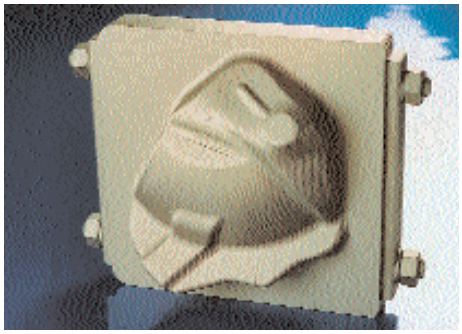
Fraunhofer Institut Werkstoff- und Strahltechnik

Annual Report 2002



Internet: www.iws.fraunhofer.de

Fraunhofer Institut Werkstoff- und Strahltechnik

Annual Report 2002

Preface

Editor: The economic situation in Germany during 2002 was not particularly good. How did the IWS do under these conditions?

Prof. Beyer: We achieved a balanced budget and matched the outstanding result of 2001. All IWS employees can be very proud of this.

Editor: Reviewing the year 2002, which events should be especially emphasized?

Prof. Beyer: To begin with there was the "10th anniversary celebration event of the Fraunhofer Society in the new states" at the IWS, including the groundbreaking of the new facility extension. We consider the approval of a large-scale project grant for the laser application in the aerospace industry through the state of Saxony with the support of the Fraunhofer Society as a special highlight.

Editor: Are there any outstanding 2002 results to mention?

Prof. Beyer: In 2002 we managed to further improve the world record for the reflectivity of X-ray mirrors for lithography applications.

In the area of wear protection we deposited diamond-like coatings with a thickness of 10 µm. So far the thickness had been limited to about 1 µm due to intrinsic stresses in these coatings.

The IWS developed a novel process to harden the surface region of age-hardenable high performance steels. This process will be applied in turbine manufacturing.

Editor: Which transfers of IWS developments into industry can be emphasized for 2002?

Prof. Beyer: Among others, there are two laser induction welding systems to be mentioned which were installed in the automotive industry as well as a process controlled laser hardening machine. Beyond that we were able to integrate a large number of IWS developments and components into manufacturing systems.

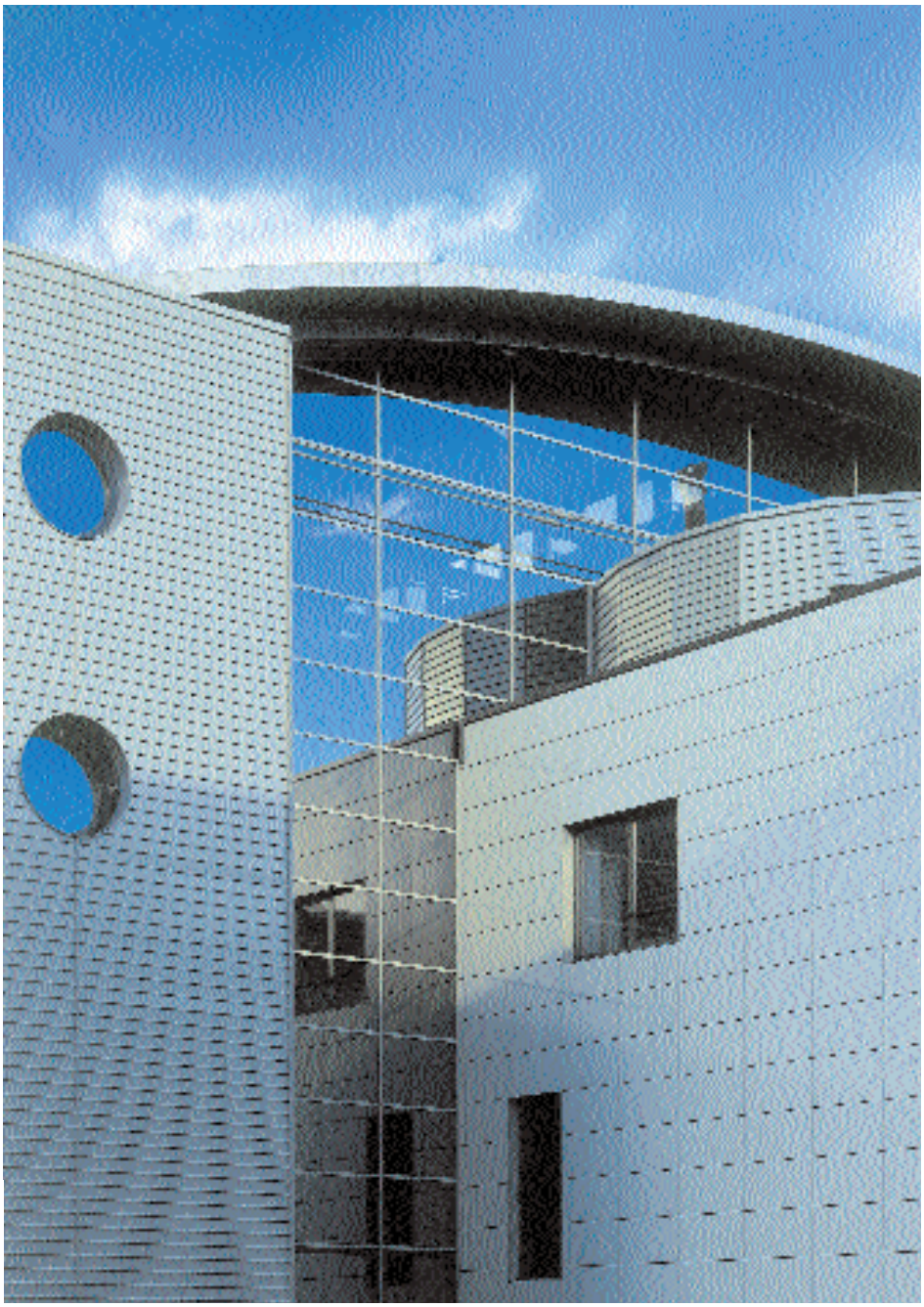
Of particular note is the launch of operation of the PVD metal band coating system at the DOC and the novel ZE-Mg coating stack for corrosion protection. Metal sheets coated in this manner can also be laser welded if the joints are overlapping.

Editor: How will the IWS position itself to "weather the storm" during the next few years when the economic conditions are predicted to become continually more difficult?

Prof. Beyer: The laser and surface technologies are cross sectional technologies. Therefore the IWS stands on two forward-looking columns, which prepare the institute well for the coming years. The utilization of our facility extension during the years 2003 / 2004 will enable us to address additional working areas.

Editor: Thank you very much for the interview.

To judge the past
to organize the present
to lead into the future



Fraunhofer-Institut
für Werkstoff- und Strahltechnik IWS

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Contents

10 Years with IWS

200 guests visited the IWS on the occasion of the anniversary celebration the "10 year anniversary of Fraunhofer in the new states". Among the guests were:

- Mrs. E. Bulmahn, Federal Minister for Education and Research
- Prof. Dr. K. Biedenkopf, Prime Minister of Saxony
- Prof. Dr. H.-J. Meyer, Minister for Science and Culture of Saxony
- Dr. W. Eichler, State Secretary in the Ministry of Culture, Sachsen-Anhalt
- Dr. K.-D. Voehringer, Chairman of the Senate of the Fraunhofer Society

The celebration was broadcast live through the Internet and approximately 1600 listeners tuned in.

Edelgard Bulmahn, Federal Minister for Education and Research (top), Prof. Dr. Kurt Biedenkopf, Prime Minster of the Free State of Saxony (middle), and Prof. Dr. Hans-Juergen Warnecke, President of the Fraunhofer Society at the celebration on the occasion of the 10 year anniversary of the Fraunhofer Society in the new states.

Anniversary celebration "10 year anniversary of Fraunhofer in the new states"

ICALEO in the Internet

The largest conference on laser technology in the world was presented completely with pictures and sound in the Internet on the occasion of Prof. Beyer's term as the President of the Laser Institute of America (LIA).

The IWS work for LIA represents a world premier.

Peter Baker, LIA (left) and Eckhard Beyer during the ICALEO 2002

The planned Airbus 380 will be manufactured with laser-welded joints

IWS Receives Large-scale Project Grant for the Laser Welding of Fuselage Structures for Airbus

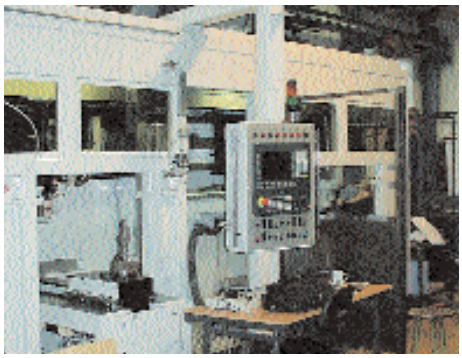
In July 2002 a large-scale project was launched to develop joining technologies for large-sized aircraft fuselage parts for the company Airbus. The objective is to replace the riveting of parts with a length of up to 10 m and a width of 3 m with the more effective and weight reducing laser beam welding. A large and unique machine system supported by the SMWK and the Fraunhofer Society will be designed and built to be available for development work early in 2004.

It is not enough to know
you have to apply
it is not enough to want to
you have to do it.
Johann Wolfgang von Goethe

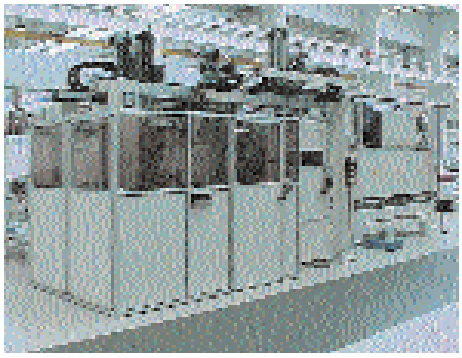
IWS Developments and Transfers into Industrial Manufacturing

Two additional IWS technology developments for inductively supported laser beam welding have been transferred to batch manufacturing: Getrag Ford Transmissions Cologne and Volkswagen Wolfsburg took machines into operation in 2002. With these there are now six laser induction systems in high volume manufacturing. Additional systems will follow shortly.

Further specialized IWS systems and processes for the laser treatment of surfaces have been transferred.



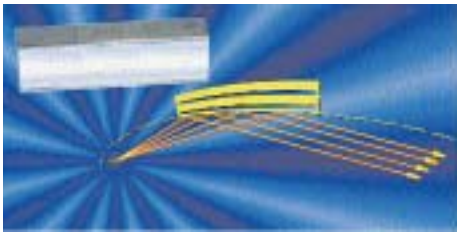
Laser induction-welding system in batch manufacturing at Getrag Ford Transmissions Cologne



Laser induction-welding system in batch manufacturing at Volkswagen Wolfsburg

World Record for EUV Mirrors Improved

Every percent point of reflectivity is enormously important for EUV mirrors. In 2002 we manufactured mirrors at IWS with a reflectivity of 71.4 %. This value has not be reached before worldwide. This IWS result represents an important step for the development of X-ray lithography technology.



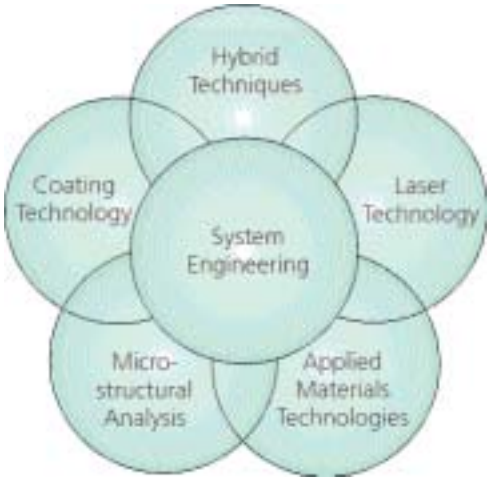
X-ray optical arrangement, based on IWS X-ray optics

Everything should be made
as simple as possible,
but not one bit simpler.
Albert Einstein

Overview

The Fraunhofer Institute for Material and Beam Technology conducts application-oriented research and development in the areas of laser and surface technology.

Key points are:
- Laser beam welding, cutting and ablation,
- Surface treatment as well as
- The deposition of thin films.



The main working areas of IWS, which enable us to provide you with one-stop solutions

A special feature of the IWS is the experience in beam and coating technologies in combination with a profound know-how in materials and comprehensive capabilities of material characterization. In order to offer optimized solutions for industrial production, we exploit the option of coupling beam technologies with other power sources. This leads to so-called *hybrid technologies*, which combine advantages of laser techniques with special features of other techniques in a cost-effective manner.

Through the close collaboration with system suppliers and equipment manufacturers, we are able to offer our customers *one-stop solutions* based on novel concepts. As a basis for this, the working system, the process, and the component performance must all be taken into overall consideration. The excellent facility at IWS enables us to respond to customer's requests with state of the art equipment. Furthermore, we are capable of running pilot production and testing, in house.

Laser Technology

- Laser welding and soldering
- Laser hardening, re-melting and cladding
- Laser surface modification with additional materials (alloying and disperging)
- Repair coatings
- Rapid prototyping
- Laser cutting and parting
- Laser cleaning and ablation (for restoration and technical purposes)
- Laser finishing
- Microstructuring, engraving and marking

Thin Film Technology

- Thin film technology on the basis of laser, vacuum arc, CVD, sputtering and electron beam processes
- Film systems and processes for hard coatings with carbides, nitrites, oxides, etc.
- Super hard amorphous carbon films
- Nanometer multilayer films for X-ray optical components
- Atmospheric pressure plasma-assisted CVD and atmospheric pressure laser-assisted CVD
- Plasma spraying

Hybrid Processes

- Induction assisted laser welding of heat treatable steels
- Plasma augmented laser processing (welding, re-melting)
- Laser assisted plasma spraying
- Thin film deposition through combined laser, vacuum arc, electron beam and CVD processes
- Modeling of short time heat treatment processes

Materials Testing

- Characterization of laser irradiated materials and components
- Wear and fatigue tests
- Mechanical, tribological and optical film properties
- Thermal shock resistance and temperature stability of ceramics
- Failure analysis

Structure Analysis

- Metallographical material characterization
- Structure analysis with electron-microscopy (REM, TEM)
- Characterization of surface properties with optical spectroscopy

System Technology

- Development of system components such as high speed beam scanners, flexible laser beam shaping units and welding monitors
- Optimization of laser machining systems
- Process diagnostic of PVD and CVD processes

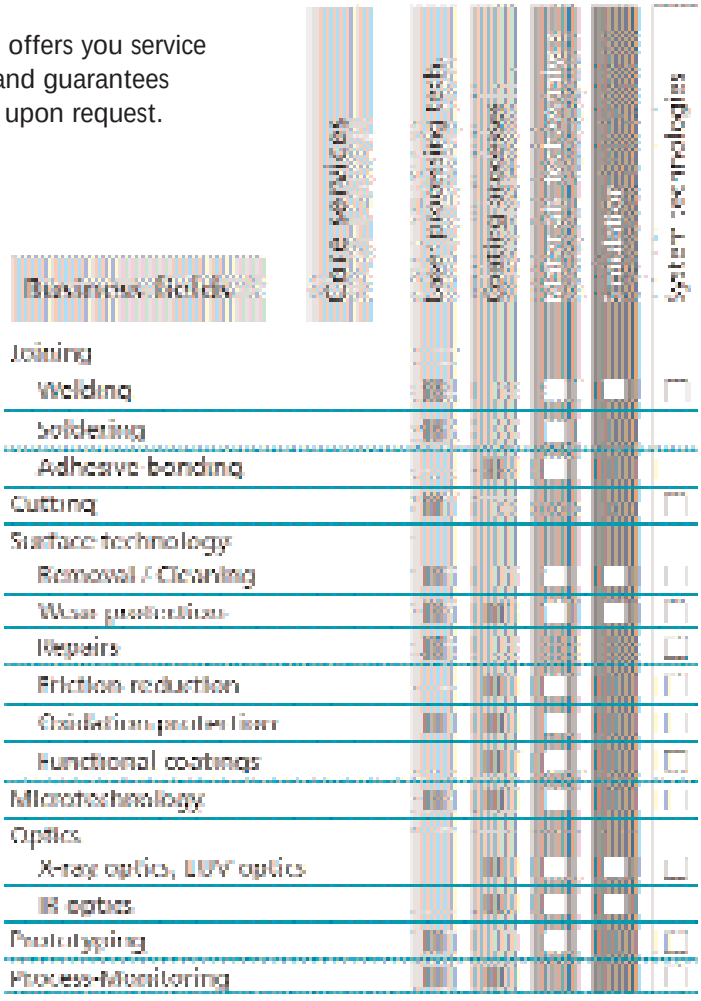
Our Offer

We offer one-stop solutions in:

- Consulting
- Feasibility studies
- Contract research and development
- Process testing
- System development jointly with industrial partners
- Design and implementation of pilot systems
- Material and component testing
- Failure analysis
- Training of scientists, engineers, operators and laboratory assistants

Contacts

The Fraunhofer IWS offers you service and contract work and guarantees strict confidentiality upon request.



