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Screened Anode N_2 Laser

M. MONTASER FOAD SABRY

Physics Department, Faculty of Science, Monofia University, Shibin El Koam, Egypt

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An experimental study of the effect of screening the discharge channel on the output energy is presented. It has been found that a screened anode nitrogen laser generates higher output energy than that of a screened cathode, and also higher than that when both cathode and anode are unshielded at higher pressures.

INTRODUCTION

Nitrogen laser working at 337 nm becomes an important dye laser pump source. Leonard[1] and Gerry[2] demonstrated that the pulsed N_2 laser, discovered by Heard,[3] could be operated with a high output power by employing fast electric dischargers. To raise the output energy of the laser, it is necessary to increase both the active discharge volume and the rate of energy deposition per unit discharge volume. The last requirement could be met by increasing the current density and field intensity. To obtain a volume discharge, it is necessary to create a sufficient initial electron concentration[4] in the cathode layer or in the discharge region itself. That cause appreciable spatial overlap of the primary avalanches and consequent smoothing of space-charge field gradients at the stage when streamer formation would otherwise occur. Realization of the volume dominated discharge could be resulted by using a discharge gap takes the shape illustrated in Figure 1.

The breakdown behavior of two electrodes shielded by parallel conducting barriers, electrically connected to one of the electrodes, is different from that of unshielded electrodes. The barriers modify the field of the gap and increase the field at the electrode surface, although

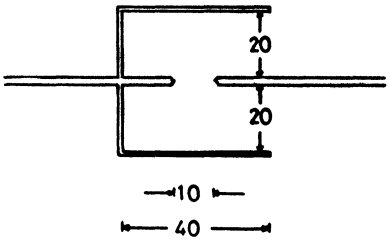

FIGURE 1 Screening shape of the electrodes.

the breakdown path itself is not interrupted. Therefore the discharge may be determined by several factors, such as the field strength in the two directions or the electron production and attachment coefficients of the N_2 and of the surface/gas interface. The effect of such field distortion of barriers on the output energy and intensity pattern of the laser beam has been studied.

EXPERIMENTAL AND RESULT

The design of the Blumlein-type TE N_2 laser used in this study has been used previously,[5] but the electrodes take the shape illustrated in Figure 1. The electrode connected to the top copper sheet of the pulse-forming side always act as a cathode, where the output energy is higher.[5] The discharge is initiated by a coaxial spark gap. The flat-plate transmission line is charged by a rectified center-tapped 15 KV transformer. Nitrogen gas of a commercial grade is flushed through the laser chamber at a constant rate. No mirror is used.

The dependence of the relative output energy of the N_2 laser on the pressure is shown in Figure 2, for the following cases: the electrodes are shielded by the barriers, and electrically connected to the cathode (screened cathode), curve (a), then to the anode (screened anode), curve (c), and both the anode and cathode are unshielded, curve (b). It could be seen, from Figure 2, that screened anode has a remarkable advantage over the others. The output energy is fairly constant over a wide range of pressures. It is fairly equal to the output energy of the unshielded electrodes at low pressures, but higher at higher pressures. On the other side, screened cathode gives the lower output energy. Moreover, up to the working pressures no arcs have

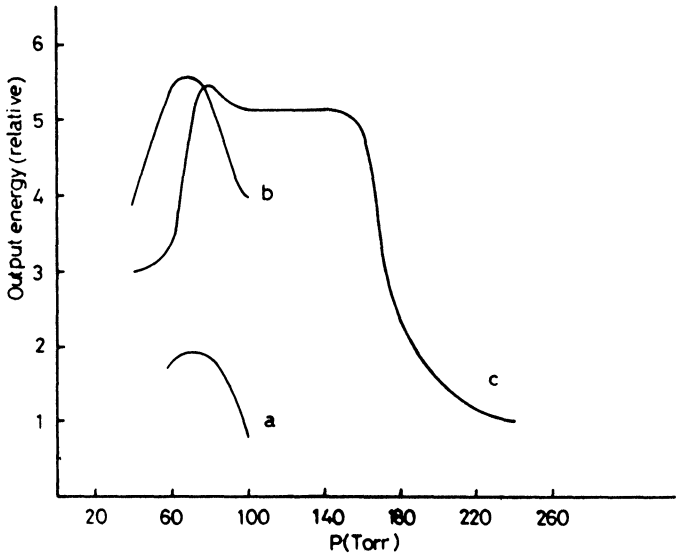

FIGURE 2 Dependence of the output energy on the pressure for: (a) screened cathode, (b) unscreened electrode, (c) screened anode.

been observed. The effect of shielding on the laser pattern is demonstrated in Figure 3. It could be noticed that for screened anode the cross section of the laser beam is larger, Figure 3a, than that from screened cathode, where it splits into two parts, Figure 3b. The laser pattern of the unscreened electrodes, Figure 3c, is given here for comparison.

DISCUSSION

For the explanation of the observed phenomena, the influence of the barrier should be considered. In the case of screened anode, the barrier change the field of the gap and increase the field at the cathode surface resulting to field emission processes. Therefore the discharge will be determined by the field strength in the two directions and the surface/gas interface, in addition to the other factors. Moreover, many anode spots[6] will be formed on the internal barrier area. The anode spots ultraviolet radiation will cause the preionized electron density to be large enough to cause appreciable spatial overlap of the primary

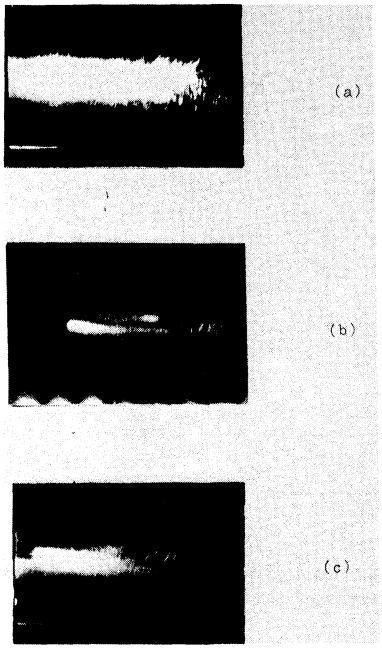

FIGURE 3 The cross-section of the laser beam. (a) Screened anode, (b) screened cathode, (c) unscreened electrodes.

avalanches. Accordingly, the cross-sectional area of the ionized gas will depend on the initial number of electrons. Therefore, a higher output energy could be obtained with the same input energy as a result of enlarging the volume of the discharge.[7]

Shielding the discharge channel would decrease the resistance of the discharge, since it is determined by the impedance of the line, and by the maintaining and applied voltages.[8] Therefore, a short duration current pulse with a fast risetime could be obtained.[9] So far, a high (E/P) can be maintained through the period of the breakdown without a transition from a glow to arc discharge. Where (E) and (P) are the field strength and gas pressure respectively.

In general, optimization of the output energy, i.e., generation of a uniform discharge profile as wide as possible requires careful placement of the barriers with respect to the discharge electrodes.

Conclusion

It is shown that screened anode N_2 laser gives a higher output energy with a wide profile of the laser spot. Moreover, it works over a wide range of pressures with a fairly constant output energy.

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