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A Cr^{2+} : CdS laser tunable between 2.2 and 3.3 μm

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***Abstract*. Lasing in a Cr^{2+} : CdS crystal is demonstrated for the first time. The output power of a Cr^{2+} : CdS laser pumped by a pulsed Tm : YAP laser at 1.94 μm achieved 4 mJ and the slope efficiency with respect to the absorbed pump energy was 39 %. The continuous tuning was obtained from 2.2 to 3.3 μm in the laser with a dispersion prism resonator.**

Keywords: *Cr^{2+} : CdS laser, IR lasers, tunable lasers, solid-state lasers.*

The necessity of the development of efficient tunable mid-IR lasers is stimulated by a number of practical problems that can be solved by using such lasers. The II – VI crystals doped with bivalent transition metal ions are promising laser media for the 2 – 5-μm spectral region. By now lasing was obtained in crystals of Cr^{2+} : ZnSe (tunable from 1.88 to 3.10 μm) [1, 2], Cr^{2+} : ZnS (2.17 – 2.86 μm) [3], Cr^{2+} : $Cd_{0.85}Mn_{0.15}Te$ (2.30 – 2.6 μm) [4], Cr^{2+} : $Cd_{0.55}Mn_{0.45}Te$ (2.17 – 3.01 μm) [5], Cr^{2+} : CdTe (2.54 μm) [6], Cr^{2+} : CdSe (2.26 – 3.61 μm) [7, 8], and Fe^{2+} : ZnSe (3.77 – 5.05 μm) [9, 10].

A Cr^{2+} : CdS crystal has a luminescence band between 1.9 and 3.5 μm and better mechanical, thermal, and optical parameters compared to a Cr^{2+} : CdSe crystal having a similar luminescence band. However, attempts to obtain lasing in this crystal have not been successful so far. This paper is devoted to the study of the lasing parameters of a Cr^{2+} : CdS crystal upon pulsed pumping.

The active element of the laser was a Cr^{2+} : CdS single crystal grown from a vapour phase on a single-crystal substrate simultaneously with doping by the method developed for growing single crystals of solid solutions of high structural quality and high optical homogeneity [11, 12]. Earlier, we obtained efficient lasing in Cr^{2+} : ZnSe [13], Fe^{2+} : ZnSe [10], and Cr^{2+} : CdSe [8] crystals grown by this method. The active-element length was 5 mm. The optical axis of the crystal in the active element was directed at an angle of $\sim 4^\circ$ to the normal to its polished faces, the angle between them not exceeding $30''$. The polished surfaces of the active element had no AR coatings.

The resonator of the Cr^{2+} : CdS laser has a length of 145 mm and was formed by a highly reflecting (HR) spherical mirror ($R = 150$ mm) and a plane output mirror transmitting 38 % of light at the laser wavelength. The active element was mounted near the output mirror so that its working faces were oriented perpendicular to the optical axis of the resonator. The crystal was pumped by 300-μs, 1.94-μm, 50-mJ pulses from a Tm : YAP laser. The pump pulse consisted of irregular spikes of duration ~ 0.5 μs. Pumping was performed longitudinally through the HR mirror transmitting 85 % of the pump radiation. Absorption in the active element at the pump wavelength was 48 %. The pump beam was focused into a ~ 1 mm^2 spot on the crystal. All experiments were performed at room temperature.

We obtained for the first time lasing in a Cr^{2+} : CdS crystal. The lasing spectrum obtained in a nonselective resonator was located at ~ 2.6 μm and had a width of ~ 50 nm. Figure 1 presents the dependence of the output energy of the Cr^{2+} : CdS laser on the absorbed pump energy. The slope efficiency of the laser was 39 %, which is comparable with 46 % obtained earlier for the Cr^{2+} : CdSe laser [8]. The absorbed threshold pump energy was 6.5 mJ. The maximum output energy equal to 4 mJ was obtained when the absorbed pump energy was 16 mJ.

The tuning of the Cr^{2+} : CdSe laser was performed by using a modified resonator with a CaF_2 prism and a HR

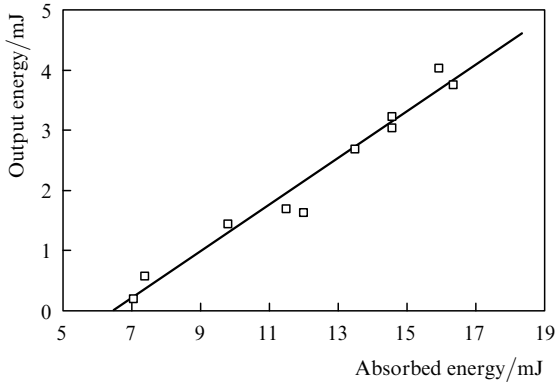

Figure 1. Dependence of the output energy of the Cr^{2+} : CdS laser on the absorbed pump energy.

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spherical aluminium mirror ($R = 500$ mm). In this case, the pump radiation passed beside the HR mirror and prism and was incident on the active element at an angle of $\sim 5^\circ$ to the optical axis of the resonator. Two plane mirrors M1 and M2 with spectral parameters presented in Fig. 2a were used as output mirrors. Continuous tuning was obtained in the spectral range from 2.2 to 3.3 μm (Fig. 2b).

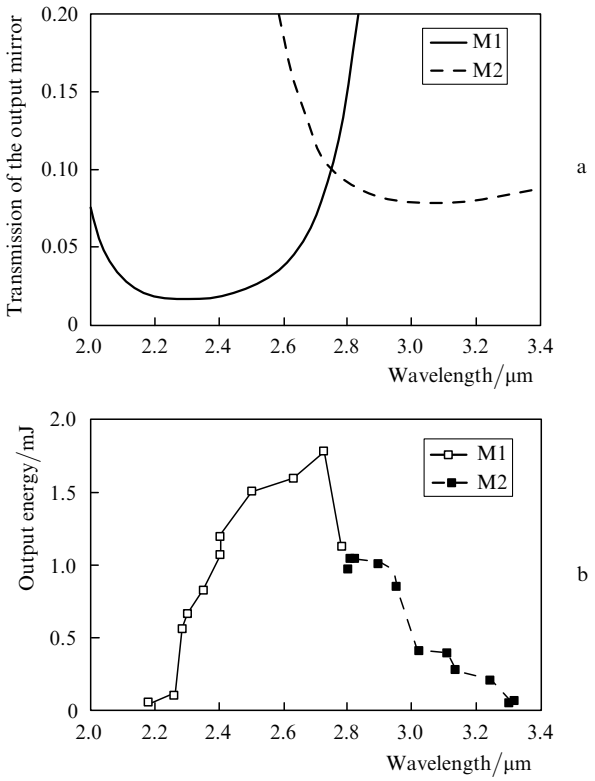

Figure 2. Transmission spectra of output mirrors M1 and M2 used in experiments on tuning the Cr^{2+}:CdS laser (a) and tuning curves obtained with these mirrors (b).

Thus, we obtained for the first time IR lasing in a new material – Cr^{2+}:CdS crystal. The slope efficiency of the laser with respect to the absorbed pump energy was 39 %. Continuous tuning was obtained in the spectral range from 2.2 to 3.3 μm.

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