L. I. Devyatkova, P. M. Lozovskiĭ, V. V. Mikhaĭlin, S. P. Chernov, A. V. Shepelev. and P. B. Éssel'bakh. *Vacuum-ultraviolet luminescence of* LaF_3 *single crystals*. Doped LaF_2 single crystals are of great interest as possible active media for ultraviolet (UV) lasers. This paper investigates the luminescence of these crystals.

The luminescence-exciting source was a hydrogen laser with the following parameters: lasing wavelength 1610 Å, pulse duration less than 1 nsec, peak power 50 kW, pulse frequency up to 400 Hz.

The radiation of the exciting laser was focused on the surface of the test specimen, which had been placed in a cryostat. The luminescent emission was analyzed with a Seya-Namioka vacuum monochromator. The spectra of the luminescence were measured in the range from 1600 to 2860 Å. Those of $LaF_3:Nd$, $LaF_3:Pr$, $LaF_3:Er$, CeF_3 and pure LaF_3 were recorded.

Strong luminescence in the vacuum ultraviolet was first observed for $LaF_3:Nd$ (Fig. 1) in the 1740 Å region. The quantum yield of the luminescence in this band is estimated at above 50%. The position of this luminescence line does not change as the Nd concentration is varied from 0.05 to 2% by weight. With the transition to liquid-nitrogen temperatures, it becomes clearly evident that the 1740 Å band is complex and that the luminescence efficiency varies insignificantly.

The luminescence spectra of $LaF_3:Pr$ single crystals (Fig. 2) have two strong groups of lines at 2500 and

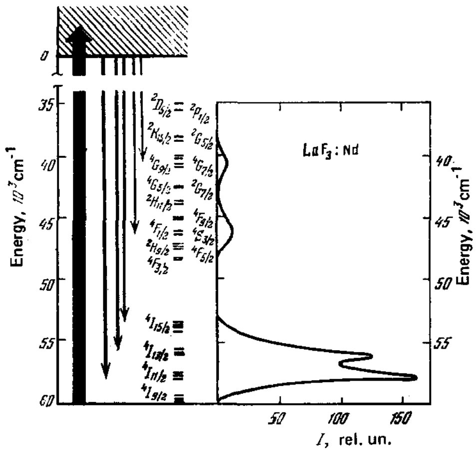

FIG. 1.

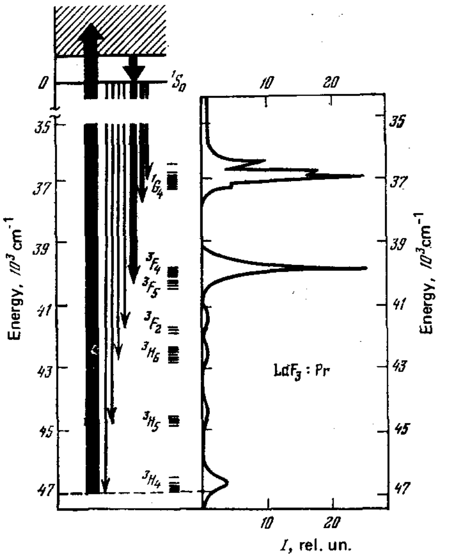

FIG. 2.

2700 Å. The quantum yield amounts to tens of percent in these bands. The luminescence efficiency varies insignificantly as the concentration changes from 0.05 to 2% by weight.

A strong ultraviolet band is observed at 2850 Å in the luminescence of CeF_3; it corresponds to an allowed transition of the Ce ion.

Bands of Nd and Pr impurities at contents no higher than 10^{-5}% are clearly evident in the case of undoped LaF_3.

The deexcitation times for these luminescence bands were measured. They amounted to no more than 20 nsec (the time-resolution limit of the equipment) for all Nd luminescence bands in LaF_3, no more than 700 nsec for all luminescence bands of Pr in LaF_3, and no more than 20 nsec for CeF_3. The equal deexcitation times for the luminescence bands studied point to the conclusion that the luminsecence in these bands corresponds to transitions that have a common upper level. The short lifetimes for Nd in LaF_3 and for Ce permit the assumption that the luminescence corresponds to allowed transitions. The long (0.7 μsec) lifetime for Pr suggests that the luminescence corresponds to transitions within the $4f$ shell.[1]

The transitions responsible for the luminescence of Nd and Pr in LaF_3 are indicated in Figs. 1 and 2.

Lasing can be expected in the strongest luminescence lines of Nd and Pr because, as we have noted, the quantum yields are quite high.[2] There is hope for tunable lasing and ultrashort pulses from the broad luminescence bands. The shortest possible pulse durations are $1.5 \cdot 10^{-13}$ sec for Pr in LaF_3 and 10^{-14} sec for LaF_3 : Nd.

The amount of absorption in the proposed lasing lines is of prime importance for successful lasing. A weak absorption band is observed in the 2400–2500 Å range, in which one of the Pr luminescence maxima lies. The strength of this absorption is about the same for all three crystals, amounting to 1.5 cm^{-1}. This band is due to the presence of a very small Ce impurity. According to literature data,[3] pure LaF_3 is transparent in this region.

The absorption is 10 cm^{-1} for the 1740 Å band of neodymium, i.e., quite strong. Lowering the absorption requires further purification of the raw material used in growing the crystals. The lasing threshold for Pr is 10 kW for the case of pumping with optical radiation in the absorption band of the Pr impurity (λ smaller than 2000 Å) at pumped-space dimensions $0.02 \times 0.1 \times 1$ cm^3. The threshold for the 1740 Å Nd band is 0.5 MW for a pumped space of the same size. The actual pumping sources may be VUV lasers, a pulsed hydrogen lamp, radiation from the plasma focus of a magnetoplasma compressor, or laser-spark emission.

There would also be interest in pumping of such lasers with hard electromagnetic radiation.[4] For example, estimates indicate a possibility of obtaining lasing by pumping with x-ray synchrotron radiation of a VEPP-4 storage ring or with γ radiation from a pulsed neutron generator.

Thus, the lasing threshold is already within reach even for the existing crystals.

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