SESAM-FREE MODE-LOCKED SEMICONDUCTOR DISK LASER

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Mode locking of an optically pumped semiconductor disk laser (SDL) without any semiconductor saturable absorber is presented. We believe the mode-locking operation is achieved via intensity dependent Kerr lens focusing with nonlinearities arising from intersubband transitions in quantum wells. The mode-locking was stable, self-starting and intensity dependant. Both slit-based and soft aperture configurations are described. Optical spectra, radio frequency spectra, pulse train and autocorrelation traces are shown.

Kerr-lens mode-locking was first experimentally demonstrated in 1991 and revolutionized the field of pulsed lasers opening new application areas [1]. To date Kerr lens mode-locking was mostly used with solid state lasers, particularly to mode-lock Ti:Sapphire lasers. Kerr lens was also demonstrated in mid-IR semiconductor quantum cascade lasers [2]. Intracavity power independent spontaneous mode-locking (SML) was also reported in SDL recently where authors claimed the unpumped region to act as a saturable absorber [3].

A six mirror folded laser cavity comprised a semiconductor gain chip, folding concave and plane mirrors, and a 1% transmission output coupler mirror (Fig. 1). The pump beam of 808 nm light was focused onto the gain material with a 14 mm focal length lens to form a 150 µm radius spot. No other semiconductor chip (e.g. saturable absorber) was present in the cavity. Two different gain chips, with intracavity diamond heat spreader and with thinned substrate, were used to achieve stable mode-locking.

The laser could be mode-locked in few different configurations. First, for the best performing sample, stable mode-locking was observed by shortening the distance L till the cavity would operate near stability limit. In such configuration output power up to 700 mW could be achieved with 18 W pump. The measured autocorrelation indicated single pulses with duration of ~1.5 ps at 200 MHz repetition rate. Secondly, stable mode-locking could also be observed by operating the cavity in the stability limit. For it, a slit was inserted near the output coupler. In this configuration pulses as short as 930 fs could be achieved at 210 MHz repetition rate. The autocorrelation trace with RF spectrum of the mode-locked laser is shown in Fig. 2. The laser operated at 985 nm and the optical spectrum had FWHM of 1.4 nm and the pulses were 1.3 times transform limited. The measured average output power was 1.5 W with 18 W pump. Calculated peak power of the laser was 6.8 kW representing almost 4 times increase as compared to SML SDL [2] and more than 20 times increase from previously reported peak powers achievable directly from SESAM mode-locked SDL [4].

To sum up, experimental demonstration of SESAM-free mode-locked SDL is presented. Sub-picosecond pulses are achieved at 210 MHz repetition rate with 1.5 W average output power. The demonstrated results remains very consistent with the existing practical knowledge about Kerr lens mode locking which suggests using intensity-dependent cavity mode shapes with the high-power mode better matched to the pumping beam profile (soft aperture) or to the hard aperture placed inside the cavity.

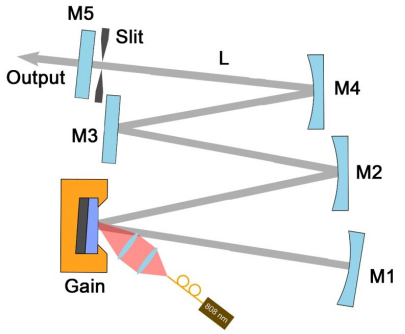

Fig. 1. Schematic drawing of folded cavity configuration.

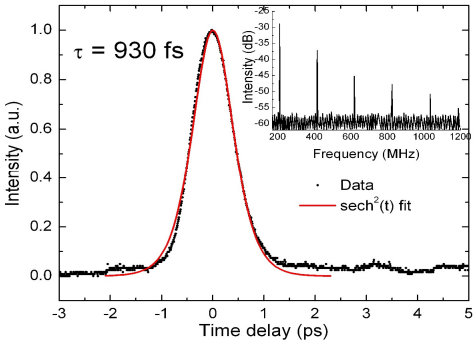

Fig. 2. Autocorrelation trace and RF spectrum of the mode-locked laser.

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