Switchless Operation of a TEA Co_2 Laser

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IN THE OPERATION OF A TEA CO_2 LASER, the main energy storage condenser normally discharges its energy into the load with the help of a spark gap or a thyratron both of which can close very fast and are also capable of withstanding high voltage and high current. In the repetitive operation thyratron is a better choice as spark gaps operate in the arc mode and suffer from recovery problem. Thyratrons, however, are expensive and have limited life. As a result there is now considerable interest in replacing these switches by all-solid-state-exciters (ASSE) in conjunction with magnetic pulse compression (MPC) [1]. Although such systems have long life and high degree of reliability, they suffer from low wall plug efficiency and bulkiness [1]. Effort has therefore been expended to eliminate the main discharge switch altogether in the operation of CO_2 lasers [2-4]. In this method the main discharge condenser is directly connected across the laser electrodes and is charged to a voltage well below the self-break down level of the laser gas mixture in the inter electrode volume. Automatic switching of this condenser occurs when the inter electrode volume is preconditioned by UV [2] or X-ray [3] photons or electrons from an external source [4]. In all these methods although the main discharge functions without a switch, the preconditioning of the inter-electrode volume is always initiated by a switch. We report here the operation of a UV preionised TEA CO_2 laser, which does not require the service of any external switch. The principle of operation of this scheme is described below.

In a typical UV preionised TEA CO_2 laser, the UV photons emanating from the spark channels placed along the length of the discharge precondition the inter-electrode region. In actual operation with a sequential spark type preioniser, all these spark channels are overvolted sequentially leading to their closure with the help of an external spark gap switch. The spark gap operates in arc mode and is itself a source of UV radiation when in conduction. Our intention was to make use of the UV radiation emanating from the spark gap itself for preconditioning the inter-electrode volume. We achieved this by segmenting the main spark gap into smaller adjustable gaps (see inset of Fig.1) and placing this integrated spark array along the length of the discharge as shown in Fig.1. A resistance (R) was connected across each of the gaps. We have successfully operated a mini TEA CO_2 laser where this spark array served the dual purpose of a switch as well as a source of uv photons for preconditioning of the inter-electrode volume.

The laser head comprised of a pair of cylindrical electrodes defining a discharge of cross-section 0.3 cm $\times$ 1.1 cm and of length 8.0 cm. The electrodes and the spark array were housed in a leak tight Perspex chamber, the two ends of which were O'ring sealed with a gold coated copper mirror (1 m ROC) and a 90% reflective ZnSe output mirror which also defined the resonator cavity of length 16.5 cm. The output energy and the power of the laser pulse were respectively monitored by a pyroelectric joule meter (Gentec, Model ED 200) and a fast room temperature detector (Photonic Solutions, Model PEM L3).

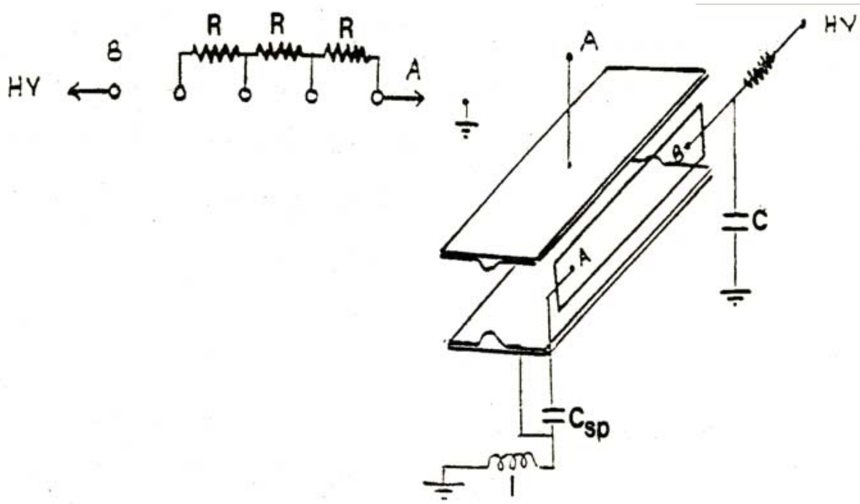

Fig. 1

operating voltage of the laser is determined by the break down voltage of the first gap in the spark array and as the array is exposed to the gas mixture any change in its composition also changed the break down voltage and, in turn, the operating voltage. The most optimised and reliable performance in terms of energy (viz., 38mj @ 7 % electro-optic efficiency) occurred for a gas mixture of CO_2:N_2:He::1:1:2.5 for which the operating voltage was ~20 kV. The efficiency would be higher if the energy expended in preionisation is accounted for. By virtue of its short cavity length, the laser emission was expected to occur on SLM, which was corroborated by the absence of any beating at t_R in the temporal profile. In order to remove the dependence of the operating voltage on the gas composition we plan to isolate the preioniser cum switch from the laser head by making use of CaF_2 windows for coupling the uv radiation into the inter-electrode volume. Result of this investigation will be reported during the symposium.

The pulser circuit used for the excitation of the laser is also shown in fig. 1. A condenser C was resistively charged to a suitable voltage 'V'. The resistance 'R' ensured that the entire voltage 'V' appears across the first gap of the spark array leading to its closure. This resulted in the closure of the second gap and subsequently all the remaining gaps in sequence. The uv photons emanating from these sparks preconditioned the inter-electrode volume. Alongside preconditioning, the preionisation current also charged up the spiker capacitor 'C_{sp}' to an elevated voltage, which was impressed across the electrodes. This high voltage impulse caused the breakdown of the preconditioned gap. The inductance 'l' provided the required delay between the pre and the spiker discharges. The remaining energy in the condenser 'C', voltage across which was reduced, now appeared in the discharge at a rate decided by the value of 'l' causing its sustenance and efficient excitation.

The laser was initially operated with a gas mixture of CO_2:N_2:He::1:1:3 and the values of C, C_{sp}, and l were optimised respectively to 2.7 nF, 300 pF, and 3.3 μH by monitoring the output energy of the laser. While optimising the gas mixture we found that the operating voltage of the laser too changed. This is because the

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