Goals and status of the German national research initiative BRIOLAS (brilliant diode lasers)

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ABSTRACT

High power diode lasers play an important role in laser and systems technology. Over the past years the necessity arose to improve power and beam quality (i.e. brilliance) of the high power diode lasers. This is not only for building pump sources but also to provide appropriate light sources for various direct applications of high power diode lasers. The funding initiative "BRIOLAS" launched by the German Federal Ministry of Education and Research (BMBF) is the answer to this demand. In ten projects diode technology, manufacturing technology, quality, pump applications, materials processing applications, medical systems and applications and also applications in the display technology are intensively investigated; the results shall be basis for new applications, for new products and for new ideas in the field of high power diode laser technology. The individual projects are vertically structured and in each project the entire technology chain necessary for the final success is represented by the participants. The first project has been launched end of 2004 in frame BMBF's funding program "Optical Technologies", the last one was started just recently. The BMBF is supporting the BRIOLAS-initiative with about 30 M€. This article provides a general overview over the target and the actual status of the initiative.

Keywords: High power diode laser; fiber laser; RGB-lasers; mounting technology; fiber coupling; compound resonators; medical lasers (PDT); remote laser processing; visualization; display technology.

1. INTRODUCTION

Optical technologies are an important and extremely innovative sector in the modern industrial community and are found in various highly technical applications as well as in daily life. Consumer products, communications and data technology, production technology, health care, bio technology, security technology and many other areas are unthinkable without the optical technologies. The importance of these technologies for the German economy may be underlined among others by the high effort which is spent by German industry for research and development: according to a study of Spectaris[a] the average expenditure for research and development in optical technologies in the field of "lasers and optical components" was at 11.1 % of turn over in 2005[1]! Nevertheless it is recognized that even such high effort is not sufficient for technological leadership, to reach the ambitious targets and to cover the risk of the research. Therefore, the German Federal Government supports these activities, which are related to about 110,000 jobs in Germany directly and about to the tenfold number indirectly[2]: in the funding program entitled "Optical Technologies", which has been launched in 2002 and which is planned for ten years about 70 M€ support per year are provided from the government.

2. THE BRIOLAS PROJECT ASSOCIATION

In many of the applications mentioned in Sect. 1 semiconductor lasers play an essential role, which is easily proven by the market analysis numbers: despite the slump in telecommunication at the beginning of the century today again 60% of the total turn over achieved with laser sources are made with diode lasers[3]. Even if the lions share of this market is

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[a] Spectaris, the German Industry Association for Optical, Medical and Mechatronical Technologies, see: www.spectaris.com

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dominated by the almost unbelievable high numbers of low power diode lasers in telecommunication, data technology and consumer electronics, an increasing demand for reliable, brilliant high power diode laser modules in a power range beyond 10 W up to the kW range is existing. This demand is reflected in the themes and targets of the BRIOLAS (**Br**illiant d**io**de **las**ers) project association. Some of the targets are the result of earlier national projects, which have been funded by BMBF from 1997 to 2003, as e.g. Novalas[4] (In**nova**tive **las**ersystems based on high power diode lasers) or MDS[5,6] (**M**odular **d**iode laser **s**ystems) in frame of the Laser 2000 initiative. The BRIOLAS initiative, funded with 30 M€ for the first five years, however, covers a wider field as compared with the above mentioned preceding programs, which have been strongly focused on materials processing.

BRIOLAS is consisting of ten joint projects, which are represented in table 1 (in alphabetic order); for budget reasons the projects have started at different time. All projects are planned for a duration of three years.

Table 1: Titles and project partners for the ten individual BRIOLAS projects[b]