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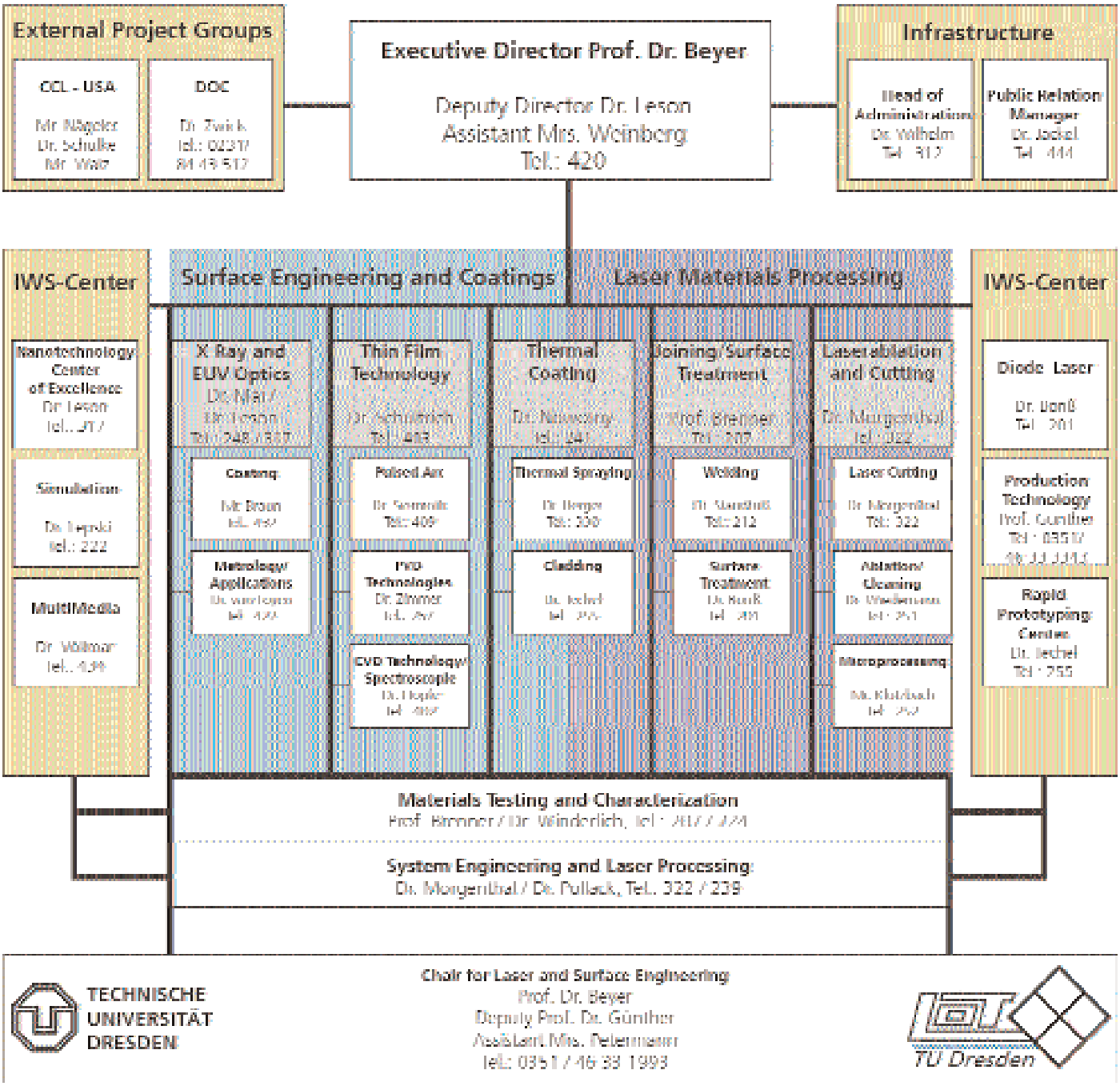
Organization and Contacts



Guest Companies Located at Fraunhofer IWS

- EFD Induction GmbH Freiburg, Dresden Branch
- ALOtec Applied Laser and Surface System Technology GmbH Dresden
- AXO Dresden GmbH
- Fraunhofer Institute for Non-Destructive Testing IZFP Saarbruecken, Dresden Branch

Connection to the TU Dresden

Chair for Laser and Surface Engineering

During 2002, 38 colleagues were employed in the university department. The third party revenues yielded more than 1 Mio. €.

The Chair is integrated into the production technology of the University. The performed projects are more basically oriented and are intended complementaryly to the work of the IWS.

The teams deal with following subjects:
- Production design
- Laser technology
- Surface technology
- Film technology
- Adhesive bonding

The following courses were offered:
- Prof. Beyer: Manufacturing technology II, (Surface and coating technology)
- Dr. Schultrich, Prof. Beyer: Coating technologies
- Dr. Leson, Prof. Beyer: Surface engineering / Nanotechnology
- Prof. Beyer: Laser basics / Laser system technology
- Prof. Beyer: Laser and plasmas in the production technology

The lectures are mainly constructed on the basis of multimedia techniques.

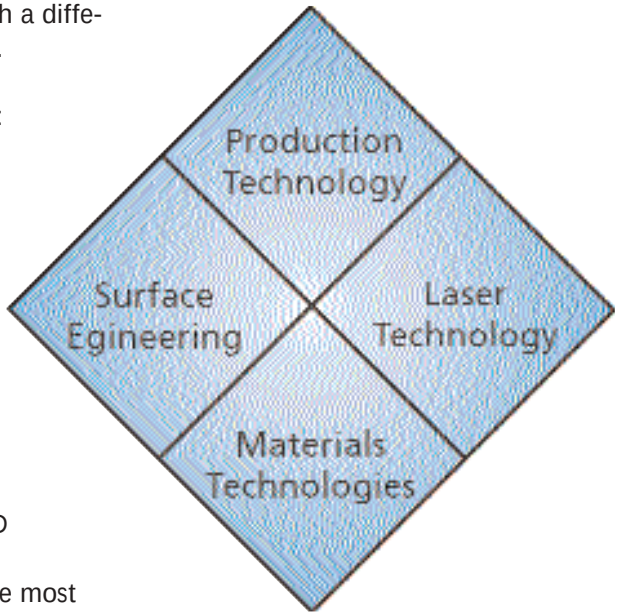
Cooperation Fraunhofer IWS - TU Dresden

A special agreement regulates the cooperation between the IWS and the TU Dresden. Prof. Beyer works simultaneously as the executive director of the IWS as well as a chairman at the University. The work is distributed as follows: Research and education are performed at the university and applied research and development are performed at the IWS. IWS employees are tied into projects at the university and vice versa. In the end the IWS and university form one unit with a different emphasis for each part.

The advantages for IWS are:
- Cost effective basic research
- Education of junior scientists for the IWS
- Access to scientific helpers

The advantages for the TU are:
- R&D involvement in industrial projects
- Integration of newest R&D results into education
- Training of students on the most modern equipment

Science needs cooperation,
in which the knowledge of the one gains
from the discovery of the other.
Jose Ortega y Garset



CD for manufacturing technology course (II)

CD laser lexicon
informations: www.laserlexikon.de

CD for laser system technology course

Centers and External Project Groups of the Fraunhofer IWS

Success only comes to those who are doing something while they wait for success.
T. A. Edison

Nanotechnology Center of Excellence "Ultrathin Functional Films"

Nanotechnology is one of the key technologies for the 21st century. Already there are products in the market such as magnetic storage media and read / write heads for data storage which are covered with nanometer films, or scanning tunnel microscopes which make the world of molecules and atoms visible. Ultrathin films are a key element of nanotechnology. Applications range from microelectronics and optics to medicine and tribological systems.

To consequently explore the possibilities of industrial applications, forty-four companies, ten university institutes and twenty-one research institutes have formed a know-how network. IWS was awarded the coordination of the network by the Federal Ministry of Research. IWS is one of the main contributors to the Nanotechnology Center of Excellence, with nanometer film structures for X-ray optics being one prime example.

A highlight in 2002 was the execution of the European nanotechnology symposium "Nanofair 2002". 200 participants from industry and science joined the fair, which was substantially arranged with the help of the Center of Excellence and the IWS.

Intensive discussions at the Nanofair: Dr. Leson in discussion with Nobel prize winner Prof. Jean-Marie Lehn

Workgroups of the Nanotechnology Center of Excellence

Application Center for High Power Diode Lasers

In cooperation with leading laser and equipment manufacturers, the Fraunhofer IWS established a high power diode laser application center with the objective to offer optimized problem solutions to our customers.

Due to their comparatively high efficiency of about 50 % and the very compact design, high power diode lasers are ideal tools for the localized distortion-free hardening and coating. The welding of sheet metal of up to 1 mm in thickness can be done faster and at higher quality compared to conventional welding techniques. In response to customer requirements over the last years, special software products such as post-processors and surface temperature based laser power control packages have been developed, which simplified the application of high power diode lasers for surface engineering and surface refinement tasks as well as improved the process stability.

The application center is capable to accomplish processing tasks with leading know-how and the newest diode laser systems.

Demonstration of a hardening machine with an integrated high power diode laser in the laser hall of IWS

Production Technology Center

The integration of efforts at the IWS and the Technical University Dresden occurs in research, development, and the application of production technology ranging from process development to the design of production flows.

Work emphasis:

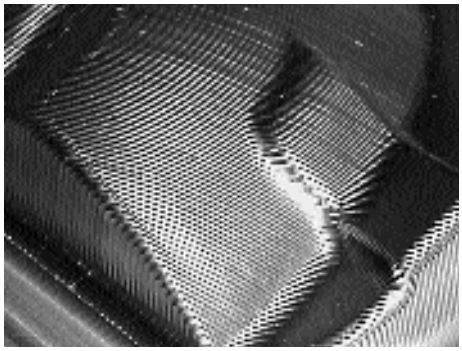
- Process development in conventional and high-speed sector as well as development of hybrid-processes
- Feasibility studies and performance analysis, studies (products, manufacturing processes, technological and logistic process chains)
- Material flow and production simulation
- 3D visualization and animation of products, production chains, and production systems

Rapid Prototyping Center

Time-to-market: the time frame from an idea to the marketing of a new product decides success or failure. This correlation caused the institute's involvement in rapid prototyping and rapid tooling beginning several years ago.

There are several prototyping systems installed at IWS. The capabilities include 3D modeling and data processing, contour scanning, the different processes to produce the models (such as laser beam generation and laser beam sintering), laminated object manufacturing (LOM) with sheet metal, and the final processing (milling, coating, measuring) of the tools.

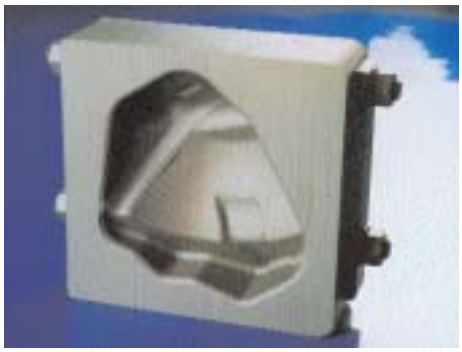
Tools can be manufactured in a fraction of the time needed in the past with the help of metal-LOM as a rapid tooling process.



Surface of a tool made by metal-LOM

Beam technology:
Water jet abrasive cutting machine

Laser integrated CNC milling center



Blank lamellas of a stamping tool

Nothing is more powerful
than an idea
whose time has come.
Viktor Hugo

Industrial Project Group at the Dortmund Surface Center (DOC) at the ThyssenKrupp Stahl AG

Dr. Axel Zwick
Manager of the project group at DOC in Dortmund
Tel.: 0231 / 844 3512

Facility of the Dortmund Surface Center

The ThyssenKrupp Stahl AG (TKS) focused its capacities and competencies in the area of surface technologies with the establishment of the Dortmund Surface Center with the participation of the Fraunhofer Society.

The largest European research and development center for the surface refinement of flat steel was launched in December 2000 on the grounds of the Dortmund Westfalen steel works. Employees of TKS and the Institute for Material and Beam Technology in Dresden work here together in a new form of "Public Private Partnership". The joint objective is to develop innovative surface technologies and processes to transfer them to industrial scale manufacturing.

A first outstanding result of this cooperation is a novel zinc alloy coating (ZE-Mg), which was introduced at the DOC symposium in December 2002. The coating combines at half the thickness the very good corrosion protection of proven zinc coatings with a considerably improved ability to further process the coated material, as the Fraunhofer project group was able to demonstrate for laser welding.

From its new 1100 m^2 facility, the Fraunhofer project group is offering a number of complementary surface refinement technologies. Most modern system technology allows the

- depositing of nearly pore-free plasma spray coatings with extreme adhesion,
- laser cladding of specifically high-stress areas of parts and components with millimeter thick wear protective coatings,
- coating of heavy parts (tons) in vacuum (PVD, PA-CVD, PDT) with nano to micro meter thick record performance coatings (e.g. Diamor® coating systems), which combine an outstanding hardness with excellent sliding properties.

The wide spectrum of these processes (which can be partially combined with each other) offered in combination with the know-how of the participating Fraunhofer Institutes, guarantees that the customer, whether it is TKS, a TKS customer, or another company, receives the technologically and economically optimal solution. With the help of a worldwide unique mobile 4 kW Nd:YAG laser and a 75 m optical fiber it is not only possible to perform process development, but also troubleshooting directly in the laboratory of the industrial customer close to production.

Fraunhofer Center for Coatings and Laser Applications (CCL)

Christian Walz
Division Manager
CCL / USA
Tel. 1-734-354-6300

Dr. Thomas Schülke
Division Manager
CCL / USA
Tel. 1-517-432 8173

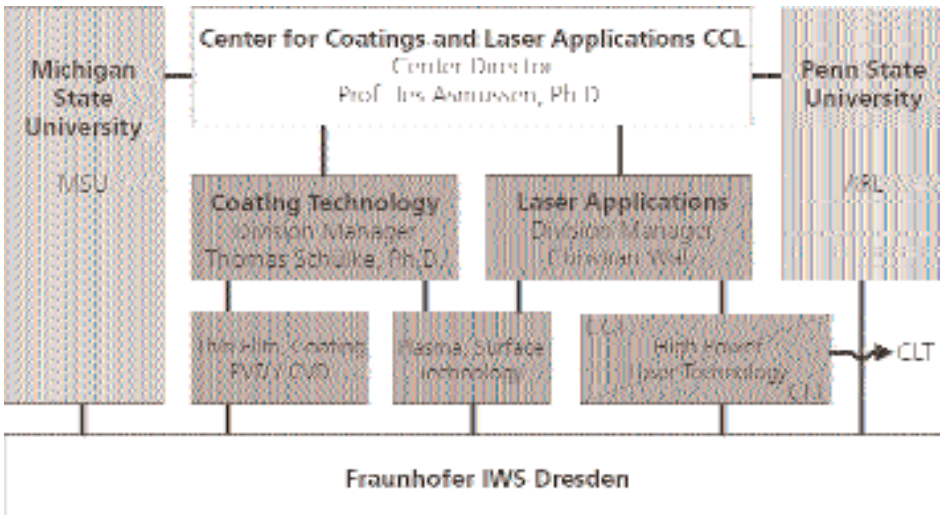
The Fraunhofer IWS activities in the USA have been significantly expanded in 2002. The previous Center for Surface and Laser Processing has been renamed to "The Fraunhofer Center for Coatings and Laser Applications CCL". Since December 2002 the center is headed by Prof. Dr. Jes Asmussen. Prof. Asmussen is a faculty member at Michigan State University and an expert in diamond coatings. His previous work is ideally complementing the IWS know-how in the area of DLC coatings and the strategy is to establish a carbon center in East Lansing under Prof. Asmussen's lead.

The CCL consists of two divisions; the "Coating Technology Division" at Michigan State University in East Lansing managed by Dr. Thomas Schülke, and the "Laser Applications Division" at the Fraunhofer USA Headquarters building, newly managed by Christian Walz. This restructuring and the move into new and bigger laboratories set the proper conditions for CCL to be even more able to respond quickly and efficiently to US industry customer requests.

