

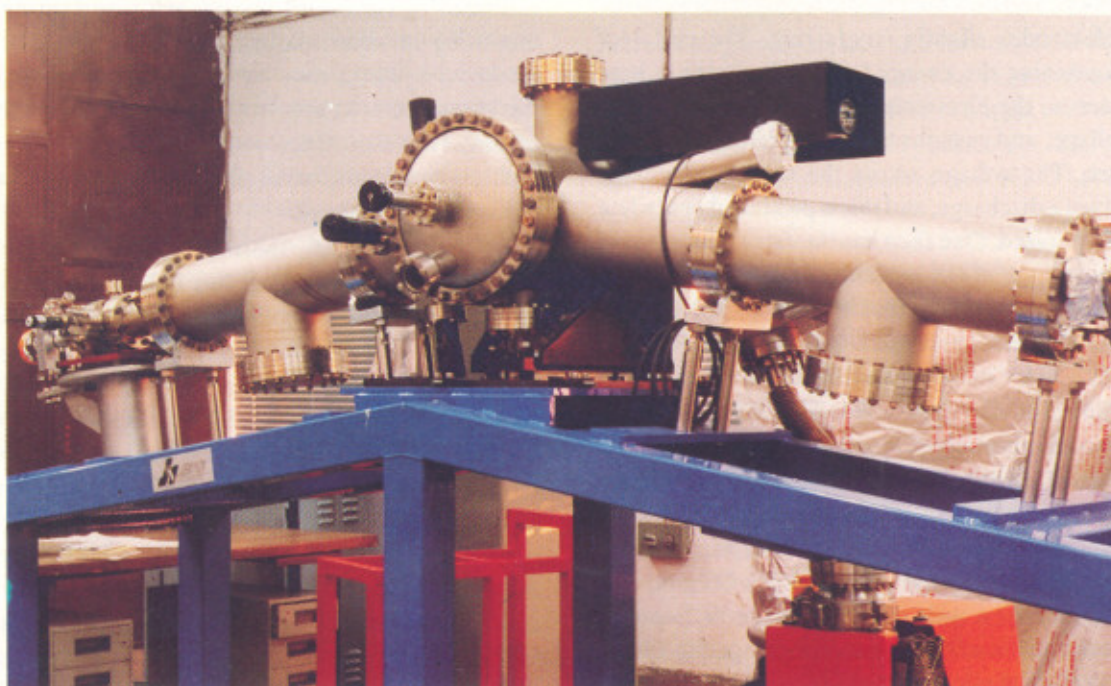
Newsletter

CENTRE FOR ADVANCED TECHNOLOGY

Year - 7

No. 2

July - December 1994



RESEARCH AND DEVELOPMENT

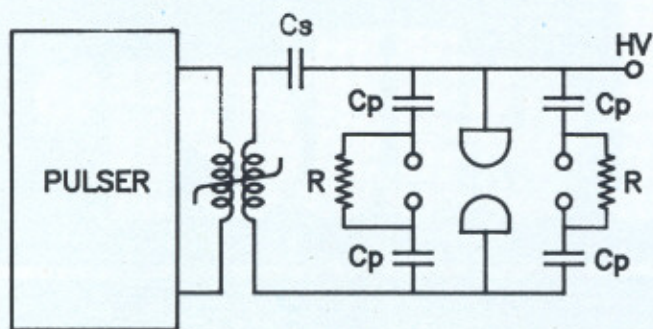
LASER PROGRAMME

Solid state switched TEA CO₂ laser

Pulsed transversely excited atmospheric-pressure (TEA) lasers operate at high voltages and high currents. Usually spark gaps and thyratrons are used as switches for these devices. Spark gaps are not reliable and thyratrons are costly devices. The recent trend has been to develop all solid state switched exciters (ASSE) for these lasers where a silicon controlled rectifier (SCR) is used as switch. While SCRs do not suffer from the lifetime limitation of thyratrons, these operate at low voltages and have dI/dt

limitations. A scheme wherein a low voltage, broad pulse (10 microsecond) is stepped up in a pulse transformer and then compressed in time to the required durations (~ 100 nanoseconds) has been used at CAT. This compression can be efficiently carried out by magnetic pulse compressors (MPC).