Project Project duration	**Title** - Project partners
BriLasI 01.10.04 – 30.09.07	**Brilliant High Power Diode Lasers for Industrial Applications** - Osram Optosemiconductor (project leader); Dilas Diodenlaser; Heidelberger Druckmaschinen; Jenoptik Laserdiode; Laserline; Rofin-Sinar Laser
BriMo 01.04.05 – 30.03.08	**New Hybrid Mounting Technologies for Potentially Automatic and Cost-effective Manufacturing of Long-term Stable and Power Scalable High Power Diode Laser Sources** - Jenoptik Laserdiode (project leader); Curamik Electronics; Fraunhofer Institut für Angewandte Optik und Feinmechanik (IOF); Grintech; Jenoptik Diode Labs
HELIOS FL 01.07.05 – 30.06.08	**Highly Brilliant Multi-Kilowatt Fiber Lasers for Industrial Applications** - Rofin-Sinar Laser (project leader); BMW (associated member); Ceram Optec; Fraunhofer Institut für Lasertechnik (ILT); Institut für physikalische Hochtechnologien (IPHT)
LaDiCoR 01.05.05 – 30.03.08	**Laser Diode Pumped Compound Resonators** - Crystal (project leader); A.R.C. Laser; CanLas; CryLas; Messtec; Smart Laser Systems
RoFaLas 01.07.05 – 30.06.08	**Innovative Laser Beam Sources for Scanner-less, Robot-controlled Remote Welding Applications** - KUKA Schweissanlagen (project leader); EADS Deutschland; IPG Laser; IWB - Institut für Werkstoff- und Betriebswissenschaften der TU München; Precitec; Precitec Optronic
RoLas 01.11.05 – 31.10.08	**Red Semiconductor Laser Sources for Medical Applications** - Osram Optosemiconductor (project leader); Ceram Optec; Dilas Diodenlaser; Dornier MedTech Laser; Fraunhofer-Institut für Lasertechnik (ILT); Fraunhofer-Institut für Optik und Feinmechanik (IOF); Unique m.o.d.e.
Scharp 01.04.06 – 31.03.09	**Damage Reduced and Productive Micro Welding with Brilliant Laser Beams** - Siemens (project leader); Forschungsgesellschaft für Strahlwerkzeuge; Robert Bosch; Schulz Systemtechnik
SeFaLa 01.12.04 – 30.11.07	**Side-pumped High Power Fiber Lasers Based on Novel Fiber Technologies** - Laserline (project leader); Heraeus Quarzglas; Heraeus Tenevo; Institut für Phys. Hochtechnologien
TRUST 01.01.05 – 31.12.08	**Reliability Analysis of Brilliant High Power Diode Lasers in Industrially Relevant Operating Regimes** - Jenoptik Laserdiode (project leader); Dilas Diodenlaser; Freiberger Compound Materials; Max-Born-Institut; Osram Optosemiconductor; Rofin-Sinar Laser
VisuLase 01.10.04 – 30.09.07	**Visualization in Automotive and Consumer Sector with Semiconductor Based RGB Lasers** - Osram Optosemiconductor (project leader); BMW (associated member); Carl Zeiss Jena; Elovis; Geringer Halbleitertechnik; Robert Bosch; Schott Glas

[b] Detailed information about the project partners can be received by their individual homepages, available via the BRIOLAS-homepage http://www.briolas.de

The BRIOLAS initiative combines different sub-projects with different targets around the core topic „diode laser". A schematic representation of the emphasized points of the projects presented in Table 1 is depicted in Fig. 1, where the projects are subdivided into the three areas, "diode lasers", "diode pumped lasers" and "applications and systems". According to this, there are four projects, which are closely related to the diode laser technology, three projects, which mainly focus on diode lasers as pump sources and finally three projects, which have the application or integration of diode lasers or diode pumped lasers in the centre of interest. As far as unclassified, in the following the targets and results of the projects shall be presented, sorted according to their priorities as according to Fig. 1.

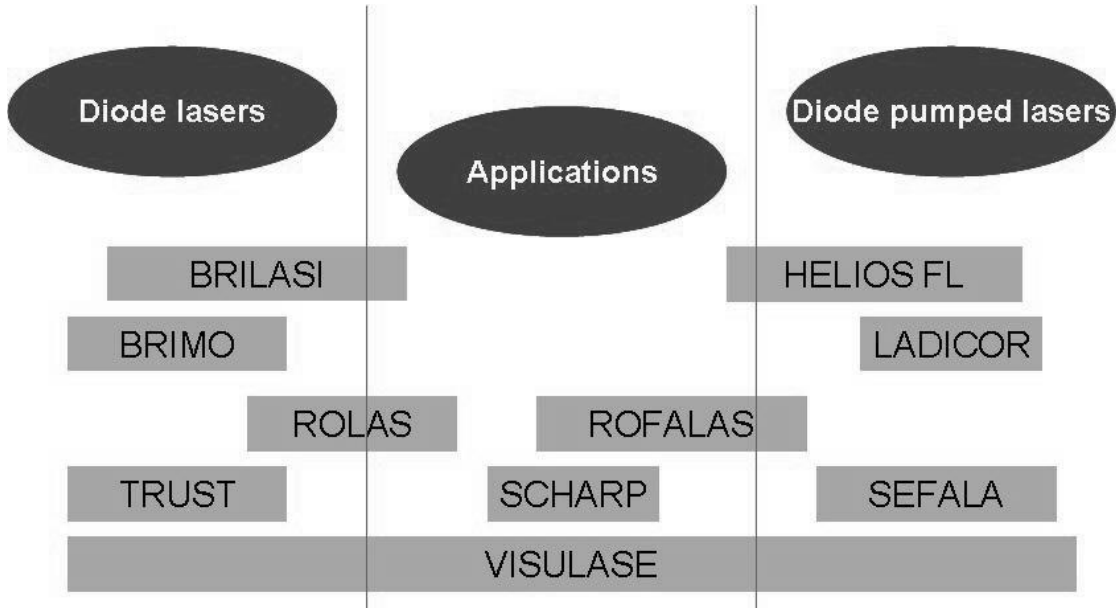

Fig. 1. Classification of the BRIOLAS projects according to the project priorities

2.1 Diode laser projects

Projects BRILASI, TRUST, BRIMO and ROLAS are closely related with diode laser technology. Closest to the original theme "brilliant diode lasers" is certainly the BRILASI-project, in which the increase of brilliance for high power diode lasers is the explicit project target. TRUST is dealing with an intensive investigation of phenomena, which are limiting the lifetime and reliability of the diode lasers; new testing methods as well as quality criteria shall be worked out in this project. BRIMO is focused on mounting technology and fiber coupling, whereas the topic of ROLAS is the development in the red spectral range for applications in the medical area, especially the therapy of cancer.

