

N₂ MOPA system with coaxial laser amplifier

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Abstract. A coaxial N₂ laser excited with a Polloni circuit has been used as an amplifier in a MOPA configuration using a conventional Blumlein N₂ laser as oscillator. A high amplification efficiency was obtained. Synchronization was achieved using a unique spark gap and an optical delay line. The experimental results presented are discussed and compared with the results reported by other workers.

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1. Introduction

Nitrogen laser systems working in oscillator-amplifier configurations have been developed to achieve the best characteristics of N₂ lasers in a unique system. It is well known that the transient nature of the population inversion in N₂ has limited the output power obtainable with these lasers [9] and only by using MOPA systems the power has been increased. Besides the improvements in the output power obtainable there are improvements in the quality of the beam by the use of amplifier configurations; spatial and spectral characteristics of the beam can be controlled very effectively by insertion of spectral filters or spatial filtering schemes. Low divergence and corrected spatial profiles are regularly obtained with these systems.

To extract high power from an N₂ medium, it is necessary to have high density excitation during a period which is short compared with the lifetime of the excited laser level (< 40 nsec). For the MOPA system to operate efficiently the oscillator pulse must always reach the amplifier at the time of maximum population inversion. This means that the amplifier excitation pulse must be synchronized with the arrival of the optical pulse by some means. Delay lines can be optical or electrical. In the first case, the optical pulse from the oscillator must travel a certain distance guided by mirrors or optical components to arrive to the amplifier at the time of optimum population inversion. Such lines are practical when the delay is less than 10 ns.

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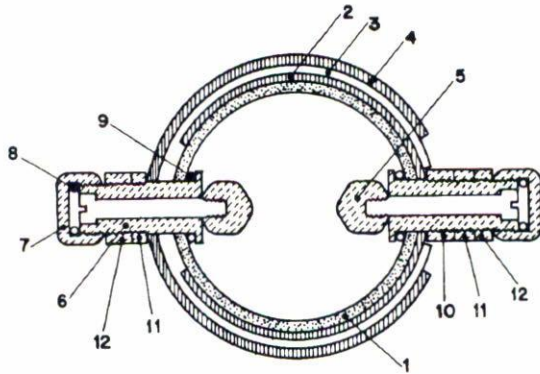


FIGURE 1. Transversal section of the coaxial amplifier 1. PVC, 2. Aluminum, 3. Mylar, 4. Aluminum, 5. Brass (Electrodes), 6. and 7. Brass, 8. and 9. O-rings, 10., 11. and 12. Brass.

Electric delay lines are inductive delay lines whose inductance can be adjusted to synchronize the electric pump pulse in the amplifier [9]. The inductance of these lines is about tens of nH. Transmission lines of different lengths have also been used to produce the delay [3]. Synchronization has also been obtained by adjusting the inter electrode separation of identical oscillator and amplifier lasers [4]. Kagawa *et al.* [5] achieved the required time delay by having appropriately different gas pressures in different discharges, the delay introduced due to pressure adjustments is of the order of nsec.

In this paper results are reported on a N_2 MOPA laser system synchronized by a unique spark gap and an optical delay line. Also, a high amplification efficiency was observed which is compared with the results reported by other workers. Finally a discussion of the results is given.

2. Construction

A coaxial N_2 laser was built following the design first introduced by B. Oliveira [1] and it is used as an amplifier. The 35 cm laser tube was built up with PVC tube of 5 cm diameter. The 30 cm long electrodes were made of brass with an inter electrode spacing of 1.2 cm. The coaxial line was made with .5 mm thick aluminum sheets attached to the PVC tube with epoxy glue, the insulator between the coaxial plates were four .1 mm thick mylar sheets. The capacitance of this coaxial line was about .5 nF. The laser tube was held together by screws threaded into the PVC tube and sealed vacuum tight with O-rings, these screws also connected the aluminum sheets and its correspondent electrodes inside the laser cavity. A transversal cut is shown in Fig. 1. Brewster windows 1.5 mm thick made of fused quartz plates were provided

