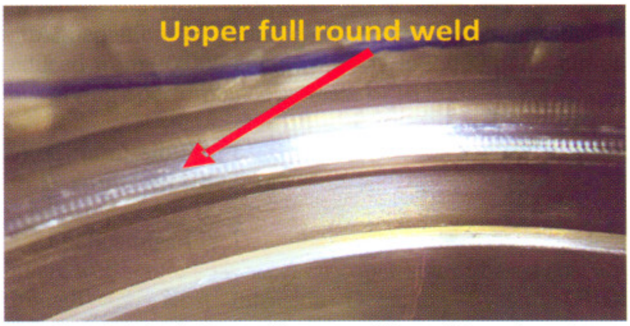

Fig. L.3.3: A View of laser welding of inter-junction of inner bellow ply & insert ring.

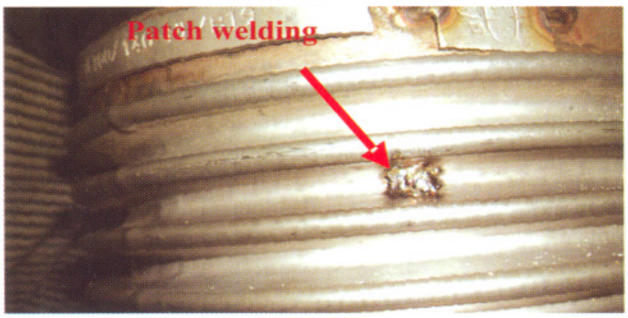

Fig. L.3.4: A view of punctured bellow ply at inner convolution after repair by patch welding.

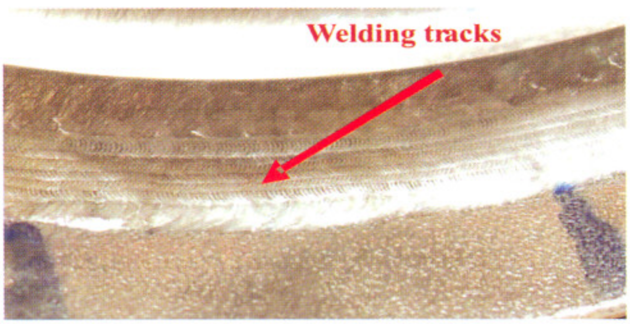

Fig. L.3.5: View of the end ring from inside after repair by fusing weld bead for small segment around.

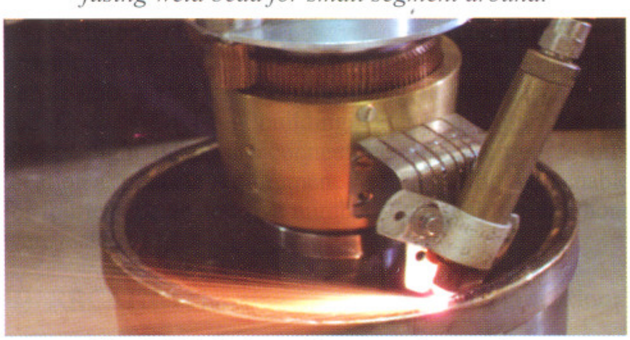

Fig. L.3.6: A view of laser cutting mock up of bellow ring joint with outer tube.

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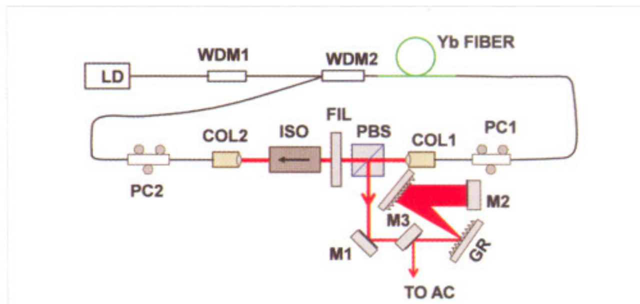
L.4: Femtosecond pulse generation from mode-locked Ytterbium doped fiber laser

There is a strong interest in the development of ultrafast fiber laser systems providing femto-second pulses as fiber based system can offer many advantages compared to the solid-state counterparts like flexibility, reduced thermal effects, diffraction limited beam quality, compactness and reliable maintenance free turn key operation. A Ytterbium (Yb) doped mode-locked fiber laser in all normal dispersion (ANDisp) configuration has been developed in the Solid State Laser Divison of RRCAT producing a train of stable pulses in the femtosecond regime.



