L.3: Generation of 100 W of CW power at 1320 nm from Nd:YAG laser

Lasers operating at 1320 nm wavelengths are widely used in laser medicine, dental surgery, etc. due to their high absorption in water molecules and low extinction in blood. Further, 1320 nm laser has low loss and minimum dispersion for silica optical fiber, hence these lasers can also be used for optical communications. The Nd:YAG laser usually operates at 1064 nm, however, 1320 nm wavelength lasing can be obtained from $^4F_{3/2}$–$^4I_{13/2}$ transition in Nd^{3+}-doped laser crystals. Nd:YAG crystal is the most suitable solid-state laser gain medium due to its excellent optical and mechanical properties over the others crystals at high pump power. About 112 W of CW power at 1320 nm from a diode side pumped Nd:YAG laser in a compact linear cavity configuration has been generated.

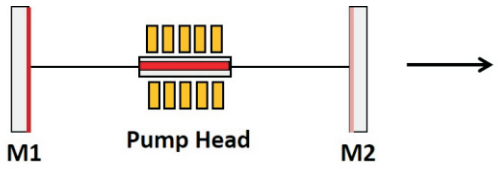

Fig. L.3.1: Schematic of experimental setup.

The experimental arrangement is shown schematically in Figure L.3.1. The laser consists of a pump head to couple the diode laser beam to the Nd:YAG rod and a compact plane-plane resonator. The pump head consists of a Nd:YAG rod, a glass flow tube, a diffusive reflector chamber and total 15 number of laser diode bars for transverse pumping of the rod in three-fold symmetry. The Nd:YAG rod is 5 mm in diameter, 100 mm long and 0.6 at.% Nd^{3+}-doping concentration with finely ground barrel surface. The rod was inserted within a flow tube with antireflection (AR) coating at 808 nm through which the coolant water flows. The diffusive reflector chamber is having three 1.5 mm narrow slits in three-fold symmetry in order to couple the pump beam from laser diode arrays. The pump power at 808 nm from the diode lasers is absorbed by the laser rod directly or after multiple reflections from the inner surfaces of the diffusive reflector chamber leading to uniform pump beam distribution inside the rod. The effectively pumped length of the rod is about 60 mm at the central portion of the rod. A total diode pump power of ~750 W is coupled to the pump chamber at the maximum operating current for diode lasers. The temperature of the Nd:YAG rod and laser diodes was maintained at 20 °C by using a water chiller unit.

The laser resonator is compact and consists of two plane mirrors. Resonator has been designed on the basis of measured thermal focal length of the pumped Nd:YAG laser rod in lasing condition with operating wavelength of 1320 nm. The rear mirror M1 is coated for high reflection (HR, R>99.5%) at 1320 nm and output plane mirror M2 is coated for partially reflecting at 1320 nm. To suppress the parasitic oscillations from the high gain four level transition $^4F_{3/2} \rightarrow {}^4I_{11/2}$ both the mirrors have also been coated for high transmission at 1064 nm. The geometrical cavity length is ~14 cm. The output beam at 1320 nm from mirror M2 was measured using a power meter.

The performance of the diode-pumped Nd:YAG laser at 1320 nm is shown in Figure L.3.2(a). The slope efficiency curves have been recorded for three different reflectivities (R= 92%, 95% and 98%) of the output coupler mirror. It can be seen that as the laser crosses the threshold, the output power increases with the input pump power. However, at higher pump power, the output-input slope reduces as the thermal effects become significant. The optimum transmission of the coupler mirror was found to be 8% at which the input-output relation has a threshold ~ 110 W with a slope of ~18.5%. A maximum CW output power of ~112 W was obtained with ~750 W of incident pump power. The corresponding pump to 1320 nm conversion efficiency was estimated to be ~15%. Output power stability for half an hour operation at ~100 W output power level was measured and fluctuation in power was within ±3%. Output spectrum of the laser output at 1320 nm is shown in Figure L.3.2(b). We observed that there is no high gain lasing wavelength at 1064 nm. Further, the laser was also operated for Q-switching operation by using an acousto-optic Q-switch modulator inside the cavity. For this purpose, cavity length was kept ~25 cm to accommodate the AO Q-switch near the pump head. About 30 W of maximum average power at 20 kHz of repetition rate was achieved. At this power level, the output pulse duration was recorded to be ~500 ns. Figure L.3.3 shows a photograph of Nd:YAG laser at 1320 nm.

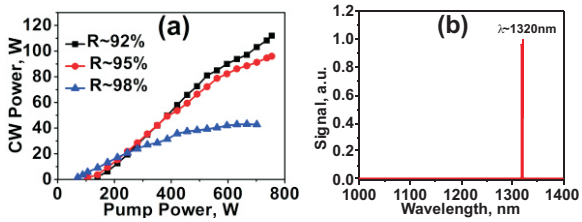

Fig. L.3.2: Lasing performance of Nd:YAG laser at 1320 nm, (a) output vs input, and (b) output spectrum.

Fig. L.3.3: A photograph of Nd:YAG laser at 1320 nm under operation.

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