IWS

Fraunhofer Institut
Werkstoff- und
Strahltechnik

Annual Report 2004

Internet: www.iws.fraunhofer.de

IWS

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Werkstoff- und
Strahltechnik

Annual Report 2004

CERTIFICATE

DIN EN ISO 9001:2000

hereby certifies that the company

Fraunhofer Institut Werkstoff- und Strahltechnik

business field:
X-Ray and EUV Optics, PVD Thin Film Technology, CVD Thin Film Technology, Thermal Coating, Joining & Surface Treatment, Ablation and Cutting

location:
Winterbergstr. 28 * D-01277 Dresden

has implemented and effectively applies a quality management system according to the standard (12/2000) mentioned above. The conformity was inspected during the certification audit documented in audit report no. A0307203. This certificate is only valid in connection with the successful performance of the surveillance audits.

Date of the first certification: 30.12.1997
This certificate is valid until: 28.10.2006
Date of the last recertification: 29.10.2003
Certificate-registration no.: 91297819/3 duplicate

Reg.Nr.: TGA-ZM-05-91-00

Prologue

Editor: The year 2004 did not yet deliver the expected economic upswing. What are the consequences for IWS?

Prof. Beyer: In 2004 the funds available for publicly supported projects continued to decline. In the previous year we were able to more than compensate for this decrease with an over proportional increase of industrial revenues. In 2004 we were not able to balance this decline in publicly available funds by further increasing industry revenues. However, despite these substantial difficulties we managed to again achieve the same outstanding result of the previous year.

Editor: Which difficulties had to be overcome in 2004?

Prof. Beyer: We expanded our building with an addition of 3000 m². Since the capacity of the old building was completely utilized we will have clearly improved working conditions in the future.

For months all employees and guests had to suffer from the noise and dust of the construction work. In addition to these conditions many laboratories were completely reconstructed which limited our ability to work on customer contracts. We had to improvise in many cases since after all every department was affected by the expansion project.

However, now we are back to being fully operational and have the possibility to grow even further. We are grateful for the support of the state of Saxony, the federal government, and the Fraunhofer Society.

Editor: Weren't these difficulties predictable?

Prof. Beyer: Reconstruction projects are of course always an additional challenge. However, as a result of a number of construction related delays the expansion was finished three quarters of a year past the original deadline. In that sense it was not possible to foresee the enormous dimension of this challenge.

Editor: Were there nonetheless some highlights in 2004?

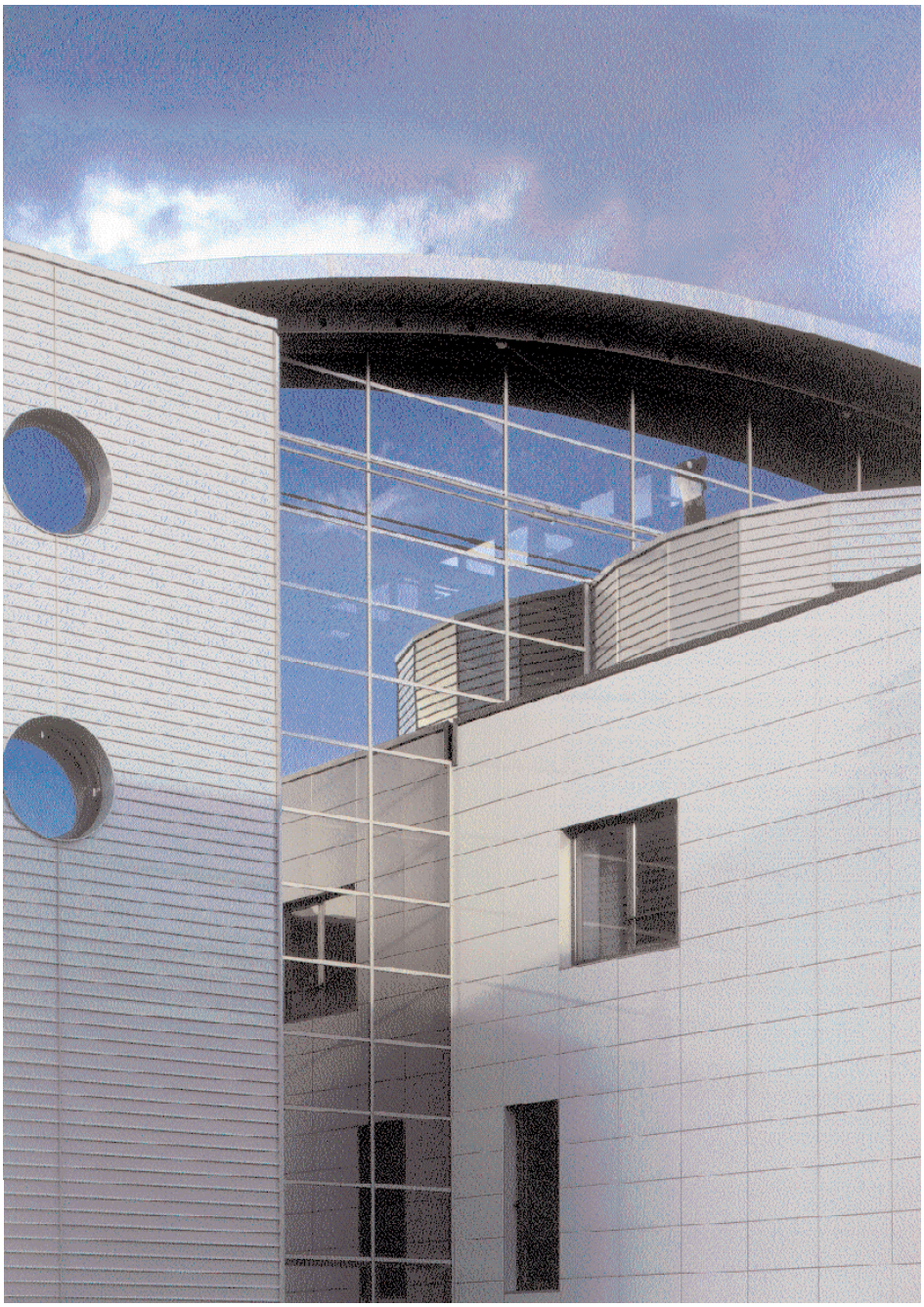
Prof. Beyer: Of course. We were again able to commercialize IWS developments by transferring them to industrial manufacturing. In addition we participated in a number of activities and events in the »Year of Technology«.

Editor: What do you expect for the year 2005?

Prof. Beyer: We expect a further decline in public funding. Therefore we will continue to increase our marketing activities and aim at intensifying the cooperation with our industrial customers. Since we were able to expand our equipment base and we will not face the additional costs incurred in 2004, we are going into the challenging year of 2005 with lots of optimism.

Editor: Thank you very much for the interview.

These grey little cells.
It is »up to them«.
Agatha Christie



Fraunhofer-Institut für
Werkstoff- und Strahltechnik IWS

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Contents

Grand opening of the second expansion stage of the Fraunhofer Institutes Center, Dresden

On the 3rd of June 2004, the four Fraunhofer Institutes located at Dresden's Winterbergstraße opened their expanded buildings. The Federal Minister for Education and Research, Edelgard Bulmahn, and the Minister President of the Free State of Saxony, Professor Dr. Georg Milbradt, participated in this ceremony. With the completion of the expansion at the Fraunhofer Institutes Center the scientists have an additional space of 10,200 m² for performing their research activities.

Mrs. Edelgard Bulmahn, Federal Minister for Education and Research, during the opening ceremony of the institute buildings

Prof. Dr. Georg Milbradt, Minister President of the Free State of Saxony, during the opening ceremony of the institute buildings

Germany's President Horst Köhler, the Minister President of the State of North Rhine-Westphalia, Peer Sterinbrück, and the Chairman of the Board of ThyssenKrupp AG, Prof. Dr. Ekkehard Schulz together with Dr. Axel Zwick (IWS)

IWS participation at the »Park of Ideas« of ThyssenKrupp

As an important research and development partner of ThyssenKrupp, the IWS was present in the »Park of Ideas«. Dr. Axel Zwick (IWS) informed Germany's President Horst Köhler together with the Minister President of the State of North Rhine-Westphalia, Peer Sterinbrück, and the Chairman of the Board of ThyssenKrupp AG, Prof. Dr. Ekkehard Schulz, about the increasing importance of surface technologies.

Presentation of Mr. Thomas Pearsall from the European Photonics Industry Consortium at the International Open House at the Fraunhofer IWS, Dresden

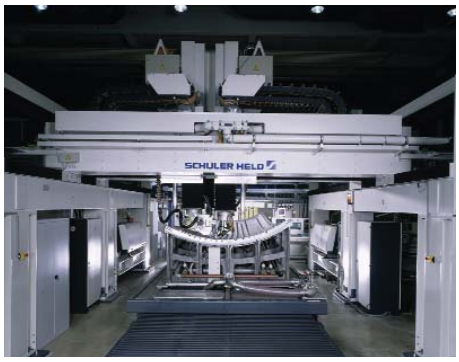
International Open House at the Fraunhofer IWS Dresden

The International Open House was hosted at the Fraunhofer IWS on September 20th and 21st right after the construction work had been finished and the new laboratories were opened. Numerous international guests from our European neighbor countries were introduced to our technical possibilities in laser materials processing and surface technologies.

Mr. Brenneis (Airbus Germany), Prof. Beyer (Fraunhofer IWS) and Ministerialdirigent Geiger (Saxony Ministry for Science and Art) (from left to right) during cutting of the ribbon

The 3D laser beam welding system for the welding of aircraft fuselage structures goes into operation

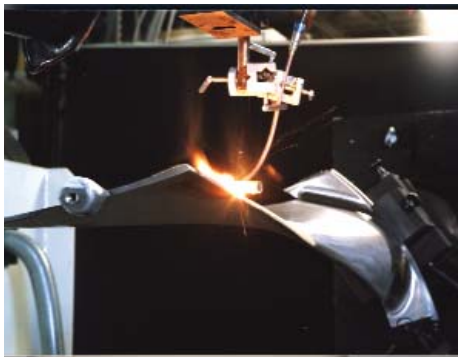
On June 25, 2004, a new laser beam welding system for the joining of large 3D parts for the aerospace industry was demonstrated to representatives of Airbus Germany, the Federal Ministry for Economy and Labor as well as the two Saxony Ministries for Science and Art (SMWK) and Economy and Labor (SMWA). It is now possible at the IWS in Dresden to develop highly productive manufacturing technologies for new passenger airliners.



3D laser beam welding system for the welding of aircraft fuselage structures

Commercialization of a new surface treatment process for the lifespan extension of turbine blades

In a project with Siemens Power Generation Mülheim a worldwide novel technology was developed for the surface hardening of large low-pressure output stage running blades, which are made from precipitation hardenable steels. This process was applied to a turbine that is used at the power plant in Incheon (South Korea). For the first time there is now a passive technique available that protects these highly stressed turbine blades from droplet impact wear while not reducing their maximum cyclical performance.



Process of the surface hardening of a turbine blade

Test stand for TMF tests on rocket engine components

In a contract from EADS Space Transportation we performed lifespan tests of rocket engine components. The extreme thermal stress conditions during the application of these components were simulated by using high power lasers as a heat source and simultaneously applying liquid nitrogen to cool the test structures. The test stand enabled through thermo-mechanical fatigue testing the experimental determination of the lifespan of selected engine components.

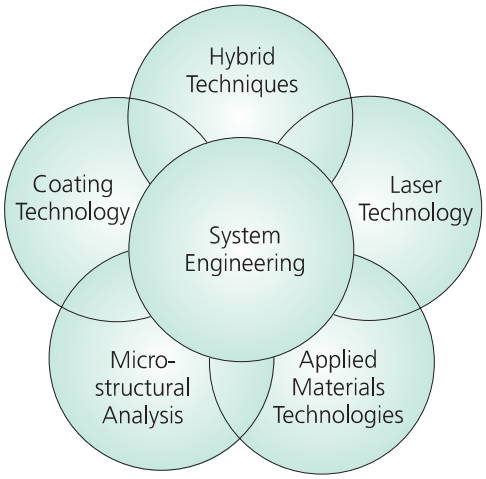
Nitrogen supply tank with delivery, mixing, and control system

In order to see clearly
it is frequently sufficient
to change the point of view.
Antoine de Saint-Exupery

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 dispersing)
- 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, nitrides, oxides, etc.
- super hard amorphous carbon films
- nanometer multilayer films for X-ray optical components
- atmospheric pressure plasma-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 electronmicroscopy (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
- coating modules for atmospheric pressure plasma CVD and PVD 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.

Business fields	Core services	Laser processing tech.	Coating processes	Materials tech. / analysis	Simulation	System technologies
joining						
welding	■	■		□	■	□
soldering	■	■		□		
adhesive bonding	■		■	□		
cutting	■	■				□
surface technology						
removal / cleaning	■	■		□	■	□
wear protection	■	■	■	□	■	□
repairs	■	■				□
friction reduction	■		■	□		□
oxidation protection	■	■	■	□		□
functional coatings	■		■	□		□
microtechnology	■	■	■	□		□
optics						
X-ray optics, EUV optics	■		■	□	■	□
IR optics	■			□	■	
rapid prototyping, rapid tooling	■	■		□		□
process monitoring	■	■	■			□

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Organization and contacts

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Executive Director Prof. Dr. Beyer
Deputy Director Dr. Leson
Assistant Mrs. Weinberg
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Infrastructure

Head of Administration
Dr. Wilhelm
Tel.: 312

Marketing / PR
Dr.Krautz /
Dr. Jäckel
Tel.: 332 / 444

Surface Engineering and Coatings

X-Ray and EUV-Optics
Dr. Leson
Tel.: 317

- **Coating** — Dr. Braun, Tel.: 432
- **Metrology/ Applications** — Dr. van Loyen, Tel.: 422

PVD Thin Film Technology
Prof. Schultrich
Tel.: 403

- **Carbon Coatings** — Prof. Schultrich, Tel.: 409
- **PVD Coatings** — Dr. Zimmer, Tel.: 257

CVD Thin Film Technology
Dr. Hopfe
Tel.: 402

- **Atmospheric Pressure CVD** — Dr. Dani, Tel.: 405
- **Process Monitoring** — Dr. Grählert, Tel.: 406

Laser Materials Processing

Thermal Coating
Dr. Nowotny
Tel.: 241

- **Thermal Spraying** — Dr. Berger, Tel.: 330
- **Cladding** — Dr. Techel, Tel.: 255

Joining/Surface Treatment
Prof. Brenner
Tel.: 207

- **Welding** — Dr. Standfuß, Tel.: 212
- **Surface Treatment** — Dr. Bonß, Tel.: 201

Laserablation and Cutting
Dr. Morgenthal
Tel.: 322

- **Laser Cutting** — Dr. Morgenthal, Tel.: 322
- **Microprocessing/ Cleaning** — Mr. Klotzbach, Tel.: 252

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TECHNISCHE UNIVERSITÄT DRESDEN

Chair for Laser and Surface Technology
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TU Dresden

Guest companies located at Fraunhofer IWS:

- EFD Induction GmbH Freiburg, Dresden Branch
- ALOtec Applied Laser and Surface System Technology GmbH Dresden
- AXO Dresden GmbH
- Arc Precision Dresden GmbH

Connection to the University of Technology (TU Dresden)

Chair for Laser and Surface Technology

During 2004, 34 colleagues were employed in the university department. The third party revenues yielded more than 1.3 million €.

The department of laser and surface technology is the driving component of the institute for surface technology and production metrology, which was newly founded on July 1, 2003, at the faculty of mechanical engineering. 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
- Prof. Beyer: Laser basics / laser system technology
- Prof. Beyer: Laser and plasmas in the surface and micro technology
- Prof. Beyer: Plasmas in the production technology
- Prof. Beyer: Rapid protocoating
- Dr. Leson, Prof. Beyer: Surface engineering / nanotechnology
- Prof. Schultrich: Thin film technology

Cooperation Fraunhofer IWS - TU Dresden

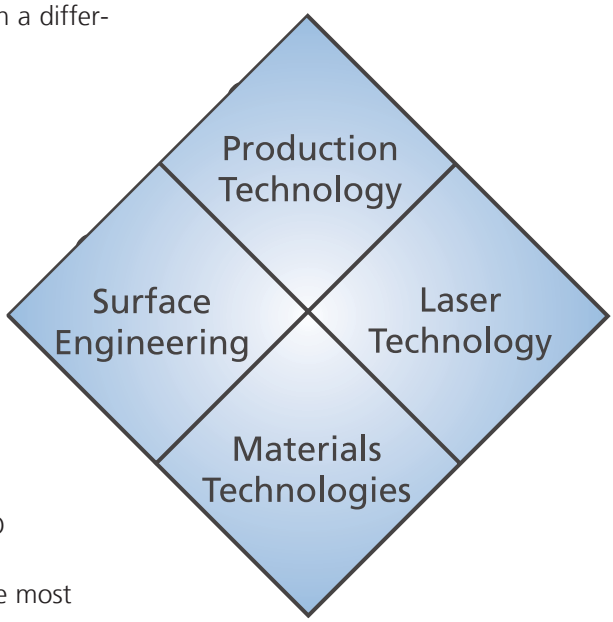
A special agreement regulates the cooperation between the IWS and the TU Dresden. Prof. Beyer works simultaneously as the executive director of the IWS as well as a chairman at the University. The work is distributed as follows: Research and education are performed at the university and applied research 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

We need men
who can dream of things
that never were.
John F. Kennedy

TU Dresden



CD for manufacturing technology course (II)

CD laser safety

CD for laser technology course

Centers and external project groups

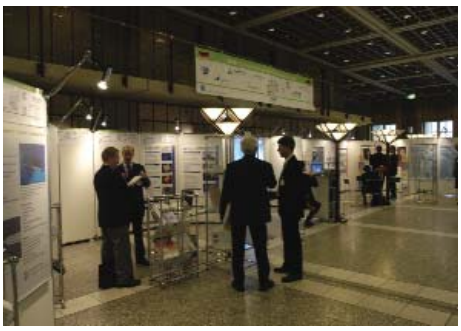
Most importantly,
doubt whatever is without question
commonly believed to be true.
Georg Christoph Lichtenberg

Nanotechnology competence center »Ultrathin Functional Films«

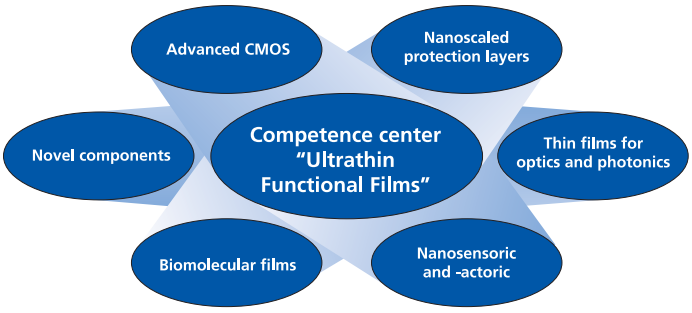
Nanotechnology is one of the key technologies for the 21st century. Already there are products in the market such as magnetic storage media and read / write heads for data storage which are covered with nanometer films, or scanning tunnel microscopes which make the world of molecules and atoms visible. 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, fifty-one companies, ten university institutes and twenty-two 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 competence center, with nanometer film structures for X-ray optics being one prime example.

