Mode-Locked Laser Operation of Bulk Crystals and Epitaxially Grown Composites of Yb:KLu$(WO_4)_2$

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MOTIVATION

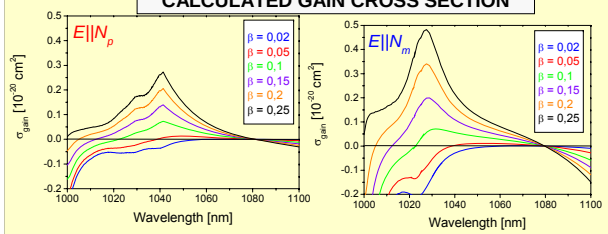
Efficient femtosecond diode-pumped lasers

- Yb:KLu$(WO_4)_2$ (KLuW) exhibits a very large absorption and emission cross section (exceeds 15 times that of Yb:YAG)
- Yb:KLu$(WO_4)_2$ has a very broad amplification bandwidth

Yb:KLuW and epitaxial Yb:KLuW layers hold great promise as new laser materials for ultrashort pulse diode-pumped laser systems

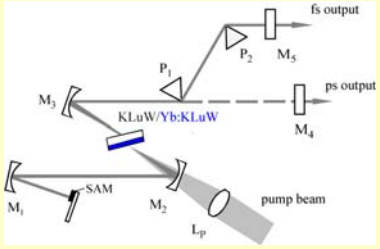
SPECTROSCOPIC CHARACTERIZATION

CALCULATED GAIN CROSS SECTION



$\sigma_{gain} = \beta\sigma_{em} - (1-\beta)\sigma_{abs}$ β: population inversion

CAVITY SETUP



L_p: focusing lens

P_1-P_2: SF10 prisms

M_1-M_3: folding mirrors

M_4-M_5: output couplers

Pulse repetition frequency:

f_{rep} = 100 MHz

Pump beam:

- Ti:sapphire (P=3W, tunable 960-1040 nm)
- Tapered Diode Laser (P=2W @ 980 nm) from Ferdinand-Braun-Institut

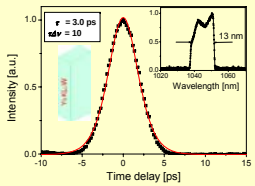
SAM: **S**aturable **A**bsorber **M**irror from Ferdinand-Braun-Institut

- 10nm InGaAs thick quantum well structure with ≈ 1% saturable absorption
- Relaxation time measured by pump-probe technique is less than 5 ps

PICOSECOND MODE-LOCKING

Bulk Crystal

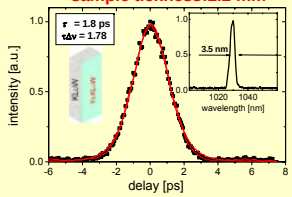
Yb(5%):KLuW
sample thickness:2.8 mm



• No dispersion compensation

Epitaxially grown composite

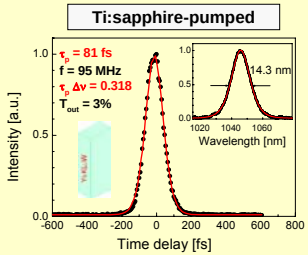
100µm thick Yb(10%):KLuW
sample tickness:2.2 mm



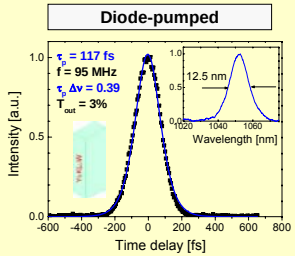
• Ti:sapphire-pumped

FEMTOSECOND MODE-LOCKED BULK LASER

Ti:sapphire-pumped

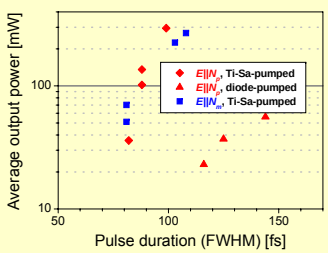


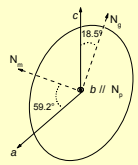
Diode-pumped



- Shortest pulse duration for a SAM mode-locked monoclinic double tungstate laser
- Central wavelength = 1046 nm and population inversion β ≈ 0.08
- Diode-pumped: lower beam quality and non-perfected match of the modes

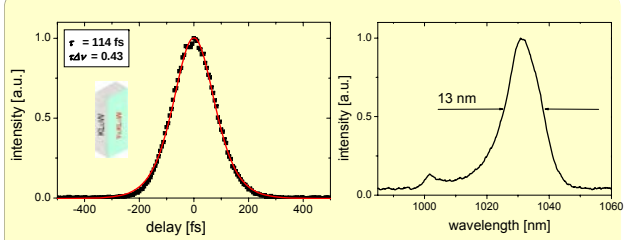
COMPARISON OF CRYSTAL ORIENTATIONS





No significant differences for E||Np and E||Nm

FEMTOSECOND MODE-LOCKED EPITAXIAL LASER



Shortest pulse: 114 fs with 32 mW average output power

Central wavelength of 1030 nm wit asymmetric spectrum and population inversion β>0.2

Composite structure with same crystal host: no parasitic reflection and birefringence effects.

Strongly reduced reabsorption (shorter wavelength) and higher population inversion compared to bulk – Shorter pulse are possible

Pulse shorter than 80 fs are expected with suitable dichroic mirror design

SUMMARY

- **First Yb:KLuW mode-locked oscillator**
- **No significant difference between crystal orientations E//N_m and E//N_p**
- **Shortest pulse duration for a SAM mode-locked monoclinic double tungstate laser (81fs)**
- **Great potential of Yb-doped tungstate composite structures for mode-locked lasers:**

  higher population inversion →

  potentially broader gain bandwidth and shorter pulses

REFERENCES MODE-LOCKED Yb:KLuW

Bulk laser U. Griebner et al. *Optics Express* ***13***, *3465 (2005)*

Epitaxial laser S. Rivier et al. *Optics Letters* ***28***, *2484 (2005)*