Under the guidance of the Fraunhofer IWS, Dresden, there have been joint projects conducted at the U.S. Laser Applications Division in cooperation with the Fraunhofer ILT, Aachen. The intention is to expand this cooperation in the future. The CCL acquired a number of projects during the last year, which directly included integration of the IWS in Dresden. Furthermore, within R&D projects, IWS employees have been working for an extended period (3 months) in US companies. Last but not least, it was also possible to cooperate with German (Saxony) small and medium-sized companies to provide system solutions for US companies.

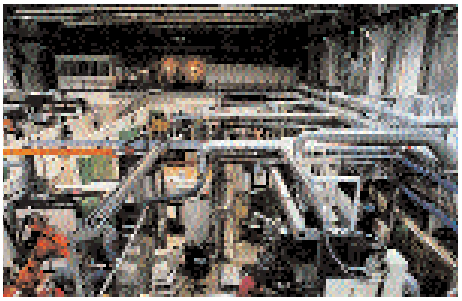
The Coating Technology Division offers the deposition of wear protective coatings such as TiN, (Ti,Al)N and other hard materials. The coatings can be non-destructively tested with the IWS developed laser-acoustic surface tester LAwave®. During the last year the tool has been mainly applied for service and projects in the semiconductor and microelectronics industry. The laser-acoustic surface tester LAwave® received the "R&D 100 Award" in October 2001.

Building of the CCL, CLT and Headquarters of Fraunhofer USA in Plymouth



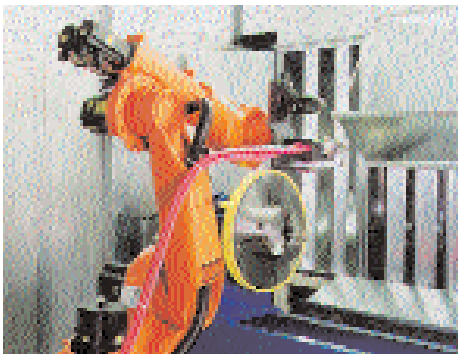
Institute Equipment

Technology does not save any time, but it distributes it in a different way.
Helmar Nahr



View of the IWS technology hall

High-speed laser cutting machine



Atmospheric plasma spraying with laser coupling

Laser Systems

Several CO_2 laser, 2 to 6 kW (HF-pumped)

Several Nd:YAG laser to 4,4 kW cw (lamp and diode pumped) and 1 kW pm laser

Nd:YAG laser system with pulse widths in the millisecond, nanosecond and picosecond range for the fine machining

Several high power diode lasers, 1.4 to 2.5 kW

TEA CO_2 laser

Excimer laser (248 nm)

Frequency-multiplied Nd:YAG laser (532 and 355 nm)

Pulsed Nd:YAG laser with OPO

Handling Systems

Gantry with 5 CNC-axes (plus external rotating axis) work range 4000 · 3000 · 1500 mm^3, with 2.5 to 6 kW CO_2 laser beams

CNC-laser processing equipment with 8 axes, speed up to 20 m min^{-1}, working range of 2400 · 1800 · 600 mm^3, with 2.5 to 6 kW CO_2 laser beams

Laser induction hybrid gantry with 5 axes (6 kW CO_2 laser, 80 kW MF induction generator)

Precision machines (accuracy class 5 µm) with 5 and 4 CNC-axes, with 6 kW CO_2 laser beams

Combined CO_2 and Nd:YAG machine (2 or 3 kW) with 4 CNC-axes for precision cladding

Cutting machine with linear drives up to 300 m min^{-1} feed with 3.5 kW CO_2 laser beams

Universal Excimer-laser-micromachine

Coating Systems

Laser PVD (LPVD) coating device (Nd:YAG, Excimer, TEA CO_2 laser) in high vacuum and ultra high vacuum

Equipment for film deposition with vacuum arc technology (Laser-arc, pulsed high current arc, DC-arc, plasma filter)

Laser CVD device with 6 kW CO_2 laser and lamp CVD machine (24 kW) for fiber coating

Devices for plasma-assisted CVD coating at atmospheric pressure (6 kW microwave, 30 kW dc-Arc)

Six inch-cluster tool for combined large area PLD and magnetron sputtering

Hybrid coating equipment: 40 kW electron beam and high current arc

Devices for atmospheric and vacuum plasma spraying with robot handling (APS, VPS)

Device for laser assisted atmospheric plasma spraying (LAAPS)

Special Components

Static and flexible dynamic beam shaping systems for beam power up to 10 kW

CNC sensor controlled wire feeder for laser welding

Power feeder and special equipment for independent laser cladding as well as temperature measurement system for process control

SCOUT sensor system for 3D shape recording (automatic teach-in) for laser handling of components (on-line / off-line contour tracing)

Beam diagnostic system for CO_2 and Nd:YAG laser

UV / VIS, FTIR und NIR diode laser spectrometer for process gas and plasma diagnostic

Camera system for short-time process analysis (4 channel high speed framing camera with 5 ns exposure time)

Special Equipment

Mobile 4 kW Nd:YAG laser in a container

Equipment for rapid prototyping by laser sintering

Portable Nd:YAG laser (6 ns pulses of $5 \cdot 10^7$ W, repetition rate up to 20 Hz) with articulated beam guide and zoom optic (Art-Light NL 102) for outdoor cleaning

Turnable laser handling system (400 ... 2000 nm, > 100 mJ) with flexible beam guide and controlled motion for the ablation of thin layers

Laser handling station with industrial robot system and CO_2 slab laser

CNC treatment center for 5-axis milling and built-up welding

Laser integrated milling center for generating and repair

Mobile equipment for anti-slip equipment of tiled floors (by diode pumped Nd:YAG laser)

Measurement Instruments

Texture analyses including:
- Metallography
- Analytical transmission electron microscopy
- Analytical scanning electron microscopy
- Adequate sample technique preparations

Materials testing:
- Servo hydraulic testing system
- Mechanical stress / strain tester
- Pendulum impact tester
- Automatic hardness tester
- Computer controlled micro hardness test system
- High frequency fatigue tester
- Flat bending torsion machine

Laser acoustic system for measuring the Young's modulus of thin films

Laser shock instrumentation with high speed pyrometer

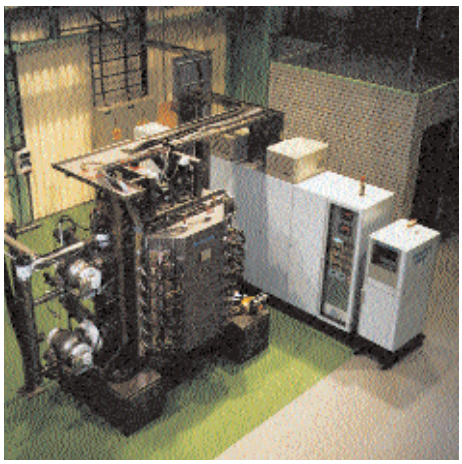
Equipment surface and film analysis:
- Automatic spectral ellipsometer (270 - 1700 nm)
- UV / VIS spectrometer
- Raman micro spectrometer
- FTIR spectrometer, FTIR microscope
- Depth sensing indentation device
- Scratch tester
- Profilometer
- Tribometer
- X-ray florescence film thickness measuring device
- Sheet resistivity measuring device

X-ray diffractometer (CuKα)
X-ray diffractometer (MoKα)

Optical 3-D coordination system

Vacuum plasma spraying

Laser-Acoustic measurement station for the non-destructive determination of thin film properties, acknowledged through the "R&D 100 Award 2001" in the USA



Laser-Arco® - the technology to deposit Diamor®

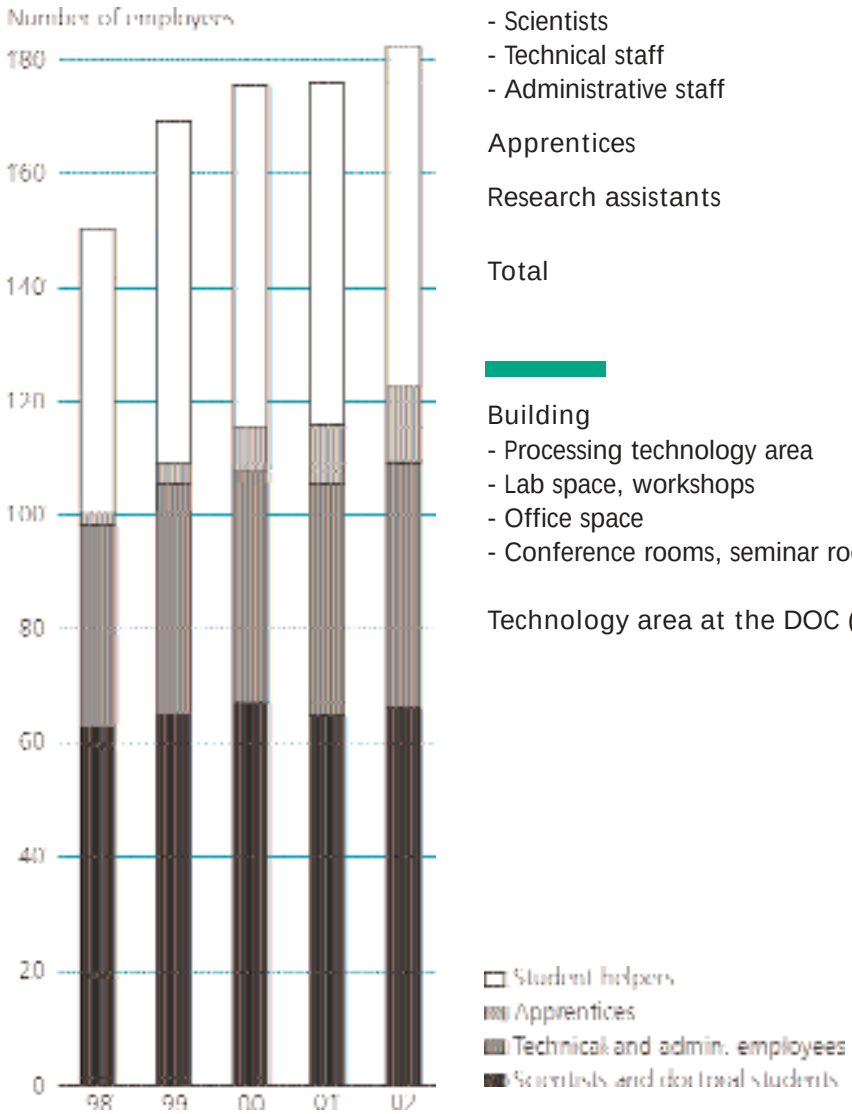
We can lick gravity,
but sometimes the paperwork
is overwhelming.
Wernher von Braun

Total Employees

The TU Dresden (chair for laser and surface engineering) and the Fraunhofer IWS are connected through a cooperation agreement. A number of university employees are working closely with IWS employees on joint projects. Basic research is conducted at the university; application related process development and system technical work is done at IWS.

For 2002 the employees are divided up as follows:

Employees of Fraunhofer IWS	Number	Employees of Chair for Laser and Surface Engineering of TU Dresden	Number
Permanent staff	110	Permanent staff	30
- Scientists	66	- Scientists	22
- Technical staff	35	- Technical staff	6
- Administrative staff	9	- Administrative staff	2
Apprentices	12		
Research assistants	60	Research assistants	8
Total	182	Total	38



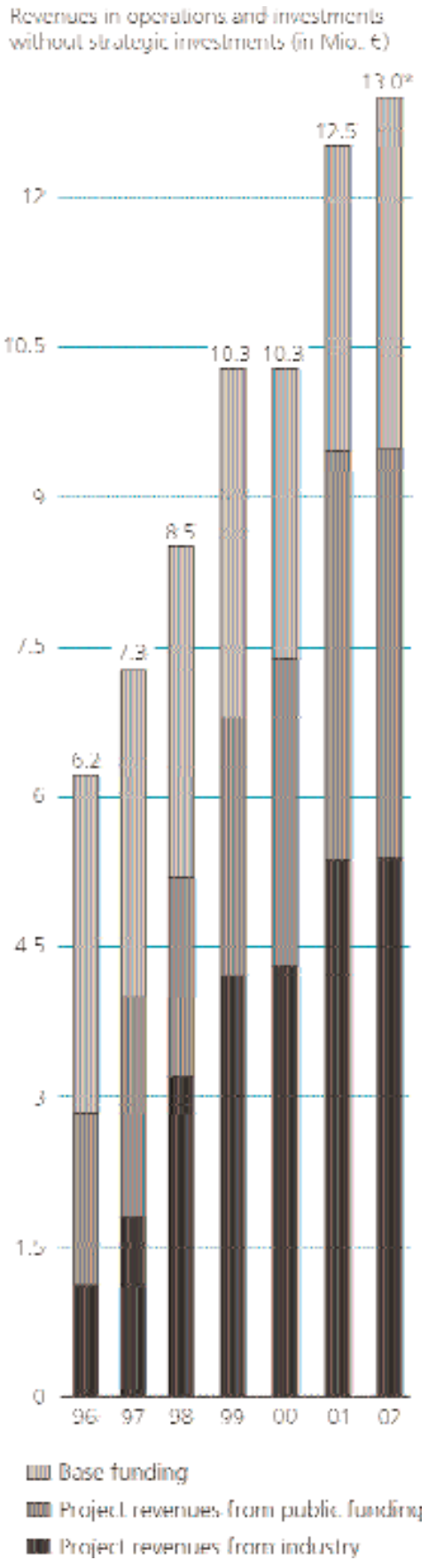
Building	5050 m²
- Processing technology area	1200 m²
- Lab space, workshops	1760 m²
- Office space	1550 m²
- Conference rooms, seminar rooms etc.	540 m²
Technology area at the DOC (Dortmund)	1100 m²

Budget and Revenue (preliminary*)

* Actual cost determination not yet finalized

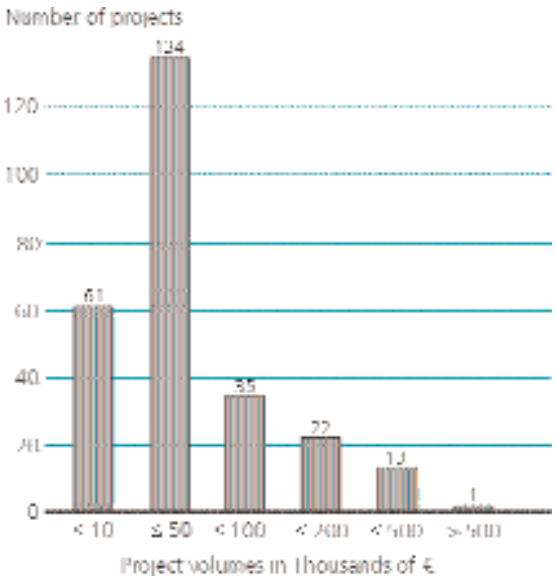
	Mio. €	
Operational costs and investments	13.0	
Budget	11.0	
- Cost of sales	5.6	
- Other expenses	5.4	
Investment	2.0	
	Mio. €	%
Revenue 2002	13.0	
Revenue operations	11.0	
- Industrial revenues	4.9	45
- Revenues of public funded projects	3.9	35
- Base funding IWS	2.2	20
Revenue investment	2.0	
- Industrial revenues	0.4	
- Revenues of public funded projects	0.5	
- Base funding IWS	1.1	

In 2002 IWS received additionally 1.0 Mio. € as strategic investment from the Fraunhofer Society.



Projects

In 2002, IWS handled 266 projects. The distribution of the projects with respect to their volume is shown in the graphic below. One hundred thirty four of the projects were for 10 to 50,000 T€ (Thousands of Euro), for example.



The state is there for people
and not people for the state.
The same can be said of science.
Albert Einstein

The Fraunhofer-Gesellschaft

The Fraunhofer-Gesellschaft undertakes applied research of direct utility to private and public enterprise and of wide benefit to society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration. The organization also accepts commissions and funding from German federal and *Länder* ministries and government departments to participate in future-oriented research projects with the aim of finding innovative solutions to issues concerning the industrial economy and demands faced by society in general.

By developing technological innovations and novel systems solutions for their customers, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. Through their work, they aim to promote the economic development of industrial society, paying particular regard to social and environmental concerns.

As an employer, the Fraunhofer-Gesellschaft offers a platform that enables its staff to acquire the necessary professional and personal qualifications to assume positions of responsibility within their Institute, in industry and in other scientific domains.

At present, the Fraunhofer-Gesellschaft maintains roughly 80 research units, including 57 Fraunhofer Institutes, at over 40 different locations in Germany. A staff of some 13,000, predominantly qualified scientists and engineers, work with an annual research budget of around one billion euros. Of this sum, approximately 900 million € is generated through contract research.