A highlight in 2004 was the European nanotechnology symposium »Nanofair 2004« in Karlsruhe. 380 participants from industry and science joined the fair, which was substantially arranged with scientists of the IWS.



German nanotechnology competence centers presentation of the Nanofair 2004



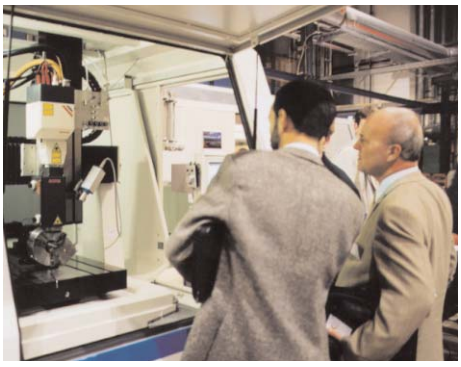
Workgroups of the nanotechnology competence center

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:

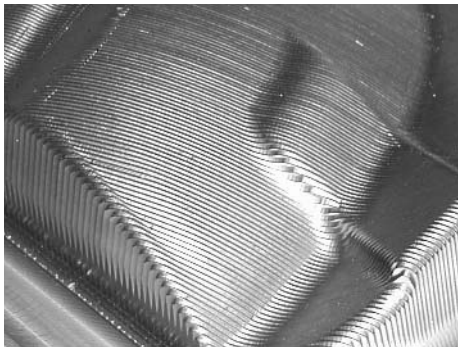
- process development in conventional and high-speed sector as well as development of hybrid-processes
- feasibility studies and performance analysis, studies (products, manufacturing processes, technological and logistic process chains)
- material flow and production simulation
- 3D visualization and 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 direct metal deposition (DMD) and laser beam sintering (SLS)], laminated object manufacturing (LOM) with sheet metal, and the final processing (milling, coating, measuring) of the tools.

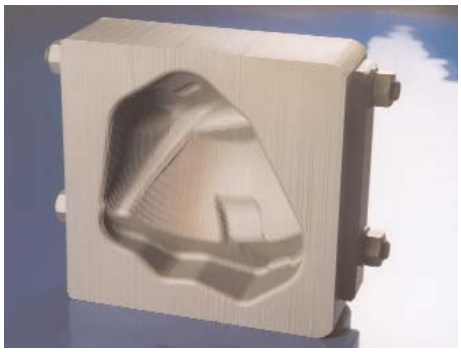
Tools can be manufactured in a fraction of the time needed in the past with the help of MELATO® (**Me**tal **La**minated **To**oling) as a rapid tooling process.



Surface of a tool made by MELATO®

Laser integrated CNC milling center

System for the rapid prototyping through direct laser liquid phase sintering



Blank lamellas of a stamping tool (MELATO®)

A wise man will not leave the right to the mercy of chance.
Henry David Thoreau

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
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Facility of the Dortmund Surface Center

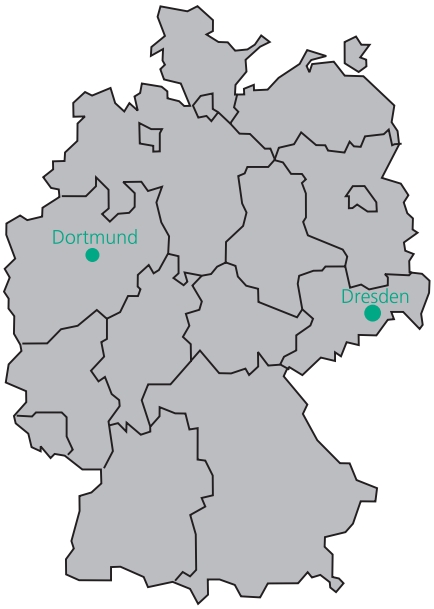
The ThyssenKrupp Stahl AG (TKS) concentrated its resources and competences in surface technologies with the formation of the DOC in which the Fraunhofer Society participates.

The DOC is the largest research and development center in the area of surface treatments for sheet steel in Europe. It was launched in December 2000 on the site of the Dortmunder Westfalenhütte. At DOC employees of TKS and the Fraunhofer IWS work jointly together in a new form of cooperation called the **»Public Private Partnership«**. A common goal is the development of innovative surface engineering processes and their transfer to industrial manufacturing.

One early outstanding result of this cooperation is a novel zinc alloy coating (ZE-Mg). The Fraunhofer project group demonstrated the case of laser welding in that these new coatings combine the corrosion protection of conventional zinc coatings at half the thickness with a significantly improved machinability of the coated material.

Beyond this the Fraunhofer project group offers in its 1,100 m² facility a number of complementing surface technologies. With modern equipment it is possible to produce nearly pore free and extremely adherent plasma spray coatings. Areas on components and tools facing aggressive wear can be coated with millimeter thick wear protection coatings through laser deposition welding techniques. Meter-long and ton-heavy parts can be coated in vacuum with nano- and micrometer high performance coatings such as the Diamor® film system, which provides an extreme surface hardness and excellent low-friction sliding properties.

The wide spectrum of the available processes and their combinations together with the expertise of the involved Fraunhofer Institutes guarantees cost effective and optimized problem solutions for our customers, whether it is TKS, a TKS-customer, or any other company. With the help of a worldwide unique mobile 4 kW Nd:YAG laser and a 75 m long optical fiber it is even possible to perform process development or »trouble shooting« directly at the customer's facility.



Fraunhofer Center for Coatings and Laser Applications (CCL)

Prof. Jes Asmussen
Center Director
CCL / USA
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The USA activities of the Fraunhofer IWS Dresden are concentrated in the Center for Coatings and Laser Applications. The CCL is headed by Prof. Dr. Jes Asmussen (Michigan State University). Prof. Asmussen is an expert in the area of diamond coatings. His work ideally complements the expertise of the IWS in the area of DLC coatings. Therefore it is the goal to establish a carbon center under his guidance in East Lansing.

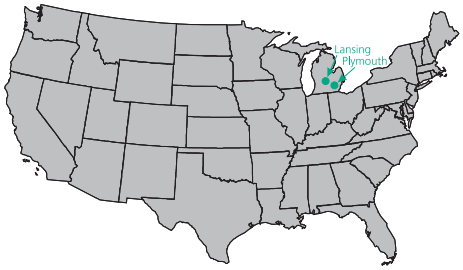
The CCL is comprised of two divisions, the »Coating Technology Division« at Michigan State University in East Lansing managed by Dr. Thomas Schülke, and the »Laser Applications Division« located in the building of Fraunhofer USA Headquarters lead by Eric Stiles.

Laser Applications Division
2004 was a very eventful year for the laser group of the CCL in Plymouth, Michigan. At the beginning of the year Mr. Eric Stiles took over the responsibilities of the Division Manager after having worked since 2002 at the Fraunhofer IWS. The closeness to Detroit led to a strong cooperation with the American automotive industry. The group experienced a considerable increase in projects especially for the laser beam welding of powertrain components such as differentials, transmissions and drive shafts. In addition the group worked on contracts for the laser hardening of crankshafts and laser cladding.

Aside from the automotive industry, the group engaged another customer from the mineral oil industry. The demanding task was to apply the build-up welding technique to oversized drilling components. Another important contract dealt with the application of laser welding for the joining of aluminum components for a manufacturer of lightweight transport casings.

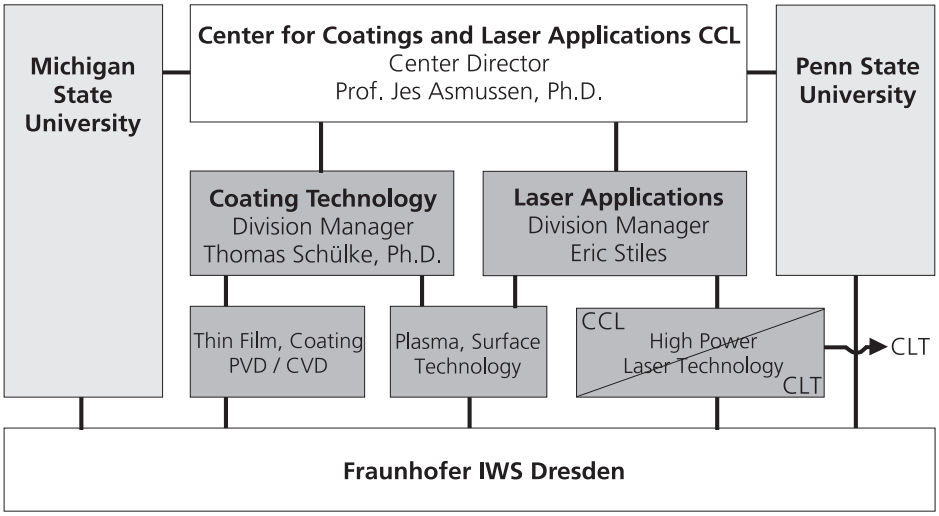
Coating Technology Division
The CCL's thin film group is in East Lansing, Michigan. The technology spectrum of the group has been substantially increased due to the cooperation with the Michigan State University. In addition to the originally offered PVD technologies the group now works on microwave based CVD and material processing techniques. The tight integration with the university enables the group also to offer extended characterization services (material composition, electron microscopy, nano-indentation, atomic force microscopy) and process development services for the manufacturing of micro-electro-mechanical systems (MEMS).

budget 2004	$3.38 million
- cost of sales	$1.15 million
- other expenses	$2.23 million



Building of CCL, CLT (Center for Laser Technology), and Fraunhofer USA Headquarters in Plymouth, Michigan

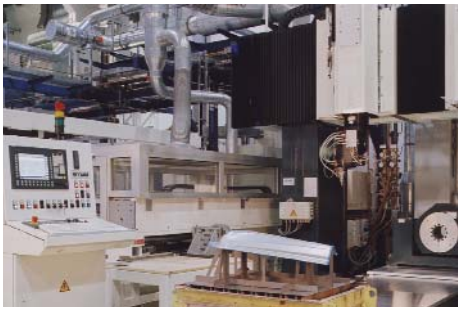
Building of CCL in East Lansing, Michigan



Institute equipment

Suddenly one finds
while one still believes to be searching.
That is the result of practice.
Kurt Schwitters

View of the IWS technology hall



High-speed 3D laser cutting system with linear drives

Laser beam welding system with 6 kW CO_2 high power laser

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 4.0 kW

TEA CO_2 laser

excimer laser (193 and 248 nm)

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

pulsed Nd:YAG laser with OPO

Handling systems

3D double gantry system, 22 axis with two 3D motion processing heads, speed up to 40 m / min, workspace 10 x 3 x 1.5 m^3, two 4.5 kW CO_2 lasers

several CNC laser processing systems with up to 8 axis,
speeds up to 20 m / min, workspace 2.4 x 1.8 x 0.6 m^3 or 4 x 3 x 1.5 m^3, CO_2 laser beam sources 2.5 to 6 kW

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) and electron beam

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 (laser assisted as well) and vacuum plasma spraying with robot handling (APS, LAAPS, VPS)

device for the high velocity flame spraying (HVOF)

device for plasma-powder-cladding (PTA, 6 kW)

Special components

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

CNC sensor controlled wire feeder for laser welding

mobile medium and high frequency induction sources (4 - 20 kHz, 100 - 400 kHz)

modular powder nozzle system COAXn for laser beam precision build-up welding

process control systems for thermal spraying, laser beam build-up welding and laser welding

software package for DCAM off line programming of robots and CNC machines for all thermal coating processes

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

system for the structural analysis including preparation techniques:
- metallography
- transmission electron microscopy
- scanning electron microscopy

materials testing:
- servo hydraulic testing system
- mechanical stress / strain tester
- pendulum impact tester
- computer supported micro hardness test system, hardness test automat
- high frequency fatigue tester
- flat bending torsion machine
- different wear testing systems (abrasive, cavitation, oscillating wear)

laser acoustic systems for measuring the Young's modulus of thin films

laser shock instrumentation with high speed pyrometer

equipment for surface analysis:
- automatic spectral ellipsometer (270 - 1700 nm)
- UV / VIS spectrometer
- Raman micro spectrometer
- FTIR spectrometer, FTIR microscope
- depth sensing indentation device
- scratch tester
- profilometer
- tribometers
- residual stress measurement system

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

optical 3-D coordination system

Vacuum plasma spraying

Device for the deposition of nano-meter multi-layers on large areas

Device for the deposition of nitridic hard material layers

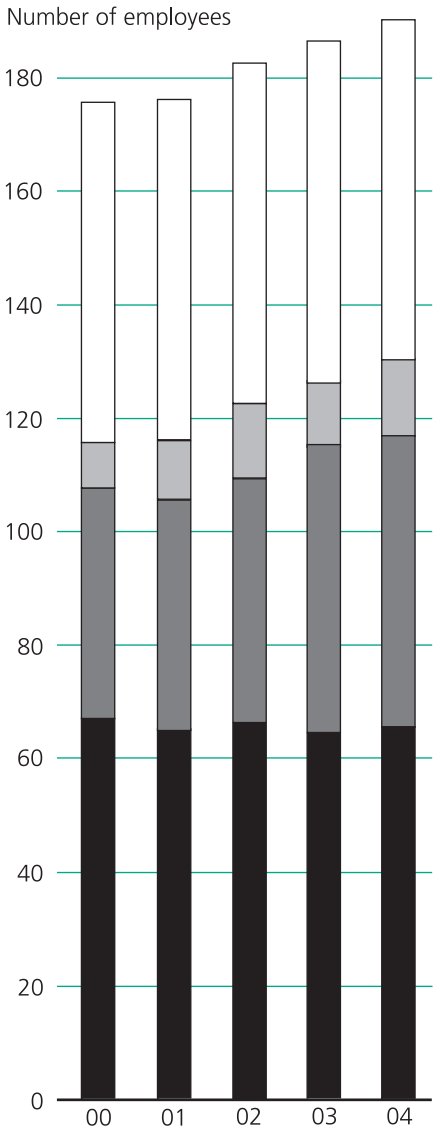
He who makes it to the point that he never errs, ceases working.
Max Planck

Total employees

The TU Dresden (chair for laser and surface technology) 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 2004 the employees are divided up as follows:

Employees of Fraunhofer IWS	Number	Employees of Chair for Laser and Surface Technology of TU Dresden	Number
Staff	**116**	**Staff**	**34**
- scientists	65	- scientists	20
- technical staff	42	- technical staff	13
- administrative staff	9	- administrative staff	1
Apprentices	**14**		
Research assistants	**60**	**Research assistants**	**8**
Total	**190**	**Total**	**42**



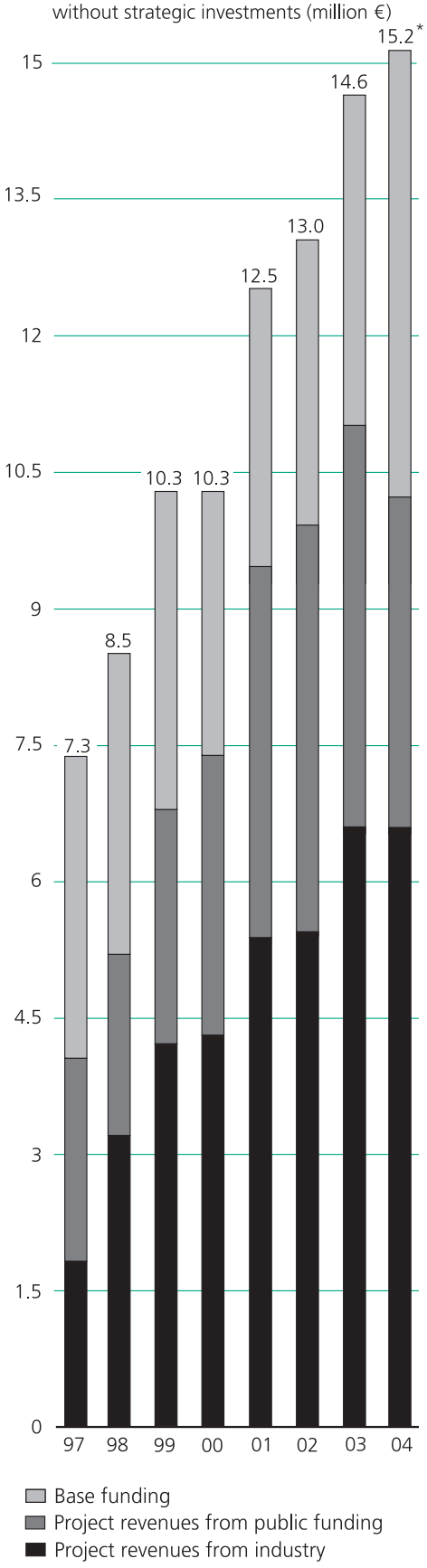
Building	Old building 5050 m²	New building 2950 m²
- processing technology area	1200 m²	400 m²
- lab space, workshops	1760 m²	1310 m²
- office space	1550 m²	1080 m²
- conference rooms, seminar rooms etc.	540 m²	160 m²
Technology area at the DOC (Dortmund)	**1100 m²**	

Budget and revenue 2004 (preliminary*)

* actual cost determination not yet finalized

	million €	
Operational costs and investments 2004	**15.2**	
Budget	**13.9**	
- cost of sales	6.2	
- other expenses	7.7	
Investment	**1.3**	
	million €	**%**
Revenue 2004	**15.2**	
Revenue operations	**13.9**	
- industrial revenues	6.4	46
- revenues of public funded projects	3.1	22
- base funding IWS	4.4	32
Revenue investment	**1.3**	
- industrial revenues	0.2	
- revenues of public funded projects	0.4	
- base funding IWS	0.7	

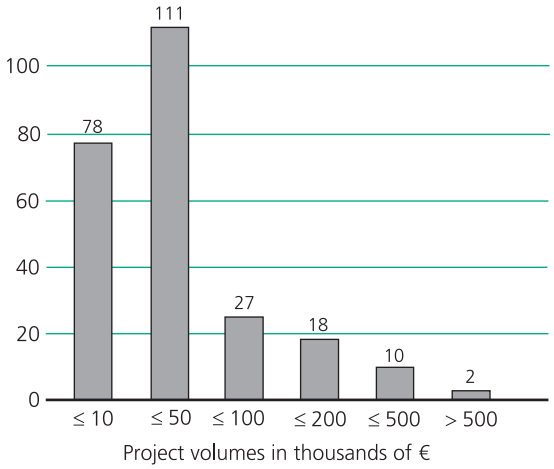
Revenues in operations and investments without strategic investments (million €)



Projects

In 2004, IWS handled 246 projects. The distribution of the projects with respect to their volume is shown in the graphic below. One hundred eleven of the projects were for 10 to 50 T€ (thousands of euro), for example.