2.1.1 The BRILASI-project (Brilliant diode lasers for industrial applications)

As well known, brilliance is proportional to power and inversely proportional to beam quality (i.e. the beam parameter product or the beam quality factor M^2). Consequently, two possibilities are given to enhance brilliance: Increase of output power at constant beam quality or improvement of beam quality at constant output power. Of course all measures must not worsen efficiency, lifetime or other important features of the unit.

One approach to improve beam quality of a single emitter and thus, the laser bar is the so called "tapered laser" (see Fig. 2); work on this technology has already been started in the MDS-project[5-8]. The results achieved in the MDS-program will be further improved in the BRILASI-project; finally an output power of 40 W per bar at $M^2<4$ for the individual emitters shall be reached; demanded lifetime ($t_{50\%}$) is 20,000 hours or 25 Mshots in the so called "long-pulse mode"[c]. To provide the possibility of wavelength coupling, units at 808 nm, 880 nm, 940 nm and 980 nm shall be provided. Furthermore, the concept of Nanostacks®[9], in which monolithically stacked pn-transitions, connected by tunnel junctions shall emit 500 W qcw is followed up in the BRILASI project; actually 300 W qcw are achieved with a threefold stacked structure and with a differential efficiency of about 3,15 W/A.

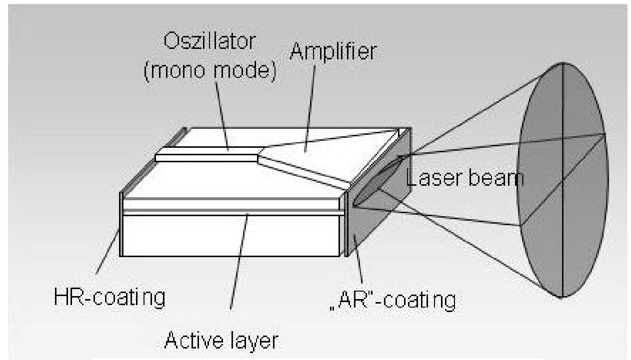

Fig. 2: Scheme of a tapered laser

Besides the above mentioned innovative concepts also traditional bars with broad area emitters are investigated in the BRIOLAS project and driven to higher brilliance and at the same time to higher reliability. Thus, the project targets are 175 W optical output power for bars at 880 nm, 940 nm and 980 nm and 110 W for 808 nm bars respectively. The lifetime target for all bars is $t_{16\%} \geq 15{,}000$ hours (or 25 Mshots respectively). Since an essential criterion for lifetime is excess heat, improvement of efficiency is highest priority in the development efforts for modern high power diode lasers, as also indicated by other programs[10]. The efficiency of the bars which are to be developed in the program is $\eta \geq 75\%$ for the broad area bars at 880 nm, 940 nm and 980 nm and $\eta \geq 60\%$ at 808 nm (Fig. 3). Just recently a record high of 64% efficiency has been reached in frame of the BRILASI project at an output power of 120 W for 808 nm bars[11, 12]. Bars with a resonator length of 1.2 mm have been used in this experiment; 150 W optical output power have been achieved with 63% efficiency with similar bars, but with a resonator length of 2 mm.

Other impressive records have also been reached in the project: In a special set-up for very efficient cooling – micro-channel coolers from both sides of the bar (Fig. 4) – 440 W optical power could be extracted from one single bar (λ=940 nm, resonator length 2 mm)[d]; a current of 480 A has been injected into the bar to reach this power[13].

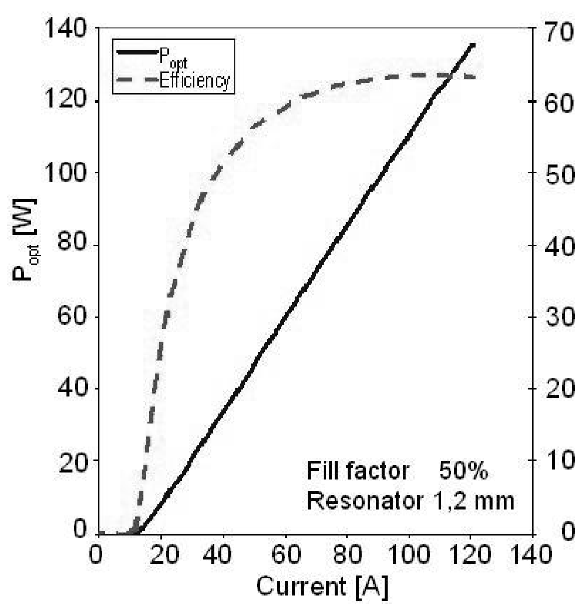

Fig. 3 (left): Output power (P) and efficiency (η) vs. current (I) for a 1.2 mm bar at 808 nm[11,12,13]

Fig, 4 (top): dual-side cooling of a diode laser bar between two micro-channel coolers[13]

[c] "long-pulse mode" stands for a running mode, which puts highest stress to the bar (see also sect. 2.1.2); typically current is risen from 0 to I_{max} at a repetition rate of 1 Hz at a 50% duty cycle.

