400-J pulsed laser using a solution of rhodamine-6G in ethanol

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Lasing was obtained with an alcohol solution of rhodamine-6G excited by a coaxial flash lamp. The electric energy fed to the lamp was 50 kJ, the lasing energy was 400 J, the lasing pulse half-width was 10 sec, and the peak power of the generated radiation was 30 MW. The beam divergence was 3.5×10^{-2} rad. The width of the generation spectrum was 9 nm.

The use of lasers to initiate chemical reactions that do not occur under ordinary conditions[1] will apparently lead to the use of organic-dye lasers, whose frequency can be tuned over a wide range.[2] The threshold character of these reactions is probably due to the fact that, first, it is necessary to exceed a certain activation energy in order to excite them, and second, losses are caused by "inactive" channels such as reradiation, intermolecular relaxation, and intramolecular relaxation. There may therefore be a need for lasers with large radiation energy, and the pulse energies attained so far[3,4] may be insufficient.

Using the setup described in [3], we succeeded in increasing the laser output energy to 400 J. The pump source was a coaxial flash lamp with a discharge gap made up of a quartz tube of 9 cm diameter and an outside cell wall of 7 cm diameter, with length 52 cm. The cell was a quartz tube 60 cm long with inside diameter 6 cm; the end faces were parallel within 0.5". The pump radiation in the far UV region was filtered out only by the cell walls. The absorption coefficient of the rhodamine-6G solution in ethanol was 6 cm^{-1} for $\lambda = 530$ nm, corresponding to a concentration 2.2×10^{-5} M.

The resonator was made up of a plane-parallel quartz plate and a dielectric-coated mirror ($r = 99.5\%$ at $\lambda = 580$ nm).

The lasing energy was measured with a liquid calorimeter[3] and with an IKT-1M calorimeter. The distribution of the radiation in the far zone was photographed on a plate placed in the focus of a lens of focal length 14.5 cm. The time variation of the distribution was recorded with an SFR-1M camera. The time scan of the lasing spectrum was with an SP-113M attachment to the DFS-8 spectrograph. The data were reduced with an MF-4 microphotometer. The waveforms of the pump and lasing pulses were recorded with FEK-12 photocells, the signals from which were fed to an S1-24 two-beam oscilloscope.

During the time of the pulse, 90% of the energy was radiated into an angle 3.5×10^{-2} rad. The radiation intensity over the beam cross section was nearly Gaussian, and during the course of the lasing development such a distribution takes place only at the initial instant. This is apparently due to the development of thermal distortions in the active medium.[5] The rate of increase of the angular divergence is 4×10^{3} rad/sec. Figure 1 shows the time characteristics of the generated radiation. The half-width of the pulse pump is 25 μsec, and that of the lasing pulse is 10 μsec.

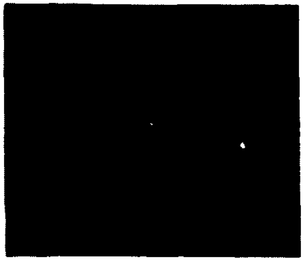

FIG. 1. Temporal characteristics of generated radiation (top-lasing pulse, bottom-pump pulse, time marker-10 μsec).

FIG. 2. Scan of spectrum of generated radiation.

Figure 2 shows the scan of the spectrum of the generated radiation. During the course of the generation, its spectrum shifts continuously towards the short-wave side, owing to the loss of harmful losses in the laser.[4] The average rate of spectrum displacement is 1.2×10^6 nm/sec. The instantaneous half-width of the spectrum changes from 2.1 to 3.2 nm, and the width of the entire spectrum is 9 nm.

A lasing energy 400 J corresponds to an electric energy 50 kJ stored in the capacitor bank, so that the laser efficiency is 0.8%, the per-unit energy delivery is 0.27 J/cm^3. The peak power of the laser radiation is 40 MW.

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