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0.1mJ pulses from a passively Q-switched fiber source

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Abstract

We demonstrate a passively Q-switched fiber MOPA generating pulses of 0.1mJ at 1.53μm and >1kHz repetition rate. We used a single pump source, large mode area fiber and multiple reflections on a SESAM.

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Fiber laser systems based on erbium-doped fibers are compact and stable sources of Q-switched pulses with an excellent spatial mode profile and the potential for large tunability. Actively Q-switched pulse energies up to 0.8 mJ have been obtained using advanced fiber designs with large mode areas [1]. Passive Q-switching allows for more compact and inexpensive systems. However, the available pulse energy is limited by the typically small modulation depths achievable. We demonstrate high pulse energies despite these limitations, by using multiple bounces on the same SESAM.

The semiconductor saturable absorber mirror (SESAM) [2] used in our experiments contains a Bragg mirror, absorber layer, and cap layer, all grown with MOCVD on a GaAs substrate, and a dielectric antireflection coating. We measured $\Delta R = 27\%$, $F_{sat} = 86\ \mu J/cm^2$, an absorber recovery time of 13 ns, and nonsaturable losses of 13%.

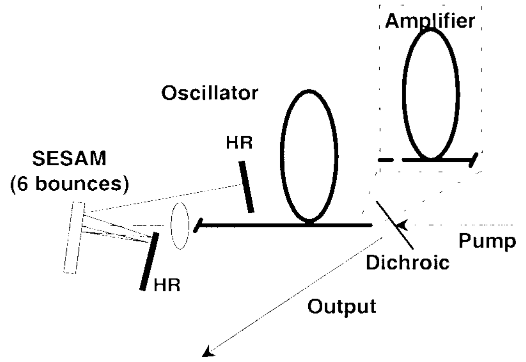

Figure 1. Oscillator with optional amplifier. The airgap in between acts as a partial reflector.

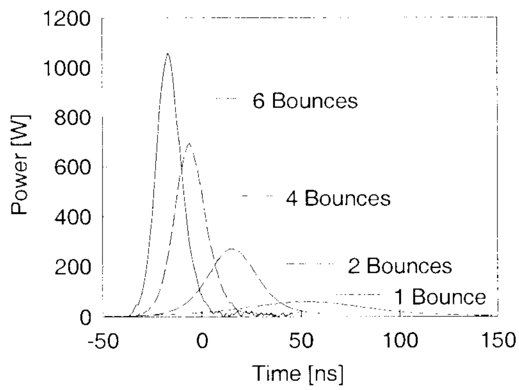

Figure 2. Oscillator output for 6 (17 μJ, 15 ns), 4 (14 μJ,18 ns), 2 (9 μJ, 27 ns) and 1(4.9 mJ, 65 ns) bounce(s).

First we built just the oscillator (Fig.1, without amplifier) with 60cm of fiber with a mode area of 300 μm^2, pumped by 2W from a Ti:sapphire laser. The front cleave acted as a 4% reflector. The light from the other end was collimated with an f = 4.5 mm lens onto the SESAM. The output was extracted with a dichroic mirror. For one bounce on the SESAM we obtained 65 ns pulses of 4.9 μJ, independent of the pump power, with a maximum repetition rate of 26 kHz (0.13 W average power). By increasing the number of bounces on the SESAM, the effective modulation depth and pulse energy increased up to 17 μJ and the pulse duration decreased down to 15 ns. (Fig. 2). The highest peak power was over 1 kW, with a clean temporal shape and a typical spectral bandwidth of 0.1 nm.

We obtained a further increase of energy with a MOPA configuration (Fig. 1, with amplifier). The amplifier section was made of 78 cm of the same fiber. The pump was launched into an angle polished end, the other end was cleaved and aligned opposite the input end of the oscillator fiber with a gap of a few microns. With four bounces on the SESAM the MOPA generated 54 ns pulses with 76 μJ and a clean temporal shape. The average output power was ~190 mW. For six bounces the pulse energy increased to 0.11 mJ, where the high peak powers (> 1 kW) were sufficient for stimulated Brillouin scattering (SBS) and resulted in a distorted pulse shape (Fig. 3). Pulse energies up to 0.14 mJ could be obtained by adjusting the air gap so that the oscillator just reached threshold. However, this regime was significantly less stable.

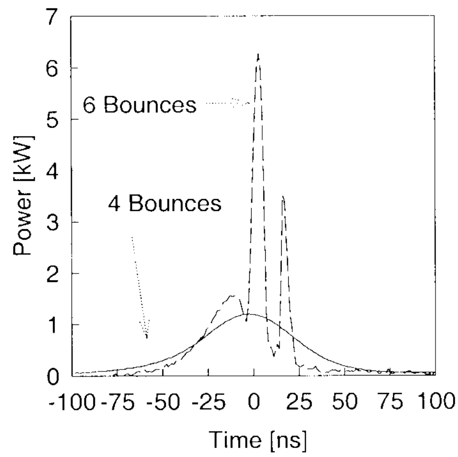

Figure 3. MOPA output illustrating distortion by SBS.

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