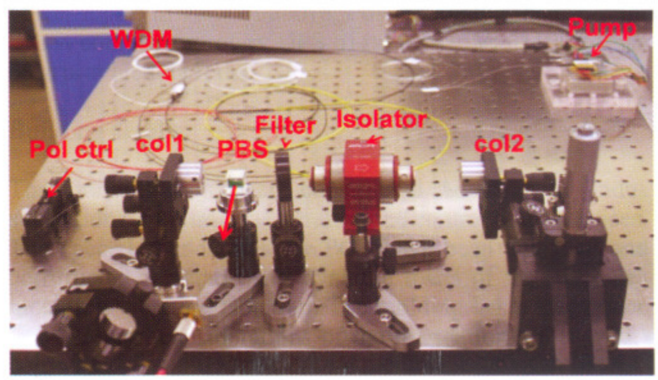


Fig.L.4.1 Schematic and photograph of the laser setup

The schematic of the mode-locked Yb-doped fiber laser setup under all-normal dispersion configuration is shown in Fig.L.4.1. The laser comprised of 150 cm long single clad single mode Yb-doped fiber and was pumped in-core by a FBG stabilized single mode fiber coupled laser diode at 976 nm. One end of the Yb-fiber was spliced to the output port of a WDM and at the other end, a standard single mode fiber (SMF) was connected. At the signal port of WDM2 a long (300cm) SMF was spliced. The free ends of the two SMFs are connected to in-fiber collimators (COL1 and COL2). The total cavity length including the free space between the collimators was measured to be 570 cm. In the free space between the two collimators a polarizing beam splitter (PBS) is placed. The PBS in combination with the two in-fiber polarization controllers (PC1 and PC2) attached to the SMFs act like a fast saturable absorber based on nonlinear polarization evolution (NPE). A bulk optical isolator (ISO) was placed in the free space for unidirectional ring cavity operation so that the saturable absorber based on NPE becomes effective and the mode-locking operation becomes self-starting. The laser cavity was made with all-normal-dispersion elements (net GVD ~0.12 ps^2) and no negative dispersing element like a grating pair is present inside the cavity for the dispersion compensation. For the purpose of pulse width management a narrow band interference filter (bandwidth 10 nm, peak transmission ~1064 nm) is placed after the PBS. The output was taken directly at NPE rejection port. Since the laser was made of all-normal dispersion components the pulses are chirped and compressed externally using a grating pair placed in a near littrow configuration. By adjusting the polarization controller a train of mode-locked pulses are readily observed at a pump power of 280 mW. Fig. L.4.2 shows the oscilloscope trace of the mode-locked pulse train. It can be seen from Fig.L.4.2 that the mode- locked pulse train was fairly stable at a repetition rate of 37 MHz. By adjusting the NPE the laser can be operated in various modelocking regimes.

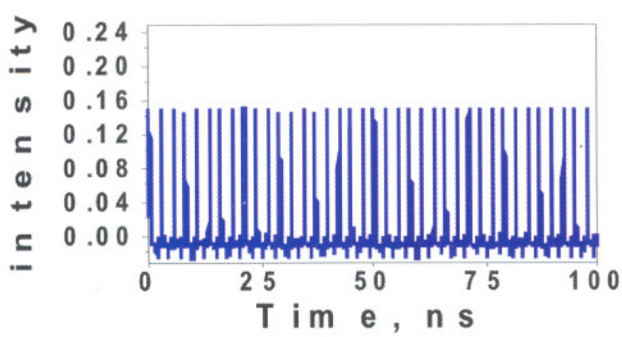


Fig.L.4.2: Oscilloscope trace of the recorded pulse train

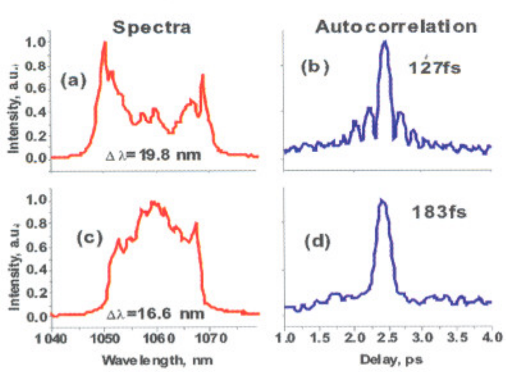


Fig.L.10.3 Spectra and the corresponding autocorrelation trace of the mode-locked pulses

In Fig.L.4.3 the spectra and the corresponding different autocorrelation traces are shown. In one regime the spectra is broad and the compressed pulse duration was measured to be 127 fs. However, the compressed pulse was accompanied with side-lobes. In another regime relatively smooth pulse was obtained, however, the pulse duration was some what broader ~187 fs. The average power of the compressed modelocked pulses was measured to be 50 mW corresponding to 1.4 nJ of pulse energy

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L.5: Swept source based fiber-optic polarization sensitive optical coherence tomography setup for near real-time imaging of tissue birefringence

Polarization sensitive optical coherence tomography (PSOCT), an extension of optical coherence tomography (OCT), can be used to provide the cross-sectional images of tissue microstructures and birefringent constituents of the tissue in real time. In contrast to bulk-optic setups, fiber based setups provide relatively stable alignment and can be coupled to endoscopic probes, thereby facilitating in-vivo applications. Zhao et al have recently described a polarization measurement scheme that uses a polarization modulator in the sample arm of a free space spectral domain PSOCT setup. Since this method requires only the intensity measurements for the determination of polarization parameters, it is expected to be insensitive to the jitters present in swept source. We have therefore developed a single mode fiber based swept source PSOCT (SS-PSOCT) setup with a linear polarizer and a polarization modulator in the sample arm to measure the polarization parameters of the sample.

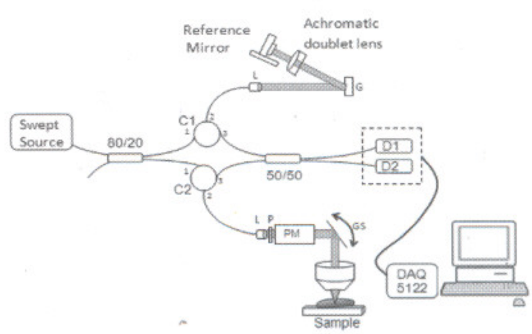

Fig. L.5.1. Schematic of the SS- PSOCT set-up: C1, C2-circulators, D1 and D2-balanced detectors, G-grating, GS-galvoscanner, L-collimating lenses and P-linear polariser, PM-polarization modulator.

The PSOCT setup (Fig. L.5.1) developed at LBAID, RRCAT uses a swept laser source (Thorlabs SL1325-P16) which has average power output of ~ 12 mW and whose wavelength can be tuned over a 110 nm range around the 1325 nm central wavelength with a sweep rate of 8 kHz. Light coming from the source is introduced into a fiber based Mach Zhender