L.1 : Frequency doubled CW fiber laser of 5 W power at 515 nm

Frequency doubled Ytterbium-doped fibre lasers (YDFLs) emitting near 0.5 µm wavelength region have wide range of applications in medical surgery, diabetic retinopathy, confocal microscopy, laser displays, pumping of dye lasers etc. Radiation at 515 nm can efficiently excite many fluoro-chromes required for spectroscopic studies and this wavelength cannot be achieved with conventional Nd:YAG laser. Due to wide range of applications of these lasers, RRCAT has initiated work on development of high power narrow line width frequency doubled YDFLs. A laboratory model of frequency doubled CW Ytterbium-doped fiber laser emitting ~5W at 515 nm with narrow line width of ~0.07 nm has been developed.

Figure L.1.1 shows a schematic of fiber laser set-up at 515 nm. The laser is developed in two stages. The first stage of laser system is YDFL emitting 1030 nm radiation, which is based on all-fiber architecture for alignment free ruggedness. This stage provides linearly polarized (LP) output radiation in narrow linewidth for efficient second harmonic generation (SHG). Commercially available off-the-shelf doped fiber and passive fiber components have been chosen for the development of this laser set-up. The active fiber and all passive fiber components are polarization maintaining (PM) in nature due to requirement of LP output from the system with maximum efficiency. These fibers have PANDA-type structure and exhibit a birefringence of ~$3x10^{-4}$. A fiber pig-tailed pump diode emitting 976 nm radiation through a ~100 µm multimode fiber has been used as a pump source for this laser system. The maximum rated output power of pump diode is 60 W. The active fiber is Yb-doped large mode area PM double-clad fiber (PMYDF) with inner-clad pump absorption of ~5 dB/m at 976 nm. The fiber has core, cladding and coating diameters of about 11 µm, 125 µm and 250 µm, respectively. The numerical apertures of core and inner cladding are 0.075 and 0.46, respectively. The pump radiation is coupled to the inner cladding of the active fiber through a compatible fiber optic pump-signal combiner (PSC). The PM YDF is spliced to the output port of PSC. The pump radiation is guided in the cladding of PMYDF by the low refractive index (n~1.37) of flouroacrylic coating and is gradually absorbed in the core. A high reflectivity (R~99%) fiber Bragg grating (FBG) is spliced to the remaining end of PMYDF for selection of wavelength and also for narrowing of linewidth of the laser. The un-spliced end of FBG has been angle cleaved at 8° to avoid any feedback due to Fresnel reflection from flat end face. Polarization selection has been done by splicing an intra-cavity in-line fiber optic polarizer (FOP) to the input signal port of PSC. The FOP has a polarization extinction ratio (PER) of ~22 dB. The laser resonator is formed between FBG and the normal cleaved end facet (R ~3.5%) of output port of FOP. The output is taken from the output port of FOP through the input signal port of PSC. This corresponds to backward pumping configuration, which by virtue of high isolation between input pump and input signal ports automatically separates unabsorbed pump power from signal. A lens L1 collimates the output beam of this YDFL. This first stage of YDFL system has been designed and developed to provide more than 20 W of linearly polarized CW output power at 1030 nm. The slope efficiency in terms of absorbed pump power is more than 70%. The linewidth of laser is less than 70 pm, which is within the spectral full-width at half maximum (FWHM) of non-linear crystal for efficient SHG. Carefully prepared splice joints of PM fibers ensured an output signal with a PER of ~22 dB. The second stage consists of a single pass external-to-cavity SHG configuration. The laser beam from stage-I is focused by lens L2 to a waist radius of about 50 µm inside an MgO-doped periodically poled stoichiometric Lithium Tantalate (Mg:PPsLT or PPLT) crystal with dimensions of 0.5 mm x 3 mm x 30 mm. The crystal is mounted in a temperature controlled oven and maintained at phase matching temperature. A dichroic mirror M reflects unabsorbed pump radiation and transmits the signal at 515 nm. About 5.5 W of output power at 515 nm has been generated with SHG conversion efficiency of ~25% using this set-up. Figure L.1.2 shows photograph of actual laser system during operation. This laser has a potential to replace Ar-ion lasers operating at this wavelength for pumping of Dye lasers.

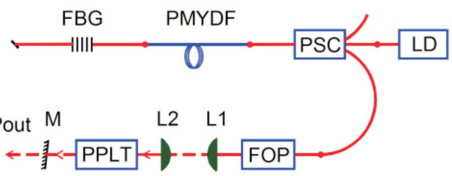

Fig. L.1.1: A schematic of fiber laser set-up at 515 nm.

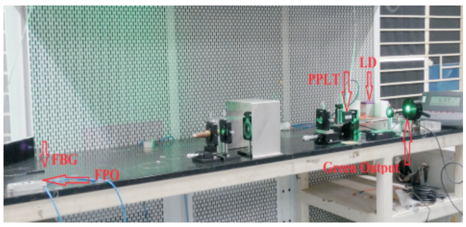

Fig. L.1.2 : A table-top view of frequency doubled Yb-doped CW laser with 5 W of power at 515 nm.

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