

NITROGEN LASER OUTPUT ENERGY MEASUREMENTS

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Abstract - Measurements of the output beam energy of the nitrogen laser were carried out. It is a pulse-operating molecular laser in UV region at a wavelength of $\lambda=337,1$ nm, pulse duration of $\tau=6$ ns and output energy of up to 9 mJ, depending on operating conditions.

Keywords: nitrogen laser, aluminum mirror, average energy, pulse repetition period

1. INTRODUCTION

This is a report of energy measurements of the nitrogen laser output beam. The laser is built at the Ruhr University in Bochum and Department of Applied Physics at the Faculty of Electrical Engineering and Computing in Zagreb. Numerous measurements were carried out under different operating conditions, such as operating with and without mirror at the end of the discharge tube and with different pulse repetition periods.

In the previous measurements it was shown that the output energy depends on charging voltage [1] and gas pressure in the discharge tube [2].

2. NITROGEN LASER

Basic parts of the laser are: discharge tube, vacuum pump, high-voltage power supply with trigger, primary capacitor and water capacitor. It should be pointed out that this laser does not have a resonator. Therefore, an aluminum mirror (Fig. 1) is used only for reflecting the backwards

beam in the opposite direction to obtain only one output beam at the front output of the laser.

The laser discharge tube is placed over the water capacitor. Through its entire length the lower electrode of the laser is connected directly to the inner plate of the water capacitor. Such connection considerably reduces the inductance and provides fast and homogeneous discharge. The upper electrode is connected to the exterior plates of the water capacitor with a thin copper sheet. To achieve better discharge homogeneity and greater insensitivity to the transient field (generated by the copper sheet), the lower part of the discharge tube is protected by the means of a copper shield connected to the lower laser electrode. The copper sheets are insulated from each other by 0,25 mm layer of Mylar. This insulation allows the operating voltage up to 30 kV.

More about construction of the laser can be found in the Ph.D. thesis of H.C. Meng [3], and articles Rebham – Hildebrandt – Skopp [4], Cubeddu – Curry [5] and Andreić – Henč-Bartolić – Kunze [6].

3. MEASUREMENTS

Our energy measurements were carried out as shown in Fig. 1. We used a GENTEC joulemeter that consists of a pyroelectric detector GENTEC ED-500 and an energy monitor. The detector head consists of pyroelectric ceramics, heat sink and optically absorbent layer. Incidental laser light is being absorbed and transformed into the heat. Energy is displayed in mJ on the energy monitor.

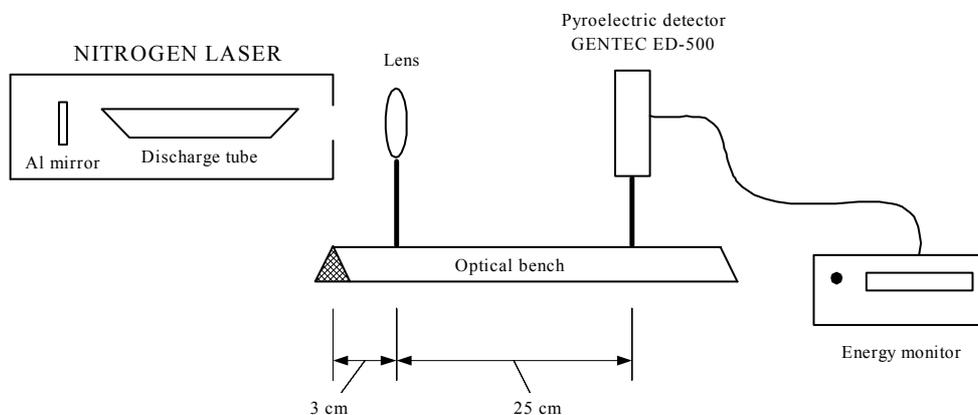


Fig. 1 Scheme of the nitrogen laser output energy measurements



Fig. 2 Micrograph of the Si target. The nitrogen laser without the Al mirror.

