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Efficient cw lasing in a Cr^{2+} : CdSe crystal

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***Abstract*. Continuous wave lasing in a Cr^{2+} : CdSe crystal is obtained for the first time. The Cr^{2+} : CdSe crystal pumped by a 1.908-μm thulium fibre laser generated 1.07 W at 2.623 μm with the quantum slope efficiency with respect to the absorbed power equal to 60 %.**

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

The II – VI crystals doped with bivalent transition-metal ions are promising active media for tunable lasers emitting in the region between 2 and 5 μm [1 – 4]. Such lasers can be used in spectroscopic studies, medicine, environment control, etc. The Cr^{2+} : ZnSe, Cr^{2+} : ZnS, Cr^{2+} : CdSe, and Fe^{2+} : ZnSe lasers can be continuously tuned in the regions 1.88 – 3.10 μm [4, 5], 2.17 – 2.84 μm [6], 2.26 – 3.61 μm [7 – 9], and 3.77 – 5.05 μm [10 – 13], respectively. Continuous wave lasing has been obtained at present only in Cr^{2+} : ZnSe and Cr^{2+} : ZnS crystals, which emitted cw output powers 2.7 W [14] and 0.7 W [6], respectively. In this paper, we obtained for the first time cw lasing in a Cr^{2+} : CdSe crystal and studied its parameters.

An active element (AE) was made of a Cr^{2+} : CdSe crystal grown from the vapour phase on a single-crystal seed at temperatures 1100 – 1150 °C. The vapour-phase mass transfer was performed by a physical transport in the helium atmosphere. The homogeneous doping was achieved by using the technology developed earlier for growing highly perfect, optically homogeneous solid-solution single crystals [15, 16]. The concentration of Cr^{2+} ions, measured from the absorption spectrum by using the absorption cross section obtained in [7], was $\sim 9 \times 10^{17}$ cm^{-3}.

The active element had a length of 5.3 mm and a transverse size of 1.5 × 5 mm. The direction of the optical axis of the crystal made an angle of ~20° with the normal to the polished working surfaces of the AE, which had no AR coatings. The crystal absorbed 76 % of pump radiation.

Figure 1 shows the optical scheme of the setup. The nearly semi-concentric resonator of the Cr^{2+} : CdSe laser was formed by highly reflecting mirror M1, transmitting 95 % of pump radiation, and output spherical ($R = 50$ mm) mirror M2 transmitting 15 % of radiation at the laser wavelength. The active element was mounted at a distance of 1 mm from mirror M1 so that its working surfaces were perpendicular to the resonator optical axis.

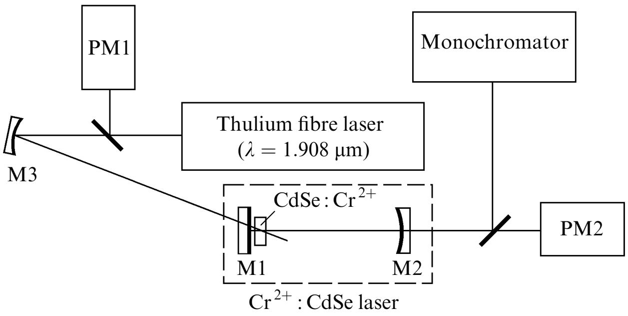

Figure 1. Optical scheme of the experimental setup: (M1, M2) resonator mirrors; (M3) focusing mirror; (PM1, PM2) power meters.

To provide the efficient cooling, the AE was clamped through indium inserts between two copper water-cooled plates. All experiments were performed with the AE at room temperature.

The Cr^{2+} : CdSe crystal was pumped through mirror M1 by a 1.908-μm, 5-W TLM-05LP thulium fibre laser (IRE-Polyus). The pump beam made an angle of ~2° with the optical axis of the Cr^{2+} : CdSe laser resonator to avoid the influence of pump radiation reflected from the resonator elements on the operation of the thulium laser. The pump beam was focused on the Cr^{2+} : CdSe crystal by spherical ($R = 300$ mm) mirror M3 into a spot of diameter 0.15 mm.

The pump and lasing powers were measured with PM1 and PM2 (IMO-2N) power meters. The laser wavelength was measured with a diffraction monochromator.

By using this setup, we obtained for the first time cw lasing in a Cr^{2+} : CdSe crystal at 2.623 μm. The half-width of the laser spectrum was about 10 nm.

Figure 2 presents the dependence of the output power P_{out} of the Cr^{2+} : CdSe laser on the absorbed pump power P_{abs}. The threshold absorbed pump power was 0.28 W. The maximum output power 1.07 W was achieved for $P_{\text{abs}} =$ 3 W. This output power is at the level of record values obtained for cw Cr^{2+} : ZnS and Cr^{2+} : ZnSe lasers. The

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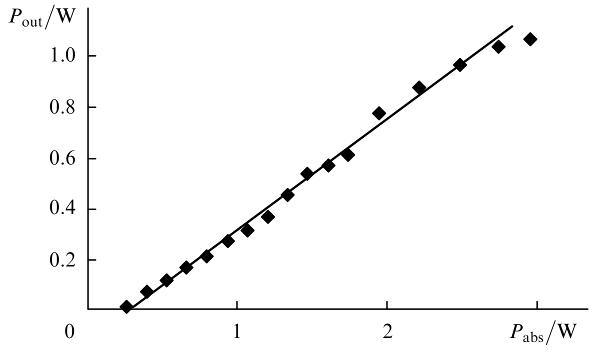

Figure 2. Dependence of the output power of the Cr^{2+} : CdSe laser on the absorbed pump power obtained with the output mirror with transmission 15 %.

slope efficiency of the laser, measured by the slope of a straight line drawn through experimental points, was 44 %. This corresponds to the quantum efficiency of the laser equal to 60 %.

Thus, we have obtained for the first time cw lasing in a Cr^{2+} : CdSe crystal with the output power above 1 W with the slope efficiency 60 % with respect to the absorbed pump power. In our opinion, the laser efficiency can be increased by optimising the transmission of the output mirror and using a scheme providing a greater overlap of the pump and lasing regions in the AE.

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