THz TE CS_2 Laser

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***Abstract*— The THz CS_2 laser with the transversally electric discharge excitation (TE) has been created. The laser radiation with wavelengths of ~46 and ~39 microns (cascade transitions 00^01-20^00-20^00-11^10) with the total output energy ~1 mJ has been registered. Experimental and theoretical researches of some modes of lasering on these transitions have been carried out.**

I. EXPERIMENTS

It is known, that CS_2 molecules are unstable and they dissociate quickly in an electric discharge plasma. Therefore during development of a TE CS_2 laser, the major attention was given to achievement of the stable sulf-sustained discharge in rather a simple and reliable system. A widely used Transverse Electrical (TE) discharge system CO_2 laser with UV preionization (see, for example, [1]) has been chosen. This system has been essentially modernized with the purpose of reduction of dissociation of CS_2 by decreasing the *E/N* ratio. The laser cavity has been formed by mirrors with an aluminum coating and the radiuses of curvature R_1=1.5 m and R_2=2.5 m. The second mirror had a hole with a diameter of 5 mm for an output of radiation. This hole was covered by a KRS-5 plate with a thickness of 6 mm. The cavity length was ~1 m, and the active media length (the length of discharge area) was 0.7 m. Width of a discharge interval was 3 cm, and distance between electrodes was 2 cm. The voltage (U_c) on the small inductive capacitor (C_u=0.2 μF) could vary from 2.5 up to 7 kV.

The mixture containing CS_2, N_2, O_2 and He gases was used as an active media. Total pressure varied from 10 up to 70 Torr. Discharge stability (no streamers) was a major factor during optimization of the active media. Experiments have shown that for the used system the homogeneous discharge is possible only at rather small (<3 Torr) contents of CS_2. The optimum structure of active media CS_2:O_2:N_2:He = 0.025:0.150:0.3:0.525 has been established experimentally. At the total pressure P=27 Torr and voltage U_c=2.5 kV the output energy of THz radiations in the range of ~1 mJ has been obtained.

Identification of laser transitions because of the lack of the corresponding spectral equipment caused certain difficulties. For this purpose the set of various optical filters (silicon (with the thickness of 0.5 mm), Ge (5 mm), mica (0.2 mm), teflon (0.5 mm), crystal quartz (3 mm), dense polythene (0.2 mm), a photographic glass plate) was used. Transmission spectra of filters specially were recorded by a commercial Fourier spectrometer. Every filter and their combinations were located before a high-sensitivity piroelectric photodetector or bolometer. On the basis of the given technique it has been established that wavelengths of generated radiation were within the limits of 38 – 50 microns. The analysis of vibrational structure of CS_2 molecule has shown that cascade oscillation under the circuit $00^01 \rightarrow 20^00$ (45.6 microns) → 11^10 (38.9 microns) most probably takes place. Further investigations of the spectral content of the TE CS2 laser output are needed.

II. THEORETICAL INVESTIGATIONS

For the interpretation of experimental results numerical modeling has been conducted. The system of the balanced equations for densities of population of bottom vibrational levels of CS_2 and the first excited vibrational level of N_2 molecule was solved. It was considered that the basic channel of pumping is the collisional energy transfer from the first vibrational level of molecule N_2 excited in the electric discharge to the CS_2 level 02^x1. For CS_2 molecules the equations for intensity of generation of radiation in the channels 00^01-20^00 (ro-vibrational line P(36)) and 20^00-11^10 (R(33) line) were also used. Necessary parameters were taken from [2-3]. The shape of the gain profile was described by the Foight function. It was assumed that the duration of a pumping current pulse was ~0.5 μs. We considered the CO_2:N_2:He =1:1:3 mixture with a total pressure of 20 Torr. The results show that after the output radiation pulse in the channel 00^01-20^00 was created with a delay of ~1 μs after the beginning of the pump pulse. Its duration on the half-width makes ~30 μs. Formation of a lasing pulse in the second channel in relation to the first one begins with a delay of ~4 μs. The duration of the pulse at the half- width is ~15 μs. The output energy in both channels is distributed approximately fifty-fifty and reaches 0.05 and 0.03 mJ/cm^3 accordingly. In the range of the considered parameters the increase in loss factors in both channels results in reduction of the output energy.

The described THz discharge pumped laser can be used for the different scientific and practical applications. The use of more optimum system of electric excitation with a smaller value *E/N* for the discharge contour will allow to increase considerably radiation power parameters of THz TE CS_2 laser.

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