Roughly two thirds of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. The remaining one third is contributed by the German federal and *Länder* governments, as a means of enabling the Institutes to pursue more fundamental research in areas that are likely to become relevant to industry and society in five or ten years' time.

Affiliated Research Centers and Liaison Offices in Europe, the USA and Asia provide contact with the regions of greatest importance to future scientific progress and economic development.

The Fraunhofer-Gesellschaft was founded in 1949 and is a recognized non-profit organization. Its members include well-known companies and private patrons who help to shape the Fraunhofer-Gesellschaft's research policy and strategic development.

The organization takes its name from Joseph von Fraunhofer (1787-1826), the illustrious Munich researcher, inventor and entrepreneur.

The Advisory Committee

The advisory committee supports and offers consultation to the Fraunhofer IWS. Members of the advisory committee in 2002:

O. Voigt, Prof.
Chairman of Windsolar AG,
Committee Chair

K. Arnold, Prof. Dr.
General Manager of Niles-Simmons Industrieanlagen GmbH

R. Bartl, Dr.
Director Production Planning MB Cars der DaimlerChrysler AG

H. Bücher, Dr.
Coordinator Innovation Management and Technology Marketing,
German Aerospace Center (DLR)

E.-J. Drewes, Dr.
Head of Research, Central Quality and Testing of ThyssenKrupp Stahl AG

H. Ennen, MinR. Dr.
Saxony Office, Brüssel

P. Lenk, Dr.
General Manager of von Ardenne Anlagentechnik GmbH

P. Linden, Dr.
Head of Production Technology of DaimlerChrysler AG

A. Mehlhorn, Prof. Dr.
President of the Technical University Dresden

R. J. Peters, Dr.
General Manager VDI Technology Center, Physics Technologies

W. Pompe, Prof. Dr.
Technical University Dresden

F. Schmidt, MinDir. Dr.
Saxon Ministry of Science and Art

P. Wirth, Dr.
Chairman of Rofin-Sinar Laser GmbH

The twelfth committee meeting took place on February 27, 2002, at Fraunhofer IWS in Dresden.

The Institute Management Committee

The institute management committee advises the executive director and participates in decision making concerning the research and the business policy of IWS.

Members of the committee are:

Prof. Dr. E. Beyer	Executive Director
Dr. A. Leson	Deputy Director
Dr. S. Wilhelm	Head of Administration
Prof. Dr. B. Brenner	Department Head
Dr. L. Morgenthal	Department Head
Dr. S. Nowotny	Department Head
Dr. B. Schultrich	Department Head

Guests are:

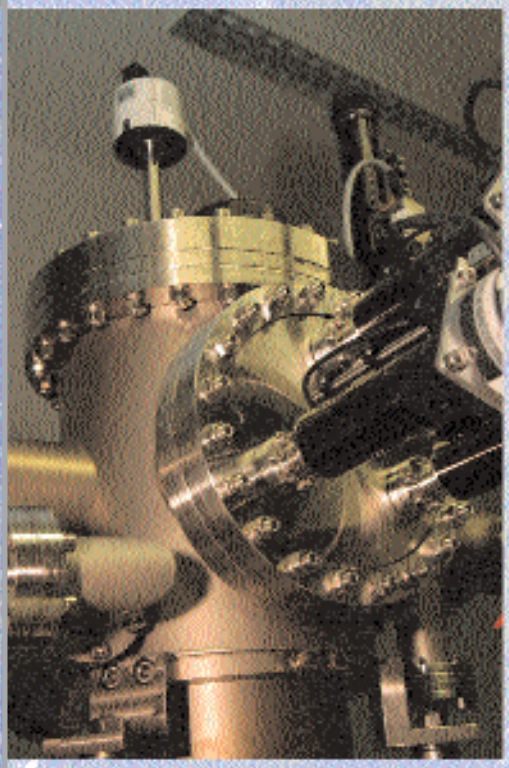
Dr. S. Bonß	WTR Agent
Prof. Dr. U. Günther	Agent of the Professorship
Dr. R. Jäckel	PR-Manager
Dr. S. Schädlich	QM Representative
Dr. B. Schöneich	Works Committee

Scientific Technical Council (WTR)

Scientific technical council of the Fraunhofer-Gesellschaft supports and advises divisions of the Fraunhofer-Gesellschaft with regard to technical and scientific policy. The Counsel consists of members of the institute management and an elected representative of the scientific and technical staff of each institute. IWS members of WTR in 2002 were:
- Prof. Dr. E. Beyer
- Dr. S. Bonß

Network Surface Engineering and Photonics

The IWS is a member of the network Surface Engineering and Photonics. Members of the network are:
- Fraunhofer FEP Dresden
- Fraunhofer ILT Aachen
- Fraunhofer IOF Jena
- Fraunhofer IPM Freiburg
- Fraunhofer IST Braunschweig
- Fraunhofer IWS Dresden



R&D-Offer: X-ray and EUV Optics

Editor: In 2002 a company manufacturing X-ray mirrors has been spun off from your department. What initiated this step?

Dr. Leson: Over the last years the IWS has established an internationally leading position in the area of nanometer multilayer coating systems and their application for X-ray optics. At the same time the demand for optics in X-ray analytics increased significantly. Therefore the conditions to form a spin-off company were very favorable. Since July 2002 the AXO Dresden GmbH is manufacturing and selling X-ray mirrors on the basis of IWS licenses. Mr. Thomas Holz, a former employee of the Fraunhofer IWS Dresden, manages the new company.

Editor: In the last year not only did you make progress in the development of new X-ray optical components, but also with longer wavelengths in the so-called EUV range. What successes did you achieve?

Dr. Leson: In 2001 we had already achieved an international top value of 71.4 % reflectivity for EUV mirrors based on the molybdenum-silicon system. In 2002 we managed again to obtain a world record by breaking through the 70 % sound barrier for the wavelength of 13.4 nm, which is the relevant working wavelength for lithographic applications. The reflectivity is measured at our independent federal Institute of Standards. Moreover we made progress in the areas of realizing freely definable film thickness gradients and temperature stability.

Editor: Within a large project with the company Carl Zeiss you are planning to build an EUV reflectometer. What is the current status?

Dr. Leson: The space situation at our Institute in Dresden is currently very tight. Therefore we are building an extension. However, it was not possible to wait for this extension with the large Zeiss reflectometer. We are building it in specially leased space in Dresden. After the testing phase we will move the system in 2003 to Carl Zeiss in Oberkochen. There we plan to use it jointly with Carl Zeiss and other project partners for measurements in the EUV range.

Anyone who has never made a mistake has never tried anything new.
Albert Einstein

Dr. Andreas Leson
Department Head
(Tel. 2583 317)

Dipl.-Phys. Stefan Braun
Team Leader Coating
(Tel. 2583 432)

Dr. Ludwig van Loyen
Team Leader Metrology / Applications
(Tel. 2583 248)

Multilayer Coatings for EUV and X-ray Optical Applications

Single and multilayer coating systems which are deposited through pulsed laser deposition and magnetron sputtering, are distinguished by:
- highest thickness accuracy,
- lowest interface roughness,
- high chemical purity,
- high lateral homogeneity and
- very good thickness reproducibility.

Coating systems of different material combinations can be deposited on plane and curved substrates with diameters of up to 150 mm with and without a gradient of the period thickness.

The main application area of these multilayer coatings is the production of X-ray optical components for beam shaping and monochromizing. Besides the synthesis of single and multilayer coatings (e.g. Mo/Si, Ni/C, Cr/Sc, W/Si, W/B_4C,C/C, B_4C/Si) according to customer specifications, we also offer our extensive experience in the area of preparation, characterization, and simulation of X-ray optical components.

Metrology and Applications

This group emphasizes on reflectometry, diffractometry, and the development of optical systems and measurement techniques.

Standard X-ray analysis tools apply Cu-K-α or Mo-K-α radiation for non-destructively measuring the coating thickness, roughness, and density as well as the qualitative phase analysis. Measurements are predominantly done on thin and / or multilayer coatings, but also on powders. Special beam shaping optical elements such as beam collimators and beam compressors have been developed to optimize the analysis techniques.

Optical components for applications in the range of extreme ultraviolet (EUV) radiation also require their characterization in the EUV range. Therefore we have developed a special laboratory tool, an EUV reflectometer, for the analysis in the wavelength range form 10 to 16 nm.

Substrate loading at an EUV precision coating machine for the manufacturing of nm-multilayer coatings

Overall view of the EUV reflectometer

Exampled of the work in 2002

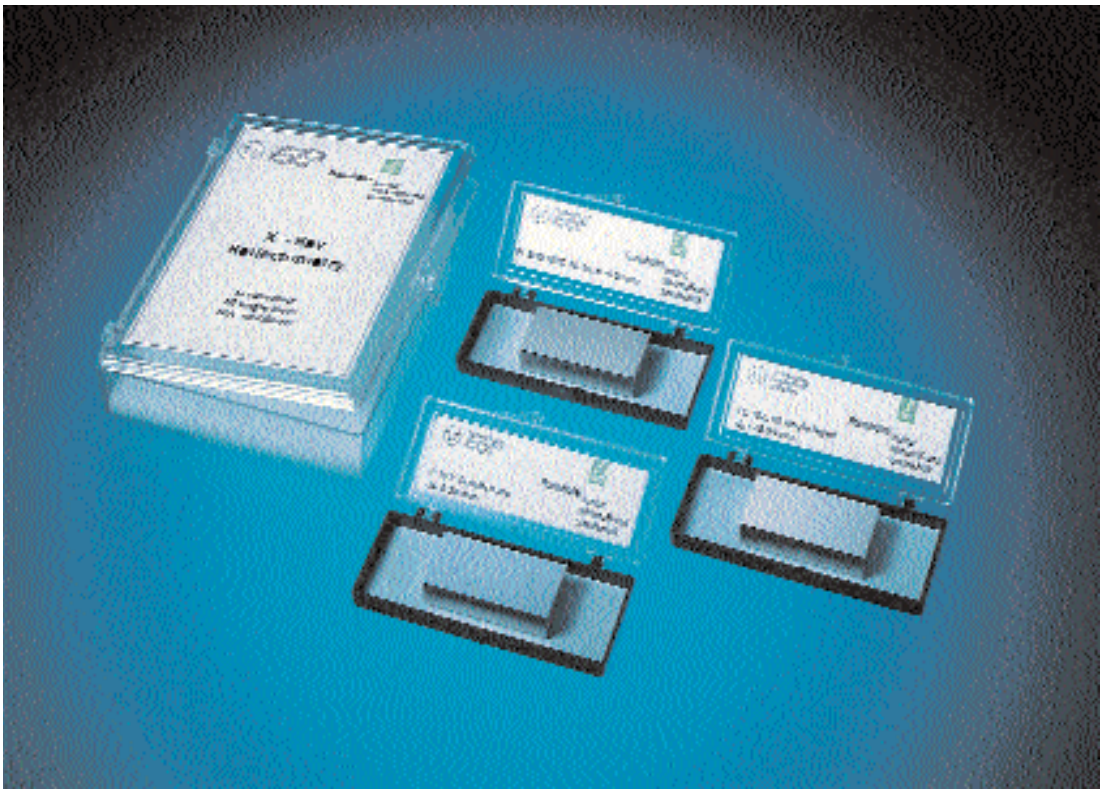
1. X-ray optical systems for reflectometry and diffractometry

2. Highly reflective EUV coatings on plane and curved surfaces

3. Highly resolving nm-multilayer coating for the EUV and X-ray ranges

4. Tailored inner diameter coating of components

5. Laboratory reflectometer for large optical components in the wavelength range from 10 to 16 nm



Different precision X-ray mirrors for the X-ray diffractometry, manufactured with pulse laser deposition

R&D-Offer: Thin Film Technology

Editor: The laser-acoustic testing system LAwave® received the American "R&D 100 Award" in 2001. What are the applications for this innovative technique?

Dr. Schultrich: An especially promising area is the microelectronic industry. Here laser-acoustics enables a highly effective and comprehensive analysis method, which cannot be matched by any other available technique. Examples are the evaluation of the surface quality of wafers, the optimization of photoresist coatings, or the characterization of highly porous low-k-dielectric materials. With the newly developed LAwave® 300 version we are addressing the specific needs of the semiconductor industry especially for the characterization of 300 mm wafers.

The worldwide sales of LAwave® systems is meanwhile an important part of the IWS spin-off company ALOtec GmbH. The just recently signed contracts for LAwave® orders from Japan and the USA show the increasing customer interest in this flexibly usable testing technique.

Editor: A new technology for the deposition of computer hard disks has been developed and successfully tested at an industrial coating system with partners in the Nanotechnology Center of Excellence "Ultrathin functional films". Can the results be transferred to other products?

Dr. Schultrich: Yes, the carbon coatings developed jointly with IBM Mainz for the scratch and corrosion protection of computer hard disks are interesting for a variety of other micro and nano systems and especially for those with moving components. The IWS technology has been integrated into the IBM coating system. Super smooth coatings have been deposited yielding more than twice the hardness of sputtered coatings, which represent the current state of the art. Especially important for micro and nano tribological applications is the fact that the extreme hardness and the outstanding corrosion protection can be achieved with ultra thin coating between 3 and 5 nm.

He who doesn`t know his goal, can`t know his way.
Christian Morgenstern

Dr. Bernd Schultrich
Department Head
(Tel. 2583 403)

Dr. Peter Siemroth
Team Leader Pulsed Arc
(Tel. 2583 409)

Coating and Surface Modification with Arc Technologies

Arc discharges as a source of energetic vapor jets are extensively used in the industrial hard coating of tools. The achieved coating and surface properties are excellent. Good adhesion can be realized at low deposition temperatures. Other promising applications (e.g. component coating, surface activation for adhesively bonded joints) offer development potential for arc technologies.

Innovative solutions in this area are developed at the IWS based on the experience with basic processes and applications of arc techniques and the utilization of modern pulse techniques. The broad application spectrum ranges from ultra thin protective coatings to activated large area coatings.

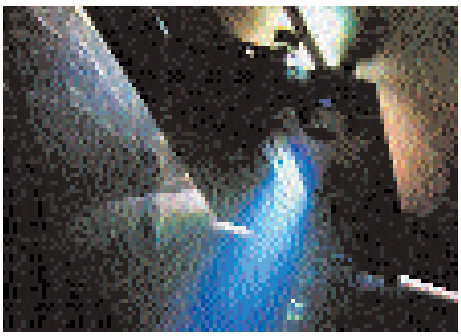
Dr. Otmar Zimmer
Team Leader PVD Technologies
(Tel. 2583 257)

Coating with Activated High Rate Processes

PVD (physical vapor deposition) processes are used for the deposition of coatings with thicknesses from a few nanometers to some tens of microns. Techniques from high rate vapor deposition to highly activated plasma processes as well as their combinations are available at IWS. Based on these technologies we offer:

- Demonstration coatings
- Mechanical and tribological characterization
- Development of deposition processes
- Development of coating systems
- Cost and feasibility studies
- Development and manufacturing of adapted system components

Preparation of Diamor® coated samples for the micro analysis



Arc coating of temperature sensitive fibers

Dr. Volkmar Hopfe
Team Leader CVD / Spektroskopie
(Tel. 2583 402)

CVD Coatings at Atmospheric Pressure with Plasma and Laser Activated Hybrid Processes; Process Control

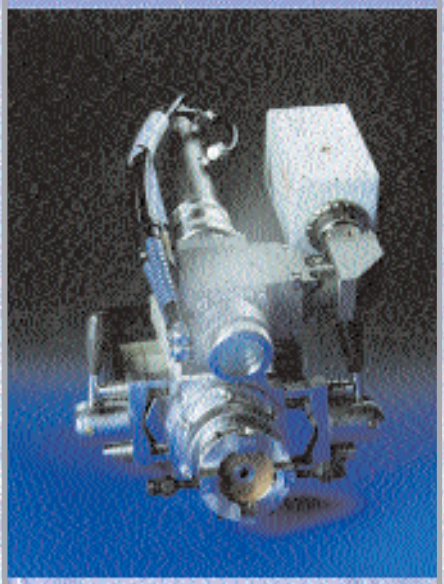
Processes at atmospheric pressure can be easily integrated into technological production flows, in the continuous coating of bands of metal for example. Deposition temperature and rate can be controlled with plasma and laser deposition. The enables the coating of temperature sensitive materials such as certain steels, glasses, and plastics.

