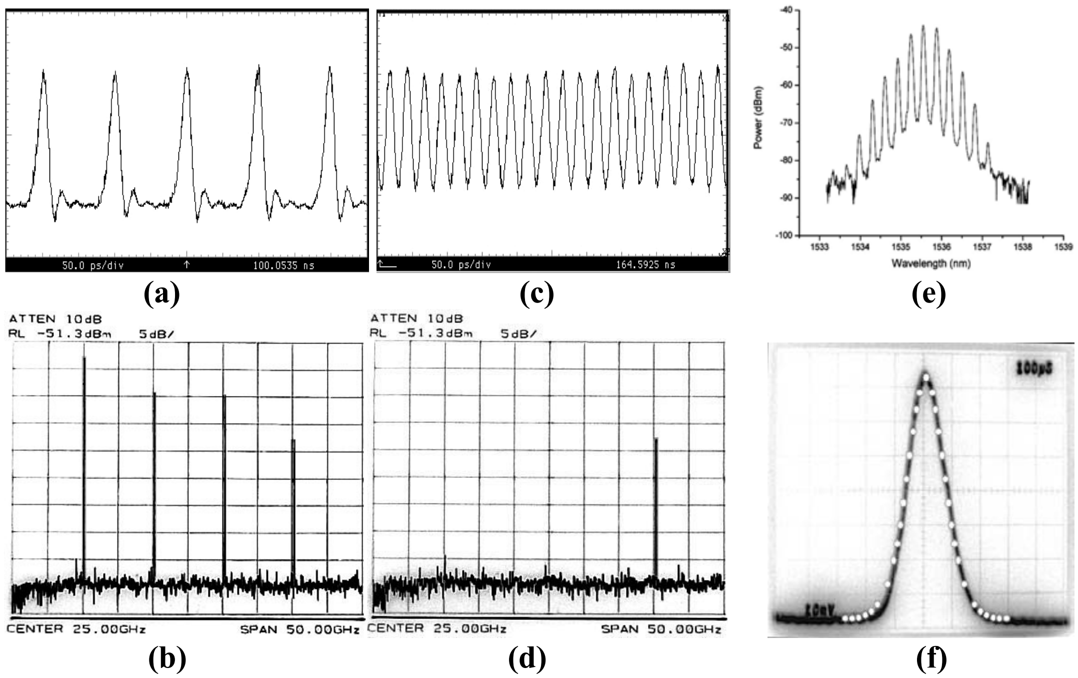

Fig.2 Experimental results including the pulse traces and microwave spectra of 10 GHz pulse train (a), (b) and 40 GHz pulse train (c), (d), respectively. (e) shows the optical spectrum of 40 GHz pulse train and (f) the autocorrelation trace of the laser source fitted on a hyperbolic secant profile.

increased, while the bandwidth of the filter remains practically the same. The results obtained are summarized in figure 2, including pulse traces and microwave spectra at 10 and 40 GHz respectively (figure 2 (a), (b), (c), and (d)). The amplitude modulation of the 40 GHz signal is less than 0.13dB. The 10, 20 and 30 GHz harmonics are suppressed by more than 40 dB. Figure 2 (e) shows the optical spectrum of the 40 GHz pulse train while figure 2(f) shows the autocorrelation trace of source pulse with FWHM of 3.8 ps. The pulse follows a hyperbolic secant profile, it is pedestal free and it is close to transform limited with a time-bandwidth product <0.47. The r.m.s. timing jitter of the source was measured less than 100 fs.

3. Conclusions

We demonstrate an upgraded 40 GHz low jitter passively mode-locked Er:Yb:glass laser source. The generated high repetition rate pulse train is very stable and has negligible amplitude modulation. The proposed approach can potentially solve the physical cavity length restriction towards rates greater than 50 GHz in solid state lasers. By simply adding in a FPF with appropriate FSR and moderate finesse, passively mode-locked solid state lasers can be in principle upgraded to provide pulse trains at 160 or 320 GHz.

4. References

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