LASER PROGRAMME

Output power of transverse flow CW CO_2 laser doubled to 5 kW

The transverse flow CW CO_2 laser (See Dec.91 issue of CAT Newsletter) has been scaled-up from 2.5 kW to 5 kW output power level. This has been accomplished by modifying the discharge electrode design, improvement in the gas flow velocity and its uniformity, systematic optimization of various parameters viz gas mixture, gas pressure, pulser voltage and its repetition rate, and accurate positioning of the optical resonator in the zone of maximum gain. Maximum electrical input power of 35 kW was dissipated without deterioration of discharge quality and output laser power of 5.2 kW was obtained with an electro-optic efficiency of 15%. The laser has been used for studies on surface modification of several alloys, in particular, Al-Si alloy, which due to its light weight, finds many industrial applications. The range of applications, however, gets limited by its poor surface wear resistance. The experiments carried out with the CO_2 laser show that laser melting, followed by rapid solidification, produces refinement of microstructure resulting in significant improvement of wear resistance.

Symmetry of the nonlinear optical response of fullerenes

The current interest in the nonlinear optical properties of the recently discovered fullerenes having non-crystallographic rotation axes has motivated a group at CAT to study symmetry properties of the polarizability tensors for such systems. Two rather interesting results have been obtained. First, it has been found that upto third order, the optical polarizabilities of C_{60} molecule (symmetry group I_h) have the same symmetry as that of an isotropic system. Second, it has been found that the second order polarizability (β) vanishes for C_{70} (symmetry group D_{5h}) even though the molecule is not inversion symmetric. These results open-up the interesting possibility of using optical harmonic generation for obtaining information on the inter molecular overlap of the electron density in solid C_{60} and C_{70}. This follows because circularly polarized light produces no third harmonic in an isotropic medium like an atomic gas or glass. Thus if solid C_{60} is treated as an assembly of independent molecules, as appropriate for a molecular crystal, it would behave like an isotropic material as far as optical properties upto third order are concerned. However, the crystal actually has been shown to have a cubic space group with the molecules orientationally ordered at low temperature and disordered at room temperature. Any third harmonic signal from circularly polarized light in solid C_{60} will, therefore, give a measure of the cubic modification of the molecular electron density due to intermolecular interactions. From a microscopic point of view, such a qualitative modification of the optical response results from a relaxation of the dipole selection rules due to the overlap of the orbitals of the neighbouring molecules, on forming the solid. The use of third harmonic generation to probe such electron density overlaps is especially interesting as no real excitations need be created unlike for a direct probing of the change in selection rules by optical absorption.

C_{70} is, on the other hand, reported to crystallize in non centro-symmetric structures, which can, in principle, produce second harmonic generation (SHG) within the dipole approximation, although the molecular β is zero. The SHG measurements on solid C_{70} can therefore probe solid state effects on the molecular electron density of C_{70}, in a manner analogous to that described above for C_{60}.

High power Nd:glass laser and plasma diagnostics system

A 1 GW, 30 ns Nd:glass laser chain comprising of a Q-switched oscillator followed by four amplifier stages is being developed at CAT for XUV soft x-ray generation in laser produced plasmas. The system is operational upto second amplifier stage and can provide 2 J in 30 ns pulses or by using an electro-optic pulse slicer 0.5 J in 8 ns pulses. The system is fully microprocessor controlled and adequate care has been taken to protect hygroscopic Nd:phosphate glass rods by mounting them in specially designed low humidity enclosures. The first two amplifiers have provided small signal gains of 36 and 28 respectively. A vacuum spatial filter - cum image relay system with an overall transmission of ~ 65% has also been incorporated after the second amplifier stage to remove any high frequency spatial noise in the beam.

The laser output after the second amplifier has been used to produce plasma from solid targets in a vacuum chamber system integrated with a number of plasma diagnostics. This laser produced plasma x-ray source has already been used for initial setting up and testing of an x-ray streak tube.