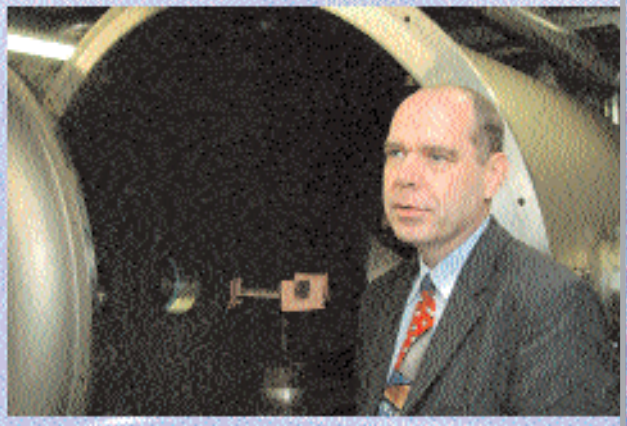
IWS develops application specific technologies including in-line reactors and process control systems. Sensors based on optical spectroscopy are developed for process control in CVD systems to monitor reactive and aggressive gasses at high temperatures. For customer specific solutions to continuously monitor the chemical composition and concentration of gas mixtures IWS is using the FTIR or NIR diode laser spectroscopy.

Arc-jet CVD reactor during the coating of stainless steel

Examples of the work in 2002

1. Extended application potential through super hard carbon coatings in the micrometer range
2. Developing the vacuum arc coating technology for microelectronics applications
3. Application of the laser acoustic test method LAwave® for the semiconductor technology
4. Carbon films as antistick coatings
5. Particle filters for the industrial vacuum arc coating technology
6. Atmospheric pressure plasma CVD for the coating of mass products
7. Development of spectroscopic sensors for system control applications
8. Quality control in the industrial hard coating industry through laser acoustics





R&D-Offer: Thermal Coating

Editor: The new hybrid process "Laser Assisted Atmospheric Plasma Spraying" (LAAPS) has been developed and patented at the IWS over the last years. What is the current status?

Dr. Nowotny: Only by setting up new equipment during the last two years did it become possible to demonstrate the principle and the advantages of the laser assisted plasma spraying for practical applications. A new laser-integrated spray gun for inner diameter coating allows us for the first time to apply LAAPS to inner surfaces with a minimal bore diameter of 70 mm. There are now results showing the extreme stress resistance of those coatings, especially for hard metallic alloys. The coating itself is faster and more cost-effective compared to laser cladding.

Editor: So, laser cladding is now out of the picture?

Dr. Nowotny: No, the opposite is the case. The patented and modular IWS system of coaxial nozzles for laser cladding is widely asked for by industry and research institutes. As opposed to laser assisted spraying, laser cladding is used for high precision applications and 3D structural build-up. During last year only we transferred 6 of these systems including supporting technologies to repair shops for mould and tool, aircraft engines, and stationary gas turbines. The customers came from Germany, Switzerland, Holland, the USA, and Japan.

Editor: Parallel to this, the MELATO techniques make headlines. Which successes could be achieved here?

Dr. Nowotny: The MELATO (metal laminated tooling) technology is a new process for the fast manufacturing of bigger tools and moulds made of steel. The CAD models of the tools are sliced in parallel wafers and transferred to sheet metal wafers and cut out with a laser. These cut pieces are then stacked and joined and form layer by layer, the tool. This allows, for instance, to make fully functional stamping tools in only 10 % of the conventional manufacturing time. This technology is developed in a project sponsored by the BMBF. Currently we can manufacture real tools, which have already been successfully tested by industrial partners.

The investment into knowledge always brings the best returns.
Benjamin Franklin

Dr. Steffen Nowotny
Department Head
(Tel. 2583 241)

Dr. Lutz-Michael Berger
Team Leader Thermal Spraying
(Tel. 2583 330)

Wear Protection and Functional Coating

The atmospheric (APS) as well as vacuum based (VPS) plasma spraying and flame spraying are available at IWS for the coating of components made of steel, light metals or other materials with metals, hard metals and ceramics. The hybrid technology Laser Assisted Atmospheric Plasma Spraying (LAAPS) complements the technology spectrum.

Based on the most modern spraying equipment, and in cooperation with other institutes of the Fraunhofer Institute Center in Dresden we offer:

- Conception of stress adapted coating systems
- Development of complete coating solutions from the material to the coated part
- Development and manufacturing of system components
- Participation in system integration
- Support of the user with technology introduction

Dr. Anja Techel
Team Leader Cladding
(Tel. 2583 255)

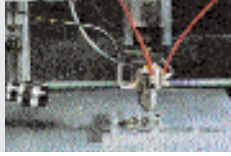
Repair and Generating

Laser beam and plasma powder cladding as well as hybrid technologies in combination of laser, plasma, and induction sources are available at the IWS for the repair and coating of components, moulds, and tools. Cladding, alloying or disperging of metal alloys, hard materials and ceramics can generate coatings and 3D structures. The complete process chain from digitizing and data preparation to the final processing can be utilized for all the technologies.
For these application fields we offer:

- Fast and flexible work piece digitization and data processing
- Precise repair and coating of components and tools, even with complex shapes
- Manufacturing of metallic and hard material containing samples and prototypes directly from the CAD data of the customer
- System components and support during the introduction of the technology into production

Plasma spraying of a shaft

Different powder nozzles developed at IWS



Examples of the work in 2002

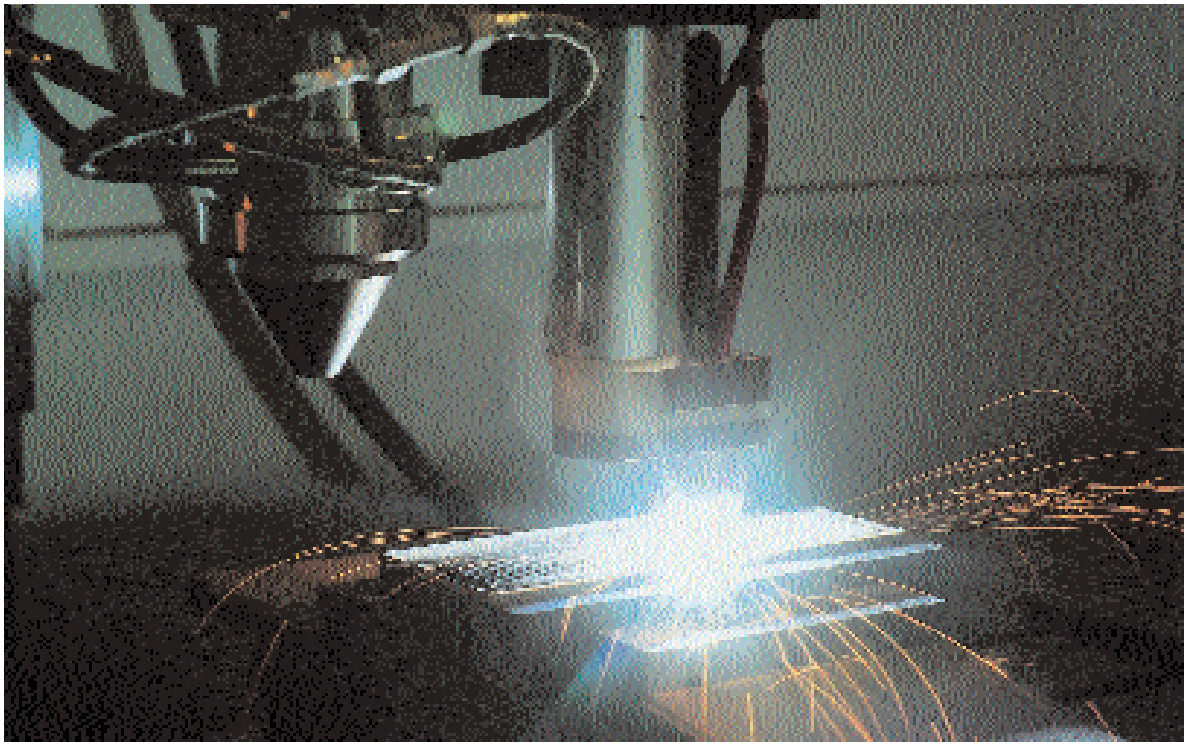
1. Progresses with the manufacturing of lamellated tools

2. Generation of titanium and aluminum through laser powder deposition welding in a controlled atmosphere

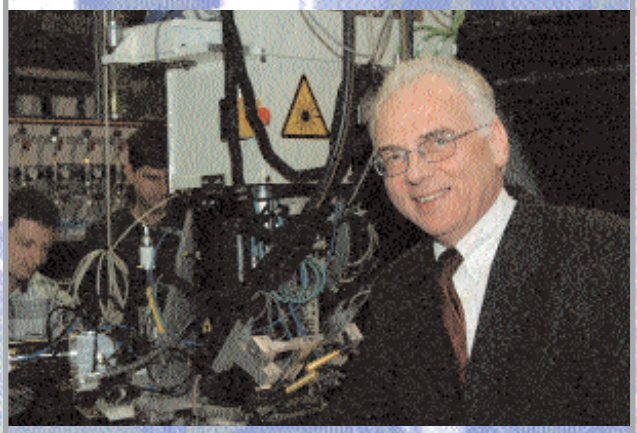
3. KOAXn: powder nozzles for the precision deposition welding in extreme welding positions

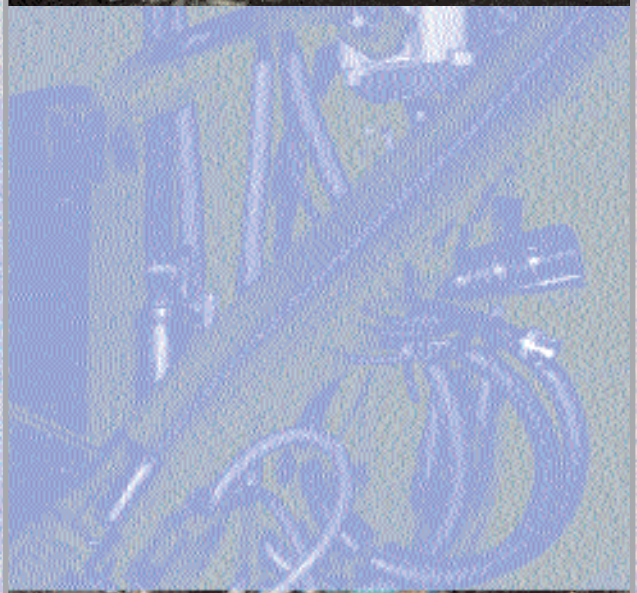
4. Inner diameter coating head for the laser assisted atmospheric plasma spraying (LAAPS)

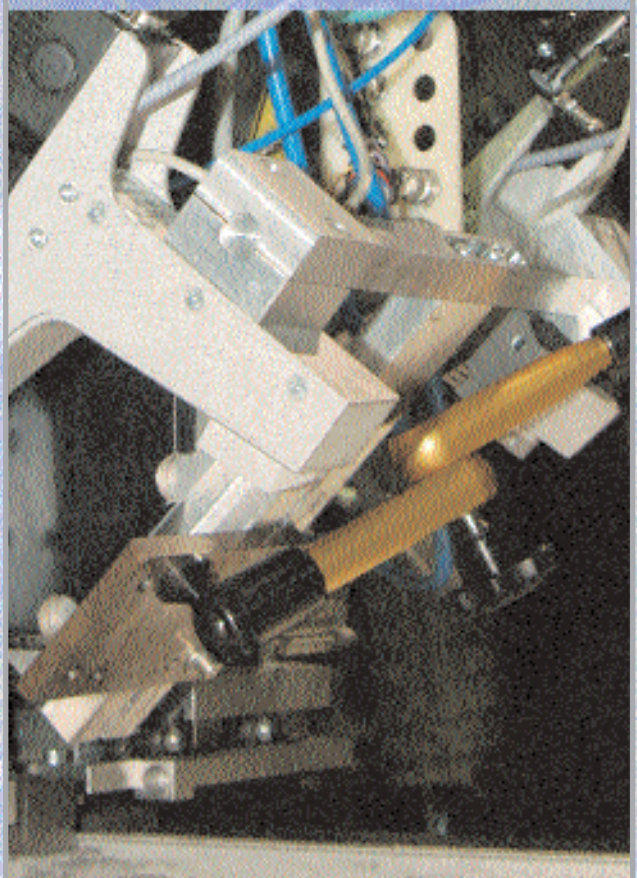
5. Thermal spray technology for demanding coating systems



Plasma powder cladding process







R&D-Offer: Joining and Surface Treatment

Editor: The activities in the development of laser beam welding processes for aircraft fuselage structures achieved a new highlight during the last year. How do you judge this?

Prof. Brenner: The large-scale project sponsored by the Saxony ministry of science and art and the company Airbus Germany GmbH (the German partner in the European Airbus consortium) was launched in July 2002. The objective of the project is to develop joining technologies for large-sized and damage tolerant aircraft fuselage structures. The core of the project is the conception and procurement of a so far unique laser beam welding system for the simultaneous 3D joining of reinforcement elements with work pieces of up to 10 m in length and 3 m in width with two high power lasers of highest beam quality. After a Europe wide solicitation, the order has been issued to a German system manufacturer during 2002. We expect the system setup during the first quarter of 2004. This will mark the point in time when we will begin to transfer the already on smaller systems developed technologies and many new creative ideas in better quality to reality.

Editor: But that was not the only success during the last year, since more technology transfers of inductively assisted laser beam welding have been realized. How do you see the further perspective of this technology?

Prof. Brenner: Yes, we successfully implemented two technology variations for an automotive transmission and a drive train in high volume production. The basic technology was developed some years ago at the Fraunhofer IWS Dresden. Together with renowned special equipment manufacturers such as Arnold Ravensburg and EFD Induction Freiburg we are capable to transfer highly modern system concepts and technologies to industry. The steady trend towards compact and lightweight construction at reasonable or even reduced manufacturing costs requires the shift to highly rigid materials, which can be especially advantageously joined with this technology. We predict therefore an increasing market window for this technology. This expectation is supported by the fact that we already have orders for two additional special systems of this kind for 2003. To be prepared for the expected development we initiated further research on more materials, work piece geometries and semi-manufactured products.

As long as man imagines
that he can`t do something
it will remain impossible for him to do it.
Spinoza

Prof. Dr. Berndt Brenner
Department Head
(Tel. 2583 207)

Dr. Steffen Bonß
Team Leader Surface Treatment Technologies
(Tel. 2583 201)

Optimized Technologies for the Hardening of Steel Components through Laser and / or Induction

If conventional hardening technologies are not suitable because of certain geometric shapes, material and wear conditions, laser hardening can be ideal to produce wear-resistant parts with an increase in service life. This technology is especially suitable for the selective hardening of multi-dimension faces, inner or hard to reach surfaces, sharp edges steps, bores and grooves, as well as for low distortion hardening. With a strong foundation of long term experience in the broad fields of wear protection and hardening, we are able to offer:

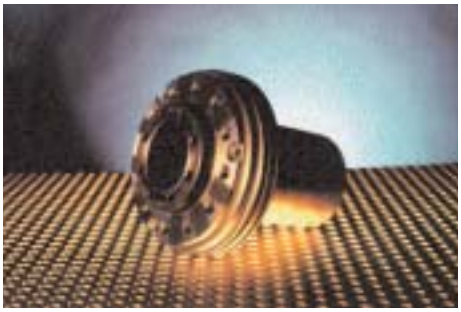
- Development of surface hardening technologies with high power diode lasers, CO_2 lasers, Nd:YAG lasers and / or induction,
- Prototype, process and system optimization.

Dr. Jens Standfuß
Team Leader Welding
(Tel. 2583 212)

Welding of Hard to Weld Materials

Laser welding is a modern welding process that is widely utilized in industry, especially in mass production. Such welding with a laser using a integrated heat treatment cycle developed at IWS offers a new process for the manufacturing of crack-free welded joints of hardenable steels, austenitic steels and special alloys. With our extensive experience in metal physics and a unique welding station with our integrated heat treatment process, we are able to offer:

- Development of welding technologies,
- Prototype welding,
- Process and system optimization,
- Preparation of welding instruction.



