Yb^{3+}-doped monoclinic $KLu(WO_4)_2$: crystal growth, spectroscopic studies and laser operation

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Yb^{3+} is a very promising activating ion possessing a number of advantages over Nd^{3+} for laser operation in the 1 µm spectral region which are related to its simple two-level energy scheme. Yb-doped monoclinic $KRE^{3+}(WO_4)_2$ single crystals are host-dopant combinations interesting for highly efficient pumping with InGaAs laser diodes near 980 nm. The doping level can reach the stoichiometric structure $KYb(WO_4)_2$, or KYbW [1], but thermo-mechanical limitations do not allow the fabrication and use of active elements with a thickness less than 100 µm corresponding to the absorption length. Thus, layers of KYbW on KYW can be used for thin-disk lasers, however, the crystal lattice mismatch of KYW and KYbW seems to be the basic limitation on the achievable interface quality [2]. The isostructural $KLu(WO_4)_2$ (hereafter KLuW) is potentially interesting for KYbW/KLuW epitaxies due to the closer unit cell parameters of KYbW and KLuW (differences ranging from 0.02 to 0.5% against 0.4 to 1% for KYbW and KYW).

Here we report on the crystal growth of KLuW and Yb:KLuW, present optical and spectroscopic characteristics and demonstrate cw laser operation at room temperature. The Top-Seeded Solution Growth slow-cooling method was used to synthesize single crystals of KLuW and Yb:KLuW with various dopant concentrations ($KLu_{1-x}Yb_x(WO_4)_2$, where x=0.005, 0.05 and 0.1). Inclusion-free crystals with dimensions of 13×7.5×11.5 mm^3 were obtained. The optical transmission of KLuW extends roughly from 320 to 5400 nm. The N_p principal optical axis coincides with the *b* crystallographic axis, and N_g is located at 18.5º clockwise from the *c* axis in the *a-c* plane. The absorption band of Yb:KLuW between 850-1100 nm (11765-9091 cm^{-1}) in Fig.1a is associated with the Yb transition $^2F_{7/2} \rightarrow {}^2F_{5/2}$. Absorption and emission measurements at room and low temperature allowed us to establish the energy level scheme depicted in Fig.1a. The fluorescence decay time measured at room temperature for 0.5% doped Yb:KLuW is 375 µs.

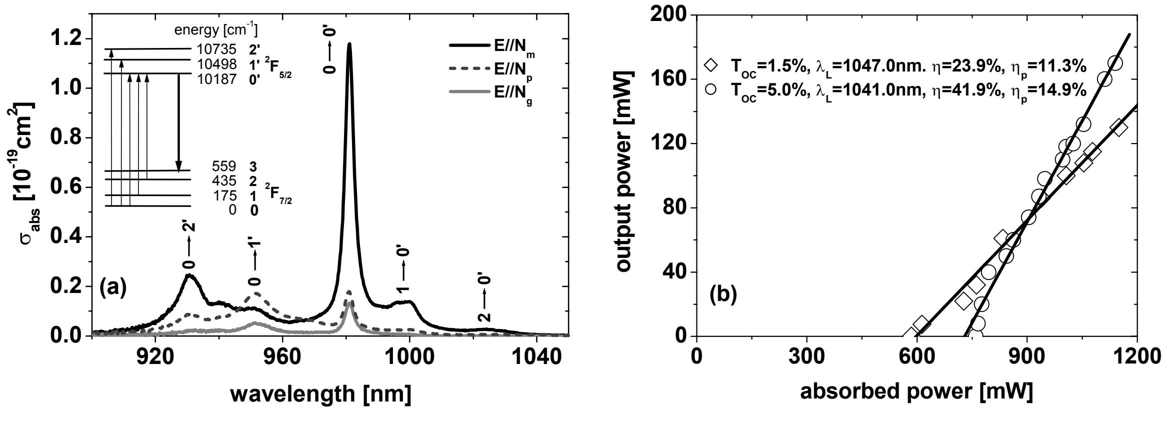

Fig.1: (a) Absorption cross section of Yb:KLuW for the three polarizations ($n_p<n_m<n_g$) and energy level scheme (inset). (b) Output power versus absorbed power with laser diode pumping at 980 nm of the 5% Yb-doped KLuW. λ_L is the laser wavelength and T_{OC} – the output coupling.

Uncoated samples of 5 and 10% doped Yb:KLuW were mounted without cooling under Brewster angle in a standard, astigmatically compensated *Z*-shaped cavity for laser operation. A tunable cw Ti:sapphire laser and a tapered InGaAs diode laser were used for pumping. For both doping levels and $E//N_m$ we achieved pump efficiencies as large as η_p=50% and maximum output powers of 1 W with Ti:sapphire laser pumping. The slope efficiency for T_{OC}=5% was η=56-57%. Results with laser diode pumping are depicted in Fig.1b. They were affected by the lack of absorption saturation and the imperfect overlap of the pump and laser waists in the crystal.

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2. A. Aznar, R. Sole, M. Aguilo, F. Diaz, U. Griebner, R. Grunwald, V. Petrov, Appl. Phys. Lett. (2004) submitted.