Acousto-optic modulator for mode locking

Intracavity acousto-optic modulators (AOM) are widely used for mode locking and Q-switching of lasers. An imported AOM was used in the active passive mode locked Nd:glass laser earlier developed at CAT (see Dec.89 issue of CAT Newsletter). As part of a continuing effort to indigenise the components in lasers developed at CAT an AOM has now been developed.

It consists of a polished fused quartz block to which a $LiNbO_3$ piezo electric transducer (73 μm thick) is bonded. The transducer is driven by a pulsed RF supply of 46 MHz

frequency. Between the transducer and quartz a gold layer is used as electrode and the epoxy resin (Epotek 302) for bonding. The gold layer was produced by applying gold paint to the surface and then baking it in the furnace at 500°C for about two hours. This coating was found to have better adhesion to quartz than a vacuum deposited gold coating. For efficient transfer of acoustic energy from the transducer to the fused quartz, the electrode and bonding layers should be as thin as possible as their mechanical impedance is very different from that of $LiNbO_3$ or quartz. Therefore, special care has been taken during bonding to ensure a clean, even and thin epoxy layer. With the present technique epoxy layers of 1 μm thickness can be obtained.

The first AOM was fabricated with a 10mm length x 4mm width transducer and was tested in a Nd:glass laser for stable mode locking. At present, 8W RF power is required for 80% diffraction efficiency at 1.054 μm. The transducer is not cooled so CW operation of AOM was not possible. An improved version of AOM incorporating arrangement for water cooling is being fabricated so that CW operation can also be achieved.

Diffraction filtered resonators with a copper vapor laser

As part of a continuing effort to obtain nearly diffraction limited output beam from Copper Vapour Laser (CVL), the use of diffraction filtered resonator (DFR) was investigated. Using a conventional DFR (based on a semi-confocal stable resonator) with a 25 mm bore diameter CVL, diffraction limited output with average power of 0.4 W was obtained. The low output power results because these resonators yield a poor utilization of laser mode volume. A modified DFR configuration providing a larger mode volume without significant degradation of beam divergence has therefore been developed at CAT. With this new DFR configuration the 25 mm bore diameter CVL gave 2 W average power with a beam divergence of 0.1 mrad (about two times the diffraction limit).

INFRASTRUCTURAL DEVELOPMENT

EQUIPMENT COMMISSIONED

A two axes laser work station has been made to specifications by M/s HMT Ltd, Bangalore for use in laser material processing. The system has traverse capacity of 3 m x 1.2 m with computer controlled movements. Third axis movement is manual and limited to 250 mm only. The system has composite movements - work movement along major axis and beam movement along minor axis. It employs ball screws & servomotors for drives, and linear motion guides for precision movements. The system has an overall accuracy of 0.015 mm per meter in either axis. Besides the job clamping arrangement, job loading /unloading mechanism, beam dump-trays etc. have also been provided. The machine is made of welded steel structure and is quite rugged. It has safety inter-locks and automatic lubrication system. The machine uses CNC controller for two axes contouring movements and IBM PC is available with the system for direct numerical control thus avoiding the use of tape-punch /reader. The machine has been commissioned at Laser R & D Bldg and is working satisfactorily.

COMPUTER FACILITY

The minicomputers at CAT are inter-connected via a computer network-CATNET. This network now supports DOS machines also, enabling resource sharing among these machines. The communication facility (E-mail) has also been commissioned on CATNET. The centre organised a three week course on "Programming in C". It has also developed software for leave accounting, budget management, stores, audit etc.

CONSTRUCTION PROGRAMME

The Indus-1 building has been completed and is already in use. The accelerator development laboratory and laser R&D blocks A,B&C are nearing completion. Construction of canteen building, overhead water tank, water supply distribution mains for the laboratory area has also commenced. Road area of about 40,000 sq.m. has been completed. Erection of 132 kV substation and switchyard has also been completed and pre-commissioning tests are in progress.

A total of 399 houses of various categories were sanctioned for the centre in the VII plan. Out of these, 355 houses are already complete and the construction of 30 houses is nearing completion. The construction of the balance 14 houses is likely to be started shortly. Additional 200 houses shall be constructed in the VIII plan period.