INVESTIGATION OF STIMULATED EMISSION OF CaF_2-Nd^{3+} (TYPE II) CRYSTALS AT ROOM TEMPERATURE

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We have previously obtained stimulated emission at 300°K from CaF_2-Nd^{3+} (type I) at a wavelength ~ 1.047μ.[1] In this communication we report preliminary results of an investigation of generation at $\lambda \approx 1.088$ Å and 300°K from the Nd^{3+} ion in CaF_2 crystals (type II). Unlike type I, crystals of type II contain oxygen ions in the neodymium optical centers.

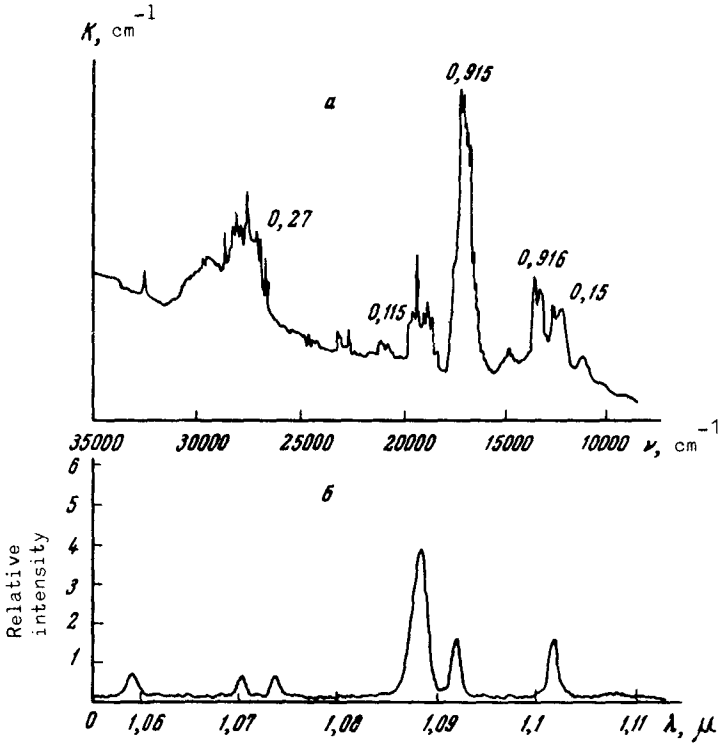

Figure 1

a - Absorption spectrum of CaF_2-Nd^{3+} (type II) at 300°K

b - luminescence spectrum of the $^4F_{3/2} \rightarrow {}^4I_{11/2}$ transition in the same crystal at 300°K

We used CaF_2 crystals with Nd^{3+} concentrations from 0.2 to 0.5%. Figure 1a shows the absorption spectrum of type II CaF_2-Nd^{3+}, obtained at 300°K with an SP-700 instrument. The Nd^{3+} concentration is approximately 0.5%. Some of the characteristic lines are marked with their absorption coefficients. The system was excited in an absorption band lying 20 000 cm^{-1} lower, using an IFP-800 xenon lamp. The infrared luminescence of the

Nd^{3+} ion begins at the $^4F_{3/2}$ level and ends at different levels of the ^4I ground state multiplet. The strongest luminescence corresponds to the $^4F_{3/2} \rightarrow {}^4I_{11/2}$ transition, just the one in which generation was attained. Figure 1b shows the luminescence spectrum of the $^4F_{3/2} \rightarrow {}^4I_{11/2}$ transition of the Nd^{3+} ion in type II CaF_2, obtained at 300°K with a DFS-12 instrument. The Nd^{3+} concentration is approximately 0.2%.

We used in the experiments an elliptical illuminating system with optical efficiency ~ 0.5.[2] The working crystals were cylindrical rods with polished ends parallel to within ~15". The crystals were ~6.0 mm in diameter and 75 mm long. The optical cavity was made up of confocal dielectric mirrors with ~ 2% transmission at 1.06 μ. The mirrors were 40 mm in diameter and of 500 mm curvature radius.

