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Simple aiid Efficient Preionization System for Gaseous Lasers[+]

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A new preionization system for pulsed gas lasers was developed. It does not required special electronic circuits and has an extreme simplicity. The system was applied to an N_2 laser, and result are shown.

Foi desenvolvido um novo sistema de preionização para lasers pulsados gasosos. O mesmo funciona sem circuitos eletrônicos adicionais, e é de uma extrema simplicidade (quando se compara com outros sistemas já conhecidos.) Apresentam-se resultados da aplicação do sistema a um laser de N_2, mostrando as diferenças de comportamento do laser quando se emprega este sistema de preionização e quando não se utiliza o mesmo.

In the development of gaseous pulsed lasers, one of the subjects which has raised more interest is the obtainment of highpeak power emission. One of the most logical ways to achieve it is to raise the pressure inside the discharge tube in order to increase the number of elements which interfere, cooperatively, with the stimulated emission

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process. On the other hand, there are two particularly serious problems which have to be solved: a) the raise of impedance consequent to the elevation of pressure and b) the decrease in life time of the energy levels of interest due to increasing collisional processes. This has lead to the need of disposing short excitation pulses (≅ 1 ns) in order to obtain an efficient population inversion as well as to the ionization of the gaseous column previous to the excitation itself as a way of drastically decreasing impedance.

In the particular case of pulsed CO_2 lasers, the results has been the employment of electrodes with a Rugovski profile[1] one of which has the preionization system. On the other hand, for high pressure N_2 lasers, an interesting way consists in working with a particular electrode profile of the type shown by von Bergmann et *al*[2] which does not need any additional electronics and is very effective (Figure 1). Although, it presents some secondary difficulties which are listed below:

a) The progressive raise in pressure makes it necessary to work with very small distance between electrodes. Under such conditions the efficiency of the system is conditioned to the relation between the distance of the "excitation" profiles and the already existing one between the secondary (ionization) profiles. That is to say that it is necessary to dispose of a pair of electrodes for each value of functioning pressure if we want to improve the functioning conditions. It is woorthwhile mentioning that their construction becomes ever so complicated the more we increase pressure, because of the already mentioned relation between main electrodes and the preionization ones.

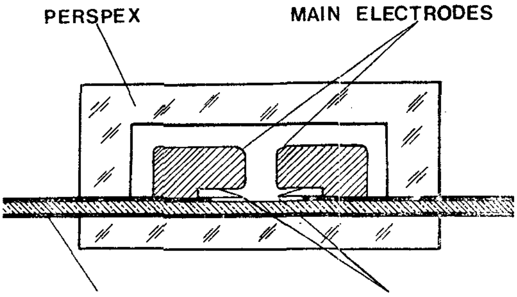

Fig. 1 - Model of typical electrodes, showing preonization profile (in accordance with 2).

b) The construction of this kind of electrodes for medium length tubes (≅ 80 cm) does not seem to be very simple, at least from the mechanical point of view.

The ideal type of electrodes should not only be able to dispense any additional electronics for preionization but should also have a simple design. This would allow the same pair of electrodes to be employed for any discharge distance.

We therefore propose the model based on Fig. 2. It shows electrode sections of two kinds. In a) the excitation pulse arrives at the electrode at point A. This pulse can only propagate towards the discharge channel ("conventional" model). b) shows a very simple modification which is the basis of the present paper. The excitation pulse arrives at the same point of electrode A as before. Neverthelles, it is now possible to have the pulse propagating in two opposite directions (towards and away from the discharge channel). In this way A' and A'' are generated. A' then reaches - and discharges over - the laser channel producing the necessary preionization. Meanwhile, A'' has been travelling in the opposite direction, arriving at the open end and suffering the corresponding reflection. After a certain delay t, A'' reaches the laser channel. This delay is very easily regulated by controlling the dimensions of the electrodes. These dimensions will determine the distance to be covered by A" in excess over the corresponding distance covered by A'. This model was experimentally tested by using a N_2 laser of the type employed Ref.2, with distance between electrodes of 7,5 mm (d_1) and 3 mm (d_2).