Part of the main drive shaft of a lathe, which was hardened with a high power diode laser

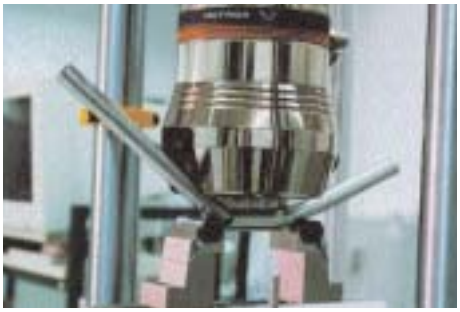
Laser beam welding of a gear for automotive manual shifter, 16MnCr5 hardened

Dr. Bernd Winderlich
Team Leader Materials Testing and Characterization
(Tel. 2583 224)

Complex Materials and Component Characterization

The control of modern joining and surface engineering processes requires knowledge from structural changes to the resulting component properties. Based on long term experience and extensive equipment in the area of structural, microanalytical and mechanical materials characterization we offer:

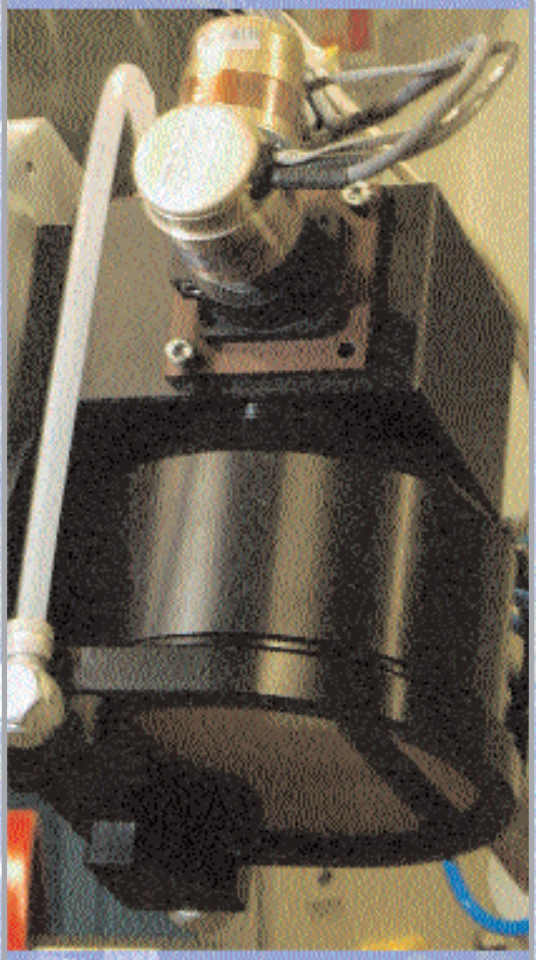
- Metallographic, electronmicroscopic (SEM, TEM) and microanalytical (EDX) characterization of the microstructure of metals, ceramics and compound materials,
- Determination of material data for component dimensioning and quality assurance,
- Property evaluation of surface treated and welded components,
- Strategies for materials and stress adapted component design,
- Failure analysis.



Testing of car windshield wiper linkage made of aluminum

Examples of the work in 2002

1. Inductively supported laser beam welding of axial and radial round seams on highly stiff work pieces with rotational symmetry
2. Realization of new passenger car door concepts though laser beam welding
3. Laser beam hybrid welding of structural work pieces made of high-strength fine grain construction steels
4. New software for the parameter optimization during laser beam hardening replaces experiments
5. Spot welding with high power diode laser
6. Beam splitter optics for high power diode laser
7. Melting bath convection during heat conduction welding with laser
8. Band shaped welding additives - an alternative for the improvement of weldability
9. Characterization of structure and properties of laser gas nitrided titanium alloys
10. Investigation of the microstructure processes during laser shock hardening of bcc metals.
11. Investigations of thermo-cycle resistance of (Ti,Al)N wear protective coatings



R&D-Offer: Laser Ablation and Cutting

Editor: The activities in the areas of micro processing and micro structuring have been driven forward in the last year. Which concrete projects are you currently pursuing?

Dr. Morgenthal: The application possibilities of micro material processing are seriously expanding with the increasing engagement of the micro systems technology and the possibilities offered through frequency multiplied Nd:YAG lasers as we use them in our institute. These deliver very high energies in extremely short times. This enables the micro processing of very temperature sensitive materials. Our industrial applications for these laser types range from the automotive industry and biotechnology to medical and semiconductor applications. As examples I would like to mention the structuring of suppressors for minimal invasive surgery and of sensors as well as the cutting of silicon wafers.

Editor: And you also made progress in building a mobile system for the anti skid processing of polished natural stone tiles. By when will the first system be ready to use?

Dr. Morgenthal: The laser based anti skid treatment of polished natural stone tiles has been meanwhile 5 years on the market and it is performed by several companies based on IWS licenses. Last year we signed a contract with a renowned manufacturer of natural stone to have the company building and marketing mobile systems for this treatment. The first prototype has since been reduced in size as there are also smaller hotel foyers, which we want to treat in the future according to legal regulations.

Imagination is more important than knowledge.
Johann Wolfgang von Goethe

Dr. Lothar Morgenthal
Department Head
(Tel. 2583 322)

Dr. Lothar Morgenthal
Team Leader Laser Cutting and System Engineering
(Tel. 2583 322)

Cutting Technology

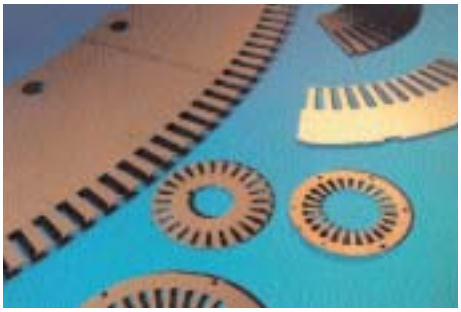
Metal-physical, process and manufacturing technological investigations of laser beam cutting can be carried out with lasers of different beam powers and wavelengths as well as on CNC tools. The treated parts can have dimensions of some millimeters up to meters. The main emphasis is the contour precise 2D high speed cutting of sheet metal on a highly dynamic cutting machine tool with linear drives. We use a flat part measurement & digitizing scanner system as well as materials characterization for the result control and quality assurance for part dimensions of up to 1800 mm · 1200 mm. We offer:

- Feasibility studies, sample production and R&D projects for all variations of laser beam cutting on materials and part samples,
- Technology and system development, testing and optimization,
- Development of system components for high speed processes, process control.

System Engineering and Laser Processing

IWS extended its specific offer for the development, testing, and production-ready realization of process adapted system solutions. Our departments offer:

- Processing optics, beam scanning systems, sensors for high speed and precision processing as well as process control,
- Handling systems, process control for industrial utilization of high power diode lasers for surface processing,
- Prototype development of coating equipment or their core modules for the PVD precision coating of bulk parts and the continuous atmospheric pressure band PVD including machine and process control software,
- Measurement systems to characterize coatings, non-destructive testing of parts with laser acoustic and spectroscopic methods.



Laser-cut electro sheet metals

Welding of the tube / base plate joint of an exhaust gas heat exchanger utilizing a beam scanning optics

Dr. Günter Wiedemann
Team Leader Ablation / Surface Cleaning
(Tel. 2583 251)

Ablation and Surface Cleaning

IWS has versatile technical equipment, scientific know-how and extensive practical experience in utilizing lasers for the ablation of thin layers or cleaning of surfaces in technical and restorative areas.

We offer:
- Consulting, feasibility studies,
- Technological investigations, including the generation of sample surfaces with excimer, Nd:YAG and TEA-CO_2 lasers,
- Application investigations,
- Structural analysis and testing (metallography, petrography, spectroscopy, SEM / EDX).

Dipl.-Ing. Udo Klotzbach
Team Leader Microstructuring / Engraving
(Tel. 2583 252)

Microstructuring with Lasers

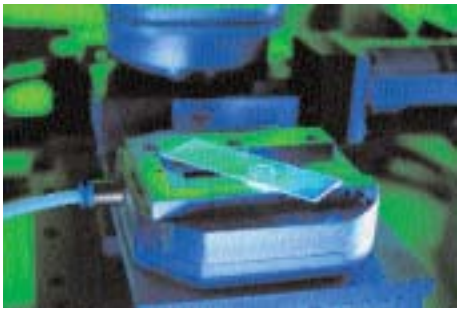
With state-of-the-art equipment and a solid know-how in the field, the work group follows the trend that laser micromachining gains importance with the miniaturization of functional elements in mechanical engineering, equipment manufacturing, and the automotive industry. In the same way the biotechnological and medial industries require the manufacturing of 3-D structures in the sub-mm range. The materials range from polymers, metals, and ceramics to quartz-like and biocompatible materials.

We offer:
- Microstructuring of different materials with excimer and Nd:YAG lasers for 3-D shaping and marking,
- Subsurface engraving of transparent materials,
- Microdrilling with high aspect ratios and a variety of bore geometries,
- Structural analysis and testing.

Examples of the work in 2002

1. Programming environment for mobile remote laser system
2. Optical sensor for the position detection of welding seams
3. Laser beam cutting of shadow masks with CO_2 lasers in cw operation
4. Prototype of a mobile system for the anti skid treatment of polished floors
5. Laser beam cleaning for the preparation of surface to be jointed
6. Laser separation of transparent linseed oil coatings on original oak wood panels of the Green Vault in Dresden
7. Cutting of a Mo mask for the ion irradiation of implants
8. Structuring of suppressors for the minimal invasive heart surgery with frequency multiplied Nd:YAG laser

Anti-slip preparation of polished flooring with laser micro structuring



Precision engraving of glass with frequency tripled Nd:YAG laser


Fadal

R&D-Offer: Multimedia and Simulation

Editor: In addition to the 5 departments at IWS there are two additional groups addressing areas such as modeling, simulation and education. Based on the development of models, it is one goal of the scientists working here to improve the process understanding of the technologies that are maintained at the IWS. This way it should be possible to calculate upfront the results and to optimize processes. Last year the BMBF project SIMKOPP was finished which generated a software platform for the process optimization of different coating processes. Which results have been achieved?

Dr. Lepski: The goal of the project was to develop software for the upfront calculation of results of different industrially relevant coating processes to ultimately shift the process optimization from the expensive production system to a "virtual machine". For example: At the IWS we developed the software SIMKOPP-LAVA to simulate the coating formation during the laser powder deposition welding, which calculates on a PC within minutes the processing result to be expected (welding track geometry, mixing, temperature distribution in the process zone, powder efficiency etc.) and gives recommendations for the step by step process optimization.

Dr. Voellmar: In the framework of the same project we developed at IWS the program SIMCOAT for the simulation of the vacuum arc coating process. The critical problems have been solved for both processes even though some of the models still have to be further developed. Until we can provide a robust and production-ready software we have to work out many more details preferably with potential users.

Editor: So there is still the need for research. On the other hand you finished the project "Laser lexicon on CD-ROM". How is the customer resonance?

Dr. Voellmar: With the delivery of the first CD-ROM "Laser Lexicon" in March 2002, we offered to our customers a multimedia and html-based tool to inform themselves quickly about technical terms around laser technology supported by animations and video clips. This way we addressed the increasing need in that area. Besides the CD-ROM "Laser Safety", there is now an additional tool available to especially help employees who are qualifying laser systems in the automotive and supporting industries based on modern multimedia and Internet techniques.

Editor: These are two examples from the area E-learning. Are there other activities at the WS in this area?

Dr. Voellmar: The BMBF project "Medi@Train" follows the goal to integrate new and still under development multimedia techniques into practical training programs for companies. The achieved results will be presented in February 2003 jointly with other Fraunhofer institutes at the "Learntec" fair in Karlsruhe.

There is nothing more practical than a sound idea.
Immanuel Kant

Dr. Siegfried Völlmar
Team Leader Multimedia
(Tel. 2583 434)

Dr. Dietrich Lepski
Team Leader Simulation / Fundamentals
(Tel. 2583 222)

Competence Center Multimedia

The explanation of the IWS research and development results requires frequently the utilization of modern communication technologies due to their complex character in a technological, material science and physical context. By combining text, image, video and audio we can illustrate invisible or fast running processes. This is especially important for safety relevant processes. We offer the following:

- Photography and video recording with most modern digital equipment
- Manufacturing of marketing material for technologies and products
- Recording of scientific events with life representation in the Internet or as permanently available downloadable data
- Design of presentations
- Implementing of physical-technical processes in 3D simulations
- Development work to provide modern "virtual reality" and "augmented reality" tools for the technological research
- Design of a system for education and training events in laser and surface technology

Process Simulation and Software Development for the Laser Material Processing

The saying goes "Trial and error outweighs the theoretical". However, with modern high technologies "trial and error" might get very expensive. A possibly deep understanding of the processes in laser material processing makes their further development and optimization not only easier but also more cost-effective. Therefore process simulation at IWS has become an integral part of process development. This is also true for process modeling up to point of developing production capable software (e.g. laser hardening, laser powder deposition welding).

Model supported estimates (feasibility studies) make it easier to decide which methods have to be applied to fulfill concrete customer requests and they support the finding of proper process windows. Beyond this we develop at IWS material for training and education (e.g. laser lexicon, laser safety).

Examples of the work in 2002

1. LAVA - simulation software for the laser powder deposition welding
2. SimCoat - simulation program for the optimization of coating deposition processes in industrial systems
3. "Virtual" congress participation via Internet
4. Multimedia representation for science, technology, and education

Masters Thesis

V. Franke
(Hochschule Mittweida (FH))
"Untersuchung verschiedener Bohrtechnologien zu reproduzierbaren Herstellungen von Düsenbohrungen in Metallen mit diodengepumpten Nd:YAG-Lasern"

M. Glausch
(Technische Universität Dresden)
"Witterungsbeanspruchte Bauteile aus Holz - Möglichkeiten und Grenzen des Einsatzes von Laserstrahlung zur Oberflächenbehandlung witterungsbeanspruchter Holzkonstruktionen"

G. Göbel
(Technische Universität Dresden)
"Beitrag zur rechnergestützten Optimierung der Bestrahlungsparameter beim Laserstrahlhärten"

T. Kretzschmar
(Hochschule für Technik und Wirtschaft Dresden (HTWD))
"Reparatur und Generieren von Bauteilen durch Laser-Hybridverfahren mit Zwischen- und Endbearbeitung durch Fräsen"

T. Kuntze
(Hochschule Mittweida (FH))
"Experimentelle Realisierung eines Aufbaus zur Excimerlaserbearbeitung mittels reflektiver Phasenmaske"

L. Piepo
(Fachhochschule Hildesheim)
"Einsatzmöglichkeiten von Laserstrahlung zur Reinigung glasierter Terrakotta"

M. Polster
(Westsächsische Hochschule Zwickau (FH))
"Abscheidung von dotierten Kohlenstoffschichten mit dem laserinduzierten Vakuumbogen"

P. Rost
(Berufsakademie Sachsen - Staatliche Studienakademie Dresden)
"Konzept und Erstellung einer plattformübergreifenden Komponente zur Darstellung von 3D-Daten und deren Integration in Simulationsumgebungen am Beispiel einer Laser-Beschichtungsanlage"

Dissertation

W. Grählert
(Rheinisch-Westfälische Technische Hochschule Aachen)
"Simulationsrechnung zur FTIR-reflexionsspektrokopischen Charakterisierung von Schicht- und Fasersystemen"

J. Kaspar
(Technische Universität Dresden)
"Untersuchung der durch Einwirkung kurzer hochenergetischer Laserpulse in kubisch-raumzentrierten Metallen induzierten Mikrostrukturen"

T. Rümenapp
(Technische Universität Dresden / Technische Universität Wien)
"Laserinduzierte Festphasenumwandlung in mineralischen Werkstoffen am Beispiel von Sandstein und Beton"

O. Zimmer
(Ruhr-Universität Bochum)
"Magnetische und elektrische Steuerung der Vakuumbogenbeschichtung"

Lecturing

Courses at the Institute for Production Technology at the TU Dresden in winter term 2001 / 2002:
- Prof. Beyer: Manufacturing technology II, (Surface and coating technology)
- Dr. Schultrich, Prof. Beyer: Coating technologies
- Dr. Leson, Prof. Beyer: Surface engineering / Nanotechnology

Courses at the Institute for Production Technology at the TU Dresden in summer term 2002:
- Prof. Beyer: Laser basics / Laser system technology

Courses at the Institute for Production Technology at the TU Dresden in winter term 2002 / 2003:
- Prof. Beyer: Manufacturing technology II, (Surface and coating technology)
- Dr. Schultrich: Thin film technology (special materials)
- Dr. Leson, Prof. Beyer: Surface engineering / Nanotechnology

Course at the Hochschule für Technik und Wirtschaft Dresden (HTWD):
- Dr. Nowotny: Laser materials treatment

Committees

Prof. E. Beyer:
Scientific Company for Laser Technology (WLT)

Prof. E. Beyer:
Laser Institute of America (LIA), Board of Directors, President in 2002

Prof. E. Beyer:
Member of the Materials Research Association, Dresden

Prof. E. Beyer:
Member of the Federal Association of Medium-sized Industries e.V.

