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 lightweight 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 drilling and 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. 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 1 mJ. A repetition rate of 1 kHz up to 4.5 mJ are demonstrated. The beam quality of M²=1.3 is very good and the pulse duration realised until now is 4.5 ps.

### Micromachining

Another research focus at the IFSW within PRIMUS are the applications of the ultrashort pulse laser technology in precision materials 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
microdrilling, 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 accessibility is improved and integration into the robot system is facilitated.

Another research activity deals with the magnetically supported laser beam welding (MGL), developed at the IFSW. Herein the aim is, to exce-