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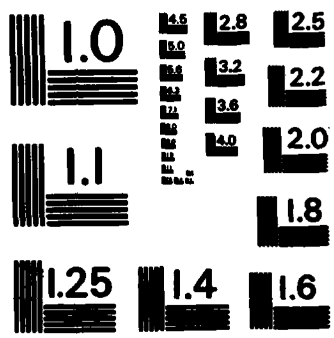

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THE Ar-N_2 TRANSFER LASER

by

Xu Shanshan and Ji Ge

FOREIGN TECHNOLOGY DIVISION

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The Ar-N_2 Transfer Laser*

by Xu Shanshan and Ji Ge
(Institute of Electronics, Academia Sinica)

Abstract

The construction of an Ar-N_2 transfer laser pumped by a radial relativistic electron beam is described. It is the first laser of this type made in China. Laser emission at wavelengths 3577Å ($C^3\pi_u v'=0 \rightarrow B^3\pi g\ v''=1$) and 3805Å ($C^3\pi_u v'=0 \rightarrow B^3\pi g\ v''=2$) has been obtained simultaneously. The laser output is 3mJ and the energy extraction volume density is 1J/liter. The characteristics of this laser are also studied.

In 1971, Dreyfus and Hodgson [1] obtained an N_2 laser (3371Å) by means of longitudinal electron-beam excitation of low pressure nitrogen. Its efficiency and laser output are not very ideal. In 1973, Ecktrom [2] proposed the excitation of rare gas atoms into ions, molecular ions and metastable atoms to collide with a laser medium and to realize electric charge and energy transfer. The upper energy level of the laser attained highly effective excitation. This principle has been widely used in Ar-N_2, He-N_2, quasi-molecular transfer and other lasers pumped by electron beam. In 1974, Searles, Ault [2,3] and Basov et al successively reported that the Ar-N_2 laser obtained oscillatory output on the 3577Å (0-1) and 3805Å (0-2) spectral lines of the second positive band $C^3\pi_u \rightarrow B^3\pi g$ of N_2 was obtained, $\eta \leqslant 0.4$ to 3%.

The following is the major kinetic process of the Ar-N_2 laser:

$$e + Ar \rightarrow Ar^+,\ Ar_2^+,\ Ar^*$$
$$e + Ar_2^+ \rightarrow Ar^* + Ar$$

* Received May 8, 1980, edited in August of the same year

$$Ar^* + N_2 \rightarrow N_2(C) + Ar$$
$$N_2(C) \rightarrow N_2(B) + h\nu$$

In order to effectively use the electron beam, a radial electron beam was adopted in the low activity volume experimental research which we carried out. When compared to other types of electron beams, it has the advantages of high utilization, greater electron energy deposits and more uniform electron excitation in laser mediums.

The power source used in our test device [5] was a 600 kV, 6kA, 40 ns MARX generator. Its typical voltage waveform (360 kV, FWHM is 40ns) is shown in fig. 1.

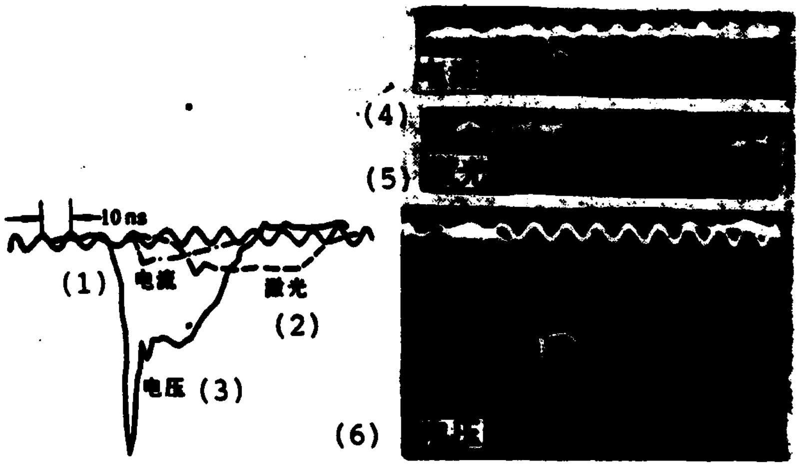

Fig. 1 Voltage, Laser Pulse, Current Waveform and Their Relation With Time

Key: 1. Current
2. Laser
3. Voltage
4. Current
5. Laser
6. Voltage

The cathode of the electron gun consisted of 3.2cm internal diameter circular tantalum foil and the anode consisted of a

0.6 cm diameter stainless steel tube with a wall thickness of 30-50 μm. The airspace within it is interconnected with the gas cell, forming the laser chamber. The 25 cm laser cavity was formed by a 1m radius of curvature dielectric film with a reflectance of 98% and a partial transmitting dielectric film with a reflectance of 73%.

