The slope efficiency and optical-to-optical efficiency are 37% and >30% respectively. The experimental set up and optical slope efficiency data are given below (fig. L.11.1 and fig. L.11.2).

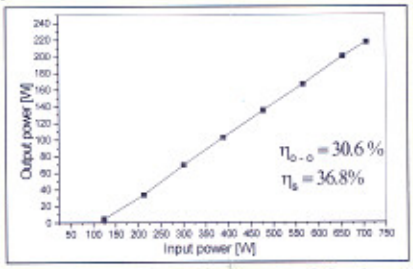

Fig. L.11.2 The efficiency of the laser

In another setup, with a laser rod of 4mm dia x 60mm length of 0.6% doping enclosed within a gold plated flow tube, except for three slits of 1mm width lengthwise 120° angularly separated for coupling of diode pump power, 60W laser power was obtained at a pump power of 180W.

(Contributed by: TPS Nathan; nathan@cat.ernet.in)

L.12 High average power intra-cavity frequency doubled green laser

High average power green beam at 532nm are useful for many basic research studies, industrial and medical applications. Such sources can be realized by intra-cavity frequency doubling in a Q-switched Nd: YAG laser. We have designed a V-shaped cavity for intracavity green generation as shown in fig. L.12.1. The cavity was folded by a curved mirror (M2) with 200mm ROC (HR@1064 nm and HT @532nm). The front mirror (M1) is highly reflecting at the fundamental wavelength. The flat end-mirror (M3) has a high reflectivity coating at both the fundamental as well as the second harmonic wavelength.

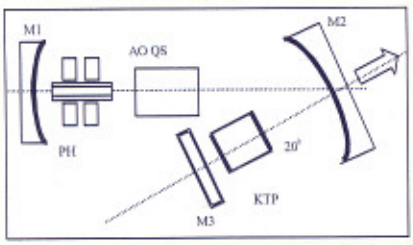

Fig. L.12.1

The spot size at the KTP, which was kept near M3, can be adjusted by adjusting the respective arm lengths. The pump head consists of a 60mm long Nd:YAG rod (4mm diameter) with 0.6at.% Nd^{3+} doping concentration enclosed within a gold-coated flow tube, described earlier, for coupling of diode pump power(fig.L.12.2). With KTP crystal 10mm long and Type-II phase matched at 80°C temperature, a maximum of 19W of average green power at a repetition rate of 8kHz has been obtained at a total diode pump power of 180W, corresponding to more than 10% optical to optical conversion efficiency.

Fig.L.12.2

(Contributed by: TPS Nathan; nathan@cat.ernet.in)

L.13 DPSS single mode IR laser (1064nm) with 100mW output power

Solid-state laser of Nd:YVO_4 with single mode, high polarization purity at 1064nm with 100mW of output power has been developed. For a typical diode pumped 3-at-% doped crystal of 0.5mm crystal length, the SLM is possible up to 5.5 times the lasing threshold. Single transverse operation is possible by adjusting the ratio of the mode to pump spot-size and by keeping the ratio around 1.3.

The experimental setup consists of a coated a-cut 3-at-% Nd:YVO_4 crystal end-pumped by a 1W fiber coupled laser diode operating at 809nm with 400mW of output power. The laser resonator is a standing wave type with the input mirror directly coated on the laser crystal and a 15% transmitting concave mirror with 80mm radius of curvature acting as the output coupler.

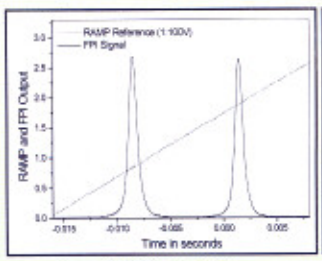

Fig. L.13.1

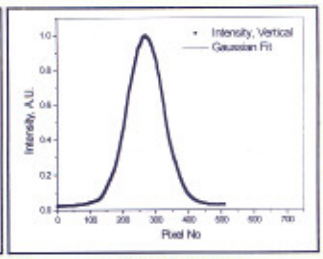

Fig. L.13.2

The SLM operation is confirmed by measuring the spectral profile with a scanning FPI. The spectral profile and spatial scan are shown below. The M^2 value is 0.99 ± 0.08. The IR output is linearly polarized parallel to the c-axis of the Nd: YVO4 crystal with more than 1:10,000 polarization ratio as confirmed by glan polarizer with high extinction ratio (fig.L.13.1 and fig.L.13.2). The output power stability recorded after 30min warm-up shows a power fluctuation < 1%. We have developed a Hansch-

Couillaud locking scheme to lock the SLM IR laser to an external resonator.

