L.1: Development of Nd:YAG green laser with 260 W of output power at 532 nm

High power green laser beam is required for various applications such as high speed processing of high reflectivity materials like silicon or metals, laser annealing, pumping of tuneable lasers such as Ti:sapphire, dye lasers and optical parametric oscillators. Intracavity frequency doubling of diode pumped repetitively Q-switched Nd:YAG laser operating at 1.064 µm is an efficient way to generate high average power green beam with high efficiency and good stability. We have developed an intracavity frequency doubled acousto-optic Q-switched Nd:YAG/LBO laser generating ~260 W of average power at 532 nm with 73 ns pulse duration at 18 kHz of repetition rate in a thermal birefringence compensated linear cavity.

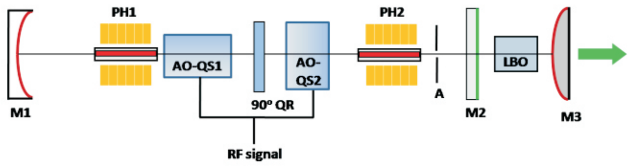

Fig. L.1.1: Schematic of high power green laser.

The laser arrangement is shown schematically in Figure L.1.1. The laser consists of two identical pump heads (PH1 and PH2) to couple the diode laser beam to the Nd:YAG rod in five fold symmetry, a 90° quartz rotator (QR), a nonlinear crystal for intracavity frequency doubling, two orthogonally placed acousto-optic modulators (AO-QS1 and AO-QS2) for repetitive Q-switching and two-mirror linear resonator. A total diode pump power of 1.2 kW is coupled to each pump chamber. For second harmonic generation (SHG), a 18 mm long LBO (lithium triborate) crystal cut for type-II phase matching at room temperature was used. The linear resonator is designed to obtain both a large mode area at the gain medium and tight spot size at the nonlinear crystal for efficient second harmonic generation. A concave-convex linear high finesse cavity is formed by two curved mirrors M1 and M3. Plane mirror M2 is a harmonic separator. The total physical length of laser cavity (distance between mirrors M1 and M3) was kept ~87.5 cm. The output is taken through the mirror M3 which was antireflection coated at 532 nm.

The laser output performance is shown in Figure L.1.2. The solid and open red circles in Figure L.1.2(a) represent the cw and average IR power under pulsed operation at 18 kHz as a function of the total diode pump power. The maximum cw and average IR power correspond to ~26.7% and 23% optical to optical conversion efficiency. In Figure L.1.2(b), solid green circles represent the average green power at 18 kHz and the open green circles are the corresponding pulse width (FWHM) of the green as a function of the total pump power. A maximum average green power of ~260 W was obtained at 18 kHz of repetition rate. The pump to green conversion and wall plug efficiency was measured to be ~16.8% and ~8% respectively. The residual IR power at maximum green power level was measured to be ~4.0 W. At the maximum output power, the green pulse duration (FWHM) was measured to be ~73 ns.

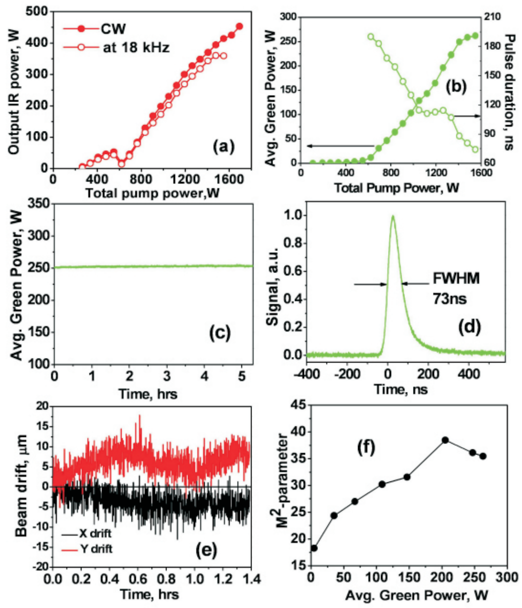

Fig. L.1.2: Lasing performance of high power green laser.

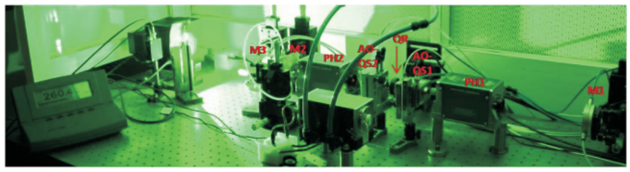

Fig. L.1.3: A photograph of green laser under operation.

The laser was continuously operated for 6 hours and characterised. Figure L.1.2(c) shows the long term stability of the average green power with ±0.83 W of fluctuation in the output power. Figure L.1.2(d) shows the temporal pulse profile. Figure L.1.2(e) represents the recorded beam drift over 1 hrs of time duration. A maximum beam drift of ~15 micron and beam stability was measured to be ±2.8 micro rad. The beam is circular in shape with measured M^2-parameter ~35 at the maximum output power as shown in Figure L.1.2(f). The laser system also showed excellent repeatability on day to day basis operation. A photograph of green laser under operation is shown in Figure L.1.3.

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