

## THEMATIC RESEARCH FOCUS

### Research area

- Laser welding including wobbling, hybrid welding (Laser-MIG, Laser-TIG)
- Laser 2D/3D cutting
- Process diagnostics
- Micromachining with a picosecond power laser
- WAAM – 3D metal printing
- Numerical simulations of laser welding, hybrid welding and WAAM
- Optical layers

### Excellence

- Diagnostics of laser welding process
- Numerical simulations
- Micromachining with IR, VIS and UV laser wavelengths

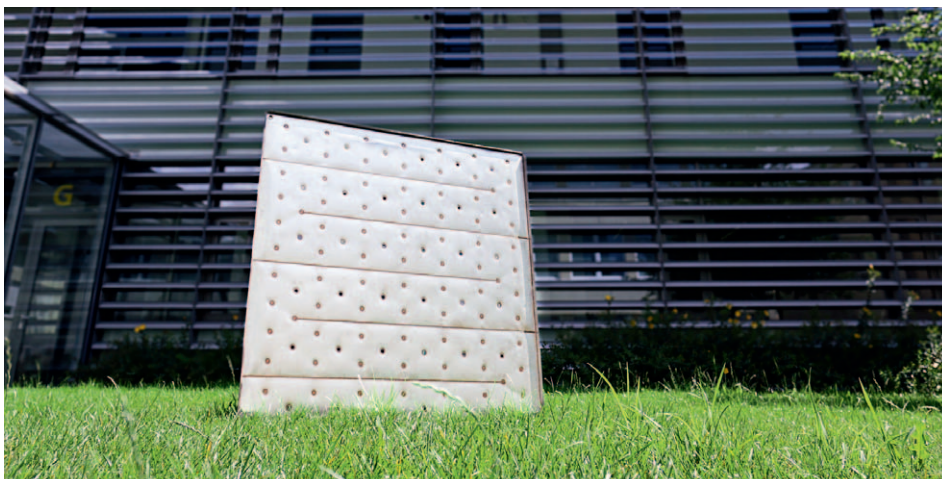
### Mission

- Theoretical and experimental research of laser welding process
- Study, monitoring and control of the laser welding process
- Application of laser welding technology for the high-tech industry and green technology
- Application of picosecond micromachining for optical elements
- Thin optical layers for laser optics and interferometry

## UP-TO-DATE ACTIVITIES

### Research orientation/focus

- Study of the welding process by means of of back reflected radiation image processing
- Numerical simulations of laser welding process
- Study of microstructure and mechanical properties of 3D printed (WAAM) samples, WAAM simulations
- Picosecond laser micromachining of materials - IR, VIS and UV wavelengths



*Laser welded solar collectors*

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- Development of optical elements using picosecond micromachining technology
- Theoretical and experimental study of laser induced damage threshold of thin film optical coatings

