Laser operation of a Tm-doped epitaxial tungstate crystal $Tm:KLu(WO_4)_2/KLu(WO_4)_2$ in the 2 µm spectral range

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Tm-doped laser materials are emerging as very interesting active media for the 2 µm spectral region due to the possibility for diode pumping near 800 nm and their broad tunability. The most important features of monoclinic potassium double tungstates ($KGd(WO_4)_2$-KGdW, $KY(WO_4)_2$-KYW, $KLu(WO_4)_2$-KLuW) are the relatively large ion separation allowing highest doping levels with minimum quenching effect and the highest absorption and emission cross sections which is partly due to the strong anisotropy [1]. Lasers based on epitaxial monoclinic double tungstates were demonstrated for Yb:KYW and Yb:KLuW [2], in particular interesting for the thin-disk laser concept. The closer ionic radii of Lu (compared to Y) and Yb or Tm make KLuW potentially interesting as an epitaxial host. Here we report on the growth and the first laser based on an epitaxial double tungstate crystal doped with Tm^{3+}-ions in the active layer.

Tm-doped KLuW layers have been grown with high crystalline quality by the Liquid Phase Epitaxy (LPE) method. The LPE experiments were performed in a vertical furnace with practically no axial gradient to obtain homogeneous epitaxial layers. By means of this technique, it is possible to control the layer thickness by adjusting the temperature and the growth time. The thickness of the Tm:KLuW layer with an Tm-doping concentration of 5%, grown on the (010) face, amounted to roughly 100 µm after polishing. The KLuW substrate thickness was 1.7 mm.

The (010)-face of the epitaxial crystal were normal to the N_p-principal optical axis and the sample was oriented for polarization parallel to the N_m-principal optical axis and propagation approximately along the N_p-principal optical axis. The sample was put at Brewster angle between the folding mirrors in an astigmatically compensated X-type cavity. A tunable Ti:sapphire laser was used for pumping near 800 nm. The measured single pass low-signal absorption of the 5% Tm/Lu-site KLuW layer at the absorption maximum of 802 nm amounted to 15%.

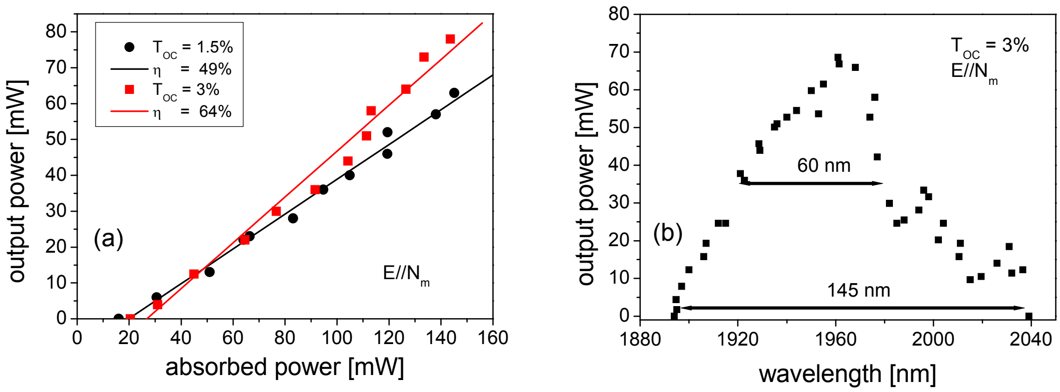

Fig.1: Input-output laser characteristics (a) and wavelength tunability using a 3 mm thick quartz plate (b) of the 100-µm thin Tm:KLuW epitaxy.

The epitaxial laser operated in the continuous-wave regime with a threshold as low as P_{abs}=16 mW (T_{OC}=1.5%) and P_{abs}=20 mW (T_{OC}=3%). The maximum output power of 78 mW for P_{abs}=144 mW was obtained with T_{OC}=3% (Fig.1a) and the corresponding slope efficiency amounts to 64% for pumping at 802 nm. Compared to a 3 mm thick Tm(5%):KLuW bulk crystal, delivering 650 mW in the same resonator and the 1.2 W maximum pump power, the laser threshold is 5 times lower and the slope efficiency 5% higher. The laser emission was at 1967 nm (T_{OC}=1.5%) and 1961 nm (T_{OC}=3%) – shifted by about 20 nm to longer wavelengths compared to the bulk Tm:KLuW. An overall wavelength tuning from 1894 nm to 2039 nm with a FWHM of 60 nm was obtained for T_{OC}=3% (Fig.1b).

In conclusion we studied for the first time to our knowledge lasing in the 2 µm spectral range of Tm^{3+}-doped epitaxial layers using the monoclinic KLuW as a substrate and host.

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2. U. Griebner, J. Liu, S. Rivier, A. Aznar, R. Grunwald, R. Solé, M. Aguiló, F. Díaz, and V. Petrov, IEEE J. Quantum. Electron. **41** (2005) 408.