[d] Outside of the BRILASI project an even higher power, 509 W at 540 A has been reached in a similar setup using bars with 3 mm resonator length

2.1.2 The TRUST-project (Reliability analysis of brilliant high power diode lasers in industrially relevant operating regimes)

Increased power as well as increased beam quality, i.e. the aimed higher brilliance is naturally leading to a higher stress on the critical sites of the diode laser and thus, causing a thread to the lifetime; from the point of view of an industrial use of the results which are achieved in the project a reduction of lifetime is not acceptable – just the opposite is the case: even if light with higher brilliance is provided lifetime must be elongated to fulfill future needs of industry. Therefore, the TRUST project is exclusively devoted to the investigation and understanding of failure mechanisms in high power diode laser bars. Contrary to single emitters, where statistical failures (i.e. failures with constant failure rate) are normally dominating, the lifetime of diode laser bars is limited by wear-out failures (i.e. failures with increasing failure rate over time). As standard statistical methods, as e.g. multi-cell test procedure, cannot be applied, the careful and comprehensive analysis of failure mechanisms is considerably more complex on one hand, but absolutely necessary on the other. Especially if later on an accelerated aging test shall be applied, it must be guaranteed, that other failure mechanisms are not initiated, which cover the true values for the aging process. A clear understanding of the physical reasons of failures is mandatory and thus, the target of this project.

The investigations in the project work are starting as early in the manufacturing process as possible, i.e. with the analysis of the wafer quality: In a so called "wafer mapping"[14] essential defects, e.g. dislocation density, local stress values and carrier concentrations are determined and registered before the further processing of the wafer is started. For each laser bar generated on this wafer its location can unequivocally be assigned (Fig. 5) and thus, a statement can be made, if certain wafer data or defects on the wafer can be correlated with corresponding failures of the laser bar.

After the mounting diode laser bars are very carefully inspected and checked for hot spots by thermo-graphical methods[15,16] (Fig. 6). It is extremely important to recognize and analyze the impact of certain effects on the long term stability; parameters continuously monitored are among others output power and temperature of the device. The influence of mounting technology (soft- or hard-solder), pulsed and cw regime etc. are of course also taken into account. Defective bars are thoroughly investigated among others by CL/PLM[e] analysis. Results are evaluated by statistical methods.

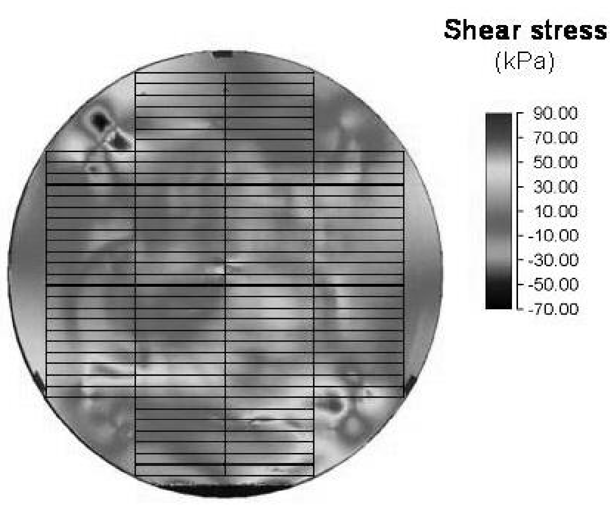

Fig. 5: Stress mapping of a wafer (SIRD® [f]). The grid gives the location of the laser bars later on; each bar is marked for later allocation[14]

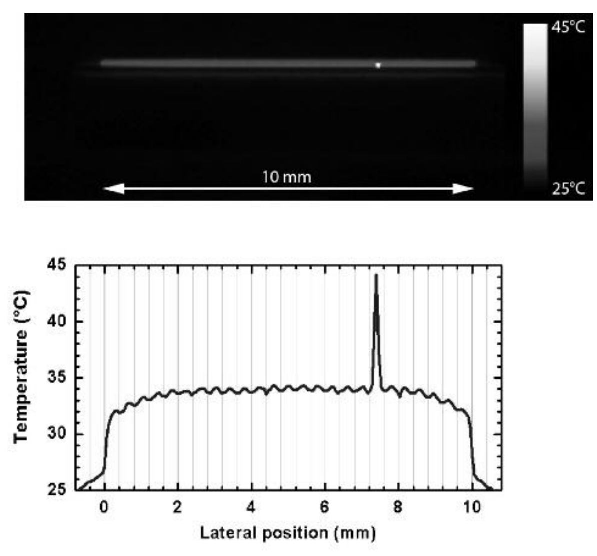

Fig. 6: Thermo-graphic measurements on a 10-mm diode laser bar and the corresponding temperature distribution[16]