Number of projects



Board of trustees

The advisory committee supports and offers consultation to the Fraunhofer IWS. Members of the advisory committee in 2004:

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

R. Bartl, Dr.
Director production planning MB Cars, DaimlerChrysler AG

I. Bey, Dr.
Head of project board production and manufacturing technology Forschungszentrum Karlsruhe GmbH

H. Bücher, Dr.
Coordinator innovation management and technology marketing, German Aerospace Center (DLR)

H. Ennen, MR Dr.
Saxony Office, Brussels

D. Fischer,
General manager EMAG Leipzig Machine Factory GmbH

F. Junker, Dr.
Member of the board of directors of the Koenig & Bauer AG, Planeta-Bogenoffset

J. Klenner, Dr.
Leader Centre of Competence Engineering Structure, Airbus

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

P. Linden, Dr.
Head of production technology of DaimlerChrysler AG

A. Mehlhorn, Prof. Dr.
Technical University Dresden

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

W. Pompe, Prof. Dr.
Technical University Dresden

F. Schmidt, Dr.
Saxony Ministry of Science and Art

R. Zimmermann, MR Dr.
Saxony Ministry of Science and Art

S. Clobes, RD'in
German Federal Ministry of Education and Research
(Guest)

U. Jaroni, Dr.
ThyssenKrupp Stahl AG
(Guest)

The 14th committee meeting took place on February 25 / 26, 2004, at Fraunhofer IWS in Dresden.

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 council 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 2004 were:
- Prof. Dr. E. Beyer
- Dr. S. Bonß

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. V. Hopfe	Department head
Dr. L. Morgenthal	Department head
Dr. S. Nowotny	Department head
Prof. 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

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

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 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 successful economic development of our industrial society, with particular regard for social welfare and environmental compatibility.

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, in other scientific domains, in industry and in society.

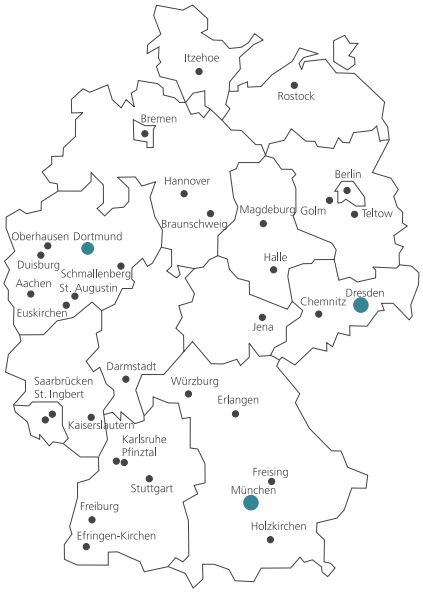
At present, the Fraunhofer-Gesellschaft maintains some 80 research units, including 58 Fraunhofer Institutes, at over 40 different locations in Germany. The majority of the roughly 12,500 staff are qualified scientists and engineers, who work with an annual research budget of over 1 billion euros. Of this sum, more than € 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, partly 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 representative offices in Europe, the USA and Asia provide contact with the regions of greatest importance to present and future scientific progress and economic development.

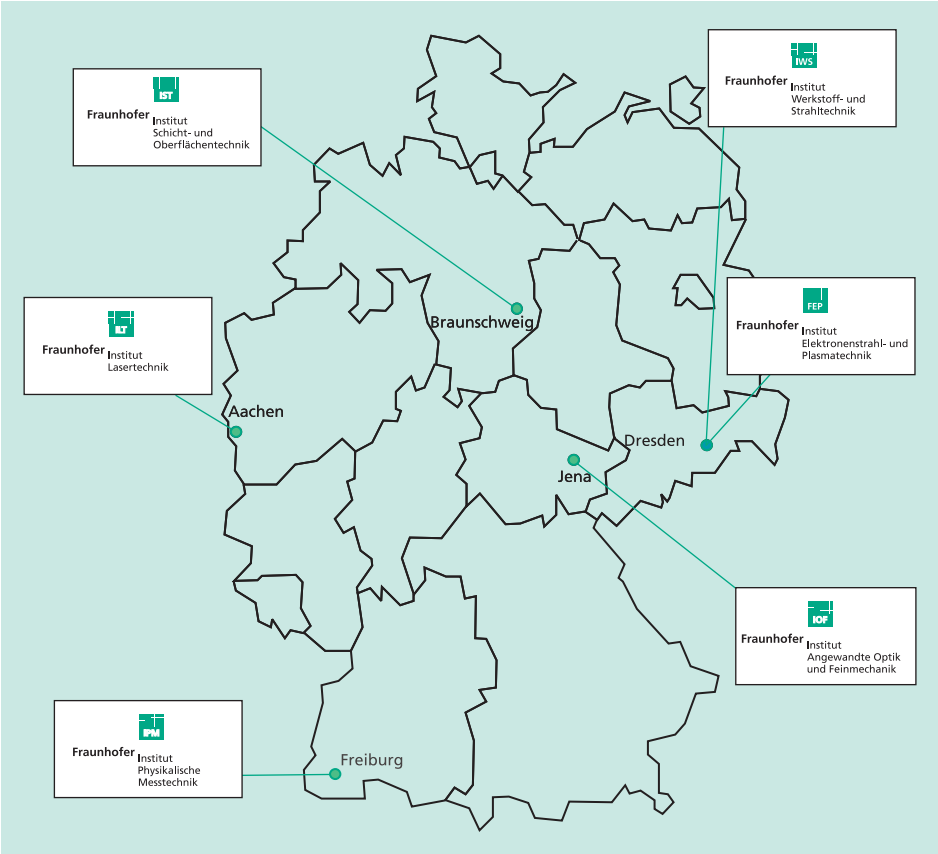
The Fraunhofer-Gesellschaft was founded in 1949 and is a recognized non-profit organization. Its members include well-known companies and private patrons who help to shape the Fraunhofer-Gesellschaft's research policy and strategic development.

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

Something new
is usually found in those discoveries
that do not fit into the scheme.
Volker Braun



Fraunhofer VOP Verbund Oberflächentechnik und Photonik



Competence by networking

Six Fraunhofer Institutes cooperate in the Surface Technology and Photonics Alliance VOP.

Complementary competencies allow to adapt the research activities to the rapid technological progress in all industrial application fields in a permanent, apace and flexible way.

Coordinated strategies, in line with the currents needs of the market, create synergy effects and provide a larger service for the benefit of the customers.

Core competences	FEP Dresden	ILT Aachen	IOF Jena	IPM Freiburg	IST Braunschweig	IWS Dresden
Coating and surface engineering	●	●	●	●	●	●
Beam sources	●	●	●	●		●
Micro and nano technology		●	●	●	●	●
Materials treatment	●	●			●	●
Optical measurement techniques		●	●	●	●	●

Contact / coordination

Speaker of the network:
Prof. Dr. Eckhard Beyer

Coordination:
Udo Klotzbach
Phone: 0351 / 2583 252
E-mail:
udo.klotzbach@iws.fraunhofer.de

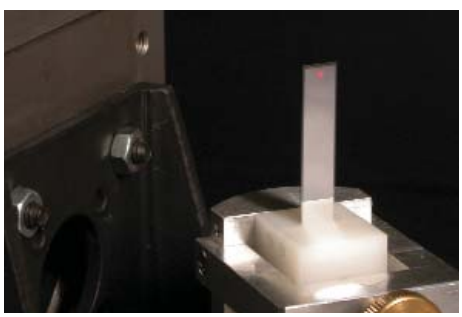
Internet: www.vop.fraunhofer.de

Fraunhofer Institute for Electron Beam and Plasma Technology FEP

The ambition of FEP is the research and development of innovative processes for the utilization of high performance electron beams and vacuum sealed plasmas for surface technology. Priority is given to problems like process monitoring, quality control, reproducibility, scaling, and profitability.
www.fep.fraunhofer.de

Fraunhofer Institute for Physical Measurement Techniques IPM

The Fraunhofer IPM develops optical systems for applications in spectroscopy and light exposure technology. A major focus is the realization of highly dynamical systems. Besides a rapid activation, they require special competencies in signal processing as realized through robust and low-maintenance measurement systems for the infrastructure monitoring of high-speed roads.
www.ipm.fraunhofer.de



Fraunhofer Institute for Laser Technology ILT

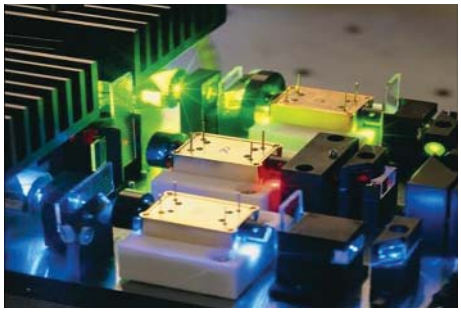
In the area of laser technology, the interactive relationship between laser development and laser applications is of prime importance. New lasers allow new applications, and new applications set the stage for new laser systems. This is why the Fraunhofer ILT is continually expanding its core competencies through close cooperation with leading laser manufacturers and innovative laser consumers.
www.ilt.fraunhofer.de

Fraunhofer Institute for Surface Engineering and Thin Films IST

As an industry oriented R&D service centre, the Fraunhofer Institute for Surface Engineering and Thin Films IST is pooling competencies in the areas film deposition, coating application and film characterization. Presently, the institute is operating in the following business fields: mechanical and automotive engineering; tools; energy; glass and facade; optics; information and communication; life science and ecology.
www.ist.fraunhofer.de

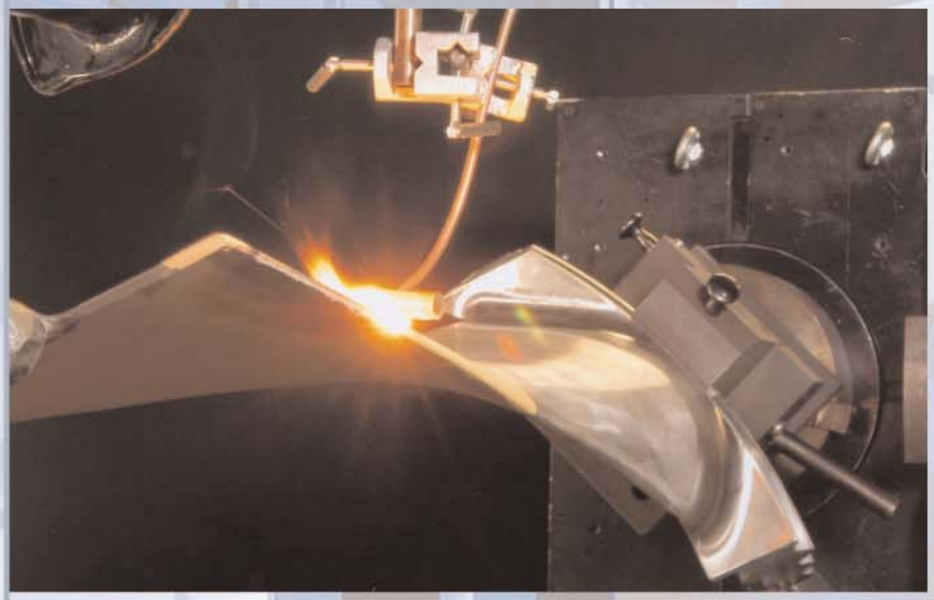
Fraunhofer Institute for Applied Optics and Precision Engineering IOF

The core of the research activity of Fraunhofer IOF is optical systems engineering aimed at a steady improvement of light control. The institute's focus is on multifunctional optical coatings, optical measurement systems, micro-optical systems, systems for the characterization of optics and components for precision mechanics assemblies and systems.
www.iof.fraunhofer.de



Fraunhofer Institute for Material and Beam Technology IWS

The Fraunhofer IWS is conducting research in the areas of laser technology (e.g. laser beam welding, cutting, hardening), surface technology (e.g. build-up welding), micro machining as well as thin film and nano technology. The integration of material testing and characterization into research and development constitutes and upgrades the IWS spectrum.
www.iws.fraunhofer.de




arnold
arnold

R&D-offer: Joining and surface treatment

Editor: During our interview for the 2002 annual report you announced new projects with Airbus for the development of laser beam welding processes for aircraft fuselage structures. What happened to these?

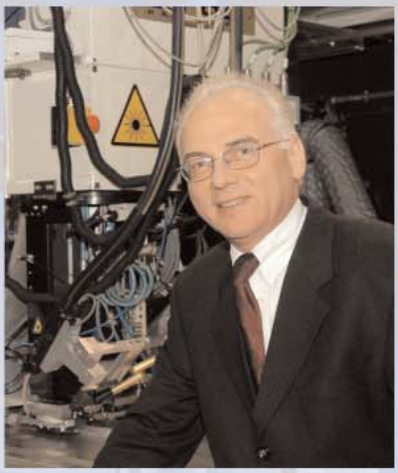
Prof. Brenner: The Saxony Ministry for Science and Art and Airbus Germany GmbH supported the project. Core part was the conceptualization, procurement and setup of a novel laser beam welding system for the simultaneous 3D welding of stiffening elements of aircraft structures of up to 10 m in length and 3 m in width. In 2004 the system was successfully setup and we could start with the technology development for the welding of the first components for Airbus.

With this system IWS has a unique technology that will enable them to join large and geometrically complex structures, which in the past could not be manufactured via welding techniques, with high accuracy, minimal heat dissipation and distortion as well as high welding speeds. With this qualitative leap in system technology we hope to be able to develop and implement welding based manufacturing processes for the aircraft industry, which have historically not been possible. In addition the system will allow us to weld large 3D structures for other branches such as railroad and commercial vehicles, shipbuilding industry, or gas turbines and steel construction.

Editor: The other process technology oriented pillar of your department is surface treatment processing. What progress were you able to make last year?

Prof. Brenner: The strategy of this group aims to specific directions. One of these directions is the new and further development of effective surface hardening technologies with improved utilization properties. The second direction is the development, field testing, and commercialization of the process specific system components for beam shaping, controlling of process atmospheres, temperature measurement and control, as well as related software. In both fields we made significant progress last year: With the development of a surface hardening process for precipitation hardenable steels we want to establish another pillar in the area of the wear protection of surface materials that have not been hardenable as of yet. A first important milestone has been achieved with the commercialization of a novel technology that extends the lifespan of low pressure stage turbine blades made of precipitation hardenable steels for large steam turbines.

In the second area we were able to develop a very affordable software controlled spatially resolving temperature monitoring system. The system is to be integrated with laser hardening systems for reproducible surface hardening of complex shaped components. The system shows its strength especially if very expensive and in small numbers manufactured parts, such as large tools, have to be precision hardened without complex test hardening.

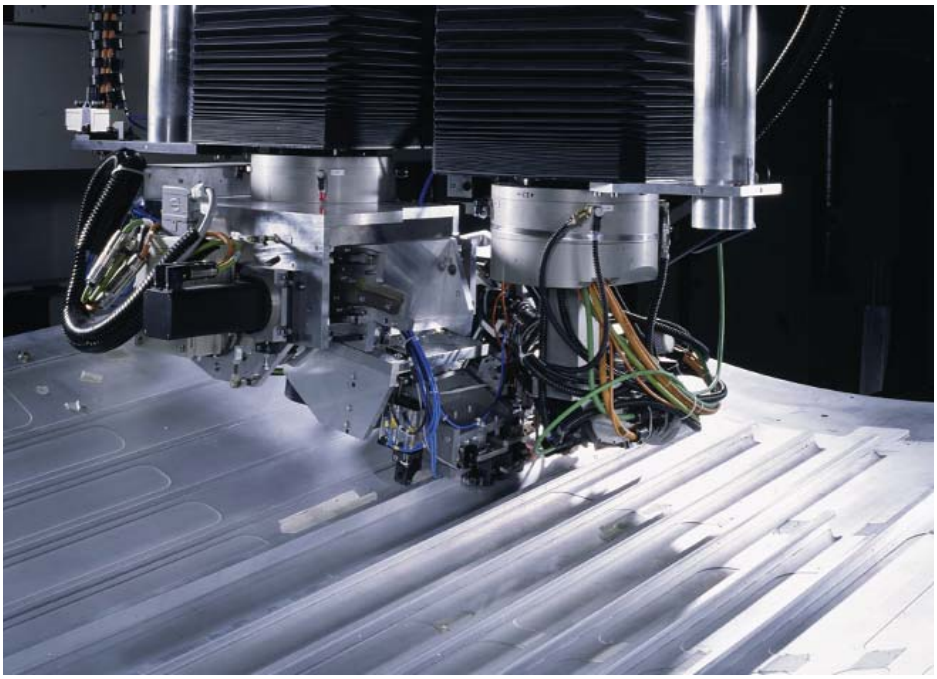


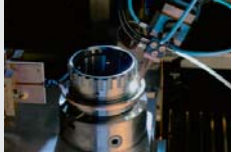
He who ceases to improve ceased to be good.
Philipp Rosenthal

Prof. Dr. Berndt Brenner
Department head
(phone: +49 (0) 351 / 2583 207,
berndt.brenner@iws.fraunhofer.de)

Examples of projects 2004

1. Spatially resolving temperature monitoring system for laser materials processing
2. Laser beam scanning extends the application potential of high power diode lasers
3. Lifespan extension of steam turbine blades made from precipitation hardenable steels
4. Welding solution for the application of magnesium sheet metal in body making
5. XXL system for the laser beam welding of large format 3D structures
6. Laser beam welding of axial round seams with filler material in rotational symmetrical components of high stiffness
7. Improved forming ability of high strength sheet metal made of multiple phase steels through laser induction welding
8. Improvement of the mechanical properties of laser gas nitrided surfaces on titanium materials
9. Efficient product development via accompanying failure analysis
10. Test stand for thermo cycle tests of highly stressed rocket engine components





Dr. Steffen Bonß
Team leader surface treatment technologies
(phone: +49 (0) 351 / 2583 201,
steffen.bonss@iws.fraunhofer.de)

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
(phone: +49 (0) 351 / 2583 212,
jens.standfuss@iws.fraunhofer.de)

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.

