PACS numbers: 42.55.Lt; 42.60.Lh
DOI: 10.1070/QE2002v032n02ABEH002155

Answer to the note 'Once again on the efficiency of a nitrogen laser'

V.F.Tarasenko

***Abstract*. An answer is given to the criticism by V.V.Apollonov and V.A.Yamshchikov [*Quantum Electron.*, 32 (2), 183 (2002)] of the author's paper published in *Quantum Electron.*, 31 (6), 489 (2001).**

Keywords: *efficiency of a nitrogen laser, plasma-voltage maximum power, runaway electron beam*

Papers [1, 2] and the new critical note of V.V.Apollonov and V.A.Yamshchikov [3] (the previous paper) are devoted to the UV laser operating on the $C^3\Pi_u - D^3\Pi_g$ band of molecular nitrogen. In addition, H_2 and F_2 lasers are also mentioned in Ref. [3]. Since the analysis of the properties of each laser requires a detailed account supplied with the corresponding dependences and oscillograms, only the nitrogen laser will be discussed here. As for the VUV lasers, we are studying them and will soon publish new results in this field.

The critical remarks made in Ref. [3] mainly contain a harsh discussion concerning the three comments made by me to the authors of Ref. [2] about the parameter E_m/p (E_m is the maximum field strength in the laser gap and p is the nitrogen pressure), the time required for attaining the maximum pump power and voltage across the gap, as well as the accuracy of voltage measurements across the discharge gap. My opinion on these issues is as follows:

(1) The authors of Ref. [2] wrote in Conclusions 'it is shown in this work that the ratio E_m/p in the discharge does not affect directly the parameters of the N_2 laser'. This is not true. The parameter E_m/p determines the maximum electron temperature during pumping. For the electron energy below ~ 12 eV, the excitation cross section for the lower laser level is larger than that for the upper level, and the lasing threshold is not achieved at such electron energies. For the electron energy exceeding ~ 20 eV, the ionisation cross section exceeds the excitation cross section for the upper laser level [4], reducing the efficiency of the nitrogen laser. Thus, there exist physical factors determining the optimal value of the parameter E_m/p (the parameter E_m/N in the general case, where N is the nitrogen concentration), and we detected optimal values of E_m/p (see Fig. 4 and the text in Ref. [1]).

(2) In the abstract to Ref. [2], the authors write: 'It is found that the maximum lasing power is achieved for a nitrogen pressure at which the maximum values of the pump power and voltage are attained simultaneously.' But the same authors state in Ref. [3]: 'However, we have not mentioned anywhere in our paper ... that the maximum pump power is achieved at the maximum plasma voltage, as was claimed in Ref. [1].' It is hard to understand what the authors of Refs [2] and [3] want to prove by making such mutually contradictory statements, but it is quite obvious that my remark is correct, since the authors have discarded their statement. Note that there are errors and contradictions in Refs [2] and [3], but their analysis was not my aim in Ref. [1], while the scope of this answer is limited. For example, if we take the maximum voltage equal to 40 kV (p. 483, Ref. [2]) and the resistance $Z = 5\ \Omega$ (p. 484, Ref. [2]) for the circuit in Fig. 1b in Ref. [2], the maximum current will be 8 kA even if the resistance $R(t_m)$ is neglected (Fig. 1b in Ref. [2]). However, the current amplitude exceeds 10 kA in Fig. 2b in [2] for a nitrogen pressure of 120 Torr. The authors of Refs [2, 3] have not presented any oscillograms of the current through the laser chamber, but state that Fig. 2b in Ref. [2] has been used to determine the discharge current through the laser chamber, its value being '... 4 kA for the maximum plasma voltage of 20 kV' (p. 484, Ref. [2]), and so on. I would advise the readers to go through our papers once again.

(3) V.V.Apollonov and V.A.Yamshchikov do not accept my comments concerning their error in determining the oscillogram of the voltage across the discharge gap (see Fig. 2a in Ref. [2]) and want me to present the correct experimental oscillograms. A fairly accurate oscillogram of voltage decay in the discharge gap is presented in Ref. [1] (see Fig. 3b) (the voltage-pulse rise time was ~ 50 ns). The questions concerning the formation of volume discharge are discussed in several articles and books (see, for example, Ref. [5], p. 251). The voltage across the gap for a volume discharge has two phases: the rapid voltage decay phase, whose duration in nitrogen does not exceed 5 ns under a pressure of several hundred torr and for $E_m/p \approx 80 - 200$ V cm^{-1} Torr^{-1}, and the quasi-stationary phase in which the voltage does not change significantly. In Fig. 2a in Ref. [2], the voltage decreases almost linearly for 35–40 ns, indicating to an error in the measurement of voltage across the discharge gap.

V.F.Tarasenko Institute of High-Current Electronics, Siberian Branch, Russian Academy of Sciences, Akademicheskii prosp. 4, 634055 Tomsk, Russia; Tel: (3822) 25-86-85; e-mail: VFT@loi.hcei.tsc.ru

Received November 1, 2001
Kvantovaya Elektronika **32** (2) 185–186 (2002)
Translated by Ram Wadhwa

(4) As for the proposal to use a beam of runaway electrons (10 keV) for increasing the efficiency of the nitrogen laser, note once again that the ionisation cross section exceeds the excitation cross section for the upper laser level for electron energies exceeding ~ 20 keV [4], resulting in a decrease in the efficiency of the nitrogen laser. Moreover, it is known that the lasing threshold is not achieved usually upon pumping of nitrogen by a transverse electron beam [6].

Note finally the most important point. The authors of Ref. [2] say nothing about the values of the efficiency of the nitrogen laser and conditions under which they can be obtained. Such data would be very useful for researchers and designers of nitrogen lasers, and the accuracy of the presented data can be verified. In addition, the parameters of the laser fabricated by the authors of Ref. [2] are rather low. For example, the lasing efficiency in nitrogen was 0.04 %, while the output power did not exceed 4 mJ. The efficiency and output power obtained in our works were several times higher (see references in [1]).

References

1. Tarasenko V.F. *Kvantovaya Elektron.*, **31**, 489 (2001) [*Quantum Electron.*, **31**, 489 (2001)].
2. Apollonov V.V., Yamshchikov V.A. *Kvantovaya Elektron.*, **24**, 483 (1997) [*Quantum Electron.*, **27**, 469 (1997)].
3. Apollonov V.V., Yamshchikov V.A. *Kvantovaya Elektron.*, **32**, 183 (2002) [*Quantum Electron.*, **32**, 183 (2002)].
4. Paterson L.R., Green A.E.S. *Can. J. Chem.*, **47**, 1777 (1969).
5. Fortov V.E. (Ed.) *Entsiklopedia nizkotemperaturnoi plazmy. Vvodnyi tom II* (Encyclopedia of Low-Temperature Plasma. Introductory Volume II) (Moscow: Nauka, 2000).
6. Derzhiev V.I., Losev V.F., Skakun V.S., et al. *Opt. Spektrosk.*, **60**, 811 (1986).

ERRATA

PACS numbers: 42.66.–p; 42.15.Fr; 42.30.Ms
DOI: 10.1070/QE2002v032n12ABEH002105

Measurement of eye aberrations in a speckle field

A V Larichev, P V Ivanov, I G Iroshnikov, V I Shmal'gauzen

[*Quantum Electron.*, **31**, 1108 – 1112 (2001)].

In the paper through the fault of the translator an error was committed in the name of the third author: instead of wrong I G Iroshnikov one should read N G Iroshnikov.
The collective of the editorial office gives its apologies to the author.