Testing and characterization of saturable absorbers for ultrafast high-power lasers

Type:	Master's thesis	Contact information:
Timeframe:	6 months, preferably starting Nov/Dec 2019	Jacob Nürnberg
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Reference:	1902MA	

1. Project description:

Ultrafast high-power laser sources deliver hundreds of Watts average power at sub-picosecond pulse duration and are pivotal to numerus industrial and scientific applications such as micromachining and high-field physics. In the ultrafast laser physics group at ETH Zurich (ulp.ethz.ch) we develop cutting-edge ultrafast high-power oscillators based on the thin-disk gain medium combined with semiconductor saturable absorber mirrors (SESAMs) [1, 2].

A crucial point in the development of these oscillators is heat extraction from the intracavity components. The SESAM, which enables modelocking (i.e., pulsed operation) is by design an absorber and hence, because of the absorbed power, can exhibit thermo-optic distortions, potentially hindering the performance of the laser. To overcome this issue, we need to improve the heat extraction from the SESAM. To this extent, we started a collaboration to develop new SESAMs, which besides the usual heatsink on the back side have an additional Sapphire-bonded window on the front face. This not only improves the heat extraction but also, potentially, allows post-processing of the SESAMs in order to improve their thermal handling capability even further.

We now have a 1st batch of these new SESAMs and expect a 2nd batch by mid-November. The goal of this thesis project is to characterize these new SESAMs and test them for modelocking. A positive outcome of these tests, which we expect according to our simulations, would be novel and of scientific interest.

2. Steps of project

1. Design and construct a state-of-the-art thin-disk oscillator (≈ 3 months)
2. Use the laser output to characterize the thermal characteristics of the new Sapphire-bonded SESAMs, similar to [3]
3. Use the new SESAMs to modelock the laser

3. Skills involved

- Hands-on work on laser oscillators – how to build a laser
- Familiarization with continuous-wave and modelocked laser diagnostics

4. Prerequisites:

A basic understanding of lasers is required, some practical experience in optics a plus, ideally you attended the "Ultrafast Laser Physics" course given by Dr. Gallmann.

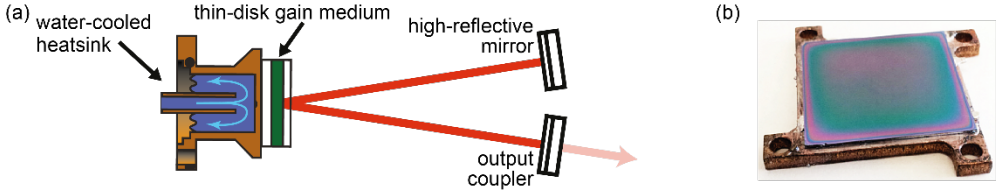

Fig 1. (a) Simplified schematic of a thin-disk laser oscillator. For modelocking we replace the high-reflective mirror with a SESAM (b), i.e., a saturable absorber.

[1] C. J. Saraceno, et al., "Toward millijoule-level high-power ultrafast thin-disk oscillators," IEEE J. Sel. Top. Quan. Electron. **21** (2015), https://doi.org/10.1109/JSTQE.2014.2341588

[2] C. R. Phillips, et al., "Advancements in Ultrafast Multi-100-W Average-Power Thin-Disk Lasers," https://www.photonics.com/Articles/Advancements_in_Ultrafast_Multi-100-W/a65052

[3] A. Diebold, et al., "Optimized SESAMs for kilowatt-level ultrafast lasers," Opt. Express **24**, 10512-10526 (2016), https://doi.org/10.1364/OE.24.010512