TiSa TD Newsletter January 2015

Although overlooked easily, high-precision laser micro-machining has gained significant impact on daily life. For example, high-precision laser micromachining is essential to produce the displays of state-of-the-art smart phones and other mobile electronic equipment. It is especially challenging to cut thin toughened glass used to improve scratch resistance and to minimize weight without chipping, burr and edge rounding.

The main goal of the TiSa TD project is to demonstrate laser processing of transparent materials like glass, sapphire, and diamond at unprecedented levels of productivity and precision using beams with a unique combination of extremely short (< 100 fs) pulses and high average power. Both high pulse energies and high repetition rates will be investigated with separate laser systems. The high pulse energies (1 mJ) produced with a chirped pulse amplifier will be used e.g. for single-pulse high-aspect ratio drilling whereas the high repetition rates (10 MHz) generated with a high-power oscillator will be used e.g. for large area structuring and cutting of thin glass.

The challenge is not only to achieve high productivity at moderate levels of precision or highest quality at low speeds, but to reach both targets at the same time. Therefore an adequate ultrafast laser source with a very high average power and well-adapted beam parameters, including pulse duration and pulse energy is needed. Additionally, the laser beam has to be applied to the work-piece in a well-defined application-specific manner. Finally, advanced processing strategies are required to obtain optimum results at high productivity.

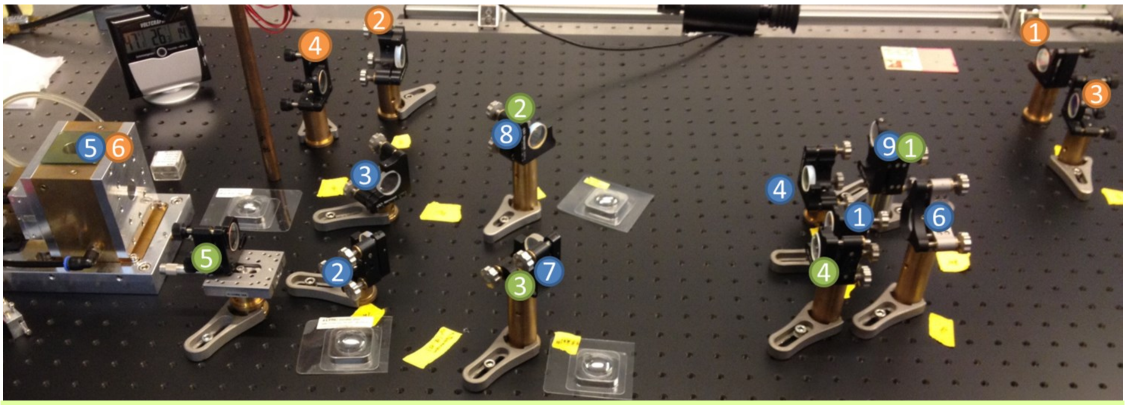
The ultrafast laser sources to be realized within the TiSa TD project are based on a combination of three key enabling technologies. The first one is the existing high-power thin-disk (TD) technology invented and further developed at USTUTT. The almost one-dimensional heat flow inside the thin laser crystal minimizes the pump-induced thermo-optical effects limiting the fundamental-mode output power of most conventional lasers. Efficient fundamental-mode cw operation in the kilowatt regime has been demonstrated with a single Yb:YAG thin disk. The second key enabling technology is the Titanium-doped sapphire (Ti:Sa) ultrafast laser technology developed by TOSA.

The unique spectral properties of Ti:Sa enable the generation of pulses with durations down to approx. 5 fs directly from an oscillator; therefore sub-100 fs pulses are achieved easily and efficiently. On the other hand, Yb-doped laser crystals show a strong trade-off between pulse duration and average output power (and efficiency) for pulse durations below 300 fs. The third key enabling technology is the low-loss single-crystal CVD diamond material developed at E6. This allows symmetrical cooling of the thin laser disk from both sides which in turn enables to increase the pump power density and therefore the gain as well as the output power significantly. Due to the low gain and the high heat generation of Ti:Sa symmetrical cooling is essential for efficient high-power operation of Ti:Sa TD lasers.

A significant impact of the new ultrafast laser sources is expected for a broad range of demanding applications requiring both high precision and high productivity. The first experimental results are expected to come in 2015.

