

LASER PROGRAMME

Output power of transverse flow CW CO₂ laser doubled to 5 kW

The transverse flow CW CO₂ 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 CO₂ 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 C₆₀ 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 C₇₀ (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 C₆₀ and C₇₀. This follows because circularly polarized light produces no third harmonic in an isotropic medium like an atomic gas or glass. Thus if solid C₆₀ 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 C₆₀ will, therefore, give a measure of the cubic

modification of the molecular electron density due to inter-molecular 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.

C₇₀ 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 C₇₀ can therefore probe solid state effects on the molecular electron density of C₇₀, in a manner analogous to that described above for C₆₀.

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 LiNbO₃ piezo electric transducer (73 μ m thick) is bonded. The transducer is driven by a pulsed RF supply of 46 MHz