Dr. Bernd Winderlich
Team leader materials testing and characterization
(phone: +49 (0) 351 / 2583 224,
bernd.winderlich@iws.fraunhofer.de)

Complex materials and component characterization

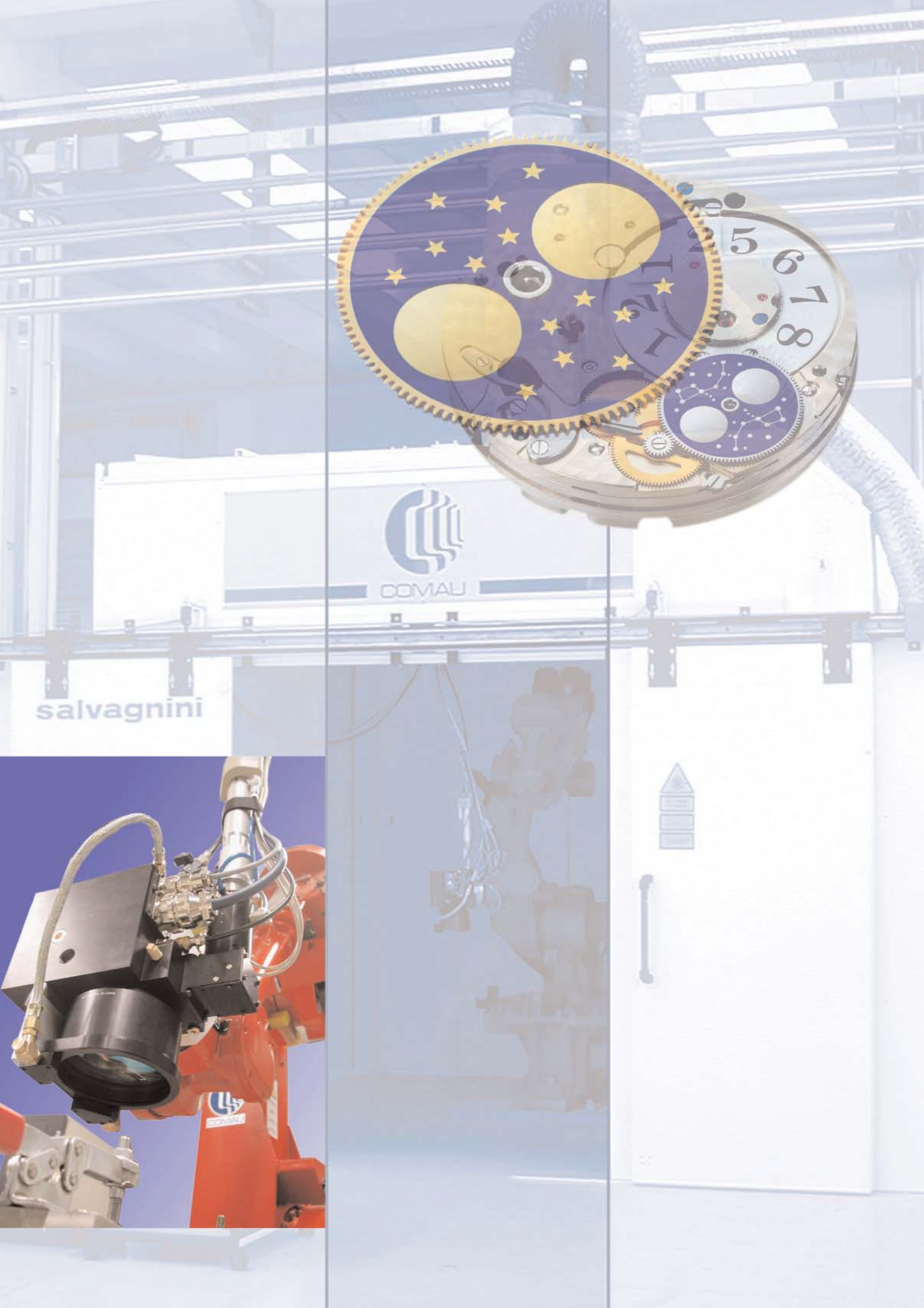
The control of modern joining and surface engineering processes requires knowledge from structural changes to the resulting component properties. Based on long term experience and extensive equipment in the area of structural, microanalytical and mechanical materials characterization we offer:

- 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.

Laser beam hardened turbo charger shafts

Laser beam welded transmission component

New testing system for head tensile tests


COVIAU
salvagnini

R&D-offer: Laser ablation and cutting, system engineering

Editor: With the completion of the expanded laser facilities in fall 2004 your department has new equipment. Can you elaborate on your plans?

Dr. Morgenthal: In the future we would like to turn towards fast and precise part cutting with the laser in the 3D workspace. From 2005 on we will have a new 3D cutting machine in the laser facility of the IWS. The automotive industry is increasingly using preformed components, which cannot be processed by stamping due to high material thickness and strength. Economical and technical improvements in 3D cutting are needed. We include in our strategy the potential of novel laser sources such as disc and fiber lasers.

Editor: Increasingly the IWS is working on problems originating from the bio- and medical technology areas. Which results did you achieve in the last year?

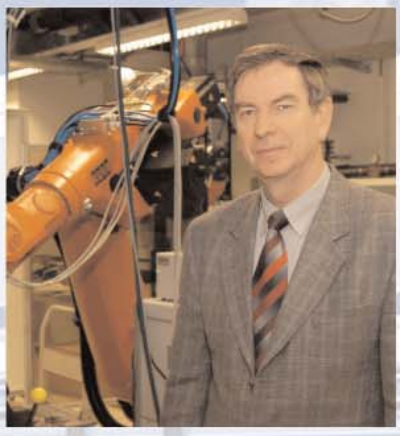
Dr. Morgenthal: The biomedical industry is increasingly asking for structures in the sub-millimeter range as well as for surfaces with certain properties. The tool »laser« as a result of the broad selection of wavelengths, fast controllability, and non-contact operation offers to process almost all materials largely damage free at high precision.

Solid state lasers with wavelengths between 355 nm (UV) and 1064 nm (IR) can be focused to highest intensities and are capable to shape even the hardest materials such as steel, ceramics or diamond in a short time. Microfluidic elements, instruments for minimally invasive surgery, stents for the prevention of artery closures, dialyzers for the cleaning of blood, and endoscope components can be manufactured close to final shape with a minimal need for post processing.

Excimer lasers with wavelengths between 157 nm and 351 nm (UV) are primarily used for the surface area processing and functionalization of surfaces. The high energy of the laser radiation is used to directly break bonds and excite the surface to for example tailor hydrophobic and hydrophilic areas.

Editor: The robot controlled remote welding with its »on the fly« processing of large parts is close to commercialization. What new results are possible?

Dr. Morgenthal: During the past years we developed the system and process technology for remote welding, which included components such as compact and highly dynamic 3D beam scanning systems, software and a corresponding laser and scanner controller as well as trace planning tools for the offline programming of complex multiple axis processing systems. These components enable us to offer together with our partners complete system solutions. We also expect that the new, on-the-threshold of commercialization, standing solid-state laser sources such as disc and fiber lasers will benefit this process with clearly improved beam quality.

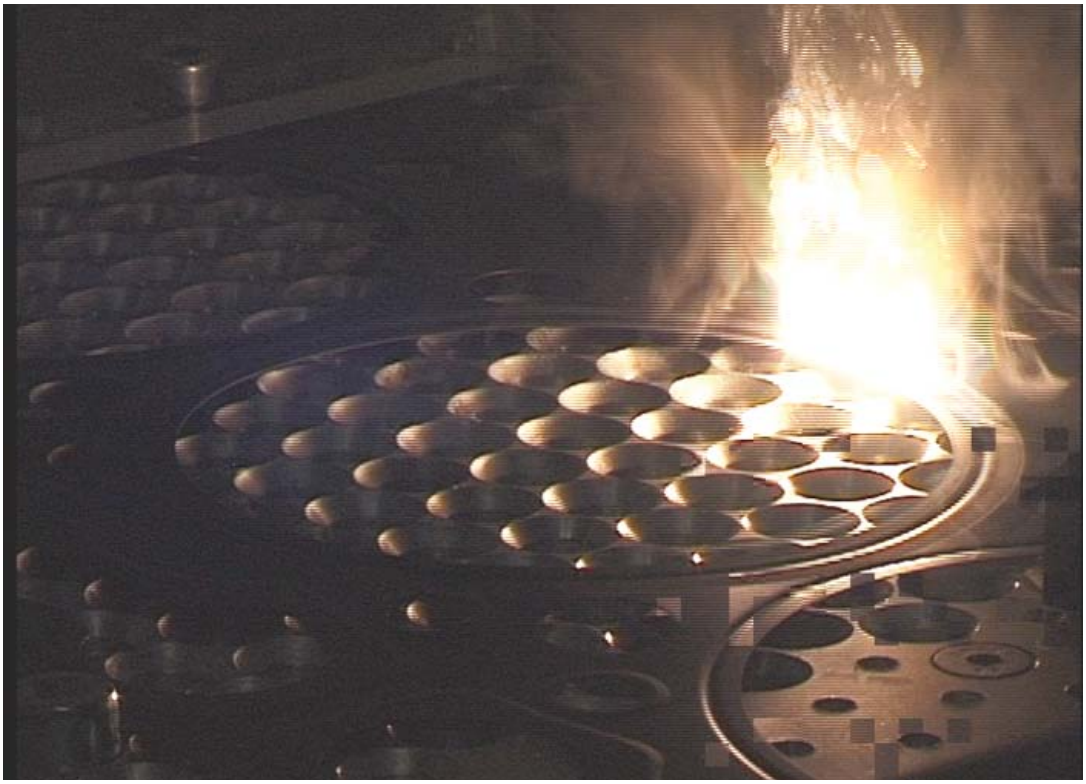


The unsolved problems keep the spirit alive, not the solved ones.
Erwin Guido Kolbenheyer

Dr. Lothar Morgenthal
Department head
(phone: +49 (0) 351 / 2583 322,
lothar.morgenthal@iws.fraunhofer.de)

Examples of projects 2004

1. Rapid prototyping of lab-on-a-chip components
2. Structuring of design elements of high value mechanical watches
3. Micro cutting of ion traps - the path to quantum computers
4. Yb:YAG disc lasers - an ideal beam source for 3D remote welding
5. Remote welding becomes flexible through position sensors
6. Decontamination of biocide contaminated art made of wood
7. Restoration of a jewelry box with laser beam welding



Dr. Lothar Morgenthal
Team leader laser cutting and system engineering
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Cutting technology

We offer applied research for laser cutting with lasers of different wavelength and power to cut parts with millimeter to meter dimensions. The focus is on precision high speed cutting on highly dynamic cutting machines with linear drives or through beam scanning. For quality control we have a flat part scanner system for part dimensions of up to 1800 mm x 1200 mm.

In detail we offer:
- technology and system development, testing, and optimization,
- feasibility studies, prototype manufacturing for all variations of laser cutting on material samples and work pieces,
- development of system components for high speed processes as well as for process control.

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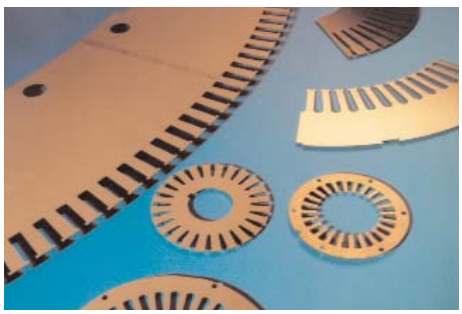
System engineering and laser processing

The departments of the IWS offer the implementation of manufacturing ready and process adapted system solutions in the following areas:
- processing optics, beam scanners for high speed and precision processing, process monitoring and control,
- handling systems, process monitoring and control for the industrial utilization of high power diode lasers for surface engineering,
- prototype development of coating systems or their core modules for the PVD precision coating of high volume parts and the continuous atmospheric pressure sheet CVD including system and process control software,
- process monitoring and control for coating processes,
- measurement systems for coating characterization and non-destructive work piece testing through laser acoustic and spectroscopic methods.

Micro structuring with laser

Extensive and modern equipment as well as our know-how foundation enable us to perform applied research in the area of micro and fine processing with laser beams for the miniaturization of functional elements in machine, system, and automotive engineering as well as for biomedical applications. Examples are 3D structures in the sub mm range and area structures on polymers, metals, ceramics or quartzitic and biocompatible materials.

We offer:
- micro structuring of different materials with Excimer and Nd:YAG lasers,
- micro drilling with high aspect ratios and different bore geometries,
- cleaning with laser technology.



Laser-cut electro sheet metals

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

Mobile system for the anti-slip preparation of natural stone


HERMLE

R&D-offer: Thermal coating

Editor: With the IWS facility expansion you were able to reinstall your thermal spraying systems in significantly larger laboratories. Did this result in an expansion of your technological possibilities?

Dr. Nowotny: Indeed. In the new 100 m^2 laboratory we combine the most important spraying processes our customers ask for. Besides atmospheric plasma spraying (APS) and vacuum plasma spraying (VPS) we now also offer high velocity flame spraying (HVOF) technology. The system can be optionally operated with kerosene or gaseous fuels and allows the deposition of hard metal layers with the highest quality available with respect to density, adhesion, and mechanical performance. For a number of parts such as highly stressed motor components we can now for the first time deposit coatings that enable lightweight solutions, reduced fuel consumption and an extended component lifetime. A future focus will be the development of oxide based functional coatings with HVOF with high deposition rates for more applications.

Editor: Over the past few years you concentrated your research efforts on the application of laser beam build-up welding for repair tasks especially in jet engine repairs. What progress did you make in 2004?

Dr. Nowotny: Due to its high precision build-up welding with laser radiation became well established in this sector. However, materials used in the aerospace industry such as titanium, aluminum or nickel alloys are under normal atmospheric conditions not flawlessly treatable. Undesired hardening occurs and the desired properties cannot be achieved. Therefore we developed for these metal alloys the entire system technology including welding strategy under controlled atmospheric conditions. Real world parts can now be treated in argon atmosphere in a work chamber of about 1.5 m^3 as well as under vacuum conditions in the VPS system. New powder nozzles and processing heads enable the build-up welding of 3D structures in a precision range of some $1/10^{th}$ of a millimeter.

Editor: Two large BMBF projects in the area of repair and generation as well as rapid tooling with laser base manufacturing processes were finished with a publicly noted presentation event. What were the concrete results of these projects?

Dr. Nowotny: The result of the first project, FAVOR, is the completely closed process chain for the precision build-up welding with laser and plasma (PTA) as well as the hybrid technology of the inductively supported laser beam build-up welding. The users benefit from these process developments in the form of shortened manufacturing times and the ability to in particular process crack-free the hard and wear resistance materials.

Work related to the MELAO® technology could also be finished at a level that allows its application. First sample tools are in manufacturing and the resonance from potential users of this new manufacturing technology promises good growth predictions for the near future.

Creativity is the ticket for the future.
Norbert Stoffel

Dr. Steffen Nowotny
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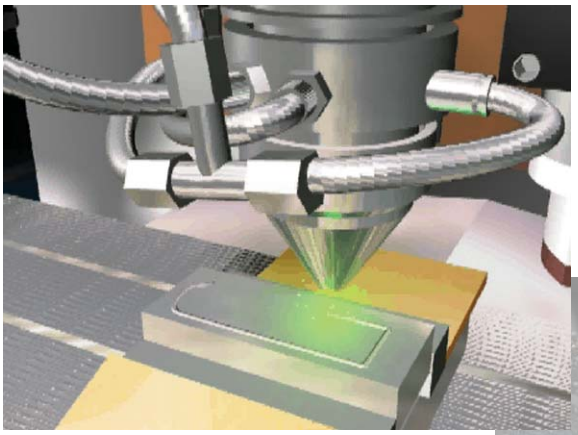
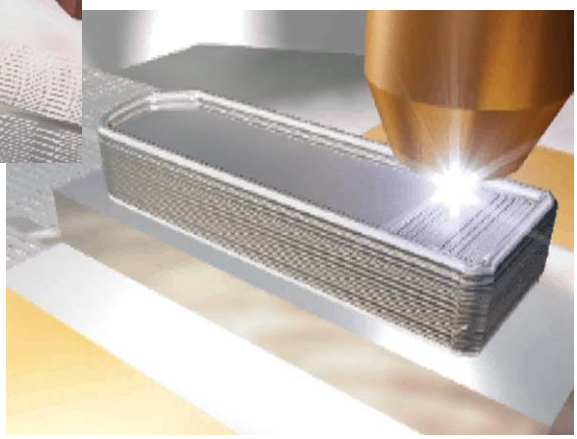
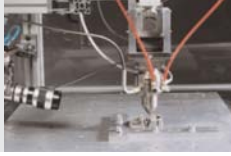
Examples of projects 2004

1. Highly accurate rapid prototyping for castings: precise cast prototyping pc_{Pro}®
2. Completely automated MELATO® processes
3. Repair of jet engine components made of titanium alloys
4. Closed process chain for the laser beam build-up welding and welding process combinations
5. High velocity flame spraying as a new coating technology at IWS
6. Tribological investigations on thermally sprayed coatings







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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, hardmetals 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.

