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CRYSTAL GROWTH AND SPECTROSCOPIC CHARACTERIZATION OF $Yb:YMgB_5O_{10}$

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Abstract. A transparent $Yb:YMgB_5O_{10}$ single crystal with dimensions up to 25×23×25 mm was grown. Absorption cross-section spectra were produced. The luminescence spectra of the Yb: $YMgB_5O_{10}$ crystal were measured in the spectral range of 950–1100 nm. The luminescence kinetics of the $^2F_{5/2}$ energy level were investigated and the lifetime was determined.
Key words: ytterbium; pentaborate crystal; growth; spectroscopic properties.

РОСТ И СПЕКТРОСКОПИЧЕСКИЕ СВОЙСТВА КРИСТАЛЛОВ $Yb:YMgB_5O_{10}$

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Аннотация. Сообщается об успешном росте кристалла $Yb:YMgB_5O_{10}$ размерами до 25×23×25 мм с высоким оптическим качеством. Исследованы спектры сечений поглощения. Проведено измерение спектров люминесценции в спектральной области 950–1100 нм. Измерены кинетики люминесценции и определено время жизни уровня $^2F_{5/2}$ ионов иттербия.
Ключевые слова: иттербий, кристалл пентабората, рост, спектроскопические свойства.

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Many Yb^{3+}-doped crystals have previously been demonstrated. $YMgB_5O_{10}$ (YMBO) borate crystals are considered as potential materials for the manufacture of laser matrices because they possess high thermal conductivity (6.2 ± 0.3 W/m·K) [1]. Here the growth details and characterization of a Yb: YMBO single crystal, as well as the results of its spectroscopic investigation, are reported.

A Yb:YMBO bulk crystal was grown using a high-temperature solution growth on dipped seeds technique [2]. A complex system, with composition 20 wt.% Yb:YMBO – 80 wt.% $K_2Mo_3O_{10}$, was used in the growing experiment. Yb_2O_3 (99.96 %), Y_2O_3 (99.96 %), MgO, B_2O_3 (were used as crystal-forming agents, which were weighed according to a composition of $Yb_{0.08}Y_{0.92}MgB_5O_{10}$. The solvent $K_2Mo_3O_{10}$ was a mixture of K_2MoO4 and MoO3 which was weighed according to the following equation:

$$K_2MoO_4 + 2MoO_3 = K_2Mo_3O_{10}.$$

Growth of the Yb:YMBO bulk crystal was performed in a vertical resistively heated furnace, equipped with precision temperature controller and a set of S-thermocouples. The temperature in the working zone of the furnace was maintained with a stability of ± 0.1 °C. As a result a transparent, colorless Yb-doped $YMgB_5O_{10}$ crystal with typical dimensions of about 25×23×25 mm and m = 10.337 g was grown (Fig. 1).

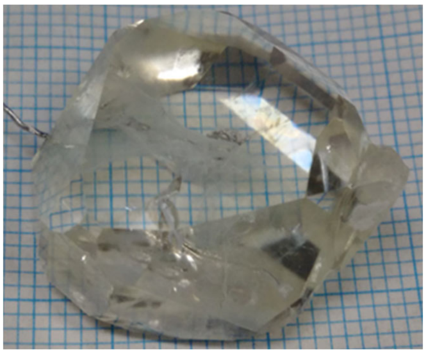

Figure 1 – The Yb:YMBO single crystal

The obtained absorption cross-section spectra of the Yb:YMBO crystal are shown in Fig. 2. There are two intensive absorption lines centered at 937 nm and 975 nm. These wavelengths correspond to the emission spectra of commercially available InGaAs laser diodes. The maximal absorption cross-section was $2.15 \cdot 10^{-20}$ cm^2 at 975 nm for the $E//N_g$ axis.

