Ultrafast_RAZipol Period 1 Publishable Summary

The Ultrafast_RAZipol project aims to demonstrate laser material processing at unprecedented levels of productivity and precision using beams with cylindrical (radial and/or azimuthal) polarization. The objectives are to achieve high productivity at high levels of precision and quality.

Therefore two laser systems (master oscillator power amplifiers: MOPA) will be built up in order to achieve the above targets for structuring of large area (e.g. lab-on-chip applications) and drilling of high aspect-ratio hole (e.g. spinnerets, nozzles). For the first application, a high-repetition rate (HRR) laser system providing an output power of 500W at a repetition rate of 20 MHz (corresponding a pulse energy of 25 µJ) and a pulse duration of approximately 1ps will be developed. In the second application case (drilling of high-aspect ratio holes), where high-energy is required, the laser system (low repetition rate: LRR) shall deliver an average output power of 200W, at a repetition rate of 200-1000 kHZ (corresponding to an pulse energy of 0.2-1 mJ) and a pulse duration of approximately 5ps.

The laser architecture followed in Ultrafast_RAZipol combines well-established laser technologies i.e. Sesam mode-locked oscillator as seed, single-crystal fiber amplifier (SCF) as pre-amplifier and thin-disk multipass amplifier as booster.

Figure 1 gives a schematic overview of the laser architecture.

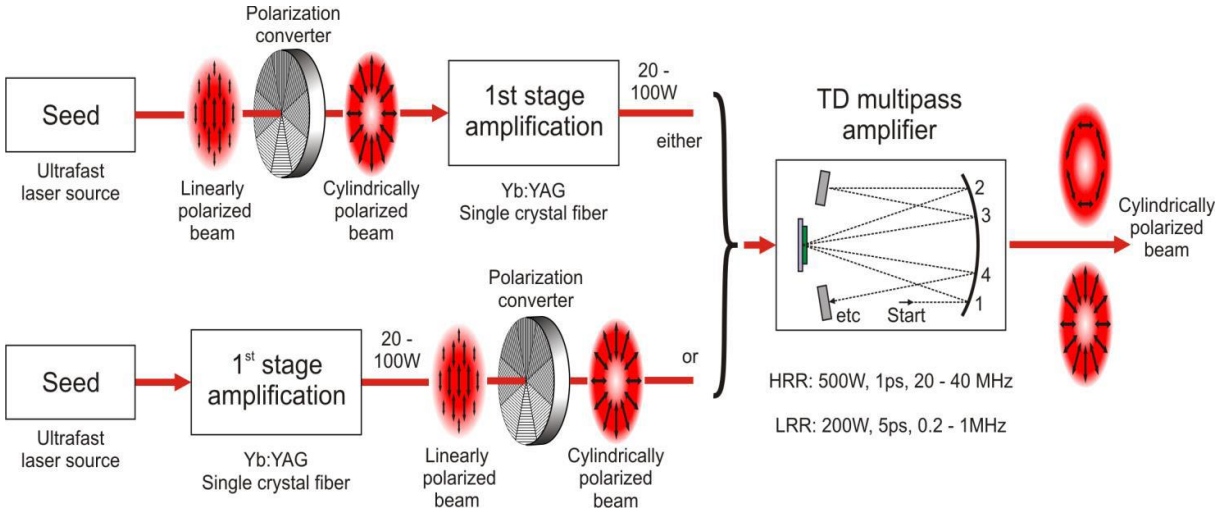

Figure 1: Schematic overview of the laser architecture

Furthermore, Ultrafast_RAZipol will address the beam steering and shaping technologies (scanners and trepanning optics) in order for the beams to be applied to the work-piece in a well-defined application-specific manner.

The main achievements within the first 18-months of the project can be summarized as follows.

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- The High-repetition rate (HRR) system

The focus of Ultrafast_RAZipol within the first 18-months of the project was mainly on the development of the HRR laser amplifier chain. A bulk Sesam mode-locked oscillator delivering 2.9W at a pulse duration of 350fs and a repetition rate of 21MHz (corresponding to an energy per pulse of 137nJ) was realized by partner JDSU. The laser oscillator delivers a linearly polarized beam with a beam quality factor which was measured to be $M^2<1.2$.

In a sub-sequent step, a 3-stages single-crystal amplifier was implemented to achieve a multi-10 Watts of amplified power. This has been realized in the lab of CNRS in a first step and integrated by Fibercryst in a following step.

Within the lab experiment performed at CNRS the following results have been achieved:

- Up to 100W of average power at a repetition 21 MHz and a pulse duration of 700 fs in a linear polarization were extracted. The beam quality factor was measured to be <1.3 in both axes.
- Up to 85W of average power at a repetition 21 MHz and a pulse duration of 700 fs in a cylindrical (radial and azimuthal) polarization were achieved.

Based on the above lab experiment, Fibercryst has realized an integrated version of the system which delivers only 61W in a linear polarization and at a pulse duration of 680 fs. Figure 2 shows a photo of the integrated SCF amplifier together with the seed laser oscillator installed at USTUTT.