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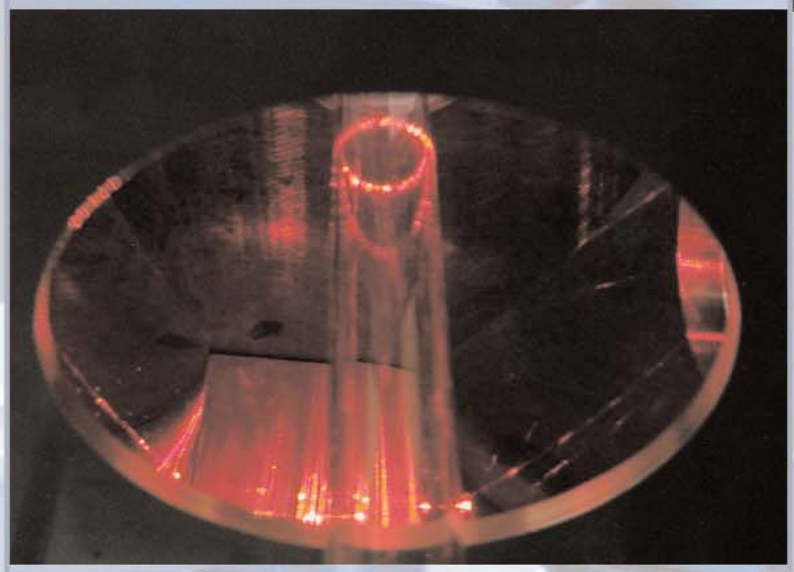
Repair and generating

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

Repair of gas turbine blades through build up welding with high power diode lasers



R&D-offer: CVD thin film technology

Editor: How did your relatively young department »CVD Thin Film Technology« develop during the last year?

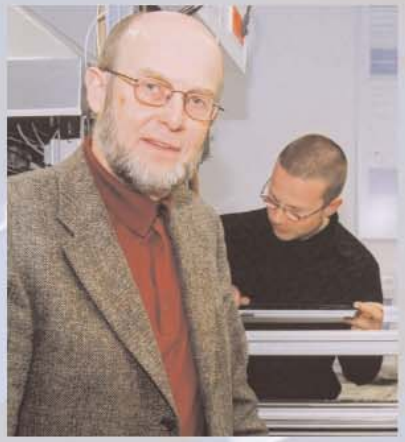
Dr. Hopfe: With a dynamic that at times tested the limits, but it offered us an excellent platform for further development. This is true for new complex projects but also for a number of industry inquiries that reflect a leap in interest in our research results. Despite the growth, by the end of the year both groups in the department reached full capacity with respect to personnel and equipment. For 2005 we would like to continue this trend of growth but we will also focus on increasing our efficiency and the expansion of our experimental basis. This creates a motivational thrust and reflects itself clearly in the achieved increase in competency of the still young groups. In the end it will benefit our partners.

Editor: In your laboratories you set up an extreme amount of equipment during the last year. What applications are behind this?

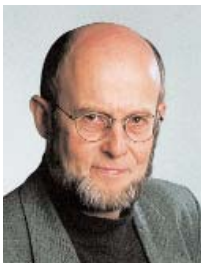
Dr. Hopfe: Actually there was no »free corner« in our laboratories at the beginning of 2004. With the completion of the IWS expansion in the fourth quarter of 2004 we were able to put to use the urgently needed laboratory space. You are referring to prototype equipment for the coating and dry etching of semi-finished products with plasma chemical processes at atmospheric pressure. The machines were developed under direct customer contracts and are currently in the process of being set up. Meanwhile more than half of the department is working on the development and testing of prototype equipment as well as the related process development. The engineering tasks necessary for »critical mass« could be established in the short-term. The deposition and etching systems are atmospheric pressure plasma inline reactors. They are designed based on thermo-fluid dynamic simulations. Simulation offers a time and cost effective design compared to the conventional intuitive and empirical approach.

Editor: In the area of process monitoring you managed to develop spectroscopic gas sensors and to test them in well-known companies. How do you value the results?

Dr. Hopfe: Jointly with medium sized companies we have meanwhile developed several prototypes of gas sensors for the control of industrial equipment. A sensor based on FTIR spectroscopy is installed at a 300 mm wafer production tool since several months for long-term tests at Infineon. Immediately upon installation the sensor delivered partially unexpected insights into the »machine life«. The principle is currently being transferred to the ceramics industry. First hopeful results demonstrated again the multivalent application potential of these developed innovative gas sensors.



If an idea does not appear absurd at first sight, it is worthless.
Albert Einstein



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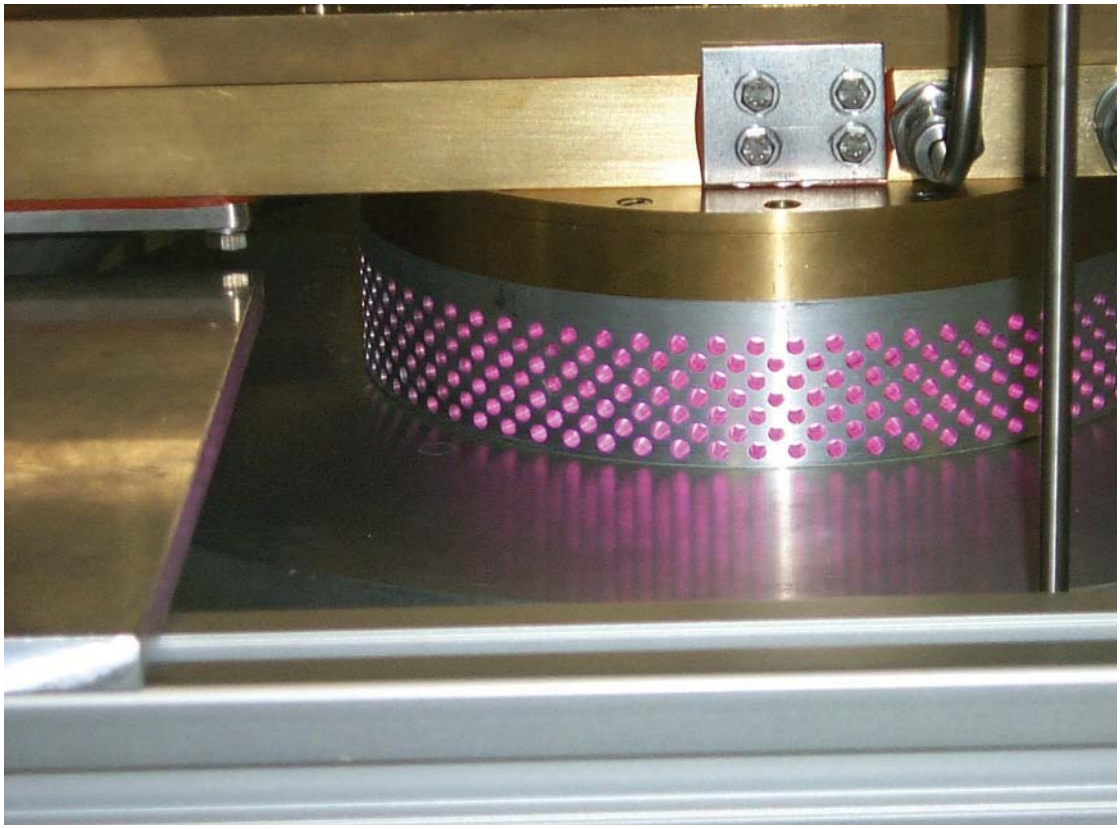
Examples of projects 2004

1. Atmospheric pressure plasma CVD for the deposition of scratch resistance coatings

2. Fluid dynamic simulations - an effective tool to design and optimize plasma CVD reactors

3. IRspecXL - a new tool for the surface analysis and quality control of large components through FTIR reflection spectroscopy

4. Process control on drying furnaces for the manufacturing of ceramic components



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Plasma activated CVD processes at atmospheric pressure

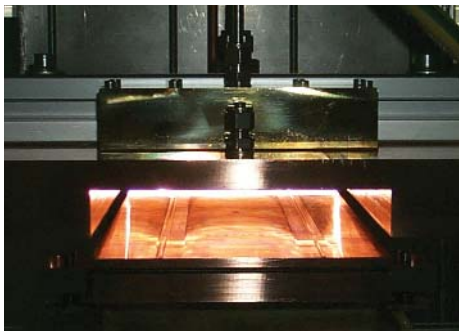
The large area deposition of high quality functional coatings is possible through atmospheric pressure plasma CVD processes (AP-PECVD) avoiding the need for expensive vacuum equipment. It is possible to implement continuous coating processes with high deposition rates on flat and even slightly curved temperature sensitive materials such as special steels, lightweight metals, glasses, and polymers.

At the IWS we develop prototype AP-Plasma-CVD in-line reactors with gas locks for the deposition of oxides and non-oxide coatings at atmospheric pressure. The optimization of the reactor design is based on experimental results and fluid dynamic simulations. The modular reactor design allows for a cost effective adaptation of the process to new application areas and coating materials.

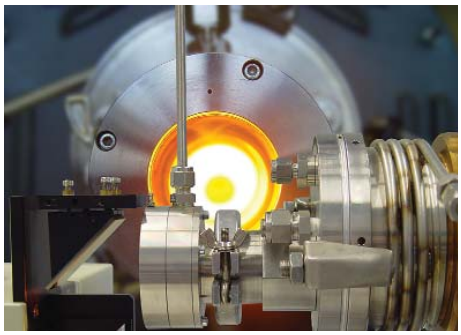
Process monitoring

In many cases the optimal function of industrial equipment and the quality of the manufactured products depend directly on the gas atmosphere inside the system. Therefore its composition has to be monitored at tight tolerance levels. An industry compatible gas analytics is essential for the quality control of chemical deposition, etching, and sintering processes and for monitoring the emissions of industrial machines. For customer specific solutions to continuously monitor the chemical composition of gas mixtures, IWS is using sensors that are alternatively based on either NIR diode laser or FTIR spectroscopy.

Furthermore we analyze surfaces and coating systems with spectroscopic methods such as FTIR spectroscopy, spectro-ellipsometry or Raman microscopy.



View of the coating area of the ArcJet-PECVD system



FTIR monitoring of high temperature processes

R&D-offer: PVD thin film technology

Editor: 2004 marked the 15th anniversary of carbon coating development based on pulsed arc technology for your department. Isn't this quite a long time to commercialize this technology?

Prof. Schultrich: Indeed. The history of this development reaches even farther into the past. We developed some years earlier the deposition of carbon coatings based on pulsed laser deposition (PLD). However, it turned out that PLD could not be scaled to the required deposition rates as a result of the limited laser pulse power. At the same time we recognized the close similarity of laser and arc plasmas. Therefore it seemed obvious to transfer the experience with the laser technology and the very promising carbon coatings to the vacuum arc technology.

Editor: At that early stage, on what did you base your optimism that you would be able to realize an outstanding coating system?

Prof. Schultrich: First of all, even back then our group and others had already demonstrated the extreme hardness of the coatings. This hardness is only exceeded by diamond. Meanwhile we learned that these tetrahedrally bonded amorphous carbon coatings (ta-C) exhibit quite a number of more attractive properties.

Editor: And which properties are these?

Prof. Schultrich: The possibilities of special combinations of the excellent properties of carbon systems are frequently surprising, even if you deal with this material for a long time. For tribological applications it is important that the material shows a low tendency to adhere to the counter face metals. Therefore the coatings are used for dry machining, for critical forming processes or as a coating for components that are in sliding contact without lubricants e.g. in the textile or food processing industries. Recent Japanese investigations showed that ta-C coatings further reduce the friction forces even in lubricated sliding contact scenarios, which enables the utilization of environmentally friendly (low additive content) lubricants. The Paul Scherrer Institute in Switzerland determined that the IWS coatings are excellent neutron deflectors, which can replace the conventionally used Beryllium for storage containers for ultra cold neutrons. This list can be continued. I would like to mention that many more application become possible due to (nano) structuring and doping of these carbon coatings.

Editor: If these ta-C coatings have such superior properties, why aren't they widely commercialized yet?

Prof. Schultrich: Potential users of tribological coatings focused initially on utilizing plasma CVD prepared a-C:H and a-C:H:W coatings which are increasingly used since the 90ies. On the other hand there was a principle problem with the ta-C deposition: the combination of high particle energy and low deposition temperature necessary for film formation. This combination limited the achievable thickness of the coatings to 1 micron. Thicker coatings would show poor adhesion to the substrate. This hurdle however is overcome now through an optimized coating design. The IWS coating with the brand name Diamor® is now available with thicknesses of more than 10 microns.

One cannot add more days to life,
but one can give more life to the day.
American Manager Rule

Prof. Dr. Bernd Schultrich
Department head
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Examples of projects 2004

1. PVD coating of temperature resistant filter media for the more effective cleaning of process gases
2. Nano structured carbon coatings for ultra dense storage media
3. Tribological behavior of super hard amorphous carbon coatings
4. Amorphous carbon coatings for super hydrophobic surfaces
5. Laser acoustic testing supports the optimization of coating technology
6. Coating of three dimensional components with the programming system SimCoat-Simulation of industrial vacuum arc deposition

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Team leader carbon coatings
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Coating with super hard amorphous carbon

Amorphous carbon coatings with tetrahedral diamond bonds (ta-C) combine high hardness, low friction, and chemical inertness. Therefore they are exceptionally useful as protective coatings. The IWS developed ta-C coating systems (Diamor®) can be deposited with excellent adhesion in the thickness range from a few nanometers up to several tens of micrometers. The deposition occurs at low temperatures in vacuum through a special developed pulsed arc process. For the commercialization of Diamor® coatings the IWS delivers jointly with partners the technology as well as the necessary deposition sources and coating equipment. The offer also includes the laser acoustic quality control and process optimization equipment LAwave®.

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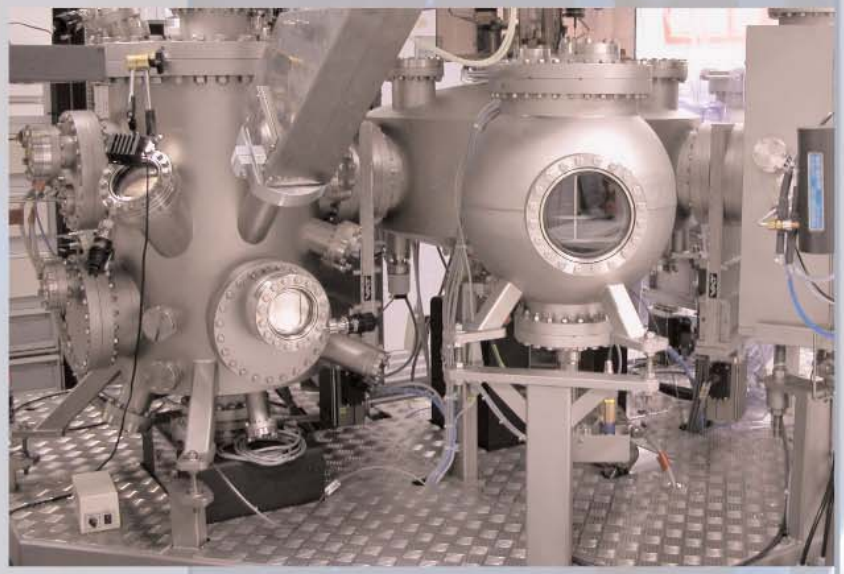
Coating through activated high rate processes

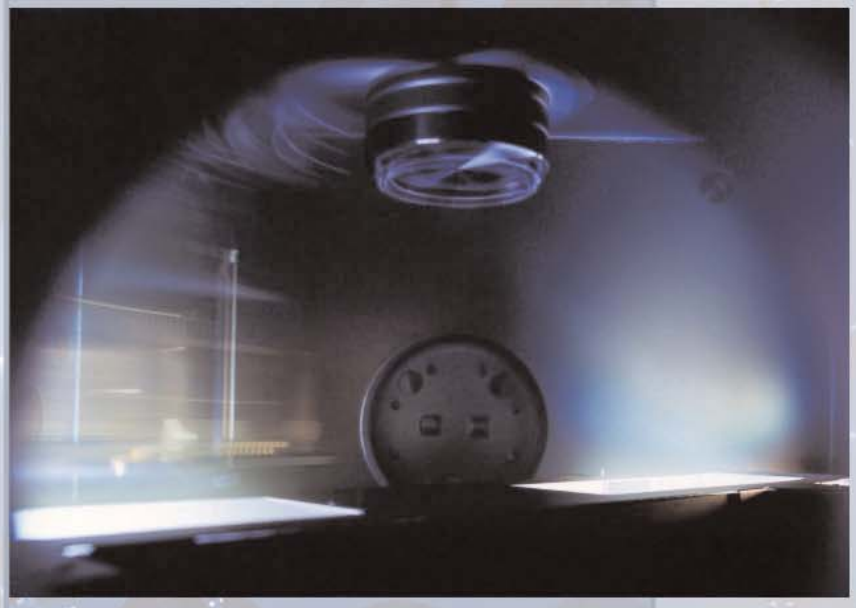
Processes involving the physical deposition from the vapor phase (PVD = physical vapor deposition) allow for the deposition of high quality tribological and functional coatings in the thickness range from a few nanometers to several tens of micrometers. At the IWS, we have a number of technologies at our disposal from high rate evaporation to highly activated plasma processes and their combinations. A special focus is the extensive utilization of arc discharges, which are the most effective source of energy rich vapor jets. Based on these technologies we offer:

- sample coatings,
- coating characterization,
- development of coating systems,
- customer specific adaptation of coating technologies,
- feasibility and cost studies,
- development and manufacturing of adapted equipment components.

Equipment for the deposition of super hard amorphous diamond-like carbon coatings (Diamor®) based on the Laser-Arc process

Metal evaporation through electron beam technology





R&D-offer: X-ray and EUV optics

Editor: The importance of optical components for the shortwave range of the spectrum down to the X-ray range is constantly increasing. What were the new developments in your department in 2004?

Dr. Leson: In 2004 we intensified our efforts to transfer our extraordinary results from coatings for the EUV lithography to other application areas. For example, we built a EUV Schwarzschild lens based on Mo/Si multilayer coatings with excellent imaging properties. It enables a new observation potential to be utilized in the soft X-ray range. In addition we used our knowledge in the EUV range to develop high quality monochromators for other wavelength ranges, which are primarily used for the X-ray fluorescence analysis.

Editor: A good two years ago you spun off from your department the company AXO GmbH (Applied X-Ray Optics Dresden GmbH). How has this company been doing since then and are you still working with them?

