

Femtosecond mode-locking of epitaxially grown Yb:KLu(WO₄)₂ composites

S. Rivier, U. Griebner, V. Petrov

Max-Born-Institute for Nonlinear Optics and Ultrafast Spectroscopy, 2A Max-Born-Str., D-12489 Berlin, Germany,
Phone: ++49-30-63921272, Fax: ++49-30-63921289, E-mail: petrov@mbi-berlin.de

A. Aznar, R. Sole, M. Aguilo, F. Diaz

Universitat Rovira i Virgili, Marcel·lí Domingo, E-43007 Tarragona,

M. Zorn, M. Weyers

Ferdinand-Braun-Institute, 4 Gustav-Kirchhoff-Str., D-12489 Berlin, Germany

Epitaxial growth of highly Yb-doped films on passive substrates is especially interesting for the strongly anisotropic monoclinic double tungstate hosts where the extremely large cross sections would permit the utilization of the thin disk laser concept with very thin (<100 μm) active layers which can be face cooled and pumped in a single pass. Recently we demonstrated efficient laser operation of Yb-doped epitaxial composites on the basis of the monoclinic KLu(WO₄)₂ (KLuW) crystal [1]. The results were superior in comparison to those we previously achieved using KY(WO₄)₂ [2] due to the closer lattice parameters of KLu(WO₄)₂ and KYb(WO₄)₂ [1].

Here we demonstrate femtosecond mode-locked operation with the same 10% Yb-doped KLuW/KLuW sample [1]. The 100-μm thick Yb:KLuW layer was grown by liquid phase epitaxy on the (010) face, normal to the N_p -principal optical axis, of a 1.1-mm thick KLuW substrate. The sample was oriented for polarization parallel to the N_m -optical axis and positioned under Brewster angle between two focusing mirrors (RC=10 cm) folding an astigmatically compensated Z-shaped cavity. The laser was longitudinally pumped through one of the folding mirrors using an $f=6.28$ cm lens by a tunable cw Ti:sapphire laser focused to a beam waist of about 30 μm in the position of the epitaxial crystal. One arm contained an additional focusing mirror (RC=10 cm) to increase the intensity on the semiconductor saturable absorber mirror (SAM) used for passive mode locking which terminated the cavity. Two SF10 Brewster prisms with a separation of 31 cm were inserted in the other arm, containing the plane output coupler, for dispersion compensation. The cavity length corresponded to a repetition rate of 100 MHz.

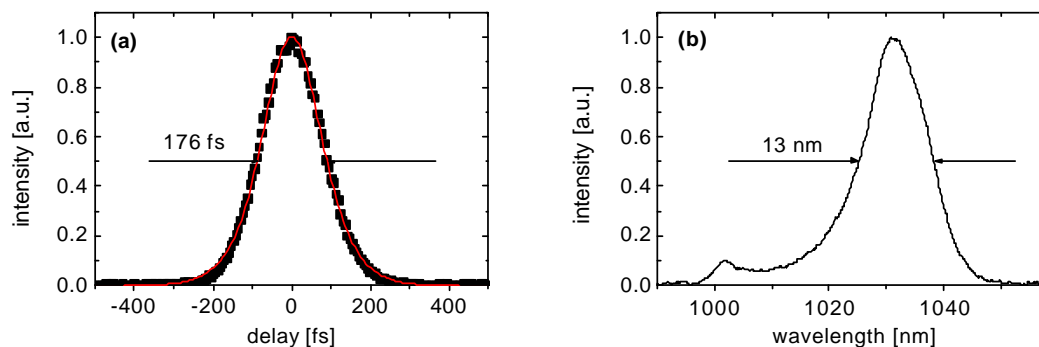


Fig. 1: Autocorrelation trace (a) and spectrum (b) of the mode-locked Yb:KLuW/KLuW epitaxial laser.

Passive mode-locking in the femtosecond regime could be achieved for absorbed powers exceeding 200 mW at 981 nm. With a 1.1% output coupler pulses as short as 114 fs (Fig. 1a) could be achieved at 1031 nm with an average output power of 31 mW for an absorbed pump power of 630 mW. The autocorrelation trace represented by symbols in Fig. 1a (FWHM=176 fs) could be fitted assuming a sech^2 -pulse shape (curve). The time-bandwidth-product of 0.43 is somewhat above the Fourier limit for this pulse shape (0.315) which is related to the asymmetric spectrum generated (Fig. 1b). We believe, the lower limit for the pulse duration and the observed deviation from the transform-limited pulse performance are related to the reflectivity of the folding mirrors which is restricted by the trade-off imposed by the small separation between the pump and laser wavelengths. The output power could be increased using a 3% output coupler and 94 mW were obtained, again at 1031 nm, for an absorbed pump power of 670 mW. The generated pulses had a FWHM of 205 fs in this case and were almost bandwidth-limited (time-bandwidth product of 0.32).

In conclusion pulse durations as short as 114 fs at 1031 nm could be obtained in what we believe to be the first demonstration of a mode-locked epitaxial Yb-laser.

1. U. Griebner, J. Liu, S. Rivier, A. Aznar, R. Grunwald, R. Sole, M. Aguilo, F. Diaz, and V. Petrov, IEEE J. Quantum Electron. **41** (2005) in press.
2. A. Aznar, R. Sole, M. Aguilo, F. Diaz, U. Griebner, R. Grunwald, and V. Petrov, Appl. Phys. Lett. **85** (2004) 4313.