Absorption and emission spectra of congruent $LiNbO_3:Er^{3+}$ crystals in the 400-1650 nm range

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INTRODUCTION

It is well known that lithium niobate crystals both pure and doped with rare earth ions and iron group ions are promising material for quantum electronics [1].

In present work we have studied the absorption and luminescence spectra of Er^{3+} ions in congruent $LiNbO_3$ crystals in visible and near IR ranges (400-1650 nm).

SAMPLES and EXPERIMENTAL TECHNIQUE

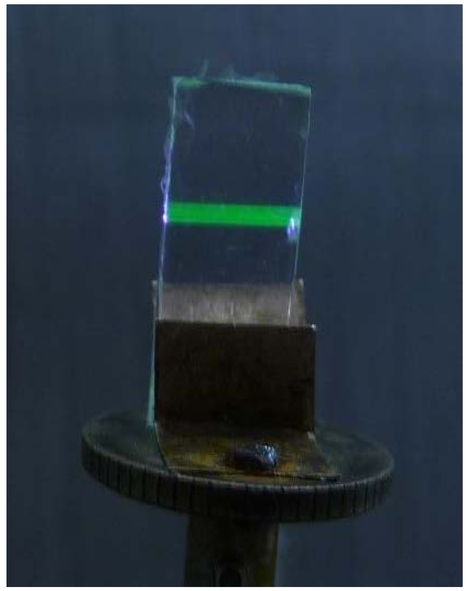

Fig. 1: Photograph of the luminescent $LiNbO_3$:Er crystal

The congruent crystals have been grown from the melt by Czochralski method using the apparatus described in [2]. The pulling rate was 1 mm/h, the rotation speed of the seed was 10 /min, the growth axis was being the trigonal <0001>. Monodomainization has been carried out in the furnace by means of passing 5 mA current through the boule after growth but before cooling down to room temperature. The activators were added to the melt in form of oxides. The concentration of Er^{3+} ions was 0.25 % by weight. Oriented (1x 5 x10) mm^3 samples were cut from bulk crystals. The domain structure was controlled by microscope after chemical etching in a mixture of concentrated hydrofluoric and nitric acids.

The experiments were carried out at room temperature. The photoluminescence (PL) spectra in the 400-1650 nm range were measured using the Horiba Jobin-Yvon T64000 spectrometer equipped with Si and InGaAs charge coupled devices (CCDs). The transmittance spectra were obtained in the 330-1650 nm range (with step 0.8 nm) using the Varian Cary 5000 spectrophotometer.

Er LEVEL SCHEME

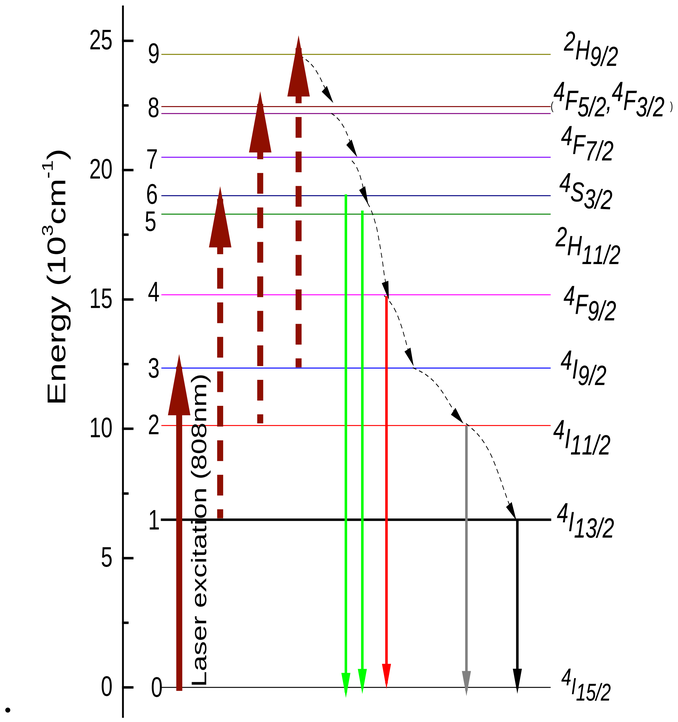

Fig. 3: Diagram of the energy levels of erbium ions

The observed lines of short-wavelength luminescence upon long-wavelength excitation are associated with the features of the processes of multiphoton energy transfer and phonon relaxation in congruent lithium niobate crystals [3].