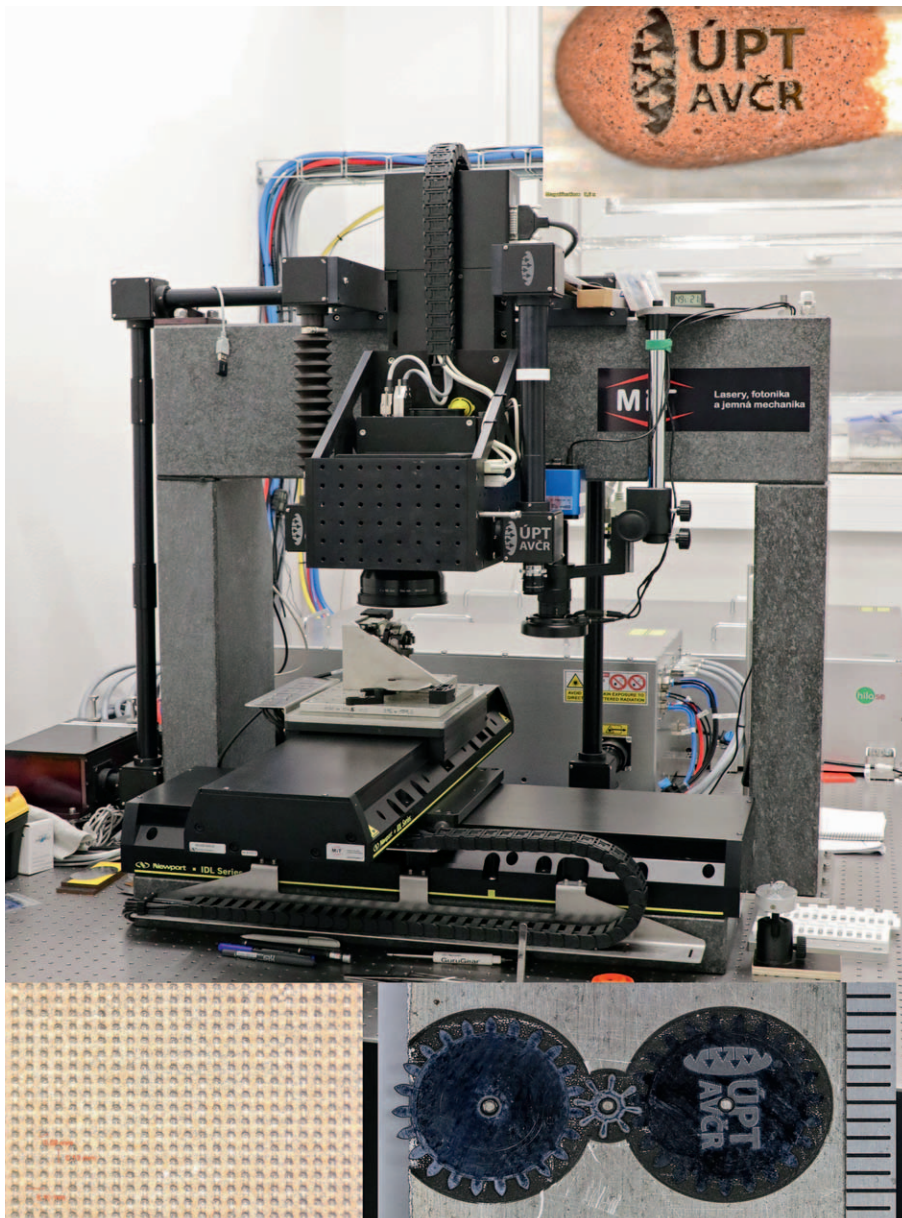
### Main capabilities

#### Basic research

- Study of laser welding process based on image analysis of back reflected laser radiation
- Numerical modeling and simulations of welding, including hybrid processes
- Microstructural and mechanical characterization of samples 3D printed with WAAM technology
- Investigation of picosecond laser micromachining

#### Applied research

- New type of a sensor for monitoring of the laser welding process
- Hybrid laser welding technology
- New type laser welded heat exchangers and solar absorbers with controlled circulation
- Development of picosecond micromachining technology for the manufacturing of optical elements
- Laser induced damage threshold test station



Micromachining station with a picosecond laser, rotary axis and two scanning heads (for 1070/515 nm and 257 nm).

Detail in the top right: example of “cold” engraving – match head with ISI logo.

Detail in the bottom left: microstructuring of stainless steel. Bottom right: Micromechanism on alumina pads pad with metal and silicon gears.

## Innovations

- Licence agreement about utilization of methods of monitoring laser welding process based on patent CZ303797