Dr. Leson: Three members of our department founded the AXO GmbH with the Fraunhofer-Gesellschaft as a partner. The company went through a successful development phase and is meanwhile well known in the market. We are cooperating in many areas to explore new application possibilities. This allows us to use our specific and complementary strengths to mutually benefit both sides. A good example is the area of X-ray fluorescence analysis, a market that we jointly explored in 2004.

Editor: Aside from the precision depositions for the X-ray applications you are using your coating competency in other areas. Which are those?

Dr. Leson: We are, for example, using the laser deposition technology not only for the generation of X-ray optical multilayer systems. We are also using this process to make extreme temperature resistant thermal barrier coatings on inner diameter surfaces. It is also possible to generate extreme hard carbon coatings on the inner surfaces of tubes, which is difficult to realize with other techniques.

He who does not strive for more settles below his potential.
Herbert Marcuse

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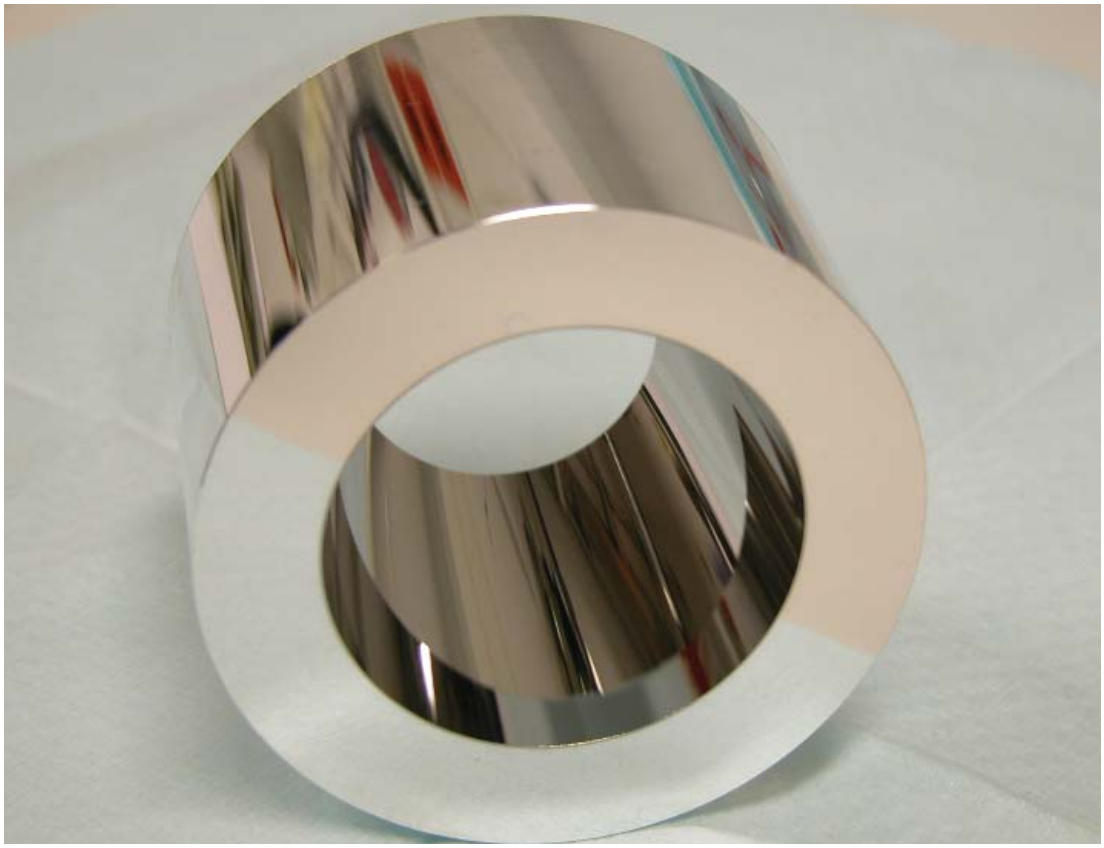
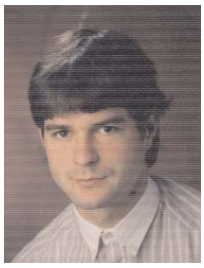
Examples of projects 2004

1. Optical quality coatings for micro mirrors
2. PLD carbon coatings to smoothen substrate roughness
3. Tailored inner diameter coatings - new possibilities through PLD
4. Monochromators for the X-ray fluorescence analysis
5. Extended measurement possibilities for the X-ray analytics
6. EUV reflectometer: measurement setup and precision





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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 according to customer specifications, we also offer our extensive experience in the area of preparation, characterization, and simulation of X-ray optical components.

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

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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-Kα or Mo-Kα 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 from 10 to 16 nm.

Overall view of the EUV reflectometer

R&D-offer: Bonding

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Example of projects 2004

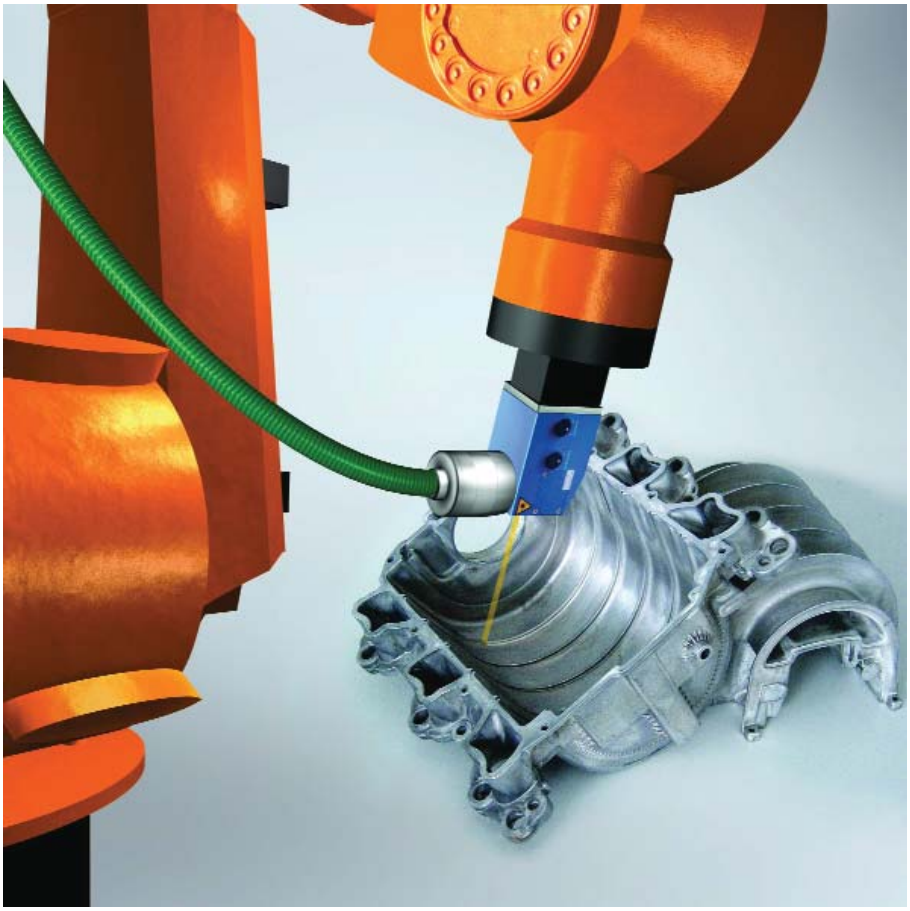
1. Preparation of fiber reinforced composite materials with Nd:YAG laser

2. Investigation of an adhesive bonding joint through laser acoustic and thermo-analytical methods

Adhesive bonding technology

The adhesive bonding laboratory at the Institute for Surface Technology and Production Metrology at the TU Dresden received in 2004 a Nd:YAG cleaning laser system and an atmospheric plasma system. With these systems we have optimal conditions for joint preparation with physical methods. The main working areas of the group are:

- surface preparation through plasma and laser techniques as well as conventional pretreatment methods,
- constructive adhesive bonding of different materials (metals, plastics, glass, wood),
- characterization of surfaces and bonded systems through contact angel, roughness and film thickness measurements, light microscopy, SEM / EDX and spectroscopic methods,
- determination of the bond strengths and aging studies,
- simulation and implementation of a database.



R&D-offer: Multimedia and simulation

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Dr. Dietrich Lepski
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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.

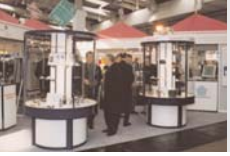
Process simulation and software development for the laser material processing

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 projects 2004

1. Implementation of a »virtual technology« for the example of laser build-up welding
2. Simulation of the inductive preheating for laser induction welding



Committees

Prof. E. Beyer:
Member of the Executive Committee of the Fraunhofer-Gesellschaft

Prof. E. Beyer:
Speaker of the Fraunhofer Network Surface Technology and Photonics

Prof. E. Beyer:
Director of the Institute for Surface Technology and Production Metrology IOF (TU Dresden)

Prof. E. Beyer:
Chairman of the work group »Engineering Sciences« as well as member of the board of the scientific society for laser technology WLT e.V.

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

Prof. E. Beyer:
Member of the Sachsenberg-Gesellschaft e.V.

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

Prof. E. Beyer:
Curator of the Palucca School Dresden, University for Dancing

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

Prof. E. Beyer:
Member of the center of excellence Aviation and Space Technology Saxony e.V.

Prof. E. Beyer:
Member of the University Center for Aerospace (UZLR) of the TU Dresden

Prof. E. Beyer:
Member of the advisory board of the European Laser Institute

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

Prof. B. Brenner:
Member of the advisory board of AiF

Dr. I. Jansen:
Member of the industrial task force »Intlaskleb« of the BMBF

Dr. R. Jäckel:
Working committee »Fairs and Public Relations« of the Materials Research Association, Dresden

Dr. G. Kirchhoff:
Working committee »Acoustic Emission Analysis« of the DGzfP

A. Kluge:
Speaker for the computer operators of the Fraunhofer-Gesellschaft

Dr. A. Leson:
Member of the international expert panel for the nanomat-program of Norway

Dr. A. Leson:
Member of the BMBF review board of the topics nanotechnology and automotive construction

Dr. A. Leson:
Speaker for the nanotechnology competence center »Ultrathin Functional Films«

Dr. A. Leson:
Committee member of the magazine »Vacuum and Research in Practice«

Dr. A. Leson:
Member of the future technologies board of the city of Dresden

Dr. A. Leson:
Member of the advisory council of the VDI

Dr. A. Leson:
Chairman of the VDI working circle »Study Programs in Nanotechnology«

Dr. A. Leson:
Member of the international advisory board of the journal »Micromaterials and Nanomaterials«

Dr. A. Leson, Dr. H.-J. Scheibe, Prof. B. Schultrich, :
Task force plasma surface technologies of the DGO

Dr. S. Nowotny:
DVS working committee V9.2 / AA 15.2 »Laser Beam Welding and Related Techniques«

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

Prof. 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

Lecturing

Lectures at the Institute for Surface Technology and Production Metrology of the TU Dresden in winter semester 2003 / 2004:

- Prof. Beyer: Manufacturing technology II, (surface and coating technology)
- Prof. Schultrich: Thin film technology (special materials)
- Dr. Leson, Prof. Beyer: Surface engineering / nanotechnology
- Prof. Beyer: Rapid protocoating

Lectures at the Institute for Surface Technology and Production Metrology of the TU Dresden in summer semester 2004:

- Prof. Beyer: Laser basics / laser system technology
- Prof. Beyer: Practical training: Laser safety and process technology

Lectures at the Institute for Surface Technology and Production Metrology of the TU Dresden in winter semester 2004 / 2005:

- Prof. Beyer: Laser and plasmas in surface and micro technology (production technology and business engineering)
- Prof. Beyer: Plasmas in production technology (mechatronics)
- Prof. Schultrich: Thin film technology (special materials)
- Dr. Leson, Prof. Beyer: Surface technology / nanotechnology
- Prof. Beyer: Rapid protocoating

Lectures at the Hochschule für Technik und Wirtschaft Dresden (HTWD):

- Dr. Nowotny: Laser materials processing
- Dr. Nowotny, Prof. Schultrich: Surface refinement and heat treatment technologies

IWS prizes in 2004

1. Best innovative product ideas

   Dr. Kirchhoff
   »Lifespan investigations on components for rocket engines«

   Mr. Sonntag
   »Acquisition and establishment of the work direction laser applications in biotechnology«

2. Best scientific technical performance

   Mr. Liebscher, Mr. Hennig, Dr. Standfuß, Dr. Pollack
   »Implementation and start-up of the XXL laser welding facility for the double-sided and simultaneous laser beam welding«

3. Best scientific performance of a junior scientist

   Mr. Hutsch
   »Possibilities and limitations of the laser for the cleaning of metallic art and cultural pieces made from copper and copper alloys«

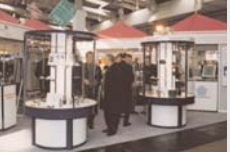
5. Special prizes

   Dr. Wiedemann
   »Application of laser technology in restoration and monument maintenance - especially laser cleaning«

   Mr. Wittig
   »Recognition for special performance throughout the building expansion phase«

Dr. Kirchhoff receives the Institute Prize for the best innovative product idea

Mr. Wittig receives recognition for his special engagement during the building expansion



Diploma theses

T. Hackel
(Technische Universität Dresden)
»*Prozessanalyse von Dünnschichttechnologien und Herstellkostenberechnung*«
»*Process analysis of thin film technologies and manufacturing cost calculation*«

C. Kiertscher
[Hochschule für Technik und Wirtschaft Dresden (HTWD)]
»*Laserschneiden und –markieren von Bahnmaterialien*«
»*Laser cutting and marking of train materials*«

M. Knechtel
(Berufsakademie Sachsen - Staatliche Studienakademie Dresden)
»*Entwicklung und Implementierung eines Intrusion-Detection und -Prevention Systems zur Erkennung und Abwehr von gezielten Attacken und anormalen Ereignissen im LAN*«
»*Development and implementation of an intrusion detection and prevention system for the detection and defense of targeted attacks and abnormal events in the LAN*«

C. Lunow
[Westsächsische Hochschule Zwickau (FH)]
»*Charakterisierung von Laserbohrprozessen in Metallen durch die zeitliche Detektion gestreuten Laserlichts mit mehreren Sensoren*«
»*Characterization of laser drilling processes in metals through the simultaneous detection of the scattered laser light with several sensors*«

S. Mälzer
[Westsächsische Hochschule Zwickau (FH)]
»*Mikrobearbeitung von Siliziumwafern mit diodengepumptem frequenzverdreifachtem Nd:YAG-Laser*«
»*Micro processing of silicon wafers with a diode pumped and frequency tripled Nd:YAG laser*«

B. Mimler
(Technische Universität Dresden)
»*Prozessorientierte Restruktion eines Fahrzeugbauunternehmens unter marktorientierten, logistischen und fertigungstechnischen Gesichtspunkten*«
»*Process oriented restructuring of a vehicle construction company under market oriented, logistic and production technological considerations*«

K. Strulik
(Berufsakademie Sachsen - Staatliche Studienakademie Dresden)
»*Untersuchungen und Analyse zum Einsatz von Tracking-Systemen bei der Simulation von Anlagen der Lasermaterialbearbeitung in virtuellen Räumen*«
»*Investigation and analysis for the deployment of tracking systems for the simulation of facilities for the laser materials processing in virtual spaces*«

C. Thoma
(Technische Universität Dresden)
»*Einfluss von Handlingsystemen bei nasschemischen Prozessen auf die Randfläche des Wafers*«
»*Influence of handling systems on the side surface of wafers during wet chemical processes*«

D. Weber
[Hochschule Mittweida (FH)]
»*Konstruktion einer flexiblen Maschineneinhausung*«
»*Design of a flexible machine enclosure*«

Doctoral theses

S. Braun
(Universität Bielefeld)
»*Gefüge- und Grenzflächenbeschaffenheit von Mo/Si-Multischichten synthetisiert mittels Puls-Laser- und Magnetron-Sputter-Deposition*«
»*Structure and interface texture of Mo/Si multilayer coatings synthesized through pulsed laser and magnetron sputtering processes*«

F. Lupp
(Technische Universität Dresden)
»*Gratfreies Microcaving von Molybdän*«
»*Burr free micro caving of molybdenum*«

J. Hohage
(Technische Universität Dresden)
»*Synthese von Bornitridschichten mittels PLD-Verfahren*«
»*Synthesis of boron nitride coatings through PLD processes*«

Special events

January 1, 2004
Arc Precision GmbH is formed as an IWS spin-off company

June 3, 2004
Grand opening ceremony of the building expansion of the four IZD institutes

June 7 - 9, 2004
Laser summer school of the scientific society for laser technology e.V. in Dresden (participating organizer: Fraunhofer IWS)

June 25, 2004
Official start-up of the XXL laser welding machine

July 8, 2004
Participation at the central event »Light signs - Optics & Electronics« in the framework of the year of technology in the international congress center in Dresden

September 2 - 4, 2004
Participation at »Park of Ideas« event at ThyssenKrupp

September 20 - 21, 2004
International Open House

September 23, 2004
Congress of the international experts task force on shell construction at the IWS

October 21 - 22, 2004
5th workshop »Industrial Applications of High Power Diode Lasers«

November 9 - 10, 2004
»New rapid technologies on their way to production - experience reports and development trends«, final presentation of the BMBF projects

November 23 - 24, 2004
3rd International nanotechnology symposium »Nanofair - new ideas for the industry« in Karlsruhe

November 30, 2004
5th Special Symposium Surface Technology at the Dortmund Surface Center of the ThyssenKrupp AG

Surface Engineering and Nanotechnology (SENT)

This designation expresses the significance of the aspects of nanotechnology for the modern thin film technology and IWS in cooperation with TU Dresden launched continuing educational seminars about industrial thin film technology. These courses are offered as general seminars at the IWS and as adapted courses within companies.