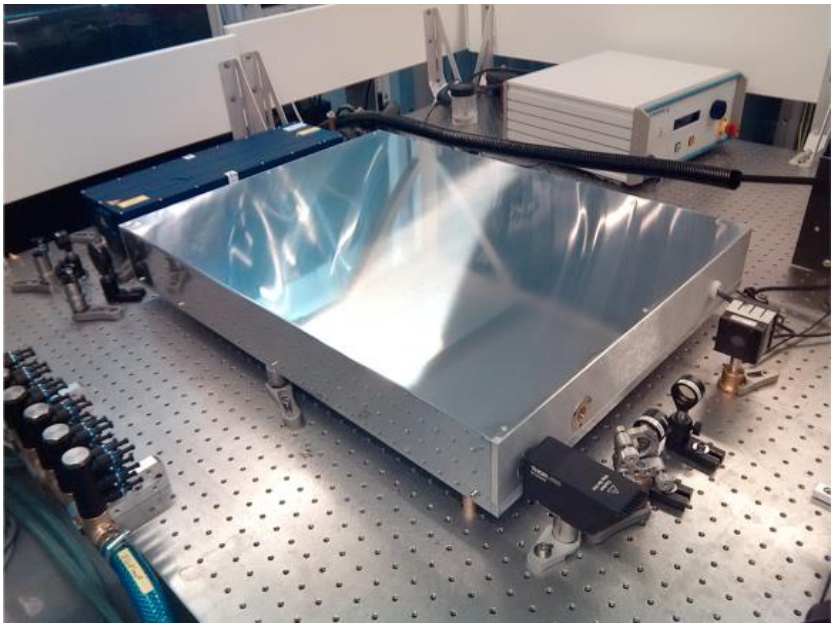

Figure 2: integrated HRR SCF Amplifier together with HRR seed oscillator

So far no experiments were performed on the HRR multipass amplifier within the 18-months period of the project. However, the complete thin-disk multipass amplifier has been assembled and tested in continuous wave (CW) regime using a 22W intra-cavity radially polarized laser beam. A CW output power of up to 158W could be extracted at a pump power of 600W. Figure 3 shows the laser characteristic of the amplified beam as well as its analysis with a rotating polarizer confirming its high-radial polarization purity.

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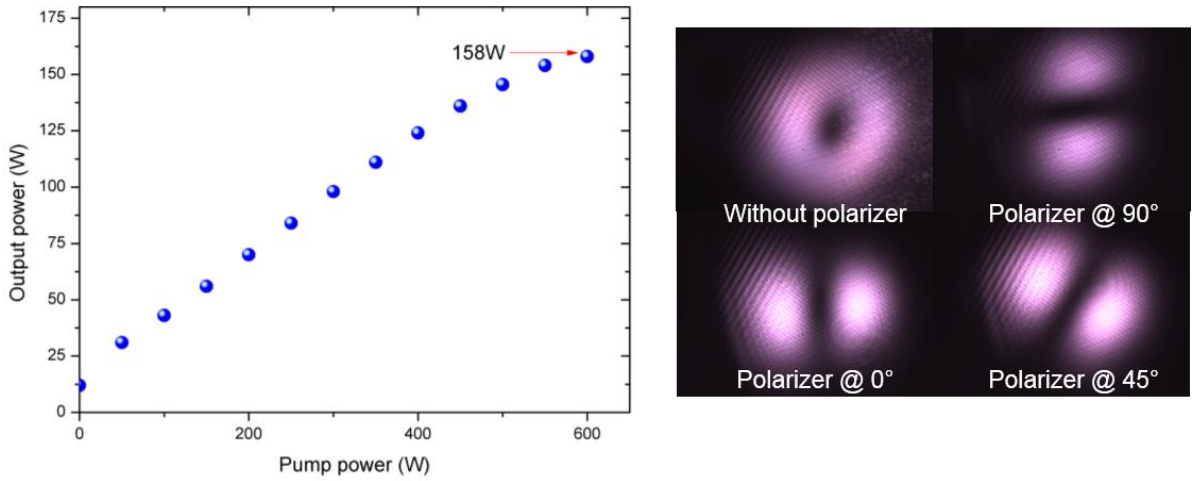

Figure 3: First amplification results of CW radially polarized beam in a thin-disk multipass amplifier

The amplification experiments of the HRR in the thin-disk multipass amplifier are currently under progress and will be performed within the second period of the project.

- The low-repetition rate (LRR) system

First experiments have been performed for the LRR system within this first period An Oscillator providing only 30 mW of stretched pulses at a repetition rate of 500 kHz could be used for the first amplification tests. An output power of 9W (M^2> 1.2) at a pulse duration of approximately 9 ps and a repetition rate of 500 kHz was extracted for the first stage of the SCF amplifier in a double-pass configuration. Sub-sequent amplification stages are currently under implementation.

In parallel to the laser development parts, the development of the polygon scanner with the appropriate coating properties for beams with radial and azimuthal polarization is under progress. Furthermore, the integration work of both laser systems in the machines including the beam trepanning or the scanners is progressing and will be reported within the second period of the project.

So far the results obtained are very satisfying, especially with the HRR laser and the latest experiments have shown that the estimated targets of Ultrafast_RAZipol should be reached as planned.

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