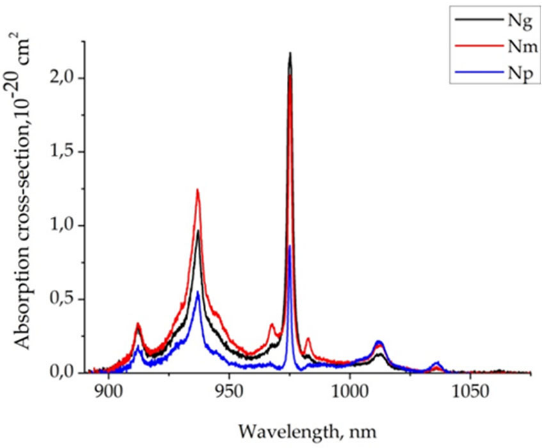

Figure 2 – The absorption cross-section spectra of Yb^{3+}:YMBO crystal

The dependence of the obtained lifetimes of the $^2F_{5/2}$ energy level on different weight content of Yb:YMBO crystalline powders in glycerin suspension is presented in Fig. 3. The inset in Fig. 3 shows that the kinetics of luminescence decay from the $^2F_{5/2}$ energy level of Yb^{3+} ions were single exponential. As a result, the lifetime of the $^2F_{5/2}$ energy level was observed to be about 580±10 μs. Considering the radiative lifetime of the $^2F_{5/2}$ Yb^{3+}, the luminescence quantum yield was estimated to be about 0.87. The difference in the obtained value from 1, that is the usual case for Yb^{3+}-doped materials, can be explained by the large phonon energy in the borate crystals which promoted an effective non-radiative depletion of the upper Yb^{3+} ion energy level.

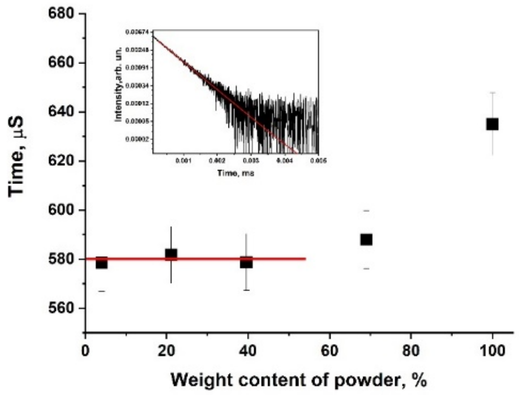

Figure 3 – The $^2F_{5/2}$ energy level lifetimes of Yb: YMBO crystal

There were structured bands in the spectral range 950–1100 nm in the luminescence spectra of the Yb:YMBO crystal (Fig. 4). Two peaks, with maximal intensity at 1010 nm and 1040 nm for $E//N_m$, were observed in the luminescence spectrum of the Yb:YMBO crystal.

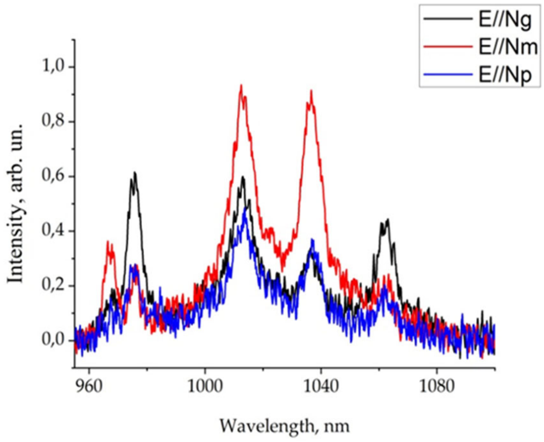

Figure 4 – The luminescence spectra

A transparent Yb:$YMgB_5O_{10}$ single crystal was grown using a high-temperature solu-tion growth on dipped seeds technique with a $K_2Mo_3O_{10}$ solvent. An investigation of the spectroscopic properties of the Yb:$YMgB_5O_{10}$ crystal was per-formed. Use of the crystal obtained for mode-locking and regenerative amplification will be addressed in future research.

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