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[e] CL/PLM: Cathodo-Luminescence / Photo-Luminescence-Microscopy

[f] SIRD: Scanning Infrared Depolarization, JenaWave GmbH, US Pat. Nr. 20060213424

2.1.3 The BRIMO-project (New hybrid mounting technologies for potentially automatic and cost-effective manufacturing of long-term stable and power scalable high power diode laser sources)

If the aging mechanisms are well understood and thus, bars show a lifetime beyond 30,000 to 50,000 hours, most probably not the semiconductor technology is the lifetime limiting component in a high power diode laser system: The limitation will then be rather controlled by the mounting and cooling technology, which is already proven by experiences in the past. Consequently a further target in a comprehensive diode laser program must be to improve the mounting and cooling technology as well as the micro-optical components for the beam forming. This matter is extensively considered in the BRIMO project.

The cooling technology, which has to be investigated in the project is based on a special heat conducting ceramic structure, which carries the necessary electrical circuits as well as the laser bar on a sub-mount (Fig. 7). The coupling of the light into a fibre requires a re-arranging of the emitted beam, which has so far been performed by a sequence of relatively complex micro- and macro-optics. This method, however, generates rather high costs as well as considerable space requirements, which leads to a reduced interest of such sources in the market. A cost efficient approach for a solution is considered to be the use of gradient index (GRIN) lenses, in which the refractive power is generated by an adapted profile of the refractive index rather than by curved – usually aspheric – surfaces (Fig. 8). Among others an important challenge in this technology is to reach the required high numerical apertures and short focal lengths, which means high dopant concentrations. A big benefit of the GRIN-lenses are the plane surfaces, which make the mounting technology simple (Fig. 9). A final goal of the project is a concept for an automatic manufacturing and mounting of such modules.

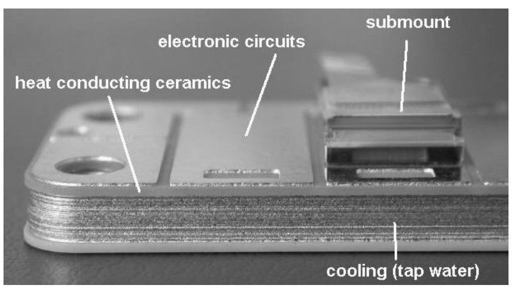


Fig. 7: heat sink with diode laser on sub-mount[17]

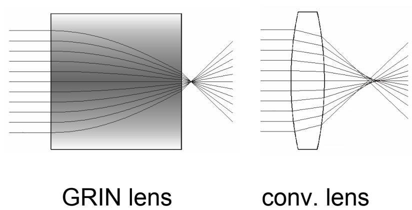


Fig. 8: comparison of GRIN lens and conventional lens[18]

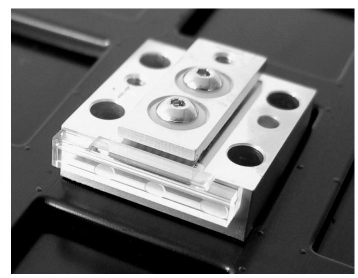


Fig. 9: fast axis collimator in GRIN technology in front of a standard laser bar[18]

2.1.4 The ROLAS-project (Red Semiconductor Laser Sources for Medical Applications)[19]

The target of the ROLAS project is the development of reliable and cost effective semiconductor laser sources in the red spectral region at wavelengths of 635 nm and 652 nm for applications in the medical field, especially for cancer therapy.

The treatment of certain tumors in the human body is either exclusively or at least in the most effective way done by photodynamic therapy (PDT). As an example, pancreas cancer can only be operated in less than 10% of all cases and is leading to death of the patient within five years in 94% of all cases. It is expected, that the application of PDT might be much more successful and leading to a considerably higher chance of survival. For the time being larger implementation of this therapy fails because of the world wide lack of cost efficient, reliable and powerful laser sources in the red spectral regime. The partners in this joint project are demanded to work out the basic technology for such laser sources to realize fiber coupled modules and to apply them in first medical tests. Fiber coupled diode laser modules with an output power of 4 W at 635 nm and 652 nm are required. These wavelengths are matched to the absorption bands of actually authorized photo sensitizers, ALA (5-aminolevulinic acid) and Foscan®. Furthermore a diode laser module with 8 individually controllable ports and an output power of 2 W each shall be realized. The appropriate fiber diameters are between 200 μm and 600 μm; but concepts for the transition to smaller diameters shall be considered for future systems.

