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Institut für Strahlwerkzeuge
Universität Stuttgart

Im Fokus

Actual Research at IFSW

The Institut für Strahlwerkzeuge at the University of Stuttgart, founded in 1986, meanwhile is recognized as one of the leading laser centers worldwide. It´s strength is based on the holistic approach that comprises the beam sources as well as their applications and extends from research on the fundamentalsto industrial implementation, see figure 1.

Two big project clusters, initiated by the IFSW, are based on this holistic approach. The project cluster LEICHTER (see also LASER MAGAZIN 2/2000) is focussing on the utilisation of disc-lasers for welding of lightwheight structures. The herein used beam sources, provided by the company Haas- Laser are based on inventions and developments of the IFSW.
Within the project cluster PRIMUS the interlocking between research on beam sources and processing development is even closer (see LASER MAGAZIN 5/2000). There beam sources with pulse durations in the range of pico- and femtoseconds and simultaneously their application for micro drillingand surface structuring is investigated. Results from the process development will immediately be taken into consideration for the development of the beam sources.
In the following most recent results from these project clusters will be reported. Additionally a new research activity, the magnetically supported laserbeam welding will be introduced.

Laser development and laser optics

The focus in the frame of the project cluster PRIMUS is put on the concept, the realisation and the investigation of a ultrashort pulse laser system for applications in materials processing, with an average power exceeding those of comparable systems, and suitable for industrial use.
As shortpulse source an oscillator amplifier system is used (see fig. 2). A mode locked oscillator produces short pulses that are amplified in a regenerative amplifier during multiple passes. The resonator of the regenerative amplifier contains the pumping optics of a disc-laser with a thin Yb:YAG-disc with a mirrored reverse that is excited optically by a diode laser. A short pulse that is reflected inside the resonator is amplified by every passage through the Yb:YAG-disc. To couple the pulse in and out of the resonator, the latter contains an optical switch (pockel cell).

With this system an average power of 10 W at a repetition rate of 10 kHz is achieved which corresponds to a pulse energy of 1mJ.Atarepetition rate of 1 kHz up to 4,5 mJ are demonstrated. The beam quality of M^2=1,3 is very good and the pulse duration realised until now is 4,5 ps.

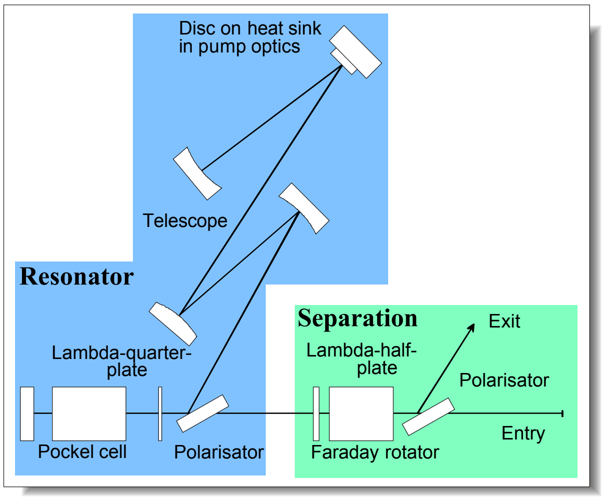

Fig. 2: Principal scheme of the regenerative amplifier

Micromachining

Another research focus at the IFSW within PRIMUS are the applications of the ultrashort pulse laser technology in precisematerials processing.
Fundamental investigations concerning drilling and surface ablation showed, that with decreasing pulse duration an improved structure precision as well as an increased ablation rate can be achieved. The often heard expectation, however, that ablation with ultrashort pulses should be free of melt production and plasma shielding, was not confirmed. Both occurred even at a pulse length as short as 120 fs. Nevertheless, an unprecedented level of accuracy was achieved by developing adequate process techniques and system components. The figure of a

