

Photodynamic Processes and Lasing in Ce,Yb:LiY_xLu_{1-x}F₄ Crystals

L.A.Nurtdinova^a

Kazan State University, 18 Kremlevskaya Str. Kazan 420008, Russia

Abstract. Measurements of photoconductivity were conducted in LiY_xLu_{1-x}F₄:RE (RE = Ce (1%), Yb (1%); x = 0..1) crystals. It was found that the excited state absorption transitions of Ce³⁺ ions are intracenter and terminate at 6s state of cerium ions. Lasing at room temperature was achieved, differential gain (up to ~22%) and tuning range were determined. By lowering the temperature of the active element and using additional antisolarant pumping at 532 nm lasing differential gain efficiency was increased (up to ~ 35%), and the tuning range was expanded.

The use of ultraviolet (UV) tunable lasers today is essential in many fields of science and technology. The most impressive applications include environmental monitoring (as a part of lidars), diagnostics of combustion processes in internal combustion engines, the production of semiconductor devices, precision materials processing optical communication, photolithography, medicine (dermatology and cosmetology, ophthalmic surgery) and biology [1-9]. However, lasing in wide-bandgap Ce-doped dielectric crystals in the ultraviolet spectral range is hampered by various photodynamic processes (FDP), arising in the active media under intense laser pumping and lasing [1]. The study of such processes as well as the combination of crystallochemical (variation of chemical composition) and photophysical factors (light, temperature) in order to tilt the balance of these processes in either direction seems very promising for both creation of new active media, and deepening the fundamental scientific knowledge in this field. The report focuses on the study of FDP resulting from photoionization of impurity cerium centers in scheelite structured double fluoride LiY_xLu_{1-x}F₄:RE (RE = Ce, Yb; x = 0..1) crystals, as well as their influence on the processes of lasing on 5d- 4f transitions of Ce³⁺ ions in these active media.

Photoconductivity spectra acquired in the studied crystals by means of conventional and microwave techniques under one- and two-step excitation (Fig. 1) revealed a band with a maximum near 260 nm, and a width of 20-30 nm. The quadratic dependence of the photoconductivity signal on the excitation energy near the threshold (300 nm) is indicative of a two-stage process of Ce³⁺ excitation. Taking into account the energy of 4f-5d ground-state transition, the position and the width of photoconductivity band corresponds to 4f-6s transitions of Ce³⁺ ions [2] followed by their quick ionization and formation of color centers of various nature, significantly impairing the properties of laser medium. The Yb-coactivated sample no photoionization band from is observed.

Lasing in LiY_xLu_{1-x}F₄:RE (RE = Ce (1%), Yb (1%); x = 0, 0.3-0.5: 1) crystals was obtained under quasi-longitudinal and transverse pumping in either selective or nonselective confocal

^a Corresponding author: nurlari@yandex.ru

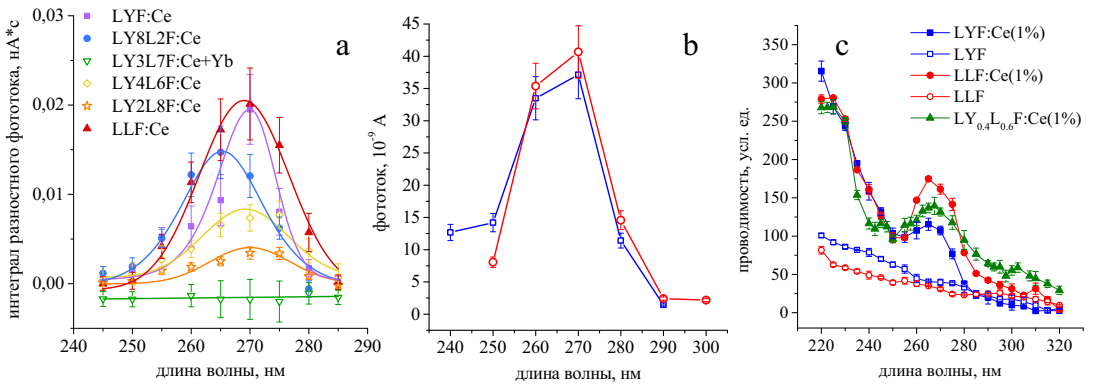


Figure 1. Photocomductivity spectra under one- (b,c) and two-step (a) excitation, registered by means of conventional (a,b) and microwave (a) techniques.

resonator. Under normal conditions, the differential gain of lasing at 310 nm was $\sim 22\%$, while tuning range consisted of 2 areas separated by the wavelength range where no laser oscillation was observed. As the temperature of active element was decreased, or antisolarant 532 nm beam was used to illuminate the pumped volume of the active element, an increase in the lasing differential gain (up to 35%) and broadening the tuning range into a one large area occurred (see. Fig. 2). Additional illumination of the active element at 260 nm and 340 nm resulted in a significant reduction of lasing energy in all objects. Samples coactivated by Yb^{3+} ions demonstrated significantly wider tuning range as compared to the non-coactivated ones.

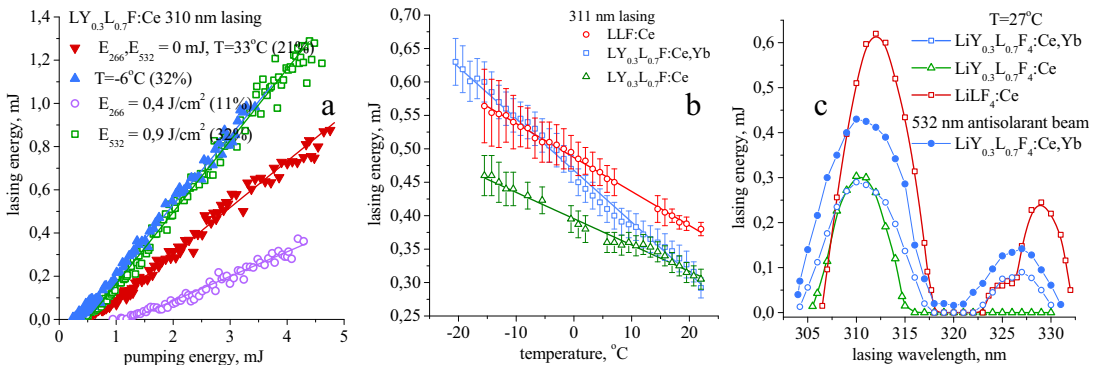


Figure 2. Photocomductivity Differential gain (a), lasing energy versus temperature (b), and tuning range (c) of lasing in $\text{LiY}_x\text{Lu}_{1-x}\text{F}_4:\text{RE}$ ($\text{RE}=\text{Ce}(1\%), \text{Yb}(1\%); x=0, 0.3-0.5, 1$) crystals.

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