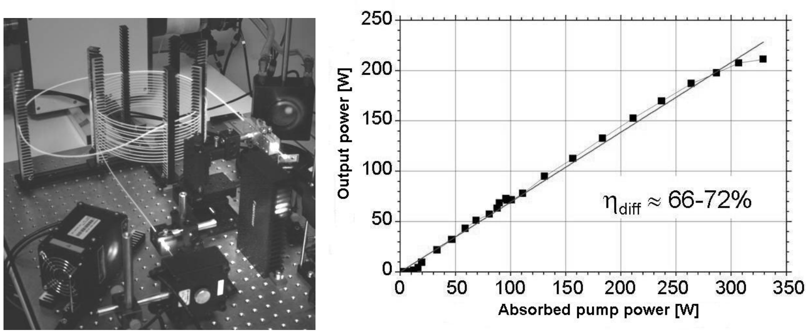
2.2 Projects related to diode pumped lasers

In the wavelength range between 750 nm and 980 nm about 25% of the turnover in the power range between 100 mW and 10 W are generated by pumping applications; if power above 10 W is considered even 35% of turnover is based of pumping applications[3]. Therefore, projects related to diode pumped laser systems cannot be missing in a funding initiative which is focused on market oriented requests for high power diode lasers. Two of the projects – HELIOS FL and SEFALA – are aiming at novel fiber laser technologies, whereas the third one in this group – LADICOR – is focused on the optimization of extremely miniaturized resonators.

2.2.1 The HELIOS FL-project (Highly brilliant multi-kilowatt fiber lasers for industrial applications)

Highly brilliant fiber lasers are at the threshold to industrial use. Nevertheless several questions are still unanswered and discussed controversially in the community. In the center of the HELIOS FL project stands therefore the work for a fair economical and technical comparison of fiber laser concepts among each other and with other diode pumped solid state lasers regarding their suitability for applications in an industrial manufacturing environment. The technical target is the realization of two experimental systems with different pumping concepts, “concentrated pumping” and “distributed pumping” [g]. The specifications for either of the modules are same and shall be 1 kW output power, linearly polarized and with a high long term stability. Two or three of such modules shall finally be coupled to a laser system with an output power ≥3 kW and a beam quality $M^2 \leq 3$.

For concentrated pumping brilliant pump modules are mandatory to realize high pumping efficiency. Tapered lasers, as investigated in the BRILASI project (see sect. 2.1.1) are one way to improve the brilliance of diode laser modules; therefore tapered lasers are also an important issue in the HELIOS FL project. In an experimental setup where tapered lasers at two wavelengths are used for concentrated pumping a differential efficiency of 70% could be reached (Fig. 10). For distributed pumping the experimental setup consists of 7 single emitters with 7 W output power each out of 100 µm fibers which are combined in a 7:1-coupler (Fig. 11). The resonator mirrors are realized by Bragg gratings.



Fig, 10: Test set-up for concentrated pumping (left); output power vs. pump power (right)[20]

Fig. 11: Test set-up for distributed pumping (7:1 coupling)[20]

The high power densities in the fiber as a consequence of the high brilliance and especially the maintaining of the polarization of the radiation require special concepts. Thus, the development of the active fiber, but also of the passive transport fiber are key activities in the HELIOS FL concept; not only classical double-clad structures are investigated in the project but also novel structures as air-clad fibers, micro-structured fibers and multiple-core structures; a cross section of a 7 x 7 multiple core fiber is shown in Fig. 12.

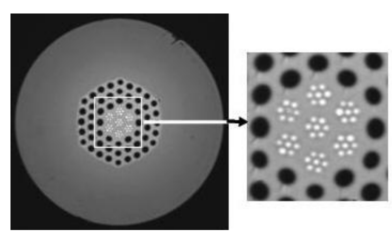


Fig. 12: Cross section of a micro-structured multiple 7x7 core fiber[21]

[g] In case of “concentrated pumping” pump power from a highly brilliant high power diode laser module is coupled into the pump core of the fiber at its end whereas in the second case several pigtailed pump modules with lower power are spliced to the pump core of the fiber.

2.2.2 The SEFALA-project (Side-pumped high power fiber lasers based on novel fiber technologies)

Quite a different strategy of fiber laser technology is investigated in the SEFALA project: By an innovative concept it shall be possible to use almost bare[h] diode laser bars and thus pumping modules at low costs as well as fibers with a large laser active volume. This is a novel approach for beam quality improvement of high power diode lasers. Target of the project is a side-pumped rare earth fiber laser (see Fig. 13) providing a cw-output power in the kilowatt range and with a moderate beam quality – which is the most significant difference to the goals of the aforementioned HELIOS FL project. Even if special fiber technology is also in the core of interested in this program the demands are significantly different to the ones in the HELIOS FL program.

In a first step a demonstrator with an output power of about 1000 W at a beam parameter product of 25 mm mrad will be realized. The final target in a second step is the power increase of the fiber laser up to 4 kW by geometrical coupling of individual modules, whereas the beam quality shall be maintained at 25 mm mrad. Of course also lifetime investigations are performed simultaneously: as a minimum 20,000 hours usable lifetime must be reached by the pumping modules.