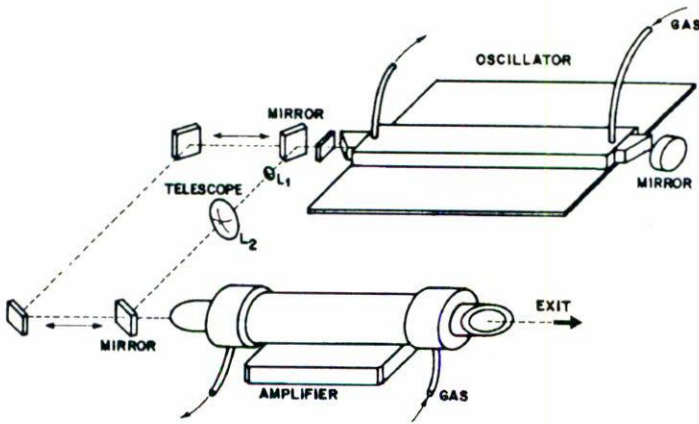


FIGURE 2. MOPA system.

at both ends of the amplifier. The nitrogen gas enters to the cavity at one end and pass through the discharge longitudinally. The storage capacitors used were 2 and 4 nF low inductance capacitors.

The Blumlein laser used as oscillator was made with 1.5 mm thick double sided printed circuit board. The 30 cm long electrodes were made of aluminum and the inter-electrode separation was about 6 mm. The capacitance of the parallel plates line was 3 nF. We used a spark gap made of two spherical shaped brass electrodes, of 20 mm radius of curvature and adjustable electrode separation. The spark gap used was operated in air at atmospheric pressure. Two vacuum systems were installed, one for each laser in order to have independent control of pressure and gas flux for each laser. A spherical mirror at the rear end of the oscillator was used to reduce the divergence of the oscillator [6,8].

A conventional Blumlein electric excitation circuit for the oscillator was used. For the amplifier laser we used the circuit first introduced by Polloni [2] which is a modification of the *C-C* charge transfer circuit with the capacitor near the laser substituted by a coaxial line with the laser cavity inside and concentric to the coaxial line. The advantages of this circuit have been shown in Ref. [1].

3. Experiment

Oscillator and amplifier were placed in a MOPA configuration. The optical arrangement is shown in Fig. 2 and the electrical arrangement is shown in Fig. 3. We used only one electric power supply for both lasers and only one spark gap to fire them both. The gas flow in the laser tube is very important, particularly during operation at high repetition rates. Therefore we used two independent vacuum systems with independent nitrogen supply. The time of initiation of the discharge in the laser

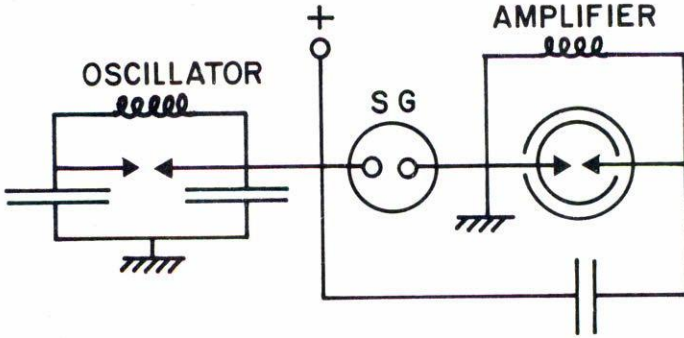


FIGURE 3. Electric connection of the MOPA system.