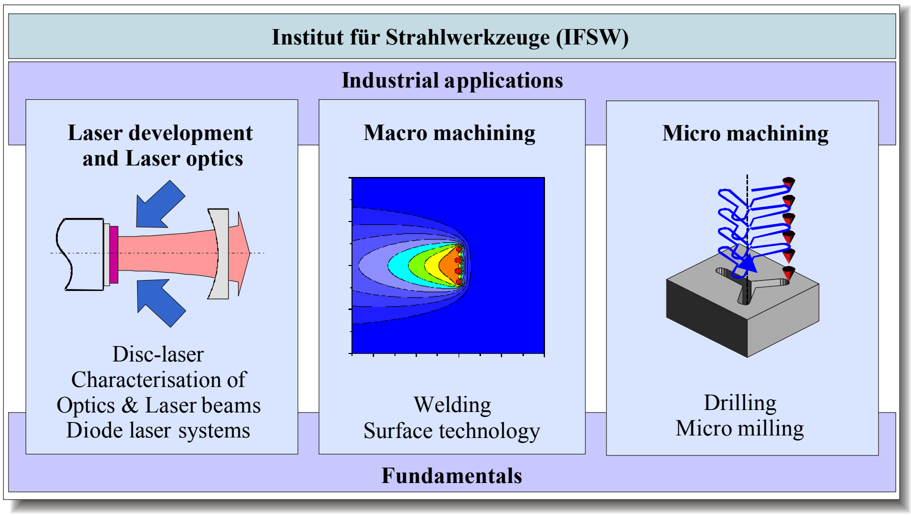

Fig. 1: Research fields and structure of IFSW

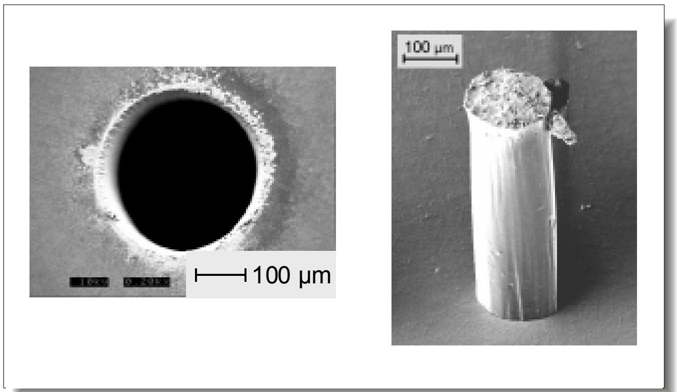

Fig.3: Left: Entrance of bore in steel of 1 mm thickness (X5 CrNi 18-10). Helical drilling with helical diameter of 100 µm, 130 fs pulse duration, 100 J/cm² energy density
Right: Replica of laser drilling in steel of 0,5 mm thickness (120 fs, 80 J/cm²)

micro drilling, taken with a scanning electron microscope (REM) shows, that by using an optimised helical drilling process in combination with ultrashort laser pulses, round bores with high accuracy and negligible redeposit at the entrance can be obtained (see fig. 3). The REM figure of the replica of the drilling demonstrates the obtainable good cylindrical shape with a high aspect ratio, sharp-edged entry and exit orifices as well as the smooth wallsurface.

Macro machining

In march 1999 the IFSW started with a BMBF project called "Innovative lightweight construction by energy reduced joining with laser systems of state of the art" (LEICHTER). Objective of the project is, to demonstrate the application potential of diode pumped solid state lasers with high beam quality for the economical production of lightweight structures.

For the first time worldwide the company HAAS-Laser is providing the institute with diode pumped solid state lasers in disc configuration for the duration of the project. The significantly improved beam quality of these systems compared to conventional solid state lasers offers noticeable advantages concerning systems- as well as process- techniques. E.g. it was immediately possible to show by experiment the positive effect of the high beam quality on the welding of aluminium alloys. In Fig.4 the influence of the focal diameter d_F on the threshold for deep penetration welding is shown. Thus with high beam quality and corresponding small d_F it is possible, to do deep penetration welding of aluminium already with a laser power of 0,5 kW. Minimal energy deposition, small distortion and therewith economical production are the result.

The high beam quality allows for the construction of slim, compact processing heads. Thereby the accessability is improved and integration into the robot system is facilitated.

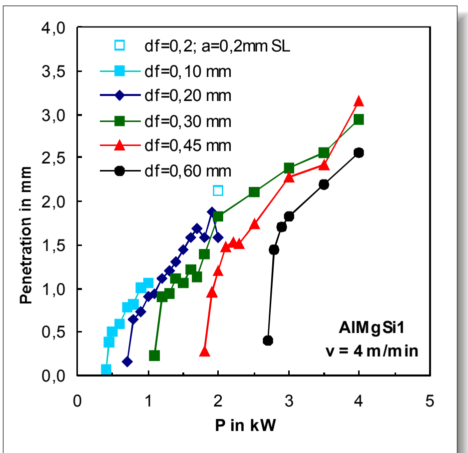

Fig.4: Influence of the focal diameter d_F on the threshold for deep penetration welding of aluminium

Another research activity deals with the magnetically supported laser beam welding (MGL), developped at the IFSW. Herein the aim is, to execute controlled electro magnetic forces on the melt pool by application of an external magnetic field, with the objectives:

- to suppress humping,
- to improve seam quality (see fig. 5),
- to reduce spatter production,
- to influence on the shape of the weld seam

and thereby obtaining a welding process overall more stable and efficient.

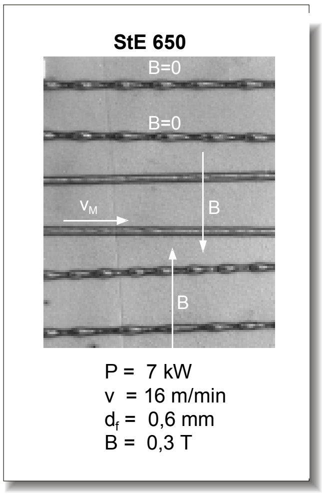

Fig. 5: Influence of the magnetic field on the seam surface

Laserbeam sources in the Micro department at IFSW

Ultrashort pulse laser:
- Clark-MR: CPA 2001+
(lamp pumped)
775 nm, M^2<2
1 kHz: 1,3 mJ; 100 fs - 3 ps
-Spectra-Physics: Hurricane
(diode pumped)
800 nm, M^2 < 2
1 kHz: 1,0 mJ; 90 fs - 7 ps

Short pulse laser:
- Lambda Physik: StarLine
(diode pumped)
1064, 532, 355 nm, M^2= 1
1 kHz: 8 mJ; 10 ns
2 kHz: 4 mJ; 20 ns
3 kHz: 2,5 mJ; 30 ns
- Haas-Laser: Vectormark
(lamp pumped)
1064 nm, M^2 < 1,5
4 kHz: 2,0 mJ; 200 ns; max. 50 kHz, cw

Laser beam sources in the Macro department at IFSW

- TLF5000turbo
CO_2-Laser
output power:
P_L = 5 kW (cw)
M^2 = 2
- HL4006D
Nd:YAG-solid state laser
power at work piece:
P_L = 4 kW (cw)
M^2=80
- HL3006D
Nd:YAG-solid state laser
power at work piece:
P_L = 3 kW (cw)
M^2 = 80
- Diode pumped Disc-Laser
Power at work piece:
P_L = 4 kW (actual) up to 6 kW (end of 2001)
M^2 < 20

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