The selected pumping concept (Fig. 13) naturally requires a construction of the pumping arrangement which is considerably different compared to the "traditional" fiber lasers. Model calculations have been performed, which provide an optimized cooling concept on one hand and the requirements for fiber coating and cooling medium on the other.

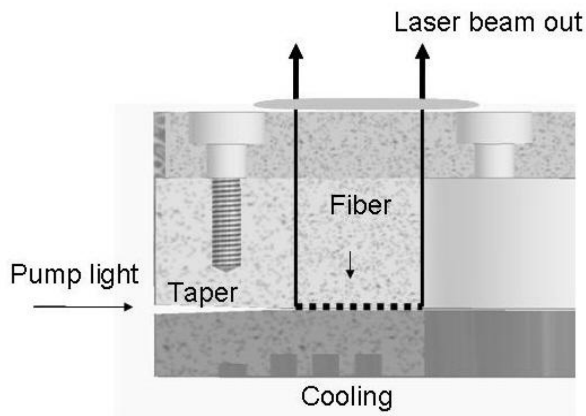


Fig. 13: Scheme of the set-up of the side-pumped fiber laser[22]

To ensure the industrial usability of this laser concept, application tests as well as long term use of the system in an industrial environment is part of the project.

2.2.3 The LADICOR-project (Laser diode pumped compound resonators)[23]

The main purpose of the project is to establish a new resonator concept, which will find a wide application area – similar as in the case of the disk laser. It offers the possibility to integrate semiconductor lasers and solid state lasers. In the project the technological preconditions for the use of multiple loop resonators in longitudinally pumped solid state lasers shall be investigated. The key components (micro-optics, active and passive coupling elements, integrated frequency doublers) will be realized. Altogether the preconditions for a new laser family shall be investigated, which can be used in different market segments (materials processing, medical technology, analytics etc.). The targeted systems shall be compact and cost efficient in manufacturing; after the end of the project it shall be possible for SME's to manufacture such systems based on commercially available pump stacks without the implementation of expensive semiconductor processes.

The basic idea consists of the fact, that the spatial structure of the radiation in a solid state laser will be adapted to the pump light distribution of diode laser bars. This way a better efficiency and a better beam quality will be reached. One possibility to use the many independent pump rays of a diode laser bar is coherent coupling within the solid state laser; the coupling of the sub-resonators will be obtained by partially transmissive mirrors. In this setup the rays of the pumping single emitters of the diode bar will be united in groups.

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[h] For beam forming only fast axis collimators are used at the pump bars

2.3 Projects focusing on applications and systems development

In the third group of projects applications and systems development is in the center of interest; requirements of and feedback with the applications or the systems are closely related to the respective laser sources.

2.3.1 The ROFALAS-project (Innovative laser beam sources for scanner-less, robot-controlled remote welding applications)

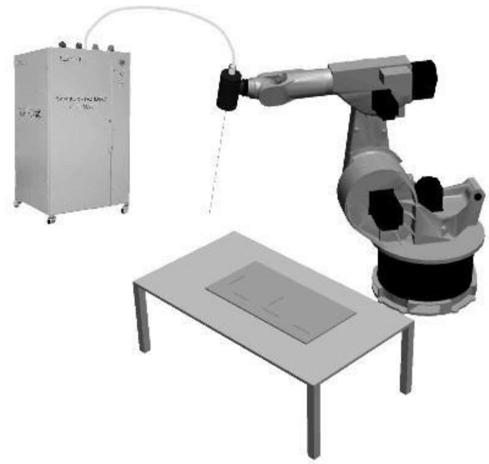

Fig. 14: scheme of the set-up for scannerless remote welding with a robot[25]

If high beam quality is provided as e.g. in high power fiber lasers the normal consequence is the realization of small focus diameter; however, this is not the sole use of high beam quality: More and more applications can be found, where improved beam quality is converted into long working distance, as in so called "remote applications", preferably "remote welding". In the existing technologies a scanner box with galvo-mirrors is preferably used for the beam positioning[24]. In the ROFALAS project the beam quality of the fiber laser shall be used for a remote welding configuration, in which no scanner is used. In the aimed set-up the robot directly positions the beam, i.e. the positioning of the welding spot on the work piece is purely performed by the robot motions of the focusing optics (zoom optic system) as shown schematically in Fig. 14. The working distance between the optic system at the robot and the work piece will be about 1 meter. The challenge for the laser development is in the required beam parameter product of about 4.5 mm mrad at an output power of 8 kW. From the targets of the project simultaneously high demands for accuracy and speed of the robot are resulting, specifications, which have not been required so far. Also new concepts for movement and track planning of the robot are mandatory. Furthermore, as in all remote applications clamping technology, protection gas feeding, and process control are topics of high importance. At the end of the project, a complete kinematic concept for scanner-less remote welding shall be available which allows the application in the industrial market segment.

