L.5: Development of DPSS green laser at 9 kHz pulse repetition rate for dye laser pumping

For effective and efficient pumping of dye gain medium for oscillator or amplifier system, high average power green laser beam with high repetition rate, high pulse energy, short pulse duration, with low amplitude and timing jitter is required. Intracavity frequency doubled repetitively Q-switched diode pumped solid state (DPSS) green lasers are attractive pumping source for dye lasers due to their high efficiency, compactness and simplicity in operation with low maintenance and cost. We have developed an intracavity frequency doubled acousto-optic Q-switched Nd:YAG/KTP laser generating ~64 W of average power at 532 nm with 41 ns pulse duration at 9 kHz of repetition rate in a linear coupled cavity configuration.

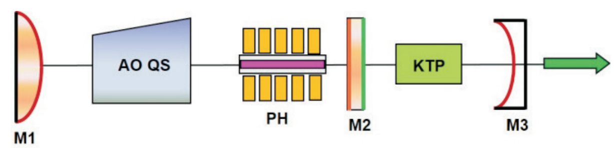

Fig. L.5.1: Schematic of DPSS green laser.

The schematic of the laser arrangement is shown in the Figure L.5.1. The laser system consists of a pump head (PH) to couple the diode laser beam to the Nd:YAG rod, an acousto-optic modulator (AO-QS) for repetitive Q-switching, a nonlinear crystal for intracavity frequency doubling and a linear resonator. A total diode power of 750 W is coupled to pump chamber to pump the Nd:YAG laser rod. For second harmonic generation (SHG), a type-II phase matched KTP crystal was used. The laser resonator was designed in coupled cavity configuration to reduce the fall time and enhancement of peak power of intracavity generated Q-switched green pulses. A concave-convex linear high finesse resonator consists of two cavities: the primary cavity for the fundamental laser beam was formed by mirrors M1 and M2, whereas mirrors M2 and M3 form a SHG cavity consisting of KTP crystal inside the main laser resonator formed by the mirrors M1 and M3. The geometrical length of the laser resonator was ~37.5 cm. The output is taken through the mirror M3, which is antireflection coated at 532 nm.

The performance of the DPSS laser system at 9 kHz of repetition rate is shown in Figure L.5.2. The threshold pump power was measured to be ~140 W. As the laser crosses the threshold, average green power increased linearly with the pump power as shown in Figure L.5.2(a). A maximum of ~64 W of average green power at 9 kHz of repetition rate with ~12.7% optical to optical conversion efficiency was obtained. Figure L.5.2(b) shows a recorded green pulse shape at maximum output power with a pulse duration (FWHM) of ~41 ns. The variation of rise time and delay time of output green pulse with respect to trigger signal is plotted with output green power and is shown in Figure L.5.2(c). Both the pulse rise time and delay time decreases with the output green power as pulse build up time becomes short due to high gain as a result of increase in pump power. At the maximum output power, pulse delay time was measured to be ~ 1.86 µs.

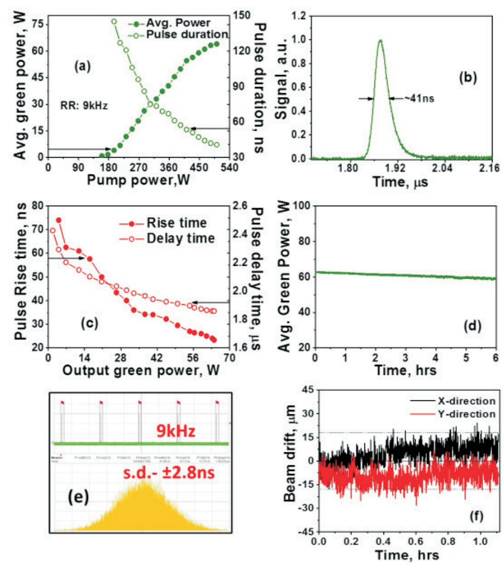

Fig. L.5.2: Lasing performance of DPSS green laser at 9 kHz pulse repetition rate.

The laser was continuously operated for ~6 hrs. to measure the output power stability, pulse timing jitter and pointing beam stability of the green beam. In Figure L.5.2(d), the long term output power stability is shown. The fluctuation in output power during 6 hrs. of operation was measured to be ±1.08 W (standard deviation). The timing jitter of the green pulses with respect to trigger signal was measured to be ±2.8 ns during 6 hrs. of operation. Figure L.5.2(e) represents the oscilloscope trace of Q-switched pulse train at 9 kHz repetition rate and the histogram of the delay time in Q-switched pulses for 6 hrs. of operation. Figure L.5.2(f) represents the recorded beam drift of output green beam at a 10 m distance and a maximum beam drift in X and Y direction was measured to be ~26 µm and 28 µm, respectively, whereas pointing beam stability was measured to be ±2.8 micro rad. The M^2–parameter of the beam was measured to be ~40 at the maximum output power level. The laser systems showed excellent repeatability on day to day basis of operation.

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