Figure 3 presents a diagram of the energy levels of erbium ions and possible transitions between levels in $LiNbO_3$ crystals. Dashed lines marks ESA – transitions contributing into up-conversion PL.

EXPERIMENTAL RESULTS

We focus on consideration of the "down " and "up-conversion" Er^{3+} transitions excited by 808 nm semiconductor laser

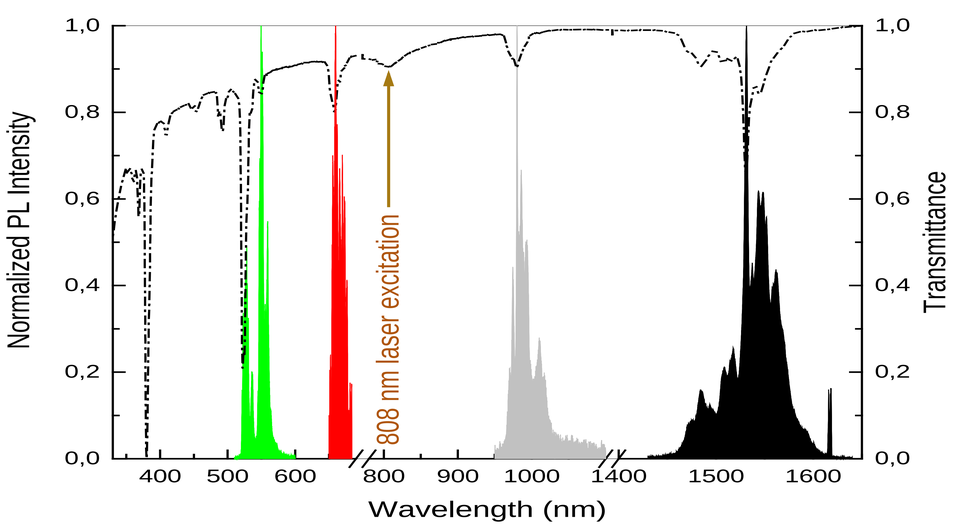

Fig. 2: Transmission and PL spectra of Er^{3+} ions embedded in $LiNbO_3$ congruent crystal

The transmission and PL spectra of $LiNbO_3:Er^{3+}$ crystals. Optical transmission studies reveal structured absorption band centered around 370 nm, 410nm, 452 nm, 493 nm, 526 nm, 550 nm,658 nm, 807 nm, 980 nm and 1533 nm, which may be connected with the intraconfigurational f-f transitions from ground $^4I_{15/2}$ manifold to the higher manifolds $^4G_{11/2}$, $^2H_{9/2}$, $^4F_{5/2}$, $^4F_{7/2}$, $^2H_{11/2}$, $^4S_{3/2}$, $^4F_{9/2}$, $^4I_{9/2}$, $^4I_{11/2}$ and $^4I_{13/2}$ correspondently.

The PL was excited by laser diode operating at 808 nm (pump power -1000 W/cm^2, FWHM - 10nm) which coincides with the $^4I_{15/2} \rightarrow ^4F_{9/2}$ transition in Er^{3+} ions. The PL study reveals two sorts of luminescence. First: the usual PL in long-wave part of spectrum peaked at 980 nm and 1533 nm connected with $^4I_{11/2} \rightarrow ^4I_{15/2}$ and $^4I_{13/2} \rightarrow ^4I_{15/2}$ transitions. Second: the anti-Stokes luminescence in short wave part of spectrum peaked at 660 nm, 550 nm and 526 nm. These emission bands are associated with $^4F_{9/2} \rightarrow ^4I_{15/2}$, $^4S_{3/2} \rightarrow ^4I_{15/2}$ and $^2H_{11/2} \rightarrow ^4I_{15/2}$ transitions.

Referenes

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