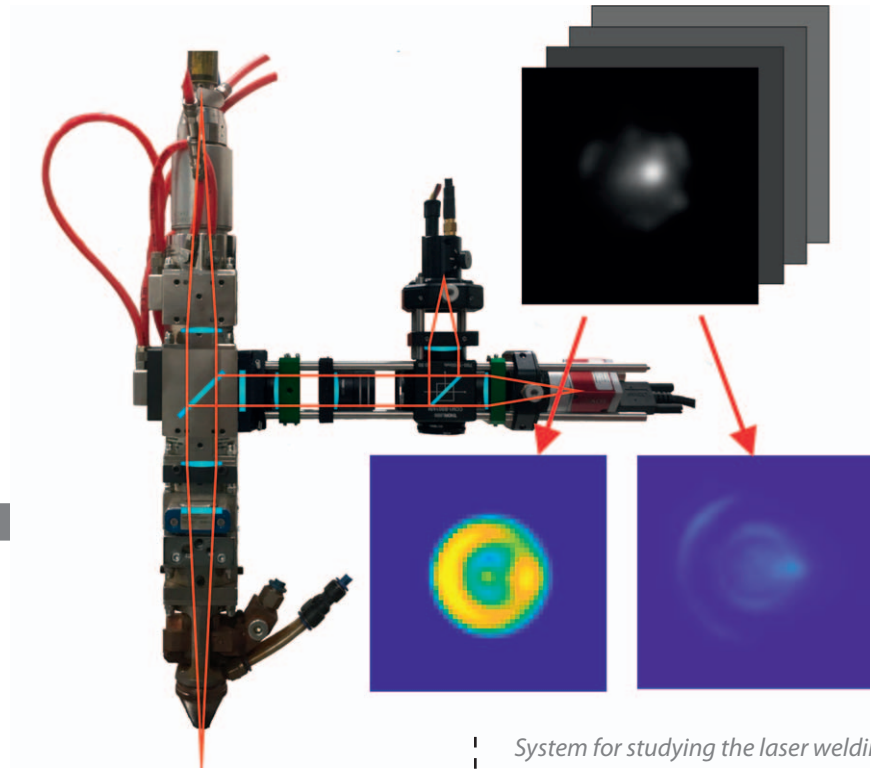
## Sub-fields of group activities

- Engineering industry related to modern methods of materials processing
- Renewable energy
- Materials science
- Optics for high-power lasers

## KEY RESEARCH EQUIPMENT

### List of devices

- Laser YLS2000 (IPG photonics)
- Welding head YW30 (Precitec)
- Cutting head YRC100, (Precitec)
- Wobble head IPG D30 (IPG photonics)
- Scanning welding head Fiber RHINO (ARGES)
- Robotic arm IRB2400 and 2-axis rotary positioner IRBP250 (ABB)
- Power picosecond laser Perla 100 IR, VIS, UV (HiLASE)
- Micromachining station (Newport)
- Infrared Camera FLIR A310
- BeamWatch BW-NIR-2-55 (Ophir)
- PIAD Electron beam evaporation coating system SYRUSpro 710 (Leybold Optics)
- Electron beam evaporation coating system Balzers BAK550
- Spectrophotometer Varian CARY 5E



System for studying the laser welding process based on the analysis of backscattered laser radiation. Detail in the top right: set of shots from HS camera. Detail in the bottom right: evaluation of a set of images according to various statistical criteria.

## ACHIEVEMENTS

- Šebestová H, Horník P, Mikmeková Š, Mrňa L, Doležal P, Novotný J. Microstructural Characterization of Laser Weld of Hot-Stamped Al-Si Coated 22MnB5 and Modification of Weld Properties by Hybrid Welding. *Materials*. 2021; 14(14):3943. <https://doi.org/10.3390/ma14143943>
- Šebestová H, Horník P, Mrňa L, Jambor M, Horník V, Pokorný P, Hutař P, Ambrož O, Doležal P. Fatigue properties of laser and hybrid laser-TIG welds of thermo-mechanically rolled steels. *Materials Science and Engineering: A*. 2020; 772: 138780. <https://doi.org/10.1016/j.msea.2019.138780>
- Darwish M, Mrňa L, Orazi L, Reggiani B. Modeling and analysis of the visualized gas-assisted laser cutting flow from both conical and supersonic nozzles. *International Journal of Advanced Manufacturing Technology*. 2020; 106: 4635–4644. <https://doi.org/10.1007/s00170-019-04915-4>
- Darwish M, Mrňa L, Orazi L, Reggiani B. Numerical modeling and Schlieren visualization of the gas-assisted laser cutting under various operating stagnation pressures. *International Journal of Heat and Mass Transfer*. 2020; 147: 118965. <https://doi.org/10.1016/j.ijheatmasstransfer.2019.118965>
- Horník P, Šarbort M, Šebestová H, Mrňa L. Study of the influence of focal position on back-reflected radiation during deep penetration laser welding and its simulation. *Optics and Measurement International Conference 2019. Proceedings of SPIE*. 2019; 11385: 1138505. <https://doi.org/10.1117/12.2542806>
- Mrňa L, Řiháček J, Šarbort M, Horník P. Solar absorber with a structured surface – A way to increase efficiency. *Acta Polytechnica*. 2019; 59 (2):134-143. <https://doi.org/10.14311/AP.2019.59.0134>