October 26 - 29, 2004
»Manufacturing and applications of thin protective coatings«

November 23 - 24, 2004
»Sputtering and vacuum arc deposition«

December 7 - 9, 2004
»Characterization of thin films«

Demonstration of the new system concept pc_{Pro}® in the technical hall of the IWS during the final presentation of the BMBF projects

Demonstration at the Fraunhofer IWS during the international experts task force congress on shell construction

Podium discussion during the 5th high power diode laser workshop

Participation in fairs and exhibitions

Fair Learntec 2004 Karlsruhe February 10 - 13, 2004

Eleven institutes of the Fraunhofer-Gesellschaft presented themselves in Karlsruhe under the motto »Knowledge & Transfer - Fraunhofer-eQualification«. The workgroup Multimedia participated in cooperation with other IWS groups for the second time at this fair. On PC workstations we presented:

- CD-ROM »laser lexicon« and CD-ROM »laser safety«
- eLearning products: »Hybrid laser beam welding processes« and »Coating Technology«.

Presentation of the Fraunhofer IWS at the Hannover Fair 2004

Hannover Fair Industry 2004 April 19 - 24, 2004

The IWS presented the latest results from applied research in laser materials and micro processing in Hall 15 - Micro Technology - at the shared 60 m² booth »laser technology«. As in earlier years partner companies such as ALOtec GmbH Dresden and Linde AG Munich participated in the booth and represented results of joint research projects.

Every other year, and as such in 2004, surface technology was a focus at the Hannover Fair. For this occasion the IWS presented at the 50 m² VDI Booth »SurfPlaNet« in Hall 5 the latest results from applied research in surface technology. Presented were the diamond-like carbon coatings Diamor® for cutting and forming tools, the new LaserArc module® with a coating length of 400 mm, the new infrared spectrometer for large samples IRspecXL and the process combination of the laser assisted plasma spraying for the generation of very well adhering coatings with high productivity. In addition the IWS-coordinated nanotechnology competence center »Ultrathin Functional Films« exhibited nanotechnology applications and products, which were provided from the members of the center.

The IWS Dresden also participated at the joint Fraunhofer-Alliance Booth »Transparent scratch resistant coatings« in Hall 5.

The decision to expand the IWS presence at the Hannover Fair in 2004 proved itself right by making 240 new and relevant customer contacts.

Visit of the Federal State Secretary Staffelt at the booth of the Aerospace Competence Center Saxony / Thuringia e.V. during the International Aerospace Exhibition in Berlin

International Aerospace Exhibition Berlin 2004 (Berlin Air Show) May 10 - 16, 2004

For the first time the IWS participate in the ILA at the airport in Schönefeld. The institute joined the booth of the Aerospace Competence Center Saxony / Thuringia e.V. We exhibited technologies for the laser beam welding of aircraft fuselage structures, the deposition of heat resistant coatings and the characterization of mechanical, thermal and tribological properties of laser treated components relevant to the aerospace industry.

Materialica Munich 2004
September 21 - 23, 2004

Our adhesive bonding technology group presented the latest results for the preparation of bonding surfaces with plasma laser technologies at the booth »Research for the future«. Advantages of these methods are the non-contact processing and the possibility to partially treat the parts. They can also be integrated in production processes and are environmentally harmless. Partially pretreated samples from automotive and aerospace applications made of magnesium, aluminum and fiber reinforced composite materials were exhibited.

Powder Metallurgy World Congress and Exhibition 2004 Vienna
October 17 - 21, 2004

The thermal coating technology department presented their performance spectrum with a focus in thermal spraying, laser build up welding and MELATO® technologies.

Euroblech 2004, Hannover (Sheet Metal)
October 26 - 30, 2004

The IWS participated for the second time at this international technology fair on sheet metal processing. We exhibited welding technology solutions for lightweight materials such as aluminum and magnesium (e.g. laser beam welded landing flap demonstrator for aircrafts, novel Al lightweight car door) and for welding of high strength body sheet metal. A second focus was the MELATO® process for the rapid manufacturing of forming tools. The presentation showed for the first time a completely automated solution for cutting, packaging, and joining of steel sheet metal sections. Many new contacts to users were established.

Parts2Clean Friedrichshafen
October 26 - 28, 2004

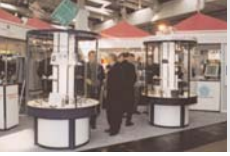
The IWS presented at this exhibition a solution for the partial laser beam cleaning of components. This cleaning step can be integrated in the automated manufacturing process, realizes short cycle times, and offers the possibility of cleaning of surfaces necessary for the subsequent processing steps in a pre-mounted state. The method avoids the need for solvents and other conventionally necessary chemicals. The solution was presented for the example of cleaning off coolant and lubricant residues as well as preservatives before a subsequent laser beam welding step.

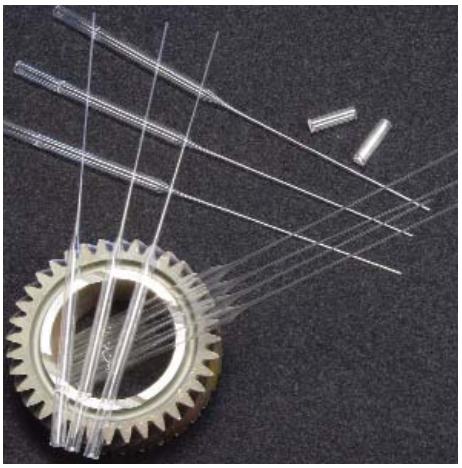
In addition, the Fraunhofer IWS exhibited a non-contact and non-destructive measurement technique using FTIR spectroscopy, which does not require sample preparation. If required this technique can be integrated into existing processes and can therefore be used for online quality control. The FTIR spectroscopy can be applied to large components and surfaces. The method detects organic as well as inorganic contaminations independent of the substrate. It is of interest to all industrial processes that need to monitor the results of component cleaning steps.

Lively exchange of thoughts at the Fraunhofer IWS booth at the Materialica 2004

Presentation of the Fraunhofer IWS at the Materialica 2004

Exchange of experiences at the Fraunhofer IWS booth at the Euroblech 2004





Laser cut flash light blanks at the Fraunhofer IWS presentation at the GlassTec 2004

Hannover Fair 2004: Surface technology as the basis for innovative applications

Monuments 2004 Leipzig
October 27 - 30, 2004

The IWS presented the laser beam cleaning of culturally and historically valuable objects made of metal, wood, and stone at this European branch fair for monument maintenance and city renewal. Exhibited as an example was a laser cleaned brass putto from the Herrenhäuser Gärten in Hannover, which was the result of a research project sponsored by the Deutsche Bundesstiftung Umwelt.

GlassTec 2004 Düsseldorf
November 8 - 13, 2004

The Fraunhofer IWS joined the two major laser manufacturers Coherent Inc. and Lambda Physics to exhibit at the glass fair »GlassTec« in Düsseldorf. The extraordinarily high number of about 54,000 visitors was interested in the new thematic areas »laser technologies« and »thin special glasses«. The IWS presented a system based on a scanner coupled Excimer laser for the damage-free marking of glass.

In addition IWS participated in the booth of the company KL-Metal Fittings. Joint research results in the area of structural glass construction were presented that had been worked on with this company as well as the company Delo and Institute for Structural Construction of the TU Dresden.

Euromold 2004 Frankfurt/Main
December 1 - 4, 2004

The IWS participated for the ninth time at this branch fair for die-, model-, and tool making as well as die casting technology. At the Fraunhofer alliance booth »Rapid Prototyping» we presented results of the project MELATO®, which established a new process chain for the rapid manufacturing of complex shaped tools of up to 1.5 m in length. The exhibited minting and forming tools were built based on the LOM process (laminated object manufacturing). The central object of the Fraunhofer booth was the small system pc_{Pro}® for the high precision rapid prototyping of casts. This system was presented to the public for the first time. Through the integration of the casting process with a milling machine it is possible to completely manufacture the half tool in one setting. The high degree of automation enables a significant increase in productivity while maintaining flexibility and component quality. We see the application potential for this technology in areas that use plastic parts.

Patent applications

[P1] E. Beyer, L. Morgenthal, V. Fleischer, A. Klotzbach

»Vorrichtung und Verfahren zur Bearbeitung von Werkstücken mittels Laserstrahlung«

Anmelde-Az.: DE 10 2004 045 408.6

[P2] B. Brenner, S. Bonß, F. Tietz, J. Kaspar, W. David

»Verfahren zur Herstellung von verschleißbeständigen und ermüdungsresistenten Randschichten in Titan-Legierungen und damit hergestellte Bauteile«

Anmelde-Az.: 10 2004 033 342.4/24

[P3] B. Brenner, B. Winderlich, J. Standfuß, J. Schumacher, H. Brenneis, W. Zink

»Leichtbau-Strukturbauteil insbesondere für Flugzeuge und Verfahren zu seiner Herstellung«

Anmelde-Az.: EP 04000743.7

[P4] B. Brenner, B. Winderlich, J. Standfuß, J. Schumacher, H. Brenneis, W. Zink

»Leichtbau-Strukturbauteil insbesondere für Flugzeuge und Verfahren zu seiner Herstellung«

Anmelde-Az.: JP 2004-9796

[P5] B. Brenner, B. Winderlich, J. Standfuß, J. Schumacher, H. Brenneis, W. Zink

»Lightweight structural component in particular for aircraft and method for its production«

Anmelde-Az.: US 10/757,419

[P6] B. Brenner, B. Winderlich, J. Standfuß, J. Schumacher, H. Brenneis, W. Zink

»Lightweight structural component in particular for aircraft and method for its production«

Anmelde-Az.: CA 2,455,791

[P7] I. Dani, W. Grählert, G. Mäder, V. Hopfe

»Vorrichtung und Verfahren zur optischen Detektion von in Abgasen chemischer Prozesse enthaltenen Stoffen«

Anmelde-Az.: DE 10 2004 028 420.2-52

[P8] R. Dietsch, H. Borrmann, T. Holz

»Monochromatisierende röntgenoptische Anordnung«

Anmelde-Az.: EP 044000400.4

[P9] T. Himmer, A. Techel

»A device and a method for manufacturing three-dimensional component parts«

Anmelde-Az.: US 10/794,936

[P10] G. Mäder, V. Hopfe, D. Rogler

»Modul und Verfahren für die Modifizierung von Substratoberflächen bei Atmosphärenbedingungen«

Anmelde-Az.: DE 10 2004 015 216.0-45

[P11] L. Morgenthal, A. Klotzbach, T. Schwarz, J. Hauptmann, R. A. Gnann, A. van Spankeren

»Vorrichtung und Verfahren für eine Bearbeitung großflächiger Bearbeitungsbereiche von Werkstücken mittels Laserstrahlung«

Anmelde-Az.: DE 10 2004 007 541.7-34

[P12] L. Morgenthal, T. Schwarz, F. Kretzschmar, D. Pollack, S. Thalheim

»Vorrichtung und Verfahren zur Bestimmung des Abstandes zwischen einer Referenzebene und einer Substratoberfläche«

Anmelde-Az.: DE 10 2004 002 253.4-54

[P13] D. Rogler, G. Mäder, V. Hopfe

»Verfahren und Vorrichtung zur Ausbildung dünner Schichten aus Siliziumnitrid auf Substratoberflächen«

Anmelde-Az.: DE 10 2004 015 217.9-45

[P14] A. Techel, R. A. Gnann

»Metallbauelement«

Anmelde-Az.: DE 10 2004 032 084.5

[P15] A. Techel, R. A. Gnann

»Metallische Verbundbauteile«

Anmelde-Az.: DE 10 2004 032 088.8

[P16] A. Techel, T. Himmer

»Verbundelement aus Metall, mit mindestens einem Temperierkanal«

Anmelde-Az.: DE 10 2004 032 085.5

[P17] C. Wallenhauer

»Schaltungsanordnung zur Reduzierung von Messfehlern analoger pulsförmiger Messsignale eines Detektors«

Anmelde-Az.: DE 10 2004 004 260.8-52

[P18] V. Weihnacht, B. Schultrich, P. Siemroth, T. Mühl

»Element mit strukturierter Oberfläche sowie Verfahren zu seiner Herstellung«

Anmelde-Az.: DE 10 2004 011 363.7-54

Issued patents

[P19] E. Beyer, S. Nowotny, S. Scharek

»Method for producing shaped bodies or applying coatings«

Veröffentlichungs-Nr.: US 6,744,005

[P20] B. Brenner, V. Fux

»Verfahren zur Erzeugung von verschleißbeständigen Randschichten mittels Laser«

Veröffentlichungs-Nr.: EP 1285 719 B1

[P21] T. Himmer

»Verfahren zum Fügen von planaren, übereinander angeordneten Laminaten oder Laminatpaketen oder Laminarbauteilen durch Laserstrahlschweißen«

Veröffentlichungs-Nr.: DE 102 11 511 C1

[P22] T. Himmer, A. Uelze

»Vorrichtung und Verfahren zur Herstellung von Laminatbauteilen«

Veröffentlichungs-Nr.: DE 102 10 420 B4

[P23] L. van Loyen, T. Böttger, S. Braun, H. Mai

»Vorrichtung zur Erzeugung eines gepulsten Plasmas innerhalb einer Vakuumkammer mittels eines Festkörpertargets, mit mindestens einer Debris-Blende«

Veröffentlichungs-Nr.: DE 102 33 567 C2

[P24] H. Mai, S. Braun

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

Veröffentlichungs-Nr.: DE 102 21 116 B3

[P25] H.-J. Scheibe, C.-F. Meyer

»Electric resistance element, which can be electromechanically regulated«

Veröffentlichungs-Nr.: US 6,788,187

Protection of trademarks

[P26] *»IRspec XL«*

Anmelde-Az.: DE 3705266

[P27] *»pcPro«*

Anmelde-Az.: US 78/481,473
Veröffentlichungs-Nr.: DE 304 17 000

[P28] *»spARC«*

Veröffentlichungs-Nr.: DE 304 38 694

[L01] L.-M. Berger

»Hardmetal Coatings by Thermal Spraying - Compositions, Processes, Properties and Applications«

Euro PM2004, World Powder Metallurgy Congress (2004)

[L02] L.-M. Berger

»Titanium Oxide - New Opportunities for an Estabilished Coating Material«

Thermal Spray Solutions - ITSC 2004, Part: Photocatalytic Materials (2004)

[L03] L.-M. Berger, M. Woydt, S. Zimmermann, H. Keller, G. Schier, R. Enzl, S. Thiele

»Tribological Behavior of HVOF-Sprayed Cr_3C_2-NiCr and TiC-Based Coatings Under High-Temperature Dry Sliding Conditions«

Thermal Spray Solutions - ITSC 2004, Part: HVOF-Processes and Materials (I) (2004)

[L04] E. Beyer

»Latest Developments in Transmission Laser Welding«

Automotive Laser Application Workshop - ALAW (2004)

[L05] E. Beyer

»Latest Developments in Transmission Laser Welding«

12th Annual Automotive Laser Application Workshop - ALAW (2004)

[L06] S. Beyer, S. Ferrara, J. Hauptmann, H. Janssen, G. Kirchhoff, J. Rösing, S. Schmidt

»Metall-Keramik-Verbindungstechniken im Bereich Raumfahrt-Antriebe«

Verlag für Schweißen und verwandte Verfahren (2004)

[L07] E. Beyer, H.-J. Scheibe, B. Schultrich, V. Weihnacht

»Deposition Technology, Tribological Properties and Applications of Superhard Amorphous (ta-C) Carbon Films«

THE Coatings (2004) S. 79-91

[L08] E. Beyer, H.-J. Scheibe, B. Schultrich, V. Weihnacht

»Laser-assisted deposition of superhard carbon coatings«

The Industrial Laser User, Issue 36 (2004)

[L09] S. Bonß, B. Brenner, H.-J. Scheibe, E. Beyer

»Laser Gas Alloying of Titanium - Process Technology and Wear Test Results«

10th World Conference Titanium - Ti-2003 (2004) S. 993-1000

[L10] S. Braun, B. Bendjus, T. Foltyn, M. Menzel, J. Schreiber, A. Leson

»Smoothing of Substrate Roughness by Carbon-Based Layers Prepared by Pulsed Laser Deposition (PLD)«

Advances in Mirror Technology for X-Ray, EUV Lithography, Laser, and Other Applications II (Proc. of the SPIE 5533) (2004) S. 75-84

[L11] S. Braun, B. Bendjus, T. Foltyn, M. Menzel, J. Schreiber, D. Weißbach

»Carbon Buffer Lasers for Smoothing Substrates of EUV and X-Ray Multilayer Mirrors«

Testing, Reliability, and Application of Micro- and Nano-Material Systems II (Prof. of the SPIE 5392) (2004) S. 132-140

[L12] S. Braun, T. Böttger, T. Foltyn, L. van Loyen, A. Leson

»High-Reflection Optics and High-Precision Metrology for Extreme Ultraviolet (EUV) Light«

Nanofair (2004)

[L13] B. Brenner, E. Beyer, S. Nowotny

»Overview of Hybrid Technology«

1st Pacific International Conference on Application of Lasers and Optics, Melbourne 19.-21. April 2004, Tagungsband

[L14] B. Brenner, J. Standfuß, A. Jahn, D. Dittrich, A. Zwick

»Neue verfahrenstechnische Lösungen zum Laserstrahlschweißen für den Karosseriebau«

22. Fachtagung »Prozesskette Karosserie«, Dresden, 21.-23. September 2004, Tagungs-CD

[L15] B. Brenner, J. Standfuß, L. Morgenthal, D. Dittrich, V. Fux, B. Winderlich, H. Brenneis, W. Zink, J. Hackius, J. Held, W. Schwabe

»Neue technologische Aspekte des Laserstrahlschweißens von Flugzeugstrukturen«

Schweißen und Löten im Luft- und Raumfahrzeugbau: moderne Anwendungen und Werkstoffe in Neufertigung und Instandhaltung, DVS-Berichte, DVS-Verlag Düsseldorf 299 (2004) S. 19-24

[L16] C. Casiraghi, A. C. Ferrari, J. Robertson, R. Ohr, M. v. Gradowski, D. Schneider, H. Hilgers

»Ultra-Thin Carbon Layer for High Density Magnetic Storage Devices«

Diamond and Related Materials 13 (2004) 4-8, S. 1480-1485

[L17] D. H. C. Chua, K. B. K. Teo, T. H. Tsai, W. I. Milne, D. Sheeja, B. K. Tay, D. Schneider

»Correlation of Surface, Mechnical and Microproperties of Tetrahedral Amorphous Carbon Films Deposited under Different Magnetic Confinement Conditions«

Applied Surface Science 221 (2004) 1-4, S. 455-466

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8. Forum »Laser in Restaurierung und Denkmalpflege«, Fulda (D). 08. Oktober 2004