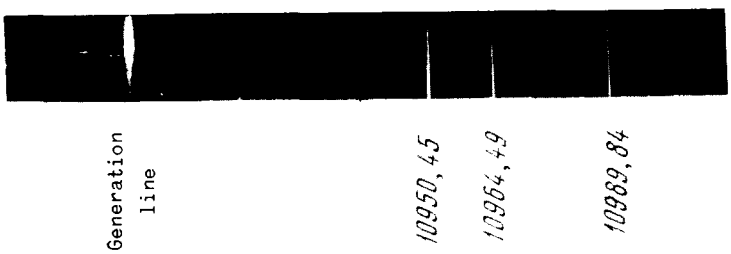

Figure 2
Stimulated emission spectrum of CaF_2-Nd^{3+} at 300°K

Figure 2 shows the emission spectrum of CaF_2-Nd^{3+} (type II), obtained with a DFS-8 instrument with 600 lines/mm grating. The dispersion of the instrument in the 1.1 μ region is 5.99 Å/mm. The reference was the third-order spectrum of the PRK-2 lamp. The generation was registered with I-1070 film. At 300°K the width of the emission line is ~ 0.9 Å (0.76 cm^{-1}). The lifetime of the excited state $^4F_{3/2}$ of the Nd^{3+} ion in CaF_2 (type II) was measured at 300°K with a tau-meter developed by us, and amounts to ~ 1.25 msec for the generating samples.

To observe the time dependence of the emission, we used a photomultiplier with oxygen-cesium photocathode and with a 1-mm filter at its input. The photomultiplier signal was fed to an oscilloscope. The recording system had a time constant ~ 10^{-6}.

Figure 3 shows oscillograms of the emission pulses from CaF_2-Nd^{3+} (type II) at threshold excitation energy and with the threshold exceeded by a factor of 3.

No.	Substance	λ, μ	Threshold elec. energy, J	Excited state lifetime, msec.	Ref.
1	$Cr^{3+}-Al_2O_3$	0.6934		3	[3]
2	$Nd^{3+}-SrF_2$	1.0370	480		[4]
3	$Nd^{3+}-CaF_2$ type I	1.047	130	~1.0	[1]
4	$Nd^{3+}-SrMoO_4$	1.0576	45		[5]
		1.0643	125		
5	$Nd^{3+}-CaWO_4$	1.0582	2	~0.2	[6]
		1.0652	3		
6	$Nd^{3+}-PbMoO_4$	1.0586	60		[4]
7	$Nd^{3+}-SrWO_4$	1.063	180		[4]
8	$Nd^{3+}-LaF_3$	1.0633	150		[4]
9	$Nd^{3+}-CaMoO_4$	1.0673	360		[4]
10	Nd^{3+}-glass	~1.06	~50		[7]
11	$Nd^{3+}-Y_3Al_5O_{12}$	1.0648	2	0.2	[8]
12	$Nd^{3+}-Y_3Ga_5O_{12}$	1.0633	250	0.2	[8]
13	$Nd^{3+}-Gd_3Ga_5O_{12}$	1.0633	350	0.2	[8]
14	$Nd^{3+}-CaF_2$ type II	1.0885	170	1.25	Present work
15	$Nd^{3+}-Y_2O_3$	1.078	260	~0.26	[9]
		1.078	350	~0.26	
16	$Nd^{3+}-Ga_2O_3$	1.0741	~36	~0.12	[10]
		1.0789	~9	~0.12	

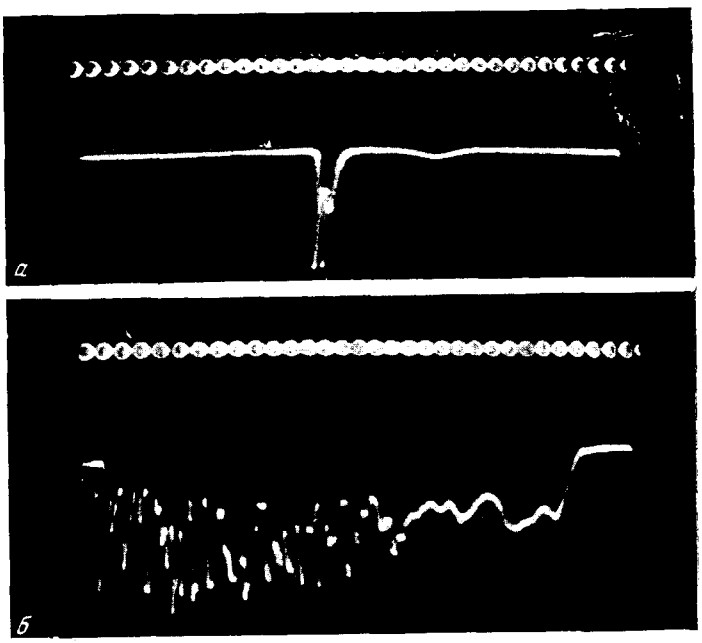

Figure 3
Time dependence of stimulated emission: a - at threshold excitation energy, b - at triple the excitation energy. The time markers indicate 20 μsec intervals.

The table lists some characteristics of lasers operating at 300°K. It shows that the laser with CaF_2-Nd^{3+} (type II) has the longest wavelength of all known neodymium lasers.

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