- Šebestová H, Horník P, Mrňa L, Doležal P, Mikmeková E. The Effect of Arc Current on Microstructure and Mechanical Properties of Hybrid LasTIG Welds of High-Strength Low-Alloy Steels. *Metallurgical and Materials Transactions B*. 2018; 49: 3559–3569. <https://doi.org/10.1007/s11663-018-1385-6>

## MAIN COLLABORATING PARTNERS

### Collaboration with academic partners

- Brno University of Technology (Brno, CZ)
- Masaryk University (Brno, CZ)

### Collaboration with companies

- Tescan Orsay (Brno, CZ)
- EBZ Hoffmann (Ostržská n. Ves, CZ)
- Garrett motion CZ (Brno, CZ)
- Narran (Praha, CZ)
- Lascam (Praha, CZ)

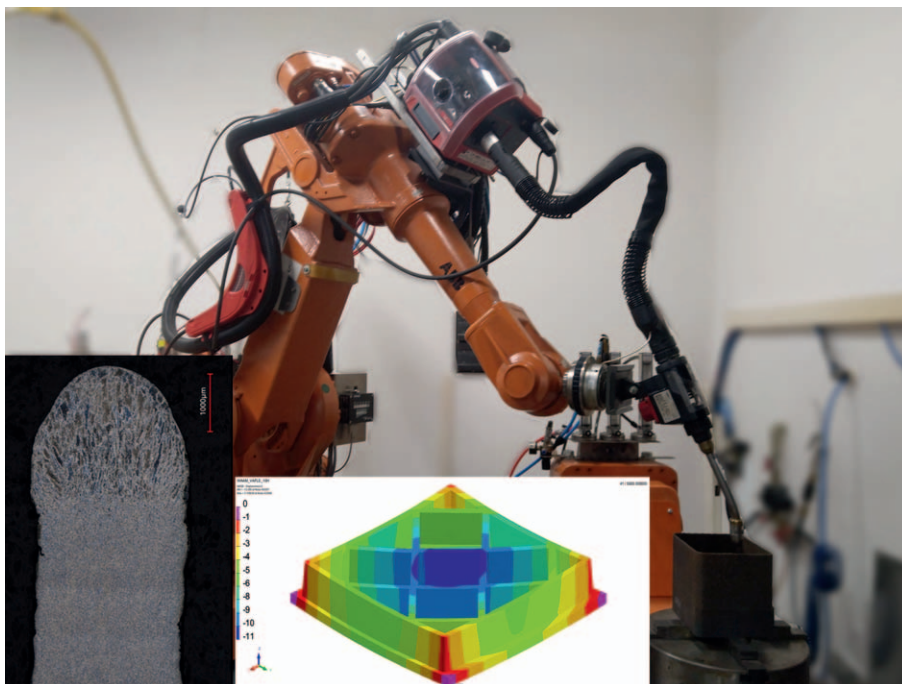
## EXPECTATIONS

### Offers

- Licensing of the patent for automatic optimization of the laser beam geometry in laser welding
- Partnership in international projects
- Contractual research in laser welding, cutting, etc.
- Consulting in the field of laser welding, cutting, surface hardening etc.
- Cooperation in the development of solar absorbers and heat exchangers
- Design and production of custom thin film optical coatings
- Consulting in the field of optical coating deposition

### Requirements

- Real interest in applied research and innovation
- Knowledge of grant projects
- Collaboration with industrial partners in common projects dedicated to applied science
- New complementary technologies



Robotic arm modified for 3D printing using the WAAM method.  
 Detail on the left: microstructure of the deposited steel wall.  
 Detail in the center: simulation of deformation of a deposited rib reinforcement.