Prof. E. Beyer:
Member of the European Research Society "Thin Films" e.V. (EFDS)

Prof. B. Brenner:
Technical Committee 9 of the AWT

Prof. B. Brenner:
Member of the Advisory Board of AiF

Dr. R. Jäckel:
Workgroup "Research Institutions Outside of Universities" for the Project "Demand Oriented Start-Up Establishments from Universities as in the Example of the High-Tech Region Dresden (Dresden exists)"

Dr. R. Jäckel:
Working Committee "Fairs and Public Relations" of the Materials Research Association, Dresden

Dr. G. Kirchhoff:
Working Committee "Sound Emission Analysis" of the DGzfP

A. Kluge:
Speaker for the Computer Operators of the Fraunhofer Society

Dr. A. Leson:
Member of the Board of the German Physical Society

Dr. A. Leson:
Speaker for the Nanotechnology Center of Excellence "Ultrathin Functional Films"

Dr. A. Leson:
Committee Member of the Magazine "Vacuum and Research in Practice"

Dr. A. Leson:
Chairman of the VDI-working Circle "Study Programs in Nanotechnology"

Dr. A. Leson:
Member of the Advisory Council of the VDI

Dr. A. Leson:
Chairman of the Steering Commitee in the VDI-competence Area Nanotechnology

Dr. A. Leson:
Member of the International Advisory Board of the Journal “Micromaterials and Nanomaterials”

Dr. S. Nowotny:
DVS Working Committee V9.2 / AA 15.2 "Laser Beam Welding and Related Techniques"

Dr. B. Schultrich, Dr. H.-J. Scheibe, Dr. A. Leson:
Working Committee Plasma Surface Technology of the DGO

Dr. B. Schultrich:
Member of the Board of Directors of the European Research Society "Thin Films" e.V. (EFDS)

Dr. A. Techel, Dr. S. Nowotny:
VDI Working Committee "Rapid Prototyping" in the VDI District Society, Dresden

Dr. B. Winderlich:
Work Group "Stability and Construction" of the DVS-BV Dresden

Dr. S. Nowotny
Association of Thermal Sprayers e.V. (GTS)

Special Events

February 26, 2002
Celebration of the 10-year anniversary of Fraunhofer Institutes in the new states at the Fraunhofer Institute Center in Dresden

February 26, 2002
Groundbreaking ceremony of the second building phase of the Fraunhofer Institutes Center Dresden

February 27, 2002
Meeting of the IWS Board of Trustees

October 14 -18, 2002
Surface Engineering and Nanotechnology (SENT)

The term SENT emphasizes the importance of the nanotechnology for the modern thin film technology. In collaboration with the TU Dresden the IWS started education courses about industrial thin film technology. The courses are taught as general courses at IWS and in the form of especially adapted versions at companies.

December 4, 2002
3. Symposium on surface technologies at the Dortmund Surface Center of the ThyssenKrupp Stahl AG

Prizes at IWS in 2002

1. Best innovative product idea

   Mr. Kretschmar, Dr. Schwarz
   "Development of a system of seam-finding positioning sensors NFP-2"

   Mr. Seifert
   "Development of a temperature controlled laser power regulation for the laser material processing"

2. Best scientific-technological achievement

   Dr. Luft, Mr. Tietz
   "Development of a novel method for the surface region refinement of age-hardenable high performance steels"

   Dr. Weihnacht
   "Development of a substrate pretreatment for the deposition of super hard DLC coatings with thickness beyond 10 µm"

3. Best scientific achievement of young talented scientist

   Mr. Foltyn, Mr. Moss, Mr. Pfeiffer
   "Use of masks for the manufacturing of nm multilayers"

4. Best scientific achievement of a student

   Mr. Franke
   "Investigation of different drilling techniques for the reproducible manufacturing of nozzle bores in metals with diode-pumped Nd:YAG lasers"

   Mr. Beese, Mr. Hofmüller
   "Design of an optical measurement cell for the in-situ analysis of process gases with diode laser spectroscopy"

5. Special prizes

   Mr. Roever
   "Organization of the worldwide first Internet broadcasting of a conference"

Celebration of the 10-year anniversary of Fraunhofer Institutes in the new states

Groundbreaking plate of the second building phase

Groundbreaking ceremony of the second building phase of the Fraunhofer Institutes Center Dresden

Participation at Industrial Fairs

Hannover Industrial Fair 2002, April 15 - 20, 2002

The IWS participated in the joint 80-m^2 booth "Laser Technology" in hall 6 - Micro Technology - by presenting the newest results in applied research in the area of laser material processing and micro processing. Results of joint research projects were presented together with IWS partner companies such as ALOtec GmbH Dresden, Arnold GmbH & Co. Ravensburg, EFD Induction GmbH Freiburg, Linde AG Munich and Primes GmbH Pfungstadt, which have been regularly participating in the event.

Intelligent systems utilizing lasers were shown under the new trademark "lasertronic®". At one station a robot was demonstrating an IWS developed high power beam scanning system, which is for instance used in the high volume production of exhaust gas coolers for diesel engines at the company Behr GmbH & Co. in Stuttgart.

The surface technology is a major emphasis at the Hannover fair every other year. On this occasion the IWS presented its newest results in the area of surface technology at the joint 60-m^2 booth "SurfPlaNet" with the VDI. The booth was located in the newly built hall 27. IWS presented diamond-like carbon coatings Diamor® for cutting and forming tools, the laser-acoustic measurement tool LAwave® for the characterization of the Young's modulus of thin films, a worldwide unique commercially available laser-acoustic measurement system, and the process combination of the laser assisted plasma spraying for the manufacturing of adhesive coatings at very high productivity. Besides this, the Nanotechnology Center of Excellence "Ultrathin Functional Films", which is coordinated by IWS, showed applications and products of nanotechnology, which have been provided by the members of the center.

The decision to represent IWS at the Hannover fair 2002 proved fruitful and yielded 190 relevant customer contacts.

Fair Optatec 2002 Frankfurt / M., June 18 - 21, 2002

The IWS department "X-ray and EUV Optics" participated this year at the 6th Optatec, an industry fair for optics and optoelectronics. The focus of the representation of the Nanotechnology Center of Excellence "Ultra Precise Surface Processing" was on X-ray mirrors and related systems. The information and experiences collected at the fair confirmed the real market need in the area of X-ray optics.

Fraunhofer IWS presentation at the Hannover fair 2002

Lively discussion about thin film technology at the Hannover fair 2002

Fair Euro-Blech 2002 Hannover, October 22 - 26, 2002

In 2002 the IWS Dresden and ALOtec GmbH Dresden participated in this international technology fair for sheet metal processing for the first time. We showed application examples for laser beam hardening and cutting as well as a complete automated solution for cutting, stacking and jointing of steel sheet metal cuts based on the principles of the LOM (laminated object manufacturing) process.

Fair Glasstec 2002 Düsseldorf, October 28 - November 01, 2002

The new working group "adhesive bonding techniques" and the construction-engineering group of the TU Dresden participated in the international glass fair in Duesseldorf. The presentation was focused on adhesive bonding techniques for the construction with glass. We showed bonded stools, touch screen terminals, as well as parts for a newspaper kiosk. The fair yielded interesting discussions as well as contacts to the medium sized industry.

Fair Denkmal 2002 Leipzig, October 30 - November 02, 2002

At this industrial fair for the maintenance of monuments and city renewal we showcased the laser beam cleaning of culturally and historically valuable objects of wood and stone. We showed the laser cleaned baroque window wing from the castle Kriebstein (Saxony), a joint work with the restorator Karsten Pueschner (Hartmannsdorf / Saxony). Simultaneously we introduced the book "Laser beam cleaning of natural stone", which emerged under significant contribution of the Fraunhofer IWS Dresden and is now published by the Fraunhofer IRB publisher.

Fair Euromold 2002 Frankfurt / M., December 04 - 07, 2002

The IWS participated for the 7th time in this industry sector fair addressing mold, model and tool making as well as casting. We presented results from the project "MELATO", which follows the goal to develop a new process chain form the fast manufacturing of complex shaped tools with up to 1.5 m in length. The exposed stamping tools have been manufactured based on the principles of the LOM process (laminated object manufacturing). Moreover we showed samples for the 3D laser deposition welding, which can be used for the repair of tools and for wear protection. The fair yielded many new customer contacts.

Experience exchange at the Hannover fair 2002

IWS presentation at the joint booth "Saxony" at the Euromold 2002

Patent Applications

[P1] E. Beyer, I. Jansen

"Verfahren zur Herstellung eines verstärkten Rohres oder Bleches"

Anmelde-Az.: 102 21 880.3-14

[P2] E. Beyer, S. Nowotny, S. Scharek

"Method for Producing Shaped Bodies or Applying Coatings"

Anmelde-Az.: US 10/110,423

[P3] S. Braun, H. Mai

"Optisches System mit einer Strahlungsquelle für elektromagnetische Strahlung im extremen ultravioletten Bereich und einem reflektierenden Element"

Anmelde-Az.: 102 21 116.7-51

[P4] S. Braun, H. Mai

"Vorrichtung und Verfahren zur Ausbildung von Gradientenschichten auf Substraten in einer Vakuumkammer"

Anmelde-Az.: 102 39 163.7

[P5] R. Dietsch, T. Holz

"Anordnung für röntgenanalytische Anwendungen"

Anmelde-Az.: WO 02-065 481

[P6] R. Dietsch, H. Borrmann, T. Holz

"Erhöhung der nutzbaren monochromatischen Strahlintensität durch optimierte Kombination von Multischichtoptiken und geeigneter Strahlung einer Röntgenquelle"

Anmelde-Az.: noch nicht vorhanden

[P7] T. Himmer

"Verfahren zum verzugsfreien Fügen von Blechen durch Laserstrahlschweißen"

Anmelde-Az.: 102 11 511.7-34

[P8] T. Himmer, A. Uelze

"Vorrichtung und Verfahren zur Herstellung von Laminatbauteilen"

Anmelde-Az.: 102 10 420.4-14

[P9] T. Himmer, A. Uelze

"Laminatbauteil oder Bauteil mit mindestens einem aus miteinander verbundenen Laminaten gebildeten Modul sowie ein Verfahren zu deren Herstellung"

Anmelde-Az.: 102 14 055.3-16

[P10] T. Holz

"X-Ray Fluorescence Analysis Device"

Anmelde-Az.: US 10/019,918

[P11] V. Hopfe, G. Mäder, D. Rogler, C. Schreuders

"Verfahren und Vorrichtung zur großflächigen Beschichtung von Substraten bei Atmosphärendruckbedingungen"

Anmelde-Az.: 102 39 875.5

[P12] V. Hopfe, D. Rogler, G. Mäder

"Verfahren zum Hybrid-Plasma-CVD bei Atmosphärendruck"

Anmelde-Az.: noch nicht vorhanden

[P13] C.-F. Meyer, H.-J. Scheibe, H. Schulz

"Vorrichtung und Verfahren zur Separation von Partikeln von einem Target zur Beschichtung eines Substrates erzeugten Plasmas im Vakuum"

Anmelde-Az.: 102 40 337.6-33

[P14] L. Morgenthal, D. Pollack, R. Gnann, A. van Spankeren

"Verfahren und Vorrichtung zur aktiven Sicherheits-Endlagen-Dämpfung für bewegte Maschinenteile, insbesondere von Hochgeschwindigkeitsmaschinen und insbesondere für die Vermeidung des Havariefalls, beispielsweise einer Kollision mit der Endlage"

Anmelde-Az.: 102 34 403.5

[P15] L. Morgenthal, T. Schwarz, F. Kretzschmar, D. Pollack, S. Thalheim

"Online-Abstandsmessung bei der thermischen Bearbeitung von Werkstückoberflächen"

Anmelde-Az.: noch nicht vorhanden

[P16] L. van Loyen, T. Böttger, S. Braun, H. Mai

"Schutz ausgewählter Flächen im Vakuum, vorzugsweise optischer Bauelemente, gegen Debris-Ablagerungen aus gepulsten Plasmen"

Anmelde-Az.: 102 33 567.2-52

[P17] M. Weihnacht, P. Siemroth, V. Weihnacht, R. Kunze

"Akustisches Oberflächenwellenbauelement"

Anmelde-Az.: 102 16 560.2

[P18] O. Zimmer, P. Siemroth, B. Schultrich, S. Schenk, B. Schuhmacher, U. Seifert, C. Hecht, R. Ekkehart

"Vorrichtung und Verfahren zum reaktiven Elektronenstrahlaufdampfen von reaktiv gebildeten Schichten auf Substraten"

Anmelde-Az.: 102 28.925.5-45

[P19] A. Zwick, B. Schumacher, M. Meurer, R. Leuschner

"Vorrichtung und Verfahren zur Herstellung von schmelztauchbeschichteten Stählen"

Anmelde-Az.: noch nicht vorhanden

Issued Patents

[P20] J. Berthold, T. Witke, P. Siemroth

"Vacuum Arc Evaporator"

Veröffentlichungs-Nr.: US 6 361 663 B1

[P21] E. Beyer, R. Imhoff

"Method and Device for Processing Components; in which a Molten Phase is Produced by Local Energy Input"

Veröffentlichungs-Nr.: US 6 423 921 B2

[P22] E. Beyer, J. Hauptmann, G. Wiedemann

"Vorrichtung und Verfahren zur Oberflächenstrukturierung von verlegten Fußbodenbelägen"

Veröffentlichungs-Nr.: DE 198 16 442 C2 und EP 1 071 536 B1

[P23] E. Beyer, S. Bonß, J. Standfuß

"Method and Device for Laser Beam Welding"

Veröffentlichungs-Nr.: US 6 444 947 B1

[P24] B. Brenner, A. Wetzig, D. Naunapper, C. Duscheck

"Wear-resistant Camshaft and Method of Producing the Same"

Veröffentlichungs-Nr.: US 6 398 881 B1

[P25] B. Brenner, F. Tietz

"Verfahren zur Erzeugung verschleißbeständiger Randschichten an ausscheidungshärtbaren Werkstoffen"

Veröffentlichungs-Nr.: DE 100 30 433 C2

[P26] B. Brenner, S. Bonß, H.-J. Scheibe, H. Ziegele

"Verschleißbeständiger, mechanisch hochbelastbarer und reibungsarmer Randschichtaufbau für Titan und / oder seine Legierungen sowie Verfahren zu seiner Herstellung"

Veröffentlichungs-Nr.: EP 1 032 721 B1

[P27] B. Brenner, R. A. Gnann, D. Naunapper, C. Duschek

"Method for Beam Welding of Hardenable Steels by Means of Short-Time Heat Treatment"

Veröffentlichungs-Nr.: US 6 365 866 B1

[P28] B. Brenner, R. A. Gnann, S. Bonß

"Vorrichtung zum Gaslegieren von Titan und seinen Legierungen"

Veröffentlichungs-Nr.: EP 0 829 325 B1

[P29] B. Brenner, S. Bonß, H.-J. Scheibe, H. Ziegele

"Wear-resistant, Mechanically High Stressed and Low-friction Boundary Coating Construction for Titanium or the Alloys There of and a Method for Producing the Same"

Veröffentlichungs-Nr.: US 6 410 125 B1

[P30] V. Fux, A. Uelze

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"Film Thickness Standards on the Nanometer Scale"

ASPE 17th Annual Meeting, St. Louis (USA), 20.-25. Oktober 2002

[T37] T. Himmer, A. Techel, S. Nowotny, E. Beyer

"New Developments in Surface Technology and Prototyping"

International Congress on Laser Advanced Materials Processing - LAMP 2002, Osaka (Japan), 27.-31. Mai 2002

[T38] T. Holz

"Spiegel und optische Systeme für Röntgenreflektometrie und Diffraktometrie"

Institutsseminar des Institutes für Kristallographie und Festkörperphysik, Dresden, 07. Mai 2002

[T39] T. Holz, R. Dietsch, C. Baerlocher

"X-Pointer - A High Brilliance Collimation Mo Ka Monochromator"

European Conference on Energy Dispersive X-Ray Spectroscopy (EDXRS), Berlin, 16.-21. Juni 2002

[T40] V. Hopfe

"In-situ Monitoring for CVD Processes"

4th International Conference on Coating on Glass (4th ICCG), Braunschweig, 03.-07. November 2002

[T41] R. Jäckel

"Deposition of Thin Carbon Films and of Multilayers - Two Examples of the Center of Competence Ultrathin Functional Films"

German-Israeli Symposium in Materials Research, Nanomaterials and Nanochemistry, Karlsruhe, 19. Februar 2002

[T42] J. Kaspar, A. Luft, S. Bonß, B. Brenner

"Untersuchungen der Mikrostruktur der Legierung Ti6Al4V nach dem Lasergasnitrieren mit unterschiedlichen Stickstoffgehalten"

