A 5 cm SINGLE-DISCHARGE CO_2 LASER HAVING HIGH POWER OUTPUT

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A single-discharge self-sustained CO_2 laser has been constructed with a gap distance of 5 cm. The system has a very simple construction; it produces a very uniform discharge with an output power of 50 Joules per liter for a $CO_2 : N_2 : He$ = 1 : 1 : 3 mixture. The efficiency can be as high as 19%.

In a recent publication [1] we reported on the performance characteristics of a self-sustained discharge CO_2 laser with a gap distance of 2 cm. This system was able to produce very high output power per unit of volume and very high gain. In order to obtain large output powers it is necessary to build large-aperture systems. Usually large systems use electron beam preionization. However, such systems are rather complicated and have a low overall efficiency. That is why we studied a 5 cm system based on the same construction principle as used in [1].

Fig. 1 shows the electrode configuration of our system. We used aluminum profiles machined on a numerically controlled bench. The shape of the profiles is in accordance with a publication of Chang [2]. For his parameter k the value 0.02 is used, whereas his parameter υ is given by the value arccos $(-k)$. The width of the profiles is 160 mm and the height is 28 mm. Alongside both profiles a glass plate is glued. At both ends of the profiles glass pieces are glued to keep the profiles at the proper distance. The discharge length is about 40 cm and the cavity length 71 cm. The cavity is provided with internal mirrors: a flat germanium outcoupling mirror with a reflectivity of 78% and an aluminum reflector having a radius of curvature of 7 m.

Fig. 2 shows a cross-section of the construction. Both electrodes can be seen. Details of the side-wall construction show the glass plate together with a copper plate, which is an extension of the right electrode. Between the glass plate and the copper plate a plate of methylmethacrylate is found to adjust the distance between copper plate and left electrode. The total thickness of the insulation material is 13 mm, a rather large

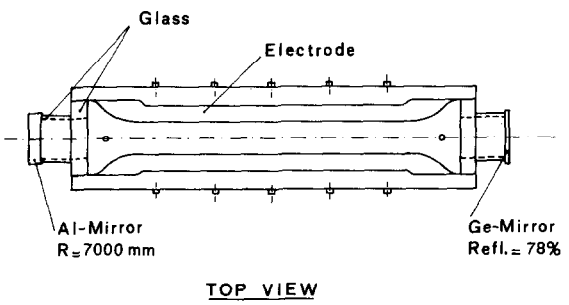

Fig. 1. Top view of the electrode construction.

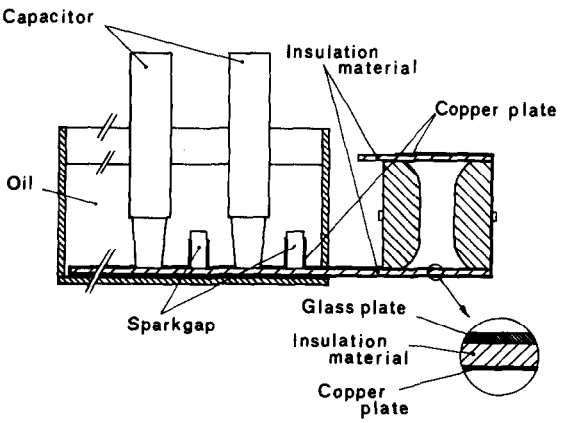

Fig. 2. Details of the side-wall construction of the laser.

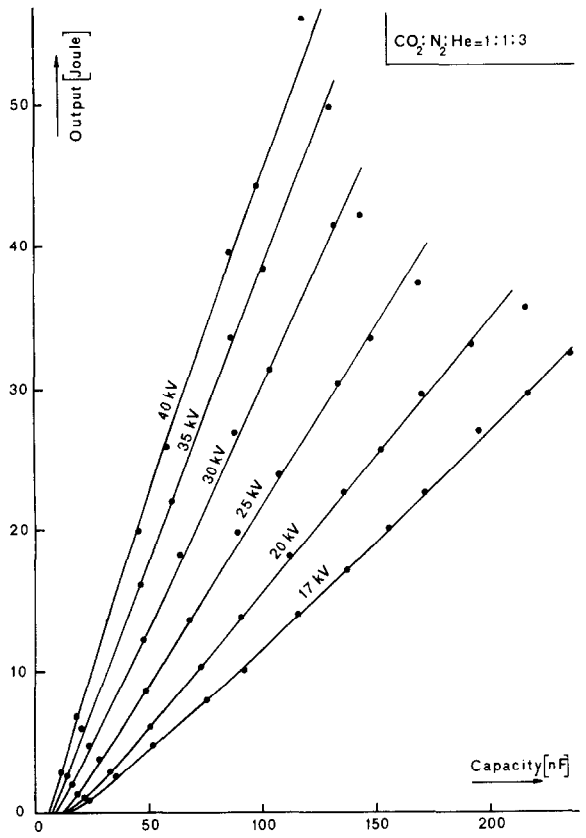

Fig. 3. The output power as a function of capacitance. At the vertical axis the output power is plotted in J/div. At the horizontal axis the capacitance of one stage of the marx generator is plotted. The parameter used in the figure is the voltage of one stage. The gas mixture is 1 part N_2, 1 part CO_2 and 3 parts He.

value, but necessary to avoid sparking between cathode and anode alongside the glass plates.

The system is activated by a 5-stage marx generator with variable capacitance, designed for low self-inductance. The total self-inductance is as low as 200 nH for a part of the capacity. The major part of the capacity is connected through a larger self-inductance, up to 1 μH. When the system is activated, a high voltage having a small rise time appears between the electrodes and because of the small distance between the copper plates and the left electrode a very high field strength causes a corona discharge to flow between both electrodes. Because of the rapid rise time of the current the UV production reaches a high level. Together with the fact that the source has a large area and good homogeneity a high-quality preionization is produced, resulting in a very stable and homogeneous discharge.

Fig. 3 shows a plot of the output power of the 5 cm system. The mixture we used was 1 part N_2, 1 part CO_2 and 3 parts He. At the horizontal axis the capacitance of one stage of the marx generator is plotted. For the case the marx generator was charged to 17 kV per stage the output power was 32.4 J. The capacitance per stage was 229 nF, resulting in an efficiency of 19%. The discharge width, determined by the half-intensity points of the output beam, was measured to be 33 mm. So the 660 cm^3 volume produced 49 J per liter. For higher voltages the output power is much higher, but since in that case the beam width has also increased, the output power per liter does not change very much.

It may be concluded that also the 5 cm system works very well and has a high output power. We believe the main reasons for it to be the very strong UV production so that a large preionization level can be reached, the relatively low self-inductance in the circuit, and the fact that no time delay between main voltage and preionization is present.

References

[1] G.J. Ernst and A.G. Boer, Optics Comm. 27 (1978) 105.
[2] T.Y. Chang, The Rev. Sci. Instr. 44 (1973) 405.