Compact high-power Ytterbium thin-disk laser based on kaleidoscopic reflections of pump radiation

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Abstract:
We present a new pump geometry for compact thin disk lasers. Multi-pass pumping without external pump optics is realized with a uniquely coated wedged laser medium. CW output powers of 700 W are achieved.

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1. Introduction

Due to the low absorption and amplification in a thin disk laser, the pump radiation has to be redirected multiple times onto the active medium. The output coupling has to be reduced to several per cent in order to achieve efficient lasing. Therefore, the pump optics in current systems require a large volume compared to the thin disk itself and multiple optics have to be aligned correctly with each other [1]. Our compact monolithic pump geometry (KYLIE - Kaleidoscopic reflections in Ytterbium disk Laser for Intensifying Emission) consist of a thin, wedged Yb:LuAG laser disk with dielectric coatings that traps the light for several internal reflections within the laser medium. This is achieved for different angles of incidence for pump as well as laser radiation lowering the complexity of the elementary laser setup significantly compared to a typical thin-disk laser.

2. KYLIE principle

KYLIE is a variation of a Wedged Optical Light Interference-filter Trap (WOLIT) [2]. It consists of a wedged laser disk with a wedge-angle of α. The front side of the laser disk is coated with an angle sensitive dielectric long pass (LP) filter. It may be characterized by its edge-angle $\Theta_e(\lambda)$. Radiation of a wavelength λ_p will be reflected

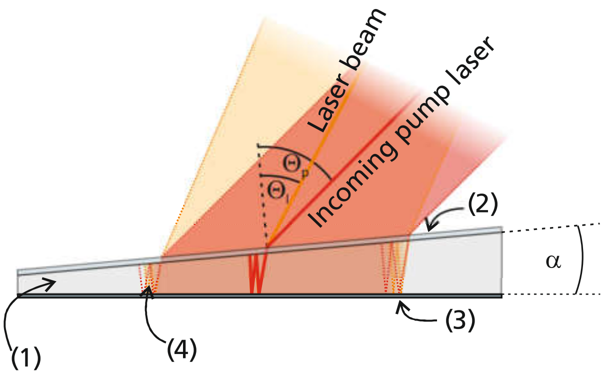

Fig. 1. Main concept of KYLIE. The incoming pump radiation is coupled into the thin, wedged (wedge angle α) laser disk (1) and passes the dielectric long pass coating (2) with an angle of incidence of Θ_p. The pump light is reflected at the high reflective coating (3) back onto the long pass (LP) coating (2) multiple times(4). The same applies for the laser light at Θ_l.

at an angle of incidence $\Theta < \Theta_e$ and transmitted at greater angles $\Theta \geq \Theta_e$. In a KYLIE arrangement the radiation is directed to the laser disk with an angle of incidence of $\Theta \gtrsim \Theta_e$ and therefore transmitted into the laser medium.

After passing the laser medium the radiation reaches a highly reflective (HR) coating on the backside of the thin laser disk. By passing through the disk, a portion of the pump radiation is absorbed, as well as the laser radiation being amplified, and redirected due to the reflection on the HR-surface.

As depicted in Figure 1, it is possible to redirect the pump laser radiation and the laser radiation back at a different angle with respect to the dielectric coating, by introducing a wedge-angle α creating an effective $\Theta < \Theta_e$. Through this arrangement the pump and laser light will be reflected at the filter surface. The laser beams are trapped for several reflections between the HR and the LP surfaces and are absorbed and amplified by the disk. Eventually, the beams will be reflected into themselves and leave the laser active medium after multiple passes. By choosing a small wedge-angle α, the number of passes can be increased. This results in multiple absorption passes of the pump light as well as multiple amplification passes of the laser radiation within the disk.

3. Experimental setup and first results

Figure 2 shows the setup installed for the experiments. A fiber based 969 nm pump laser diode (1) is imaged via a lens (2) and a folding mirror (3) onto KYLIE (4). To extract the energy from the thin disk an output coupler (6) was used. KYLIE was glued onto a water cooled, 2 mm thick diamond heatsink which allowed to reach output powers of up to 700 W.

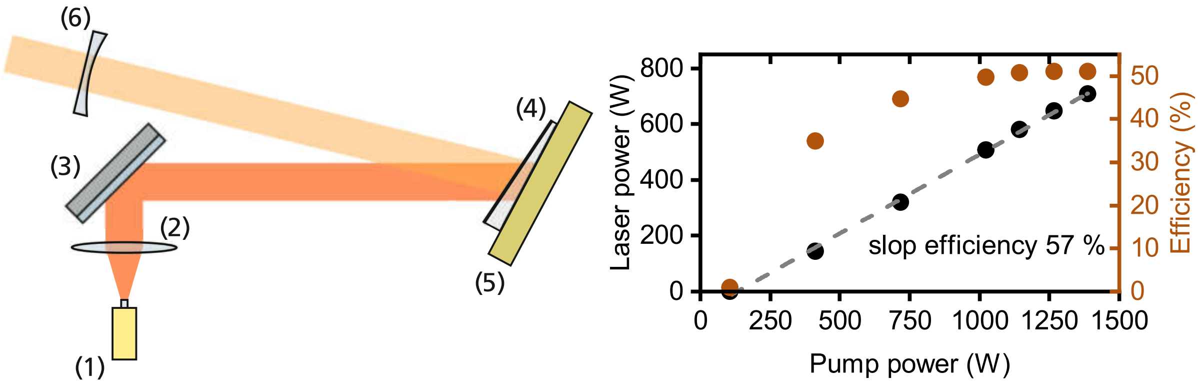

Fig. 2. left: Schematic of the experimental setup. (1) fiber based 969 nm laser diode, (2) lens, (3) mirror, (4) KYLIE, (5) copper heat sink, (6) output coupler. right: Optical output power in comparison to the optical pump power.

First results of a optical power measurement are shown in figure 2 on the right. The maximum output power of 700 W is reached at an optical pump power of 1.4 kW. This leads to an over all efficiency of 48 % and a slop efficiency of 57 %.

4. Summary

We were able to demonstrate the power scaling of the monolithic thin disk laser pump geometry KYLIE up to 700 W. With the described experimental setup we, furthermore, were able to demonstrate the successful bonding and operation of KYLIE on a diamond heat-sink for pump powers exceeding 1 kW.

References

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