Another important point incorporated in our laser concerns the operating discharge electric field. In the usual pulsed discharges this field is of the order of 10 kV/cm/atm. However, this field value is not optimum field for vibrational excitation of the molecules in the CO₂ laser gas mixture, which occurs at ~ 4 kV/cm/atm. In the pulser sustainer method of excitation, the discharge excitation is by two pulses. The first is a high voltage fast pulse containing little energy, which causes multiplication of electrons produced



Schematic of the discharge circuit is shown. Cs and Cp are storage and peaking capacitors.

by preionization, and thus making the medium between the discharge electrodes slightly conducting. The sustainer capacitor containing the energy for the discharge is kept connected across the electrode. It can be charged to the optimum voltage, and sustains the weak discharge created by the pulser. The voltage across the sustainer by itself cannot produce a discharge, and this is produced only when the pulser is operated. One then has the extra advantage of changing the voltage of the sustainer-capacitor to obtain the best vibrational excitation, thus improving the efficiency of the laser. The pulser handles a small energy (~ 1 Joule) and produces a 20 kV pulse with a risetime of 120ns. In our design, the pulser is also responsible for the preionization by causing sparks between capacitively loaded pins arranged by the side of the discharge electrodes. The pulser is a 4 stage MPC circuit. The electrodes are "Ernst" profile electrodes which produce a discharge of dimensions 1.5 cm x 1 cm x 30 cm. The optimized gas mixture is CO_2 , N_2 and He in the ratio of 1:1:6 with a total pressure of 1 atmosphere. The sustainer is a 50 nF capacitor charged to 13 kV. The laser pulse was 6 microsecond long with an energy of 520 mJ. If one considers the energy of the sustainer capacitor the efficiency of the laser is $\sim 12\%$.

At present the laser is being operated at single shot basis. Efforts are on to make a laser working at ~ 100 pulses/sec.

Laser material processing

The 5 kW CW CO_2 laser developed indigenously at this Centre is being used extensively for various studies in laser material processing. Studies on cutting of mild steel and stainless steel sheets, welding, surface-transformation-hardening of different types of steels, surface modification of Al-Si alloys by laser melting and resolidification, surface alloying of Cu with Cr; of mildsteel with Si, Al and with high speed steel powder, have all been successfully done with this laser. Laser surface modifications have been found to improve surface properties such as microhardness, wear

and corrosion resistance etc. The advantages of laser processing over the conventional processing techniques are fast heating and rapid cooling, resulting in surface characteristics usually not possible with the latter. Surface microhardness of various types of steels was improved upto factors of 2 to 3 by laser transformation hardening process. Surface alloying of mild steel with high speed steel powder, Si and Al produced marked improvement in the microhardness (upto a depth of 1 mm), and also in wear resistance. Laser melting and rapid resolidification of Al-Si alloys resulted in refinement of microstructure and improvement in microhardness by more than 100%. With improved surface characteristics, these materials will have increased engineering applications.

Studies in the applications of this laser have been extended to cutting of marble slabs and curing of thermosetting powder coating. Profile cutting of marble of thickness upto 15 mm has been carried out. At higher thicknesses, cracks appeared transverse to the direction of cutting. However, these could be minimized by cutting in multiple passes instead of single pass, at lower laser power or faster cutting speed.

In another study, thermosetting pure epoxy powder coating on mild steel sheet has been cured with the CO_2 laser radiation. Curing time was drastically reduced from several minutes usually required in oven curing to a few seconds. A major advantage in this method is that the heating is limited only to the coating and the interface, facilitating curing of coatings on heat sensitive substrates; for example low grade plastics (polyethylene, PVC, polypropylene etc.) could be coated with high grade polymers (epoxy, polyester, PVDF, ECTFE etc.). Laser cured coatings met the industrial standards in terms of adhesion, hardness and corrosion resistance. This facility has also been utilised by many academic institutes and research organisations to carry out various laser material processing studies.

ACCELERATOR PROGRAMME

Indigenous development of S-band 2 MW peak power magnetron with microwave test facilities

India's first S-band 2 MW pulsed magnetron has been successfully developed for CAT by Central Electronics Engineering Research Institute (CEERI), Pilani.

2 MW magnetron is a vital microwave component for 8/12 and 20 MeV electron accelerators (Microtrons and

Cover: *Toroidal grating monochromator for use on Indus - 1 beamline .*