

HiLASE Centre brings Superlasers to the Real World

Dolní Brežany, 2/12/2021

The research activities and projects of HiLASE Centre, Institute of Physics of the Czech Academy of Sciences lead to breakthrough results in the field of laser technologies. Thus successfully connect the areas of development, research, industry and then fulfil its mission to create Superlasers for the Real World.

HiLASE Centre is an important part of the Institute of Physics of the Czech Academy of Sciences and focuses on experimental development of a new generation of diode pumped solid-state lasers with high energy per pulse and high repetition frequency at the same time.

Project LO1602, HiLASE: Superlasers for the Real World co-financed from the National Sustainability Program (NPU I) was successfully implemented within the period from 1 January 2016 to 31 December 2020. The total financial support from NPU I was CZK 165,056,000. The main goal of the project was to ensure long-term and effective use of HiLASE's unique infrastructure such as laser devices of the HiLASE Centre for excellent research program and thus maximizing the impact of research and development results not only on the scientific community but with a benefit to the society as well. The most important research programs with a focus on research and industry users were:

1. Development of diode-pumped thin-disk solid-state laser systems of the kW class with energy up to J levels for industrial and scientific applications, i.e. picosecond thin-disk lasers.
2. Development of a multi-slab laser system of class 100 J / 10 Hz and validation of computer codes to demonstrate scalability of nanosecond cryogenic lasers to the level of 1 kJ.
3. Development of future industrial use of lasers developed in programs No. 1 and 2, and development of key technologies for high repetition rate amplifiers in cooperation with the industry.

The above mentioned programs were successful, and achieved very interesting main and partial results. Some of these results, due to their uniqueness, have also significantly influenced the world of laser technology as such. A selection of the most interesting is presented below.

A picosecond diode-pumped thin-disk laser platform PERLA 100 with emitting at a wavelength of 1030 nm was developed. The laser system contains several safety elements as well as elements for integration into application experiments. *"The system has a pulse length of 0.9 ps and beam quality of $M2 = 1.1$, which is really unique at an average power of up to 100 W,"* explains Martin Smrž, Ph.D., Head of Department: Advanced Laser Development.

From a scientific and industrial applications point of view, especially in the field of semiconductors and organic materials, it is also important to mention the development of a tunable optical parametric system emitting picosecond pulses in the spectral range of 1.5 - 3.2 μm . *"It is based on an optical parametric generator with a*

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periodically polarized LiNbO3 crystal and an optical parametric amplifier based on a KTA crystal," adds Ondřej Novák, Ph.D., Team Leader: Nonlinear Optics. Furthermore, a laser with a new type of active medium (Yb: YGAG) was demonstrated, which allows to generate pulses in the hundreds of femtoseconds while maintaining all the advantages of Yb:YAG.

The most important results include the preparation of the Yb: YAG / Cr: YAG bonded slab from a monocrystalline material and its testing in a cryogenic laser amplifier. As a result, the risk of sustainable operation of the laser system BIVÓJ, has been significantly reduced. BIVÓJ has already been used for a variety of applications in the aerospace, automotive and power engineering industries.

Another significant result is the commissioning of the wavefront sensor based on the phase retrieval algorithm. *"Basically, we managed to create a sensor that is more or less independent of the wavelength, doesn't need detector with spatial resolution, and thus it is theoretically sufficient to have only a one-dimensional detector (photodiode) and reflective material for a given wavelength,"* comments Martin Divoký, Ph.D., Team Leader: High Energy Slab Lasers.

Furthermore, a Faraday insulator for small beams was manufactured, and successfully tested. It minimized the risk in the development of a Faraday insulator for the 100 J kilowatt laser system BIVÓJ. And a high voltage pulsed power supply for Pockels' cells was completed as well.

Perhaps the greatest success is the introduction and implementation of Laser Shock Peening (LSP) technology in the Czech Republic, connected directly to the unique BIVÓJ laser, which has no parallel in the World. *"Thanks to the optimization of LSP processes and improvements in optical and laser technologies, plasma characterization can be performed with greater accuracy, which means a better understanding of the processes involved in laser-mass interactions,"* says Jan Brajer, Ph.D., Head of Department: Industrial Laser Applications. The introduction and commissioning of LSP technology brought not only interesting results, but new opportunities for cooperation as well.

HiLASE Centre is constantly developing cooperation with the international scientific community, a wide group of strategic partners from the scientific, academic, public, and industrial spheres, including professional associations, which has a demonstrable impact on increasing the overall competitiveness of the Czech Republic in the laser technology world. The main international projects of the Centre supported by the Horizon 2020 program include, for example, HiLASE Centre of Excellence, iQonic, and ATLANTIC.

The implementation of the HiLASE Centre's research activities leads to unique results, as evidenced by the recent world record of the BIVÓJ superlaser, when energy of 145 J was stably reached and a maximum of 146.5 J in a 10 ns pulse at a repetition rate of 10 Hz at a wavelength of 1030 nm. *"We have gained a great technological lead. It opens up the way to new applications for material processing, surface treatment and fundamental research into the interaction of high-power laser radiation with matter" states Head of the HiLASE Centre, Tomáš Mocek, Ph.D.*

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"The results of our research teams are published in high ranked impact factor journals and receive many citations," informs Tomáš Mocek and adds, "...at the same time, colleagues present these at international conferences and workshops. Popularization and educational activities are taking place for the general public, and we also place great emphasis on cooperation with primary and secondary schools, but, most importantly, we engage with universities. "

HiLASE Centre's activities and constant effort to increase scientific excellence and innovation capacity, also significantly affect the regional development of the Central Bohemian Region, the STAR region, and Dolní Brežany itself.

For more information, please visit www.hilase.cz

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About HiLASE Centre

HiLASE Centre (an acronym for High average power pulsed LASERs) is a scientific research centre of the Institute of Physics of the Czech Academy of Sciences. The present research programme of the Institute comprises five branches of physics: particle physics, the physics of condensed matter, solid-state physics, optics and plasma physics.

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About FZU

The Institute of Physics (IOP) is a scientific workplace dedicated mainly to basic research and is part of the [Academy of Sciences of the Czech Republic](http://www.cas.cz) (AS CR). The main activity of IOP is scientific research in the field of physics, especially physics of elementary particles, condensed systems, solids, optics, plasma physics, and laser physics.

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