JOURNAL DE PHYSIQUE
Colloque C7, supplément au n°12, Tome 48, décembre 1987

HIGH POWER, HELIUM-FREE, SUPERATMOSPHERIC CO_2 MINI-TEA LASER

S. MARCHETTI, R. SIMILI and M. GIORGI[1]

Istituto di Fisica Atomica e Molecolare del CNR (IFAM-CNR), Via del Giardino 7, I-56100 Pisa, Italy

ABSTRACT

Large Helium -free emissions are obtained in two mini-TEA CO_2 lasers , by using always a corona preionization, without additives, with a maximum energy density of 900J/lt. deposited into the discharge

INTRODUCTION

Helium is the more expensive gas component of a CO_2 laser. So by eliminating the Helium, and by using a simple catalysis of the gas at room temperature we can strongly reduce the laser running expences. So there is a great interest to reduce or eliminate the He contents in a gas laser , also tacking into account that larger contents of N_2 and CO_2 bring about larger peak power and energy stability.

Unfortunately , larger CO_2 contents have a negative effect on the onset of an omogeneous discharge. In fact to stabilyze the discharge it is necessary an elevate electron density in the gas before the high voltage peak is transferred to the electrodes. This preionization of the mixture is generally obtained by an intense U.V. light pulse produced by a synchronized auxiliary discharge, called preionization, posed near the main discharge. Now CO_2 has a large U.V. absorption coefficient, and also it preferentially dissociates under hard U.V. light, without ionization. So high CO_2 contents prevent the U.V. photons to reach the discharge zone , and also the oxigen atoms produced by the CO_2 dissociation,induce the onset of arcing in the discharge. Besides also the O_2 molecules have a large U.V. absorption . So taking into account all these negative effects we can increase the CO_2 contents only by reducing the discharge energy density(i.e. the current density), but obviously with a lower laser emission.

To obtain large U.V. density at the center of the discharge ,the laser device must be small. Moreover in this case both the total capacity and the total inductance are reduced with a faster discharge . In fact faster discharges prevent the arcing degeneration. In conclusion the mini-TEA lasers are the more suitable devices to achieve larger CO_2 contents.

Helium free , mini-TEA laser , based on spark system preionization source are reported in Ref . (1-3). In this case the U.V. radiation is produced by a serie of arcs posed near the main discharge.

Unfortunately this preionization requires rapid recirculation and an efficient catalysis of the gas, because the produced U.V. light has large short wavelength contents, with a relative high CO_2 dissociation. On the contrary a self-switched preionization based on the corona effect is less

[1] Permanent address : ENEA Dip. TIB Frascati, P.B. 65, I-00144 Frascati, Italy

sensitive to the O_2 concentration, (4). In this arrangement the U.V. radiation is generated by the electrons flowing on a dielectric surface, posed at a side of the main discharge. If dielectrics with large H contents are used the emitted U.V. is about monochromatic near the Lyman -α Hidrogen line(5) ; in a frequency region where the CO_2 has the smaller absorption, so this preionization is more effective to preionize the gas impurities present in the mixture.
However it is worthnoting that in the previous works the He-free operation near the atmosphere is obtained only at small energy density in the discharge(6), or by using additives with low ionization threshold to increase the mixture photopreionization.

RESULTS

A three mirror cavity is used to obtain line tunable single mode emission(7) (fig.1).

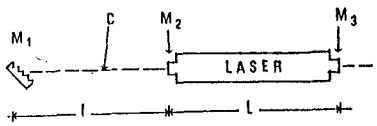


Fig1: optical cavity . M1- grating, M2, M3-mirrors, C- collimator, L-23 cm , l- variable grating distance (4-10 cm)

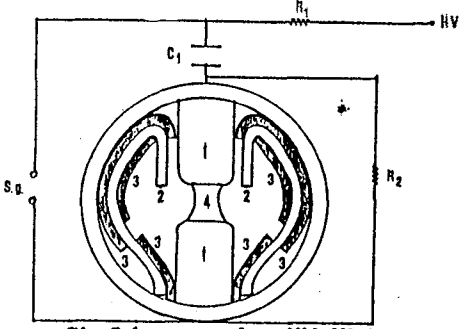
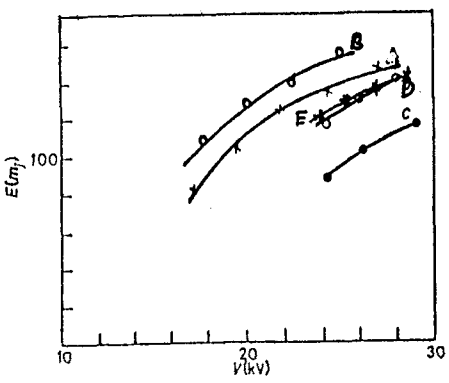


Fig.2:laser system.HV-High voltage ,R1,R2 resistences, C-capacity S.G.-spark-gap,1-electrode, 2-dielectric,3-metal,4-main discharge