[T45] R. Jacob, R. Sonnet, M. Wagner, G. Wiedemann

»Laserstrahlschweißen in der Restaurierung am Beispiel eines silbernen, teilvergoldeten Schmuckkästchens mit Kaltbemalung aus dem Bestand des Grünen Gewölbes«

8. Forum »Laser in Restaurierung und Denkmalpflege«, Fulda (D), 08. Oktober 2004

[T46] R. Jäckel

»Nanotechnologie: Ultradünne funktionale Schichten - mit großen Auswirkungen«

VDI-Workshop Nürnberg (D), 12. Februar 2004

[T47] A. Jahn, B. Brenner, B. Winderlich

»Induktiv unterstütztes Laserstrahlschweißen von Strukturen aus höherfesten Feinblechen«

Konferenz Strahltechnik, Halle (D), 26.-28. April 2004

[T48] A. Jahn, B. Winderlich, A. Zwick, R. Imhoff, B. Brenner

»Laserstrahlhybridschweißen schwingend belasteter Bauteile aus dem hochfesten Feinkornbaustahl S 1100 QL«

Große Schweißtechnische Tagung, Magdeburg (D), 22.-24. September 2004

[T49] I. Jansen

»Klebflächenvorbereitung von Magnesiumbauteilen«

Dresdener Fügetechnisches Kolloquium »Klebtechnik - Verfahren und Prozesse ziel- und qualitätsgerecht gestalten«, Dresden (D), 25.- 26. März 2004

[T50] I. Jansen

»Vorbehandlung und Klebstoffauswahl«

Glasbau 2004, Dresden (D), 02. April 2004

[T51] I. Jansen, D. Schneider

»Anwendung der Lawave-Methode in der Klebtechnik«

Dechema-Kolloquium »Klebtechnik«, Frankfurt (D), 23.-24. November 2004

[T52] E. Jelen, K. Püschner, G. Wiedemann

»Dekontamination biozidbelasteter Kunst- und Kulturgüter aus Holz«

8. Forum »Laser in Restaurierung und Denkmalpflege«, Fulda (D). 08. Oktober 2004

[T53] Klaffke, H.-J. Scheibe, V. Weihnacht

»Tribological Characterisation of Amorphous Hard Carbon (ta-C) Coatings at Room Temperature; Effect of Counterbody Material and Humidity«

4th International Conference »THE coatings«, Erlangen, 05.-07. April International Conference on Metallurgical Coatings and Thin Films - ICMCTF, San Diego (USA), 19.-23. April 2004

[T54] A. Klotzbach, V. Fleischer, L. Morgenthal, E. Beyer

»Robotergeführtes Remoteschweißen mit Hochleistungs-YAG-Lasern«

4. Jenaer Lasertagung, Jena (D), 18.-19. November 2004

[T55] U. Klotzbach

»Chances of Laser Micro Materials Processing«

International Open House, Dresden (D), 20.-21. September 2004

[T56] A. Leson

»Nanotechnologie - Vision oder Realität"

Ingenieurstammtisch des Vereins der Ingenieure, Techniker und Wirtschaftlicher in Sachsen e.V., Dresden (D), 06. Januar 2004

[T57] A. Leson

»The FhG-Thyssen Cooperation«

Nano DE 2004, Wiesbaden (D), 21.-22. Juni 2004

[T58] A. Leson

»Nanometer-Schichtsysteme für Röntgenoptiken«

Nanotechnologie in der industriellen Anwendung, Regensburg (D), 04.-05. Oktober 2004

[T59] A. Leson

»Nanotechnologie - Chancen für den Standort Deutschland?«

Berliner Republik - Innovationsdialoge: Chancen und Risiken der Nanotechnologie, Berlin (D), 30. Juni 2004

[T60] A. Leson

»XUV Optics and Applications«

Heraeus Seminar »XUV Technologies and Applications«, Bad Honnef (D), 07.-09. Juni 2004

[T61] A. Leson

»Nanotechnology in Saxony«

Commercialization of Micro and Nano Systems Conference - COMS 2004 Edmonton (Kanada), 29. August - 02. September 2004

[T62] A. Leson

»Nanotechnologie - Zukunftschance oder Fiktion?«

Tag der Technik an der Landesschule Pforta, Schulpforte (D), 12.-13. Oktober 2004

[T63] A. Leson

»German Centers of Competence in Nanotechnology Present Status and Our Experiences«

International Nanotech Workshop 2004, Venedig (IT), 19. März 2004

[T64] A. Leson, S. Braun, P. Gawlitza

»Fabrication of High-Precision Tailored Materials by Pulsed Laser Deposition«

International Open House, Dresden (D), 20.-21. September 2004

[T65] A. Leson, P. Gawlitza, S. Braun, M. Menzel

»Pulsed Laser Deposition - An Indispensable Tool for the Fabrication of High-Precision Tailored Materials«

6th Symposium of European Vacuum Coaters, Anzio (IT), 27.-29. September 2004

[T66] L. van Loyen, T. Böttger, S. Schädlich, S. Braun, A. Leson

»Aufbau und Leistungsfähigkeit des IWS-EUV-Reflektometers«

13. Arbeitstagung Angewandte Oberflächenanalytik - AOFA 13, Dresden (D), 14.-17. September 2004

[T67] G. Mäder, F. Prässler, D. Rogler, V. Hopfe

»Simulation einer Lichtbogenplasmaquelle zur Nutzung einer plasmagestützten Schichtabscheidung unter Atmosphärendruck«

Fluent CFD Konferenz 2004, Bingen (D), 29.-30. September 2004

[T68] S. Martens, C. Kleemann, V. Weihnacht, L.-M. Berger, R. Zieris, I. Schulz

»Ceramic Coatings«

COST 532 Conference, Triboscience and Tribotechnology, Superior Friction and Wear Control in Engines and Transmissions, Ghent (B), 18.-19. Oktober 2004

[T69] M. Menzel

»Abscheidung von hochauflösenden Kohlenstoff/Kohlenstoff-Multischichten auf großflächigen Substraten für röntgenoptische Anwendungen mittels Pulsed Laser Deposition (PLD)«

Laser Summer School 2004, Dresden (D), 07.-09. Juni 2004

[T70] L. Morgenthal, A. Klotzbach

»Nd:YAG Laser Remote Welding System«

International Open House, Dresden (D), 20. - 21. September 2004

[T71] S. Nowotny

»Laserstrahl-Auftragschweißen: industrielle Lösungen für das Beschichten, Reparieren und Formändern von Werkzeugen, Formen und Bauteilen«

Festveranstaltung zum Firmenjubiläum der Firma LASERVORM, Mittweida (D), 26. November 2004

[T72] S. Nowotny

»Kombination von Auftragschweißverfahren für schnelle Reparaturen und Formänderungen von Werkzeugen«

Neue Rapid Technologien auf dem Weg in die Produktion, Dresden (D), 09.-10. November 2004

[T73] S. Nowotny

»New Developments for Thermal Coating Processes«

International Open House, Dresden (D), 20.-21. September 2004

[T74] S. Nowotny

»Neue systemtechnische Lösungen zum Auftragschweißen mit Diodenlasern«

Industrielle Anwendungen von Hochleistungs-Diodenlasern, Dresden (D), 21.-22. Oktober 2004

[T75] S. Nowotny, K.-H. Richter

»Laser Cladding of the Titanium Alloy Ti6242 to Restore Damaged Blades«

Laser Materials Processing Conference - ICALEO 2004, San Francisco / CA (USA), 04.-07. Oktober 2004

[T76] S. Nowotny, S. Scharek

»Fertigungsintegration von hybriden Auftragschweißverfahren zum Oberflächenschutz und zur Reparatur von Bauteilen«

Karlsruher Arbeitsgespräche, Karlsruhe (D), 11.-12. März 2004

[T77] S. Nowotny, S. Scharek, F. Kempe

»Laserstrahl-Präzisionsauftragschweißen: industrielle Lösungen für die Reparatur und schnelle Formänderungen von Werkzeugen«

3D-Erfahrungsforum Werkzeug- und Formenbau, Dresden (D), 13.-14. Mai 2004

[T78] S. Nowotny, S. Scharek, T. Naumann

»Development in HPDL Cladding with a Wide Laser Beam«

Laser Materials Processing Conference - ICALEO 2004, San Francisco / CA (USA), 04.-07. Oktober 2004

[T79] S. Nowotny, R. Zieris, E. Beyer

»Surface Protection of Light Alloys by Laser Assisted Atmospheric Plasma Spraying (LAAPS)«

International Conference on Plasma Surface Engineering (PSE), Garmisch-Partenkirchen (D), 13.-17. September 2004

[T80] K.-H. Richter, S. Orban, S. Nowotny

»Laser Cladding of the Titanium Alloy Ti6242 to Restore Damaged Blades«

Laser Materials Processing Conference - ICALEO 2004, San Francisco / CA (USA), 04.-07. Oktober 2004

[T81] H.-J. Scheibe, C.-F. Meyer, M. Leonhardt, B. Schultrich, V. Weihnacht

»Laser-Arc-Module for Deposition of Hard Amorphous Carbon (ta-C) Coatings with Industrial Batch Coaters«

4th International Conference »THE coatings«, Erlangen (D), 05.-07. April 2004 International Conference on Metallurgical Coatings and Thin Films - ICMCTF, San Diego (USA), 19.-23. April 2004

[T82] T. Schülke

»In-situ Temperature Sensor for Cutting Tools«

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[T83] B. Schultrich

»Laser Assisted Deposition of Superhard Carbon Films«

International Open House, Dresden (D), 20.-21. September 2004

[T84] B. Schultrich, J. Berthold, H.-J. Scheibe, H. Schulz, P. Siemroth, V. Weihnacht

»Superhard Amorphous Carbon Films from 2 nm to 100 µm: Properties and Applications«

PSE, Garmisch-Partenkirchen (D), 13.-17. September 2004

[T85] B. Schultrich, C.-F. Meyer, H. Schulz, H.-J. Scheibe, V. Weihnacht

»Industrielle Anwendung und Herstellung superharter amorpher Kohlenstoffschichten«

7. Werkstofftechnisches Kolloquium, Chemnitz (D), 30.9.-01.10.2004

[T86] B. Schultrich, H.-J. Scheibe

»Laser-Arc Process and Technology for Deposition of Hard Amorphous Carbon (ta-C)«

47th Annual SVC Technical Conference and Smart Materials Symposium, Dallas / Texas (USA), 24.-29. April 2004

[T87] B. Schultrich, S. Völlmar, D. Römer

»Process Simulation of Industrial Vacuum Arc Deposition«

4th International Conference »THE coatings«, Erlangen (D), 05.-07. April 2004

[T88] B. Schultrich, D. Römer, S. Völlmar

»Influence of Planetary Kinematics and Batch Filling on Film Homogeneity and Deposition Rate in Industrial Batch Coaters- a Simulation Approach«

PSE, Garmisch-Partenkirchen (D), 13.-17. September 2004

[T89] H. Schulz

»Von Superhärte bis Superhydrophobie - amorphe Kohlenstoffschichten als ...«

Oberflächentage 2004, Dresden (D), 22.-24. September 2004

[T90] H. Schulz, M. Leonhardt, H.-J. Scheibe, B. Schultrich

»Hydrophobe Oberflächen durch modifizierte Kohlenstoffschichten«

7. Werkstofftechnisches Kolloquium, Chemnitz (D), 30.09.-01.10.2004

[T91] H. Schulz, M. Leonhardt, B. Schultrich, H.-J. Scheibe

»Ultrahydrophobic Wetting Behavior of Amorphous Carbon Films«

PSE, Garmisch-Partenkirchen (D), 13.-17. September 2004

[T92] M. Seifert, S. Bonß, B. Brenner, E. Beyer

»Dynamische Strahlformung von Hochleistungs-Diodenlasern bis 4 kW«

Industrielle Anwendung von Hochleistungs-Diodenlasern, Dresden (D), 21.-22. Oktober 2004

[T93] M. Seifert, S. Bonß, B. Brenner, E. Beyer

»High Power Laser Beam Scanning in Multi-Kilowatt-Range«

23rd International Congress on Applications of Lasers and Electro-Optics, San Francisco (USA) 04.-07. Oktober 2004

[T94] M. Seifert, S. Bonß, E. Beyer

»Advanced Manufacturing Technologies of Metallic Components with High Power Diode Lasers«

Laser System Technology and Applications for SME's, S. Asaph (GB), 12.-13. Februar 2004

[T95] P. Siemroth, J. Berthold, Petereit, H. Schneider, H. Hilgers

»A New Generation of Filtered Arc Sources for Ultra Thin Top Coats on Magnetic Hard Disks«

International Conference on Metallurgical Coatings and Thin Films - ICMCTF, San Diego (USA), 19.-23. April 2004

[T96] A. Skopp, N. Kelling, M. Woydt, L.-M. Berger

»Thermally Sprayed TiO_{2-x}-Coatings under Mixed Lubrication and Unlubricated Sliding Conditions«

Tribologie-Fachtagung 2004, Göttingen (D), 27.-29. September 2004

[T97] J. Standfuß

»Laser Beam Welding«

International Open House, Dresden (D), 20.-21. September 2004

[T98] J. Standfuß, A. Klotzbach, A. Jahn, A. Mahrle, B. Brenner

»Verfahrens- und systemtechnische Aspekte zum Laserstrahlschweißen von Strukturen aus höherfesten Feinblechen«

IIR-Fachforum »Fügetechnologien im Fahrzeugrohbau«, Dresden, 09.-10. März 2004

[T99] T. Stucky

»Kohlenstoffschichten in Theorie und Praxis«

Nanotechnologie in der industriellen Anwendung, Regensburg (D), 04.-05. Oktober 2004

[T100] A. Techel, T. Himmer, E. Beyer, T. Heptner

»Automation Solutions for Metal Laminated Tooling«

4th International Conference on Laser Assisted Net Shape Engineering - LANE 2004, Erlangen (D), 21.-24. September 2004

[T101] F.-L. Toma, G. Bertrand, D. Klein, L.-M. Berger, S. Thiele

»Photocatalytic Properties of Coatings Sprayed from TiO_x and $Ti_{n-2}Cr_2O_{2n-1}$ Powders by APS and VPS«

International Thermal Spray Conference & Exhibition ITSC 2004, Osaka (J), 10.-12. Mai 2004

[T102] C. Walz, E. Stiles, A. Groth

»Laser Cladding and Primer Application as a One-Step-Process«

Laser Materials Processing Conference - ICALEO 2004, San Francisco / California (USA), 04.-07. Oktober 2004

[T103] M. Woydt, A. Skopp, N. Kelling, L.-M. Berger

»Tribological Characterization of Titanium Suboxide Coatings Prepared by VPS Spraying«

International Thermal Spray Conference & Exhibition ITSC 2004, Osaka (J), 10.-12. Mai 2004

[T104] M. Woydt, A. Skopp, N. Kelling, L.-M. Berger

»Tribological Characterization of Titanium Suboxide Coatings Prepared by VPS Spraying«

4th International Tribology Conference, Prag (CZ), 17.-18. Juni 2004

[T105] H. Wust, I. Jansen, E. Beyer

»Vorbehandlung von Magnesium mit Laserstrahlung«

Laser-Summerschool, Dresden (D), 07.-09. Juni 2004

[T106] R. Zieris, G. Langner, L.-M. Berger, S. Nowotny, E. Beyer

»Investigation of AlSi Coatings Prepared by Laser-Assisted Atmospheric Plasma Spraying of Internal Surfaces of Tubes«

International Thermal Spray Conference & Exhibition ITSC 2004, Osaka (J), 10.-12. Mai 2004

[T107] O. Zimmer

»Vacuum Arc Deposition by Using a Venetian Blind Particle Filter«

PSE, Garmisch-Partenkirchen (D), 13.-17. September 2004

[T108] O. Zimmer, J. Vetter, P. Siemroth, B. Schultrich

»Technical Physics of the Cathodic Vacuum Arc Evaporation«

International Conference on Metallurgical Coatings and Thin Films - ICMCTF, San Diego (USA), 19.-23. April 2004

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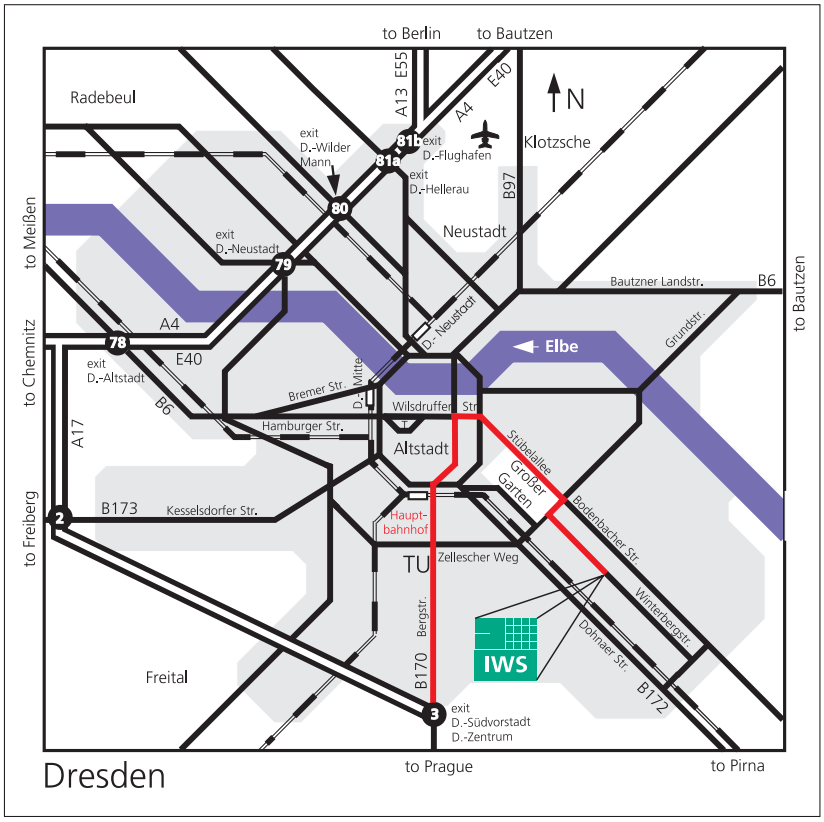

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- at the next traffic light turn left onto Winterbergstraße and continue straight until IWS

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