A LIQUID FAST-ACTING SHUTTER FOR Q-SWITCHING AN OPTICAL QUANTUM GENERATOR BASED ON NEODYMIUM GLASS

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A LIQUID FAST-ACTING SHUTTER FOR Q-SWITCHING AN OPTICAL QUANTUM GENERATOR BASED ON NEODYMIUM GLASS

(Presented by Academician A. A. Lebedev on 21 VI 1965)

Recently, solutions of various dyes having an absorption band in the spectral region near 700 mμ have begun to be used as fast-acting shutters for ruby optical quantum generators with variable Q-factor (see, for example, ([1], [2])). For glass OQG' s with a trivalent neodymium ion as the activator, generating stimulated emission at the wavelength λ 1060 mμ, only one compound has so far been known –a cyanine dye, 3,3-diethyl-9,11,15,17-dineopentylene-thiapentacarbocyanine iodide ([3]). With the aid of this compound a single pulse with an energy of 0.1 J was obtained.

In the present work the results are reported of using a solution of an analog of the indicated dye as a fast-acting shutter. The radiation of the 1060 mμ laser falls on the long-wavelength edge of the absorption band of the dye, whose maximum lies at 980 mμ.

In our experimental setup a sample of neodymium glass 15 mm in diameter and 240 mm long was used. The dye solution in a plane-parallel cuvette 20 mm long was placed inside a resonator with external mirrors separated by a distance of 1 m. The cuvette was installed between the generating rod and the output mirror. The radiation energy of one giant pulse at the output of such a generator was 1.5 J, and the pulse duration did not exceed $25—30 \cdot 10^{-9}$ sec.

When the radiation of an OQG is converted to the single-pulse generation regime, a significant narrowing of the emitted spectrum occurs. Figure 1a shows an interferogram corresponding to free generation, and Fig. 1b to single-pulse generation. As can be seen, the portion of the spectrum generated by the laser decreases from 50 to 6-8 Å. When measuring the radiation spectrum of the generator in the free-generation regime, a cuvette with pure solvent was placed in the resonator in order to take into account the influence of the cuvette itself on the losses in the resonator and on the spectral composition of the radiation.

The threshold for generation of the giant pulse, as well as its energy, depends

Figure 1

Figure 1: Figure 1

Figure 3

Figure 2: Figure 3

on the optical density of the solution. Figure 2 presents the dependences of the generation threshold (curve 1) of the single pulse and of its energy (curve 2) on the solution concentration. From these curves it is seen that generation of the single pulse arises at solution concentrations greater than $4 \cdot 10^{-5}$ mole/l. At lower concentrations free generation is observed. The energy of the single pulse, as the concentration increases, starting from the value at which single-pulse generation occurs, grows only up to a certain concentration value, after which the increase in energy ceases.

To extract the maximum amount of energy from the resonator, it is essential to choose correctly the transmission coefficient of the output mirror. As can be seen from Fig. 3, the value of the optimum transmission coefficient for the regime of free generation (curve 1), generation of several pulses (solution concentration $3.3 \cdot 10^{-5}$ mole/l, curve 2), and single-pulse···

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Fig. 1

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Fig. 3. Electron-microscopic image of the texture

generation threshold (solution concentration $11 \cdot 10^{-5}$ mole/liter, curve 3) is approximately the same.

Bleaching of an oxygen-free solution of phthalocyanine was observed by A. V. Karyakin and A. N. Terenin (4) as early as 1956 at comparatively weak illuminations (in comparison with laser illumination), which was explained by the accumulation of molecules at the triplet level, with a lifetime of the order of 10^{-3} -10^{-4} sec. There are also data on the lifetime of phthalocyanines at the singlet level (5), which is equal to several units of 10^{-9} sec. For the dye investigated by us, with an analogous level scheme, we attempted to estimate the lifetime at the triplet level. It turned out that the lifetime of the triplet state of the dye in an oxygen-free solution is less than 10^{-5} sec and could not be measured accurately on the apparatus used by us because of the low intensity of the exciting light (6). In the presence of dissolved oxygen, the lifetime at the triplet level must be still shorter and can be measured only with the aid of intense illumination from an optical quantum generator.

Fig. 2

Fig. 2

Figure 3: Fig. 2

Fig. 3

Figure 4: Fig. 3

Fig. 3

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CITED LITERATURE

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Note: Figure translations are in progress. See original paper for figures.