Generation by electron-beam-pumped $Al_2O_3:Ti^{3+}$

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The spectral characteristics of the emission of electron-beam-pumped $Al_2O_3:Ti^{3+}$ crystals have been studied.

The emission capabilities of tunable lasers using the new active medium $Al_2O_3:Ti^{3+}$ have already been studied fairly comprehensively in the case of optical (laser and lamp) pumping.[1–3] The diverse and often extremely high characteristics and also the wide range of potential applications of these new lasers have attracted particular interest to them and have stimulated a search for other pumping methods, with the goal of increasing the efficiency and the energy characteristics. Electron-beam pumping is a promising method in our opinion. This suggestion is based on the high radiation strength of the Al_2O_3 matrix and the efficient energy transfer from electron-hole pairs to the activator ions.[4]

In this letter we are reporting a study of the emission characteristics of $Al_2O_3:Ti^{3+}$ crystals during electron-beam pumping. In the experiments we used a transverse arrangement. The crystals were pumped by electron beams with energies up to 600 keV, with a current density up to 200 A/cm^2, and with a pulse length of 20–50 ns. Active elements $6\times6\times25$ mm in size were cut from $Al_2O_3:Ti^{3+}$ crystals with an activator concentration of 0.03–0.09% by weight. The C_{3v} axis of the crystal ran perpendicular to the largest dimension of the active element.

The electron beam caused an intense luminescence in the $Al_2O_3:Ti^{3+}$ crystals, consisting of a superposition of several wide bands in the region 350–1100 nm (Fig. 1). The most intense of these bands peaked at $\lambda = 800$ nm and was definitely associat-

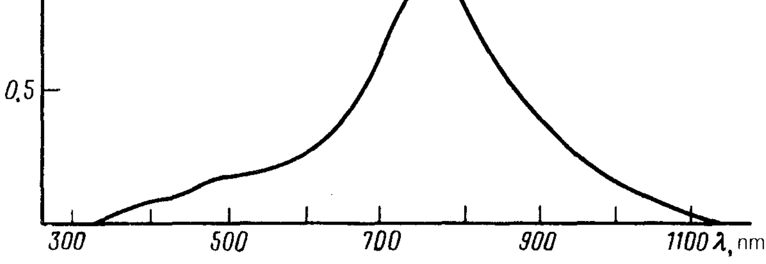

FIG. 1. Luminescence spectrum of $Al_2O_3:Ti^{3+}$ crystal.

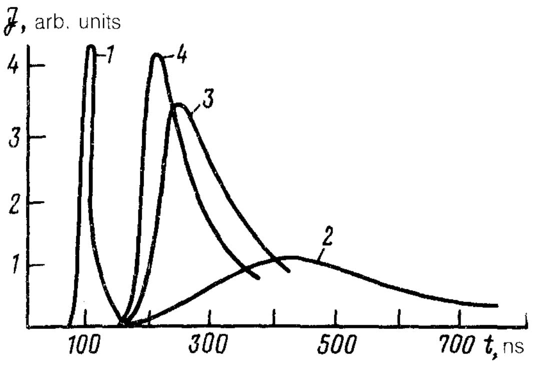

FIG. 2. Shape of the luminescence pulse and position of this pulse with respect to the pump current pulse (1). 2—Shape of the luminescence pulse for the case in which the distance from the window of the electron gun to the crystal is 4 mm; 3—80 mm; 4—340 mm.

ed with Ti^{3+} ions. The kinetic features of the luminescence depend on the beam current density, which was varied by varying the distance from the anode of the electron gun to the crystal; see Fig. 2. It can be seen from this figure that as the current density of the exciting beam is increased, there is a decrease in the luminescence rise time (because of the particular processes by which the excitation is transferred from the matrix to the activator ion). There is also a decrease in the decay time, because of the onset of superradiance. In addition to the superradiance pulse, two stages can be distinguished in the emission, with time scales of 3.5 μs and 0.1–0.5 s. The first corresponds to the ordinary luminescence of Ti^{3+} ions; the second is associated with the radiative decay of trapping centers followed by a transfer of excitation to the activator ion.

In the experiments on generation we used Al_2O_3:Ti^{3+} crystals on whose ends mirrors were deposited. The mirrors had a reflectance of 98% in the region of the assumed generation. Generation occurred at current densities $\geqslant$10 A/cm^2 of the pump beam. The generation spectrum was a broad band in the region 790–820 nm, with a complex structure. As the current of the pump beam was increased, the spectrum shifted in the long-wavelength direction. The generation pulse appeared with a delay

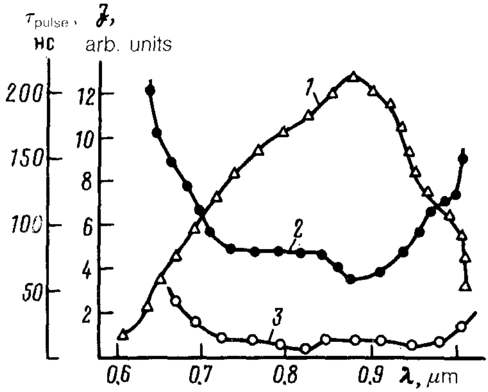

FIG. 3. Spectra of various properties. 1—The generation intensity; 2—the length of the generation pulse at half-maximum; 3—rise time of the generation pulse.

of 100–150 ns after the pump pulse and had a duration of 80–100 ns at half-maximum. The generation beam had the shape of a flat ribbon with a divergence of 3 mrad in the direction of the pump electron beam and 5° in the perpendicular direction. These results can be explained satisfactorily on the basis of the experimental geometry. We also achieved generation in a resonator formed by external mirrors, with reflectances of 97% and 98% and a radius of curvature of 300 mm in an approximately spherical configuration. By varying the selective properties of the resonator we were able to achieve stimulated emission over the range 650–1000 nm (curve 1 in Fig. 3). Also shown in this figure are the spectrum of the length of the generation pulse at half-maximum (curve 2) and the rise time of the pulse (curve 3). To record a tuning curve, we used mirrors with a reflectance of 99.6%. The output energy in this case was 0.7×10^{-6} J at the maximum of the tuning curve.

In summary, this study has demonstrated that it is possible to achieve generation in the spectral region 650–1000 nm in $Al_2O_3{:}Ti^{3+}$ crystals pumped by an electron beam.

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