(Contributed by: TPS Nathan; nathan@cat.ernet.in)

L.14 Hand operated laser manipulator for cutting of coolant channel of feeder coupling bolts in PHWR

Hand operated laser manipulator has been used for cutting operation at Madras Atomic Power Station. One of the major activities during the shut down for preventive maintenance is the replacement of coolant channels. Grayloc coupling based mechanical seal joints are fitted on two ends of the coolant channel and D_2O (inlet and outlet) feeders. For replacing the coolant channels all the joints are to be opened by some mechanical means e.g., powered torque wrench. Due to excessive corrosion and jamming of the bolts, it is expected that it will not be possible to open some of the joints. So, it is needed to cut these bolts. These joints are made up of two of high tensile M16 bolts (fig. L.14.1).

Fig. L.14.1

Industrial Nd:YAG Laser with 250W maximum average power delivered through optical fiber beam is connected to the cutting head mounted on the manipulator. An improvement in cut quality is possible with either pure inert gas or inert-oxygen mixture as assist gas.

(Contributed by: TPS Nathan; nathan@cat.ernet.in)

L.15 Laser cutting tool for steam generator tubes in PHWR

In pressurized heavy water reactor based nuclear power plants, mushroom type steam generators (SG), made up of non-magnetic INCONEL-800 material, and are being used. The SG is a sheet and tube type heat exchanger. The SG tubes with inner diameter 14mm and outer diameter 16mm are mounted in the tube sheet in diamond pattern with tube-to-tube distance 22mm. The tubes are U-shaped and running up to 7-8meter height. Leakages in the SG tubes have been identified at various power plants in the country. To identify the reason of thinning of the tubes and leakage, it is necessary to get the sample of the tube from the location of leakage and investigate the reason behind leakage from SG tubes, e.g. material problem, local indentation problem, erosion problem etc., by further metallurgical examination. Laser based cutting mechanisms are being developed to take out the lower portion of the tube or cut a small window from inside and take it out from inside of the tube.

An industrial Nd: YAG laser having 250W average output power with fiber optic beam delivery and manipulator has been designed and developed, which will go inside the tube up-to a desired height and will be moved by motorized rotary mechanism mounted on the bottom of tube sheet A miniature cutting head with outer diameter 13.6mm and 85mm over all length has been developed, so that it can be inserted through 14mm ID SG tube as shown in fig. L.16.1 above. Fig.L.15.1 shows cut quality with oxygen and argon as assist gases.

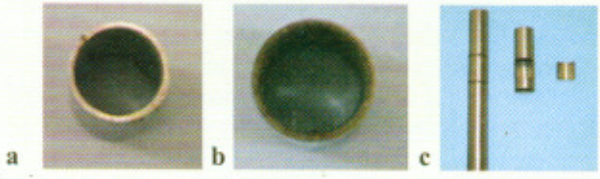

Fig. L.15.1

Many cutting trials for both, circumferential and window cutting were carried out. The debris produced in both the cases had just surface adhesion and apparently no adverse effect on the adjacent tubes.

(Contributed by: TPS Nathan; nathan@cat.ernet.in)

L.16 Silicon nano particles with blue – UV photoluminescence

The Si nanostructures have attracted significant attention in the past several years for the photoluminescence studies in the red – green region. Recently oxygen containing silicon fine structures have extended the emission in blue region, which has wider optoelectronic applications. A new technique of generating silicon nano-particles using an ultra dispersive powder (UDP) has been setup. With the thermal evaporation in controlled and varied atmospheres, silicon particles as fine as ~ 60nm were produced with enhanced PL in Blue-UV region.

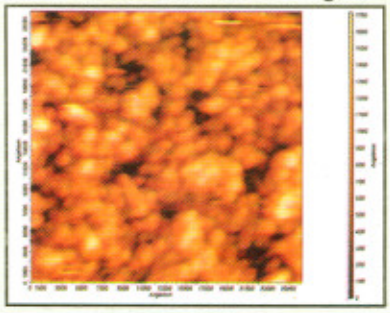

Fig. L.16.1 AFM of Si/SiO_x crystallites