The TiSa TD project has received funding from the European Community's Seventh Framework Programme under Grant Agreement No. 619177

THE PARTNER'S ROLES & CONTRIBUTIONS



The Yb-based thin-disk oscillator (target specifications: pulse duration ~ 300 fs, pulse energy ~ 5 µJ, repetition rate ~ 5 MHz) shown here in an early development stage is prepared for the partner OXFORD to allow materials processing investigations early in the project. To increase the gain, the laser beam is passing through the laser crystal several times per roundtrip through the resonator. At the same time, the required repetition rate is achieved by increasing the resonator length to approx. 30 m .

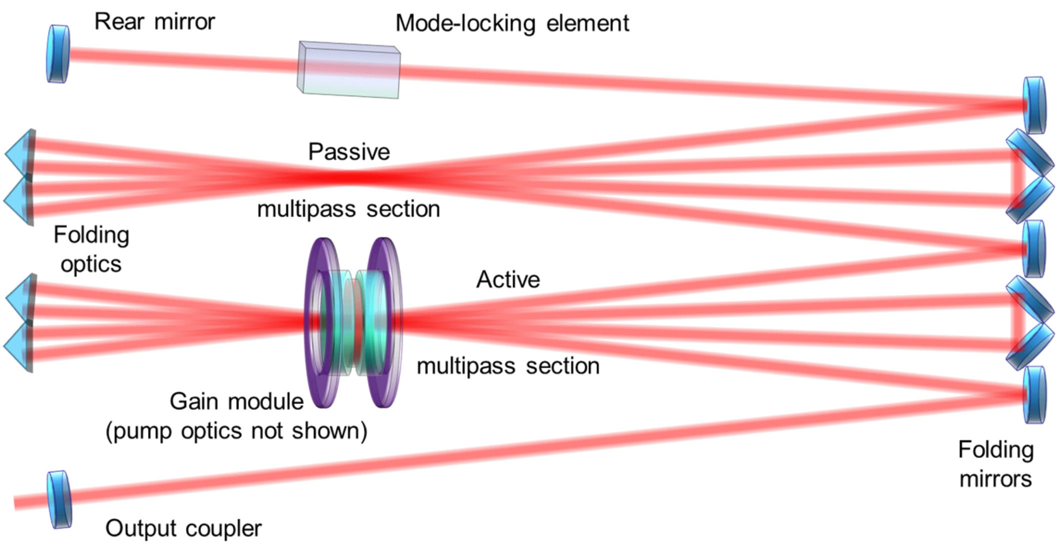
Universität Stuttgart — IFSW UNIVERSITÄT STUTTGART INSTITUT FÜR STRAHLWERKZEUGE STUTTGART LASER TECHNOLOGIES

USTUTT is the Coordinator of the Project and is designing, realising and characterising the high-power mode-locked Ti:Sapphire thin-disk oscillator.

THALES

TOSA is realising the Ti:Sapphire crystals adapted for thin-disk technology.

They are also designing, realising and characterising the high power Ti:Sapphire thin-disk amplifier.



The design of the Titanium-doped sapphire (Ti:Sa) thin-disk oscillator shown here, consisting of an active and an optional passive multipass section, is similar to that of the Yb-based thin-disk oscillator shown before. The main difference is that, in contrast to the single-side cooled conventional thin-disk design, in this case the laser beam passes the symmetrically cooled Ti:Sa disk in transmission. The double-sided cooling using transparent diamond heat spreaders allows for substantially higher pump power densities and therefore higher single-pass gain. The goal of the project is to achieve an average output power of 200 W at a pulse duration of below 100 fs and a pulse energy of 20 µJ. A chirped-pulse Ti:Sa thin-disk amplifier with 200 W average output power and 10 mJ pulse energy will also be developed .

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THE PARTNER'S ROLES & CONTRIBUTIONS

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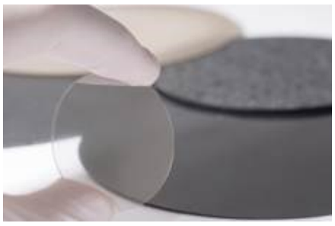
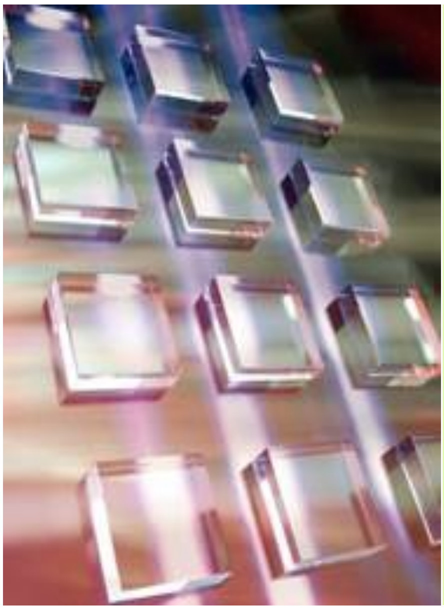
Is in charge of modelling, designing, manufacturing and testing the crystal cooling assemblies. They are also developing low absorption and low birefringence diamonds necessary for the project.





