

## Laser program

### L.1 Design, development and characterization of a large aperture disk amplifier for high power Nd: glass laser chain

High power, high energy Nd: glass lasers are widely used as pulse power drivers for studies of inertial confinement fusion, generation of intense thermal x-ray radiation, pumping of x-ray lasers etc. These lasers are built using the master oscillator-power amplifier configuration. In the latter case, a master oscillator provides a laser pulse of the desired spatial and temporal profile, which is amplified in a series of power amplifiers of successively increasing apertures, to restrict the laser intensity below the damage threshold. The amplifier stages are coupled by relay systems and with spatial filtering at appropriate locations. However the amplifiers of large size (typ > 75mm, dia) with gain media in rod geometry have higher gain at the edges and poor gain in the center and also suffer from thermo-optic problems. These drawbacks are circumvented using disks in place of the rod as a gain medium. In Laser Plasma Division, we have a 2- beam high power Nd: glass laser chain capable of delivering 50J in 1- 1.5ns giving an intensity of  $\sim 1\text{GW}/\text{cm}^2$  after 80mm Nd: glass rod amplifier. In order to increase the output energy to 100J, an Nd: glass disk amplifier has been developed and coupled to the laser chain.

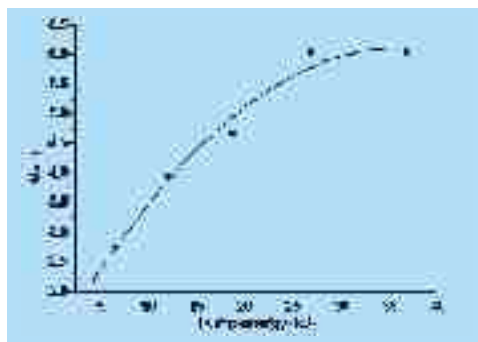
The amplifier consists of 3 disks of Nd: Phosphate glass (doping 2.2 wt% of  $\text{Nd}_2\text{O}_3$ ), of size 114mm x 214mm x 20mm. The disks are premounted in cassettes and then loaded in a rectangular cross sectional mechanical housing at Brewster angle ( $\sim 57^\circ$ ) and optically pumped using 10 Xe filled flashlamps of 600mm arc length (fig. L.1.1). Drycooled nitrogen gas is circulated to remove the heat formed in the disks during the pumping process. Also it helps in protecting the hygroscopic phosphate glass disk surfaces from degradation. The disc assembly is sealed using AR coated glass windows at the laser entrance and exit faces and with glass blast shields on the flashlamp array side. For this purpose a two stage dry nitrogen cooling system has been set up, which consists of columns of silica gel, and molecular sieves as moisture traps. The thermal recovery of the disk amplifier was found to be 13 minutes.

The disk amplifier system was energized using a bipolar power supply. This consists of two capacitor banks, each of 3000 $\mu\text{F}$ , which can be charged to  $\pm 3500\text{V}$ . For each flashlamp the pulse shaping circuit includes capacitance of 150 $\mu\text{F}$  (two numbers of 300 $\mu\text{F}$  in series) and inductance of 80 $\mu\text{H}$ . The flashlamps can be operated from 6kJ up to 36kJ (electrical energy) and the disk amplifier was characterized for gain and its spatial variation along its minor axis. The

pump pulse duration was measured to be 450sec. Fig. L.1.2 shows the gain obtained as a function of input pump energy. It is observed that the gain increases linearly with pump energy up to  $\sim 20\text{kJ}$ , and thereafter saturates to a value of  $\sim 6$  at a pump energy of 36kJ. This is primarily due to the amplified stimulated emission, parasitic oscillations and also due to the change in the flashlamp spectra. At the pumping of 20kJ, the small signal gain is 5. This corresponds to a stored energy of 930J, which is about 5% conversion of the pump energy. The available gain at the operating intensity of  $1\text{GW}/\text{cm}^2$  is calculated to be 3.65. The spatial gain variation, along the minor axis of the disk aperture was also studied. The variation was found to be from 2.5 to 3.1 (min max). The disk amplifier was coupled to the laser chain and laser pulse output of 105J /1.5ns was obtained at operation at  $\sim 1\text{GW}/\text{cm}^2$ .



*Fig. L.1.1 Disk amplifier module of Nd: glass high power laser chain.*



*Fig. L.1.2 Gain characteristics of the Nd:glass laser disk amplifier.*

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### L.2 A new method for ultrashort laser pulse characterization

Generation and application of ultrashort laser pulses require reliable characterization techniques to determine various pulse parameters like duration, shape, chirp, spatio-temporal distortions etc. Several diagnostic systems such as simple autocorrelation methods, frequency