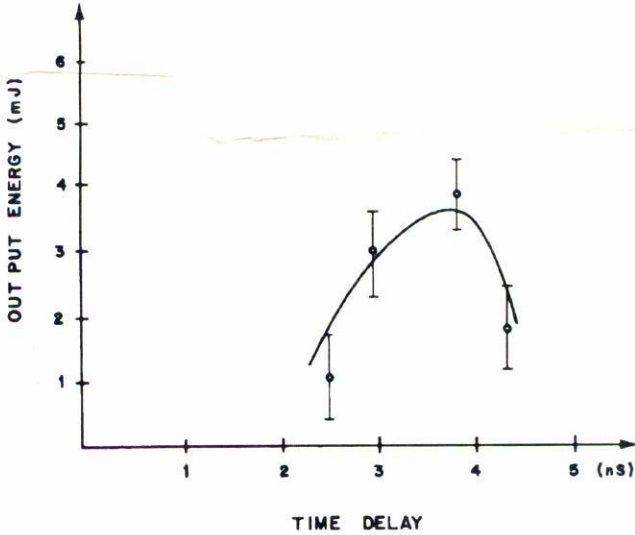


FIGURE 4. Output of the MOPA vs time delay in the optical delay line.

depends on the pressure of the gas and hence it is easier to synchronize when both lasers are operated at about the same pressure in the oscillator and the amplifier. Fine adjustment was achieved by varying the optical delay line joining the output of the oscillator and the input of the amplifier as it is shown in Fig. 2. An example of the synchronization results is shown in Fig. 4. Using a Tektronix 845 and PIN diodes

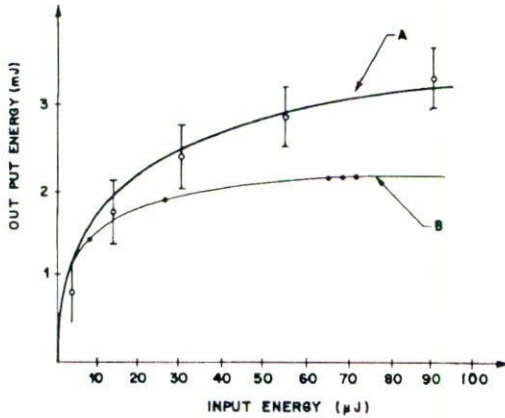


FIGURE 5. A. Input-output behaviour of the MOPA amplifier reported by the authors. B. Input-output behaviour of the MOPA amplifier reported by Santa *et al.* (from Ref. [7]).

MRD500 to measure the pulse duration and a Molectron Joulemeter JD-100 with a pyroelectric detector J25, 12 nS FWIIM and up to 4 mJ pulses were obtained regularly with the MOPA. The characterization for various input energy pulses is shown in Fig. 5-A for a repetition rate of 1 Hz. Higher repetition rates up to 4 Hz, produced a rapid deterioration of the spark gap. Fig. 5-B shows the input-output energy behaviour of a MOPA system reported by Santa *et al.* [7] build out using a TEA N₂ laser oscillator producing similar energy pulses as ours and a TE N₂ amplifier, both of them with 30 cm long electrodes as ours. As can be observed on these figures, for similar input energies the amplification efficiency is higher for our Polloni amplifier. Adjusting an exponential $y = \exp(Px)$ to Figs. 5-A and 5-B we obtain a P value of 0.574 and 0.397, respectively, which gives for our amplifier a P -coefficient 44.6% higher. This higher efficiency is due to the characteristics of the Polloni electric excitation circuit used in the amplifier. The low inductance of the circuit allows for a short rise time discharge electric pulse which makes possible a high population density inversion which accounts for the higher laser amplification efficiency.

4. Conclusions

A coaxial N₂ laser amplifier excited with a Polloni circuit has been used together with a conventional N₂ Blumline laser acting as oscillator in a MOPA system. The amplification efficiency of our Polloni-type amplifier showed to be higher than similar ones reported elsewhere. Synchronization was achieved using a unique spark gap and an optical delay line.

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Resumen. Un láser coaxial de N₂ excitado con un circuito Polloni fue empleado como amplificador en una configuración MOPA usando un laser Blumline de N₂ convencional como oscilador. Se obtuvo una alta eficiencia de amplificación. La sincronización se realizó utilizando una sola bujía y una línea óptica de retardo. Los resultados experimentales presentados se discuten y comparan con los presentados por otros investigadores.