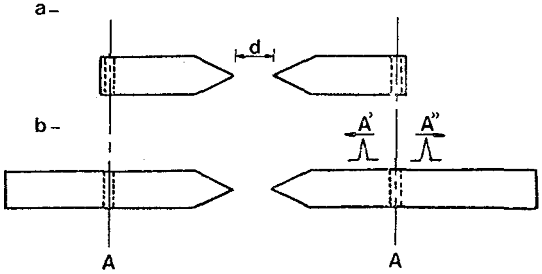

Fig. 2 - a) "Conventional" electrodes, without preionization b) Electrodes used in this work, where the divisioa of the excitation pulse - as it comes into contact with the electrodes at point A - in two pulses (A' and A") is clearly shown.

The corresponding diagram of the laser is shown in Fig. 3. +HV charges the two upper plane sections positively, which results in a negative charge for the lower plate. In this way, C_1 and C_2 capacitors are formed (3 and 2 *nF*, respectively). Once the suitable voltage ($\cong$ 15 kV) is reached, SG_2 (Spark-Gap) discharges the C_3 condenser. This generates a pulse which - propagating inside the coaxial cable (CC) - creates an ignition pulse on SG_1 (Spark-Gap). This is the way in which C_1 discharges. Correlatively, a high and sudden voltage difference is created between the electrodes of the laser tube, thus discharging the C_2 energy on it.

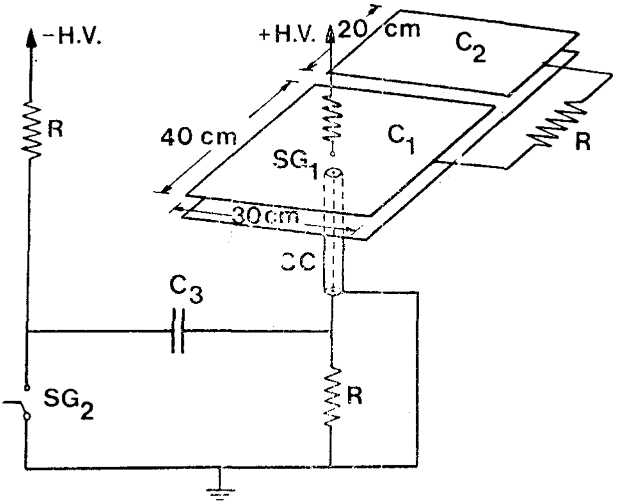

Fig. 3 - Excitation circuit. + HV: Positive high voltage; -HV: Negative high voltage; C_1: 3 nF capacitor; C_2: 2 nF capacitor; SG_1: Main spark-gap; SG_2: "Trigger" spark-gap; C_3: 1 nF capacitor ("trigger" capacitor); CC: Coaxial cable.

Radiation was detected by a photoviolet EGG SGD 040 detector and a 7904 Tektronix oscilloscope. Commercial nitrogen was used in the discharge tube and a system of neutral filters, in order to attenuate the incident stimulated radiation on the detector.

Results were registered by using 4 different discharge tubes, with the following characteristics, concerning distance between electrodes (*d*) and electrode configuration (in accordance with classification given in Fig. 2).

Tube n?	d(mm)	Electrode Configuration
1	7,5	a)
2	7,5	b)
3	3,0	a)
4	3,0	b)

Results are shown in Fig. 4. The optimum pressure for laser operation is clearly shifted to higher values when "preionization" electrodes (Fig. 2-b) are used, in both cases (d = 7,5 mm and d = 3 mm).

We wish to point out that:

a) The profile of the electrodes is far more simple than those which, to our knowledge, have been employed previously.

b) From the mechanical point of view, there are no difficulties in constructing electrodes of any length.

c) The method is efficient and, comparatively, of as good quality as the existíng ones.

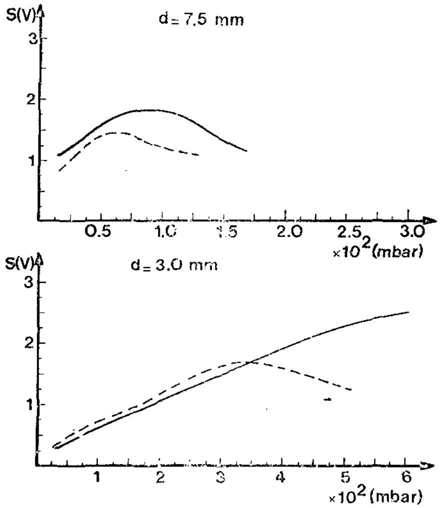

Fig. 4 - a) Output - in volts - as a function of the N_2 pressure

(V ≈ 15 kV) ------ with tube n? 1

——— with tube n? 2

b) Same as a)----- with tube n? 3

——— with tube n? 4

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