The nitrogen laser radiation was focused onto the target by a 70 mm quartz lens. Fig. 2 shows an example of a burnt mark on a silicon target (using a metallurgical microscope with 38 \times magnification). The shape of the burnt mark on the target shows that the laser beam was not uniform over the beam area, so the size and shape of the focal spot and energy distribution on the target were also not uniform. Near the cathode, the intensity of the beam was much higher than the intensity on the anode area. The size of the focal spot was about 3 mm \times 0,3 mm.

The experimental measurements included detecting the laser beam output energy with different pulse repetition periods (Δt) and with/without the Al (aluminum) mirror. The charging voltage was kept constant on 19 kV. The pressure of the flowing nitrogen in the discharge tube was also kept constant at 34 mbar which is in the stable operating range [6]. Relative air humidity was 42%. Fig. 3 shows the example of the results obtained after measuring 20 pulses.

The laser beam output energy measured without the Al mirror and with different pulse repetition periods (Δt) has following average values: $E_{av}=1,9$ mJ and deviation of 20% with pulse repetition $\Delta t=10$ s, and $E_{av}=1,9$ mJ and deviation of 21% with pulse repetition $\Delta t=6$ s. Considering this and diagram in Fig. 3, it can be concluded that there is no significant difference between those two energies. Even with the higher repetition period ($\Delta t=6$ s), the nitrogen gas in the discharge tube and the capacitors recover completely.

The measurement results of the laser beam output energy with the Al mirror shows the average energy of $E_{av}=6,5$ mJ and deviation of 18%. Considering the pulse duration of $\tau=6$ ns, the calculated average power is $P_{av}=1085$ kW.

Energy deviation from average value of the particular pulses with the Al mirror are approximately the same as those without the Al mirror.

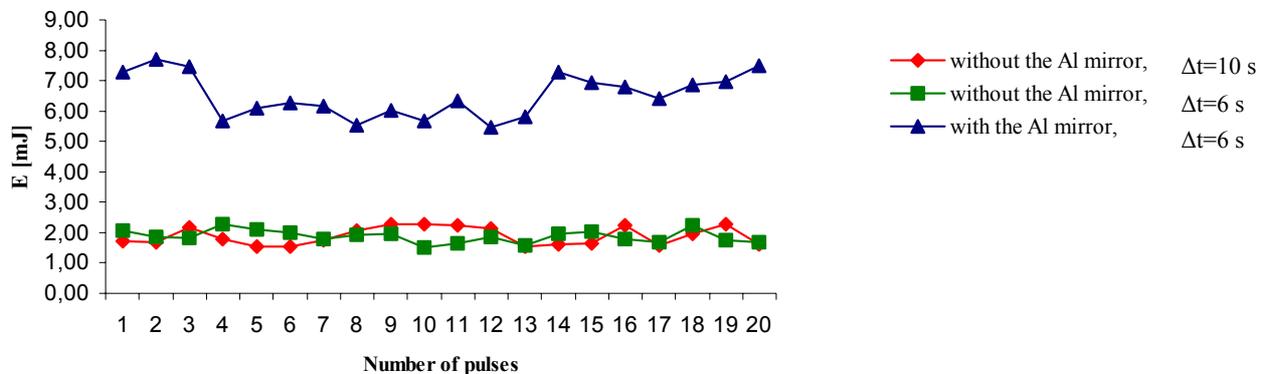


Fig. 3 Laser beam output energy with different pulse repetition periods (Δt), and with/without the Al mirror

4. CONCLUSION

The output energy is not constant, but it varies in range of about 20%. The optimal operating pulse repetition frequency of the laser is 0,2 Hz. Using the Al mirror, the output energies are about four times higher than those without the mirror, which means that the reflected laser beam from the Al mirror performs additional stimulated emission on the remained excited molecules.

This type of nitrogen laser can be used as a pumping source for dye lasers, in medicine for researching the fluorescence effects on tissues [7] and for analysis of laser-solid interactions [2].

5. REFERENCES

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