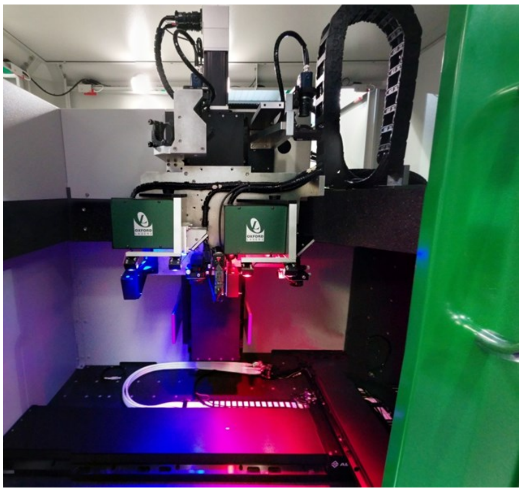
For disk laser structures diamond has proved to be an exceptional heatspreader material to maximise the one dimensional thermal management that such systems rely on. For a number of years such systems have used polycrystalline diamond as a heatspreader external to the laser cavity. Moving the diamond inside the cavity (onto the inside of the gain material) has been prevented by the high scatter and birefringence of polycrystalline diamond.

Single crystal diamond products have not traditionally been available in the areas sufficient to be used with most disk lasers, however the TiSa TD project is driving the development of larger single crystal parts, with exceptionally high optical quality that can be used in a sandwich structure in the laser cavity. The diamond will be some of the largest area optical grade single crystal synthesised, with new surface processing techniques developed.

The project has already identified processes to produce diamond with low absorption, low birefringence and larger areas than previously achieved in combination, and continues to drive towards larger area parts.

OXFORD LASERS INDUSTRIAL DIVISION

Is in charge of application development and is a lead participant in femtosecond laser process development. They will be in charge of demonstrating the project target specifications for the 200 W Ti:Sapphire thin-disk oscillator. They also play a major role in the market exploitation research for the project.



As part of the project, OXFORD have dedicated several Applications Engineers and a temperature controlled lab space comprising an optical table, XYZ CNC table (travel 350x450mm, 2µm accuracy), digital encoded galvanometer scanner, motorised attenuator and several beam focussing options to exploit the unique properties of the TiSa TD developed thin-disk femtosecond laser oscillators.

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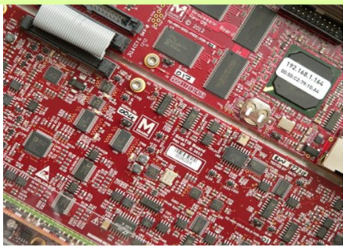
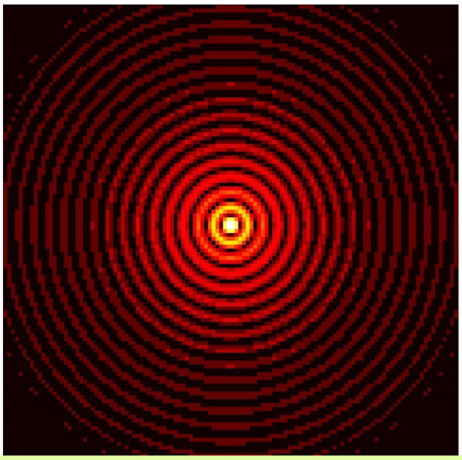
THE PARTNER'S ROLES & CONTRIBUTIONS

M Squared Lasers develops the pre-prototype system. They design and implement custom electronics, mechanics and software algorithms. Within the project, they also have a role in the exploitation activities.

M Squared's range of ICE-BLOC electronic control modules enable low-noise operation with remote access through Ethernet-controlled browser-based user interfaces, for effective user control.





Above, an image of a simulation of the beam that CNRS will use for laser machining with high energy pulses.

Is designing and testing the laser processing set-up with nondiffracting beams. They are also developing high pulse energy femtosecond laser amplifier processing ultrahigh aspect ratio drilling and dicing.

KITE is working closely with the Coordinator USTUTT to ensure that all the administrative, reporting and financial aspects of the project are managed in an effective and timely manner.

For more information on the TiSa TD project please visit our website

www.tisa-td.eu

You can also watch the project's first video available on YouTube

http://youtu.be/53Zy87DlVNo

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