AWT-Tagung "Nitrieren - Stickstoff am Randgefüge metallischer Werkstoffe", Aachen, 10.-12. April 2002

[T43] J. Kaspar, A. Luft, S. Bonß, B. Winderlich, B. Brenner

"Mikrostrukturelle Charakterisierung eigenschaftsdegradierender Mechanismen während der Schnellerwärmung und -abkühlung beim Laserstrahlschweißen und Lasergaslegieren von Titanwerkstoffen"

DFG-Kolloquium Schwerpunktprogramm "Kurzzeitmetallurgie", Bremen, 09.-10. Oktober 2002

[T44] A. Klotzbach, S. Nägeler, L. Morgenthal, V. Fleischer, E. Beyer

"Coupled Axes Systems (CAS) for Remote Laser Welding"

10th Annual Automotive Laser Applications Workshop - ALAW 2002, Dearborn (USA), 12.-13. März 2002

[T45] U. Klotzbach, M. Panzner, T. Kuntze, H. Wust, E. Beyer

"Processing of Silicon by Nd:YAG Lasers with Harmonics Generation"

International Congress on Applications of Lasers and Electro-Optics - ICALEO 2002, Scottsdale (USA), 14.-17. Oktober 2002

[T46] H. Kötter, E. Beyer

"Lasertechnik für die Produktion"

Lehrveranstaltungsreihe "Produktion im 21. Jahrhundert", Dresden, 14. Mai 2002

[T47] D. Lepski, H. Eichler, V. Fux, S. Scharek, E. Beyer

"Simulation of the Powder Injection Laser Beam Cladding Process"

International Conference "THE" Coatings in Manufacturing Engineering and EUREKA Partnering Event, Thessaloniki (Griechenland), 28.-29. November 2002

[T48] A. Leson

"Nano Goes PowTech"

Internationale Fachpressekonferenz der Messe Nürnberg, Nürnberg, 09. Oktober 2002

[T49] A. Leson

"Nanotechnologie - Realität und Sience-Fiction"

Fachpressetag des Vereins Deutscher Ingenieure, Düsseldorf, 31. Januar 2002

[T50] A. Leson

"Nanometer Film Systems - Manufacturing and Applications"

University of Sao Paulo, Sao Paulo (Brasilien), 04. März 2002

[T51] A. Leson

"Nanometer Films Systems - Cooperation within the Center of Competence"

University of Pernambuco, Recife (Brasilien), 07. März 2002

[T52] A. Leson

"Nanometer-Schichtsysteme für Röntgenoptiken"

Nanotechnologie - Die Schlüsseltechnologie des 21. Jahrhunderts in der industriellen Anwendung, Regensburg, 22. Oktober 2002

[T53] A. Leson

"Resume of the Conference and Concluding Remarks"

Nanofair 2002, Strasbourg (Frankreich), 25.-26. November 2002

[T54] A. Leson

"Cooperation within a Center of Competence on Nanotechnology"

Czech-Slovak-German Joint Meeting, Prague, 05. Dezember 2002

[T55] L. van Loyen

"Konzeption und Erprobung eines Labor-Reflektometersystems für Röntgenoptiken (SX-Reflektometer)"

Carl Zeiss SMT AG - Statusreport, Oberkochen, 23. Januar 2002

[T56] A. Mahrle

"Simulation der lokalen Temperaturverteilung beim Laserstrahltiefschweißen"

Institutsseminar des Fraunhofer Institutes für Werkstoff- und Strahltechnik (IWS), Dresden, März 2002

[T57] H. Mai, S. Braun

"Der Sputterprozess und seine Anwendung zur Synthese von Nanometer-Multischichten"

Workshop "Sputtertargets für die Dünnschichttechnik" am Fraunhofer-Institut für Fertigungstechnik und Angewandte Materialforschung (IFAM), Dresden, 26. September 2002

[T58] S. Nowotny, E. Beyer

"Increased Efficiency for Large Area Coatings by Laser/Plasma Hybrid Spraying"

8th International Conference on Plasma Surface Engineering - PSE 2002 Garmisch-Partenkirchen, 09.-13. September 2002

[T59] S. Nowotny, T. Himmer, A. Techel, E. Beyer

"Recent Developments in Laminated Tooling by Multiple Laser Processing"

International Congress on Applications of Lasers and Electro-Optics - ICALEO 2002, Scottsdale (USA), 14.-17. Oktober 2002

[T60] S. Nowotny, A. Richter, R. Zieris, E. Beyer

"Using Lasers for the Production of Ceramic Coatings"

International Conference on Metallurgical Coatings and Thin Films - ICMCTF, San Diego (USA), 23. April 2002

[T61] S. Nowotny, S. Scharek, T. Naumann, R. Gnann, T. Heptner, E. Beyer

"Laserstrahl-Auftragschweißen zum Oberflächenschutz, Reparieren und Generieren"

Laser Workshop Jena, Jena, 28.-29. November 2002

[T62] S. Nowotny, S. Scharek, R. Zieris, T. Naumann, E. Beyer

"Laser Based Hybrid Techniques for Surface Coating"

International Congress on Applications of Lasers and Electro-Optics - ICALEO 2002, Scottsdale (USA), 14.-17. Oktober 2002

[T63] S. Nowotny, R. Zieris, T. Naumann, K. Nassenstein, E. Beyer

"Laser/Plasma-Hybridtechnik zum Erzeugen dichter, flächenhafter Beschichtungen"

International Thermal Spray Conference and Exposition - ITSC 2002, Essen, 04.-06. März 2002

[T64] F. Papa, C. Engdahl, M. Becker, T. Schülke

"The Analysis of Tungsten Carbide Surfaces by Laser-Acoustic Surface Waves"

International Conference on Metallurgical Coatings and Thin Films - ICMCTF, San Diego (USA), 23. April 2002

[T65] W. Pompe, S. Beyer, T. Sebald, P. Gawlitza, H. Mai

"Inside Coating of Combustion Chambers of Rocket Engines"

International Symposium TurboMat - Advanced Thermal Barrier Coatings and Titanium Aluminides for Gas Turbines, Bonn, 17.-19. Juni 2002

[T66] I. Retzko, W. E. S. Unger, H. Schulz, H.-J. Scheibe

"Analysis of Carbon Materials by XPS"

Materials Week, München, 30. September - 02. Oktober 2002

[T67] H.-J. Scheibe, C.-F. Meyer, B. Schultrich, H. Schulz, M. Schwach

"Diamor® - Superharter amorpher Kohlenstoff, eine neue Generation von reibungsarmen Verschleißschutz-schichten"

Tribologie-Fachtagung 2002, Göttingen, 23.-25. September 2002

[T68] H.-J. Scheibe, B. Schultrich

"Harte Kohlenstoffschichten für die Umformung und Zerspanung mit vermindertem Schmierstoffeinsatz"

VDI-Seminar "Trockenzerspanung in der Serienfertigung", Dresden, 21.-22. März 2002

[T69] H.-J. Scheibe, A. Zwick, T. Stucky, B. Schultrich

"Industrial Laser-Arc Coater for the Deposition of Superhard Amorphous Carbon Films (Diamor®)"

International Conference on Metallurgical Coatings and Thin Films - ICMCTF, San Diego (USA), 23. April 2002

[T70] D. Schneider, S. Carvalho, M. Leonhardt, B. Schultrich

"Characterizing Defect Density an Porosity by Laser Acoustics"

International Conference on Metallurgical Coatings and Thin Films - ICMCTF, San Diego (USA), 23. April 2002

[T71] B. Schuhmacher, W. Müschenborn, M. Stratmann, B. Schultrich, C.-P. Klages, M. Kretschmer, U. Seyfert, F. Förster, E. Blumenfeld, H.-J. Tiller

"Novel Coating Systems for Steel Strip by Means of Innovative Technologies in a Continuous Process"

Materials Week 2002, München, 30. September - 02. Oktober 2002

[T72] B. Schultrich

"Möglichkeiten und Grenzen der Puls-Laser-Deposition"

Institut für Laserphysik, Hamburg, 28. Januar 2002

[T73] B. Schultrich

"Nanostructured Carbon Films and Their Tribological Applications"

Nanofair 2002, Strasbourg (Frankreich), 25.-26. November 2002

[T74] B. Schultrich

"Harte und superharte Nanoschichten und Nanoschichtsysteme"

Frühjahrstagung der Deutschen Physikalischen Gesellschaft, Regensburg, 12. März 2002

[T75] B. Schultrich

"Superharte Kohlenstoffschichten durch Nanometer-Schichtdesign"

Drittes Fachforum Nanotechnologie "Die Schlüsseltechnologie des 21. Jahrhunderts in der industriellen Anwendung", Regensburg, 22.-23. Oktober 2002

[T76] B. Schultrich, P. Gawlitza

"Nanoskalige funktionale Schichten für Tribologie, Wärmedämmung und Korrosionsschutz"

Workshop ANTARES - Analyse der Nanotechnologie-Anwendungen in Raumfahrtentwicklung und -systeme, Köln, 04. Juni 2002

[T77] B. Schultrich, H. Jäger

"Simulation of Growth of Tetrahedrally Bonded Amorphous Carbon Films by High Energy Ions"

8th International Conference on Plasma Surface Engineering, Garmisch-Partenkirchen, 09.-13. September 2002

[T78] B. Schultrich, C. M. Schneider

"Ultrapräzisionsbeschichtungen"

Arbeitskreis Ausrüstungen, Materialien und Dienstleistungen für die Halbleiter-industrie, Dresden, 05. März 2002

[T79] B. Schultrich, T. Schülke

"Qualitätssicherung von Diamant-beschichtungen mittels Laser-Akustik"

AK Diamant-Werkzeuge, Berlin, 05.-07. November 2002

[T80] B. Schultrich, S. Völlmar, D. Römer

"SimCoat - A Simulation Program Package for Industrial Vacuum Arc Coaters"

International Conference on Metallurgical Coatings and Thin Films - ICMCTF, San Diego (USA), 23. April 2002

[T81] T. Schülke

"Nondestructive Testing of Damage Layers in Semiconductor Materials by Surface Acoustic Waves"

International Symposium on Advanced Microelectronic Manufacturing and Nanotechnologies, Santa Clara (USA), 06.-07. März 2002

[T82] H. Schulz, C. Fröck

"Wechselwirkung von amorphen Kohlenstoffschichten mit Polymeren"

10. Neues Dresdner Vakuumtechnisches Kolloquium, Dresden, 17.-18. Oktober 2002

[T83] H. Schulz, H.-J. Scheibe, P. Siemroth, B. Schultrich

"Pulsed-Arc-Deposition of Superhard Amorphous Carbon Films"

Jahrestagung der DVG - Vakuum-gestützte Wissenschaften und Technologien, Magdeburg, 17.-20. Juni 2002

[T84] C. Schwerdt, M. Riemer, B. Schumacher, S. Schenk, O. Zimmer, B. Schultrich, G. Grundmeier

"Metallurgical and Corrosion Aspects of Highly Corrosion Resistant PVD ZnMg Alloy Coated Steel Strip"

International Conference on Industrial Surface Technology, Stockholm (Schweden), 29.-31. Mai 2002

[T85] M. Seifert

"Gut gesteuert ist halb gewonnen! - Neuartige Anwendungen des Laserstrahlhärtens durch verbesserte Temperaturregelung"

Hannover-Messe 2002, Hannover, 17. April 2002

[T86] M. Seifert, S. Bonß, B. Brenner, E. Beyer

"Extended Possibilities for High Power Diode Laser Heat Treatment Using Special Optics"

International Congress on Applications of Laser and Electro-Optics - ICALEO 2002, Scottsdale (USA), 14.-17. Oktober 2002

[T87] P. Siemroth, H.-J. Scheibe, B. Schultrich, J. Berthold, T. Schülke, W. Hentsch, H. H. Schneider, H. Hilgers, B. Petereit

"Deposition of High Quality Films by Fully Ionized Plasmas from High Current Pulsed Vacuum Arc Discharges"

European Workshop on Pulsed Plasma Surface Technologies, Dresden, 05.-07. Juni 2002

[T88] J. Standfuß, D. Dittrich, B. Brenner, E. Beyer

"Laser Beam Welding of Magnesium Light Weight Structures"

International Congress on Applications of Lasers and Electro-Optics - ICALEO 2002, Scottsdale (USA), 14.-17. Oktober 2002

[T89] P. Thomsen-Schmidt, K. Hasche, G. Ulm, K. Herrmann, M. Krumrey, G. Ade, J. Stümpfel, S. Schädlich, W. Frank, M. Procop, U. Beck

"Realization of Thickness Standards below 100 nm Thickness"

Jahrestagung der DVG - Vakuumgestützte Wissenschaft und Technologien, Magdeburg, 17.-20. Juni 2002

[T90] A. Torosyan, M. Becker, T. Schülke

"New Method for Surface Modification and Hard Coating"

International Conference on Metallurgical Coatings and Thin Films - ICMCTF, San Diego (USA), 23. April 2002

[T91] J. Vetter, P. Siemroth, H.-J. Scheibe, T. Schülke

"Carbon Coatings for Dry Machining and Forming Operations Deposited by Non-Reactive (ta-C) and Reactive (a-C:Me) Cathodic Arc Processes"

International Conference on Metallurgical Coatings and Thin Films - ICMCTF, San Diego (USA), 23. April 2002

[T92] S. Völlmar, B. Schultrich, D. Römer, T. Stucky

"SimCoat: Ein Simulationsprogramm für Vakuumbogenbeschichtungen"

Jahrestagung der DVG - Vakuumgestützte Wissenschaft und Technologien, Magdeburg, 17.-20. Juni 2002

[T93] S. Völlmar, B. Schultrich, D. Römer, T. Stucky

"SimCoat: Ein Simulationsprogramm für Vakuumbogenbeschichtung"

Jahrestagung der DVG - Vakuumgestützte Wissenschaften und Technologien, Magdeburg, 17.-20. Juni 2002

[T94] P. Vuoristo, A. Määttä, T. Mäntylä, L.-M. Berger, S. Thiele

"Properties of Ceramic Coatings Prepared by HVOF and Plasma Spraying from Titanium Suboxide Powders"

International Thermal Spray Conference and Exposition - ITSC 2002, Essen, 04.-06. März 2002

[T95] V. Weihnacht

"Grenzflächenfestigkeit und Schichthaftung"

7. Workshop Nanoschutzschichten, Braunschweig, 05.-07. Juni 2002

[T96] V. Weihnacht, B. Schultrich

"Ultrathin and Nanolayered Carbon Films"

36th IUVSTA Workshop "On the Mechanisms of Formation and Application of Hard Nanostructured Coatings", Plzen (Tschechien), 20.-24. Oktober 2002

[T97] G. Wiedemann

"Laserstrahlreinigen in der Lebensmittelindustrie"

IWS-Workshop "Potenziale der Lasertechnik in der Verpackungsmittelindustrie", Dresden, 19. November 2002

[T98] G. Wiedemann

"Laserstrahlreinigen von Kunst- und Kulturgut mit Laserstrahlen"

Dresdner Brunnentag, Dresden, 25. Mai 2002

[T99] H. Wust, E. Beyer, G. Wiedemann, M. Panzner, P. Haller

"Experimental Study of the Effect of a Laser Beam on the Morphology of Wood Surfaces"

Wood Based Materials - Wood Composites and Chemistry, Wien (Österreich), 19.-20. September 2002

[T100] H. Wust, G. Wiedemann, P. Haller

"Experimental Study of the Effect of a Laser Beam on the Morphology of Wood Surfaces"

1st European Wood Conference, Hamburg, 07.-10. Oktober 2002

[T101] R. Zieris, S. Nowotny, E. Beyer

"Werkstoff- und prozesstechnische Synergieeffekte durch die Zusammenführung von Plasmastrahl und Laserstrahl"

2. GTV Kolloquium, Luckenbach, 21. Juni 2002

[T102] J.-H. Zollondz, J. Krauser, A. Weidinger, C. Trautmann, D. Schwen, C. Ronning, H. Hofsass, B. Schultrich

"Conductivity of Ion Tracks in Diamond-Like Carbon Films and Field Emission"

Diamond 2002 - 13th European Conference on Diamond, Diamondlike Materials, Carbon Nanotibes, Nitrides & Silicon Carbide, Granada (Spanien), 08.-13. September 2002

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Quotations:	The quotations are translated faithfully to their meanings	

Title Photos

top: Deposition of ZrO_2-thermal insulation layers (internal coating)

middle: Stamping tool made by Metal Laminated Object Manufacturing (LOM)

bottom: Inductive assisted laser beam welding of an output shaft for 6 gear manual transmission gear box