## L.3 : Power amplification of mode-locked Yb-doped fiber laser

Mode-locked fiber oscillator-amplifier systems producing high average power with train of ultrashort pulses in the femtosecond regime is required for many applications like in precision micromachining, tissue processing, nano-surgery metrology etc. Earlier we have demonstrated ultrashort pulse generation by mode-locking of Yb-doped fiber laser in all-normal-dispersion (ANDi) configuration. The chirped pulse-duration from the oscillator was measured to be 5 ps which were compressible to 150 fs in an external grating pair. However, the average power was only 50 mW (pulse energy 1.3 nJ) and the pulses exhibit considerable side-lobes when compressed in the femtosecond duration. In this work we have generated clean mode-locked pulses from the ANDi oscillator and amplified the average power to more than 4W (pulse energy 110 nJ) in a multistage Yb-doped fiber amplifier.

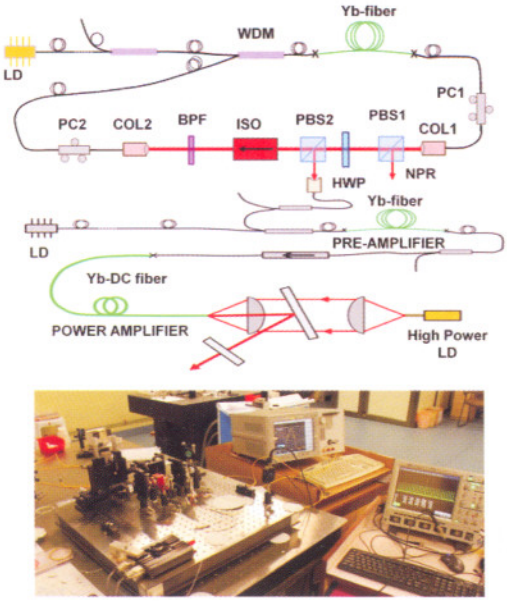


*Fig.L.3.1: Schematic ( top) and photograph ( bottom) of fiber oscillator-amplifier setup.*

The schematic of the oscillator-amplifier setup is shown in Fig. L.3.1(top). The oscillator consists of a 300 cm long single mode fiber (SMF) spliced to a 70 cm long Yb-doped fiber (YbDF) and then to 105 cm long SMF, followed by two polarizing beam splitters (PBS1 and PBS2) and a band pass filter (BPF) with 10 nm transmission bandwidth at 1060 nm. The PBS1 represents the NPR (Nonlinear Polarization Rotation) port and PBS2 represents an output coupler (OP) to extract the pulses after the NPR port. The output coupling of the OP port can be varied over a wide range with the help of a half wave plate (HWP). Under stable mode-locking operation, a maximum average power of 50 mW at ~37 MHz repetition rate was obtained from the OP port. The output signal from the OP port was amplified in the preamplifier stage constituted by a 1 m long Yb-doped standard single mode fiber and ~ 245 mW of average power was obtained from the preamplifier. In Fig.L.3.2a we show the spectral profile of the pulses from the preamplifier stage at the maximum pump power. It can be seen that the amplified spectra is nearly dome shaped with negligible ASE contribution. The intensity autocorrelation trace of the compressed pulses from the preamplifier stage is shown in Fig.L.3.2b. The AC trace is very smooth without any side-lobes with a pulse duration ( FWHM) of 156 fs.

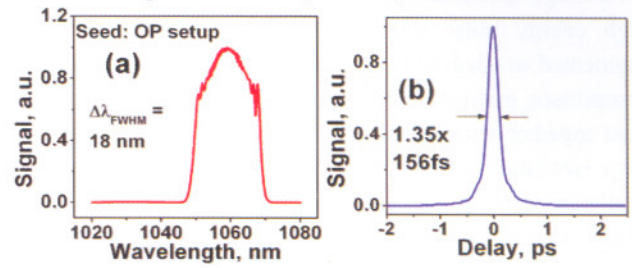


*Fig.L.3.2: Recorded (a) spectral profile and (b) autocorrelation trace of the preamplified pulses.*

For power amplification a 2 m long double clad Yb doped fiber with core diameter of 10 micron and inner clad diameter of 100 micron was employed. The preamplifier output was directly spliced to one end of the Yb DC fiber. A 200 micron multimode fiber-coupled laser diode was used for pumping of power amplifier. The maximum pump power coupled to the Yb-DC fiber was ~9.3W. The signal and the pump beam were used in counter propagating geometry.

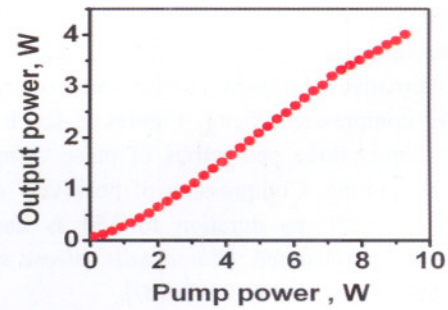


*Fig.L.3.3: Variation of amplifier output power with coupled pump power*

In Fig.L.3.3 the variation of output power from the amplifier as a function the pump power coupled to the fiber is shown. Around 4.2 W of amplified output power was obtained at a coupled pump power of around 9.3 W corresponding to 110 nJ of amplified pulse energy.

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