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A pulsed overtone CO laser with efficiency of 16 %

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***Abstract*. It is shown that the efficiency of a pulsed e-beam sustained discharge overtone CO laser in the multiline regime achieves 16 % and in the single-line regime its efficiency is 0.75 %. The theoretical and experimental data are in good agreement taking into account the local specific energy input.**

Keywords: *e-beam sustained discharge laser, overtone CO laser, electrooptical efficiency, local specific energy input.*

Investigations of lasers operating at the first vibrational overtone of CO molecules attract considerable attention [1 – 9]. This is explained, in particular, by the fact that the overtone CO laser emits in a broad spectral range from 2.5 to 4.2 μm [1 – 3] covering the transparency window of the atmosphere (see, for example, [10, 11]). Due to weak absorption in atmosphere, radiation of this laser can propagate over large distances. The energy parameters of the lasers are important for a number of applications. By now various methods of excitation of the active medium in an overtone CO laser have been studied. These include excitation by a pulsed e-beam sustained discharge [1 – 4], by a repetitively pulsed EI discharge [5, 6], by an RF discharge followed by supersonic circulation of the gas mixture [7, 8], and by a low-pressure self-sustained discharge [9]. The highest efficiency (11 %) of an overtone laser, defined as the ratio of the specific energy output to the specific energy input, was obtained in a pulsed e-beam sustained discharge CO laser [1, 3]. The experiments were carried out on a laser setup with a large excitation volume (~ 18 L). The optical volume of the active medium in the laser cavity was restricted by the size of laser mirrors and did not exceed 2.5 L. Investigations of the lasing parameters of a pulsed e-beam sustained discharge overtone CO laser were performed in [1 – 4] assuming that the energy input to the local volume, corresponding to the volume and position of the laser cavity, coincides with the volume-averaged energy input. However, experimental and theoretical studies of the gain dynamics at the vibration – rotation transitions of the CO molecule show that the local energy input is 25 % – 35 % (depending on the experimental conditions) lower than the energy input averaged over the volume of the discharge region [12]. Thus, for a proper measurement of the laser efficiency and a comparison of the experimental and theoretical results, the difference between the local and volume-averaged energy inputs should be taken into account.

Figure 1 shows the theoretical [1 – 3] and experimental dependences of the electrooptical efficiency of a pulsed e-beam sustained discharge overtone CO laser on the local energy input. The experimental electrooptical efficiency was defined as the ratio of the specific energy output to the local specific energy input. A good agreement was achieved between the theoretical and experimental results for an energy input not exceeding 150 J L^{-1} $Amagat^{-1}$. As the energy input was increased above 150 J L^{-1} $Amagat^{-1}$, the discrepancy between the theoretical and experimental results increased, probably due to the increasing effect of gas-dynamic perturbations of the active laser medium on lasing. The maximum value of the experimental efficiency of the pulsed e-beam sustained discharge overtone CO laser in the multiline regime was 16 %. In the single-line regime of

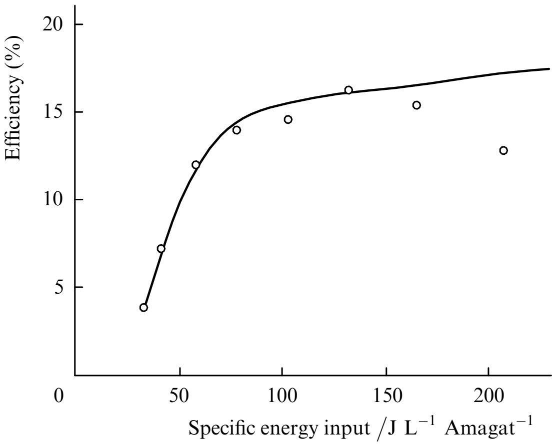

Figure 1. Theoretical (solid curve) and experimental (circles) dependences of the efficiency of the e-beam sustained discharge overtone CO laser in the multiline regime on the specific energy input for the CO : N_2 : He = 1 : 9 : 10 mixture for a density of 0.12 Amagat at temperature ~ 100 K.

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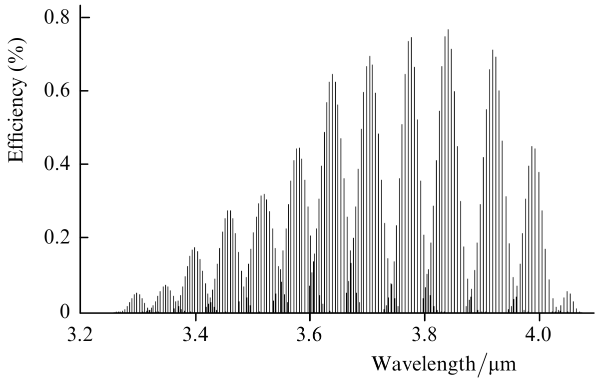

Figure 2. Dependence of the efficiency of an e-beam sustained discharge overtone CO laser in the single-line regime on the wavelength for the $CO : N_2 = 1 : 6$ mixture for a density of 0.12 Amagat at temperature ~ 100 K and a specific energy input 500 J L^{-1} $Amagat^{-1}$.

overtone lasing [2, 3], the maximum electrooptical efficiency was $\sim 0.75\,\%$ (Fig. 2).

Thus, we have shown that for a correct comparison of theoretical and experimental data, the energy input to the active region corresponding to the position of the laser cavity (local energy input) should be taken into account. The electrooptical efficiency of the pulsed e-beam sustained discharge overtone CO laser in the multiline regime achieves 16 %, while the efficiency in the frequency-selection regime is 0.75 %.

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