When the active length is 7cm and the gas cell is filled with 1.9 atm pressure argon gas and nitrogen gas (N_2 occupies 5% of this), the laser output energy was 3mJ and the corresponding energy volume density was 1J/liter which is greater than the 0.2J/liter reported by Ault in 1975 [2]. With a 3.6 cm diameter cathode, a 10cm active area length, a 39.5% transmissivity output planar mirror, a total gas pressure of 2 atm and with 5% of N_2, the laser pulse measured by a high stream tube was 1mJ which had a 20ns delay as compared to the voltage pulse. See fig. 1 for the waveform of the laser pulse.

Measurements of a series of light pulses at different charging voltage indicate that as the changing voltage increases the delay time of the light pulses decreases and the climbing rate in the front edge of the voltage quickens. This is very important for the pumping of this type of laser. Because the average life of the upper energy level of the nitrogen laser is only 40ns, it can only very quickly reach population inversion with fast pumping and thus produce sufficiently large laser pulse peak power. At 1 atm pressure, current pulse had a 10ns delay relative to voltage pulse. The time relationship between voltage, current and light pulses is shown in the photo in fig. 1.

In fig. 2, laser emission on wavelengths 3577Å (strong line) and 3805Å (weak line) was obtained, as shown in the spectral lines detected with the domestic-made WPP-0.5m radius plane-grating spectograph, with a chromatic dispersion of 7.5Å/mm.

A filter lens was used to separately photograph the laser spots of the two spectral lines. The measured angle of divergence was 10mrad.

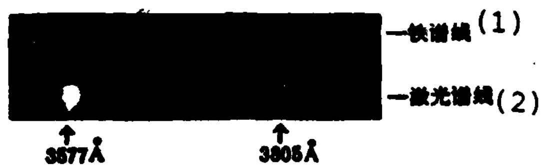

Fig. 2 Laser Spectral Lines

Key: 1. Iron spectral line
2. Laser spectral line

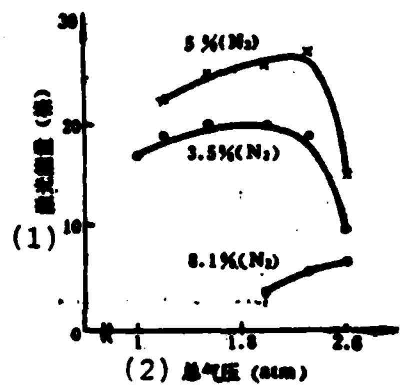

Fig. 3 Relational Curve of the Laser Energy and the Total Gas Pressure and Mixture Ratio

Key: 1. Laser energy (erg)
2. Total gas pressure (atm)

Fig. 3 shows the relational curve of the laser output when under constant excitation energy and the total gas pressure and mixture ratio. Laser output is greatest when the active length is 10cm, the power source charging voltage is 30kV and there is 5% of N_2. The output width does not vary much when the total gas pressure changes between 2.3 atm and 1.4 atm. These characteristics are very advantageous for making the device more practical. When the total gas pressure is 2 atm, there is 5% of N_2, the active length is 10cm, the output mirror transmissivity is 39.5% and the power source charging voltage is 16kV, laser oscillation is produced. At this time, the laser energy is 0.08mJ and a laser spot is visible. Moreover, when the charging voltage is 15kV, its energy reading is zero and no laser spot is visible.

When the excitation energy increases, laser output also increases. When the power source charging voltage is 30kV (the electron beam energy is equivalent to 360kV), there was still no saturation. When the active length increases and excitation energy is constant, laser output also increases. When the active length increases from 6cm to 10cm, there is a noticeable increase of the laser output (an increase of about 1/3). We also carried out experiments with 20%, 25% and 46% transmissivity output mirrors and the 25% transmissivity mirror yielded the greatest laser output.

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