2.3.2 The SCHARP-project (Damage reduced and productive micro welding with brilliant laser beams)[26]

Welding with highly brilliant (diode pumped) lasers is also the theme in the SCHARP project, but – contrary to the activities mentioned before – in the classical set-up with a welding head, an appropriate optical system and a gas feeding system, as it is used successfully in a high number of welding applications in the field. However increasing miniaturization along with intensified quality requirements brings the processes used so far to their limits. At the same time the production costs and therewith the productivity is under considerable strain. The new diode pumped fiber and disc lasers offer an opportunity for completely new process strategies as a result of their incomparable focusability at high laser power.

Extraordinarily high beam parameter quotients (power divided by focus diameter[27]) are now available. This enables deep penetration welding effects and joint geometries not achievable before and therefore never examined in the past. The small interaction zones as well as the high aspired welding speeds require new concepts within all systems, starting with work piece handling, through beam delivery, to process control.

In this project the scientific-technologic basis as well as the necessary system technology shall be examined and developed further on.

Substantial goals are:

- Minimization of distortion by minimization and/or balancing of the heat input
- Reliable welding of crack-critical material combinations by suppression and/or hindrance of metallurgical processes
- Increase of the productivity

2.3.3 The VISULASE-project (Visualization in automotive and consumer sector with semiconductor based RGB lasers)[28]

A completely different application is the theme of the VISULASE project: In this project optical and electro-optical design concepts are considered for variously applicable displays with a compact RGB light source. Demonstrator set-ups are to be realized at the end of the project for feasibility proof. The laser projection system will consist of semiconductor-based red, green and blue laser sources (RGB) with high brilliance, of a micro-mechanical deflection unit or a micro-display respectively, of modulation-, control- and deflection-electronics, imaging optics and of a suitable projection surface.

A very prominent application of such a projection system is a head-up information system for the driver in a car as depicted in Fig. 15. Such set-up is almost not possible with conventional light sources, e.g. because of the high loss at the projection screen (wind shield), because of missing possibility for compensation of the surrounding brightness and especially because of rather large volume. A laser projection system, as schematically shown in Fig. 16, can solve all the problems. Miniaturization and high demand on reliability is the yardstick. Different concepts are followed for the laser light sources: InGaAsP laser diodes for the red spectral range, frequency conversion of diode pumped solid state lasers or optically or electrically pumped semiconductor lasers for the green and the blue spectral range; beyond that also InGaN technology for the blue laser source is investigated.

This way the VISULASE project is integrating all areas in the BRIOLAS project association: Diode lasers and diode pumped lasers in the development of the RGB laser source, micro-optics, micro-mechanics and control-electronics and technology in the application.

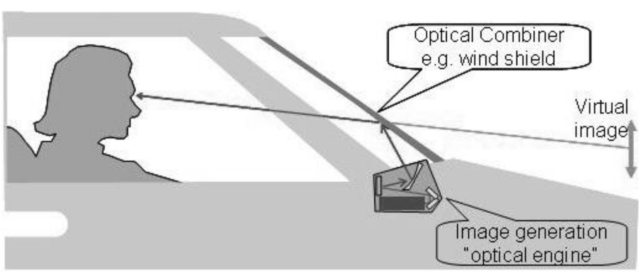

Fig. 15: Set-up for a head-up display in a passenger car[29]

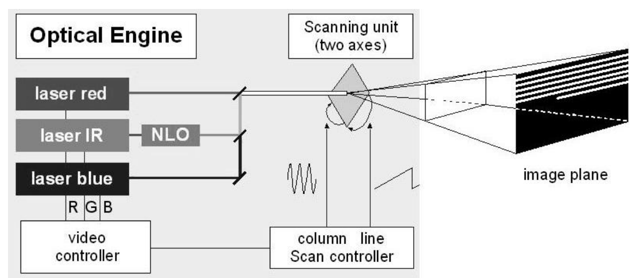

Fig. 16: Scheme of "flying-spot" laser projection[29]

3. CONCLUSION AND OUTLOOK

In frame of the funding program "Optical Technologies" the German Federal Ministry of Education and Research (BMBF) is supporting strategically and economically important key technologies in the field of optics. In the acting area "optical systems for the next generation" brilliant diode lasers are the topic of interest, grouped in the BRIOLAS funding initiative. The project association is consisting of 10 vertically structured joint research projects of which four are directly linked with diode laser technology, three are dealing with diode pumped systems and three are focusing on applications or special systems. The projects have been launched sequentially between October 2004 and April 2006 and are planned for a duration of 3 years each. The total budget of the BRIOLAS initiative is about 60 Mio. €, funded to about 47% by the BMBF. The funding program "Optical Technologies" is a ten year measure; a successful performance of the BRIOLAS initiative provides the opportunity of a follow up activity for the continuation of the work or the generation of new project ideas based on the actual work.

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[i] Association of German Engineers – Technology Center

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