The device has a 7 x 4 x 170 mm^3 discharge volume with 4 mm width. The preionization disign with Mylar as dielectric sheet is also reported in fig.2
.Some different 1 Bar pressure results are summarized in fig. 3 ,where E is the laser energy of the 9P20 line and V is the voltage . With 7.2 nF capacity and CO_2: N_2:He = 1:1:1 mixture we have curve A. With 1:1: 0.5 we have curve B. In C we have 1:1:0 mixture with 3.6 nF, while in D we have 1:2:0 with 4.9 nF and two corona preionization placed at both sides of the main discharge. In E we have1:1:0 and 4.9 nF ,one preionization but the total circuit inductance is 40% reduced. The higher peak power is obtained in case E . In general is confirmed that stabilyzed discharges are easily obtained at higher voltages with a reduced capacity, or with a reduced inductance. So we have carried out a low inductance high voltage device reported in fig.4 (8).



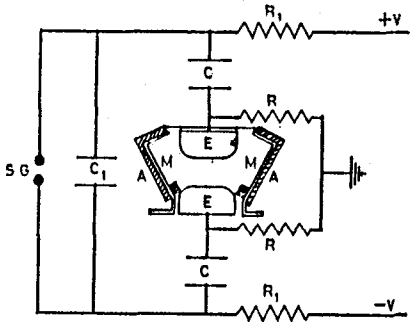


Fig 3. see text

The double bank discharge with a single spark-gap is similar to a Marx bank , but with a reduced inductance. In Fig 5 they are reported the Energy pulse the power and the time duration (F.W.H.M.) of this device vs the CO_2 in a 1.3 Bar Helium - free mixture (residual contents are nitrogen) .

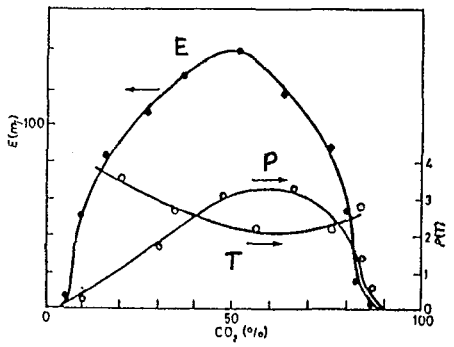


Fig. 5. Pulse energy (E) , power (P), pulse (F.W.H.M.) time duration (T) vs the CO2 contents , in an He- free CO2 +N2 mixture at 1.3 bar. P is in MW units and T in 10 ns units

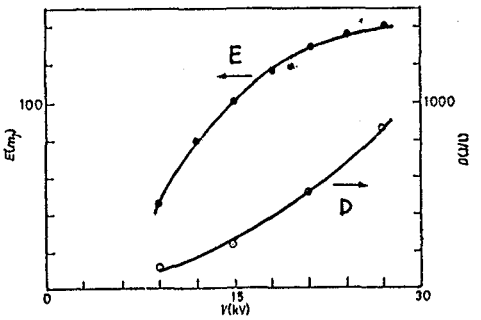


Fig6:Discharge energy density(D) and the corresponding pulse energy (E) ,vs the voltage of a single capacitor bank at 1:1:0, 1.3 Bar pressure mixture (C=7.4nF)

The best condition (in agreement with ref.1) is observed at CO_2 = 60%. In this condition the relative pulse energy and the corresponding energy density, vs the voltage of a single capacitor bank is reported in fig . 6

Arc free operation at 1.3 bar up to 900 J/lt energy density is available, but the gain is saturated for values larger than 200J/lt. the efficiency is about 10% at 100 J/lt . More than 1GW/ lt. can be obtained on a single CO_2 line , but in this case fast damage of the mirrors is observed.

1) S.Howells, AMcNeish, J.J.Harris: Opt. Quantum. Electron. 12 , 435 (1980)
2) D.S.Stark, A. Crocker, G.J. Steward: J.Phys. E: Sci. Instrum. 16 158 (1983)
3) P.E.Dyer, B.L.Tait: J.Phys. E: SCI Instrum. 16 467 (1983)
4) D.J.Brink, V.Hasson, T.I. Solomon: J .Phys. E: Sci Instrum 12 976 (1979)
5) T. Okada, M. Uraoka, M. Akazaki: Jpn. J. Appl. Phys. 19 , 1189 (1980)
6) R.Marchetti, E.Penco, G.Salvetti: IEEE J. Quantum Electron . QE 19 1488 (1983)
7)S.Marchetti, R.Simili , M.Giorgi: N.Cimento Lett. 44 442 (1985)
8) S.Marchetti , R.Simili, M.Giorgi : N. Cimento 8D 379 (1986)

Fig.4 :sketch of a double bank discharge system. S.G.=spark-gap C=7.4nF,C1=230pF,E=electrode A=copper sheet,m=Mylat sheet, V= high voltage,R,R1=resistences