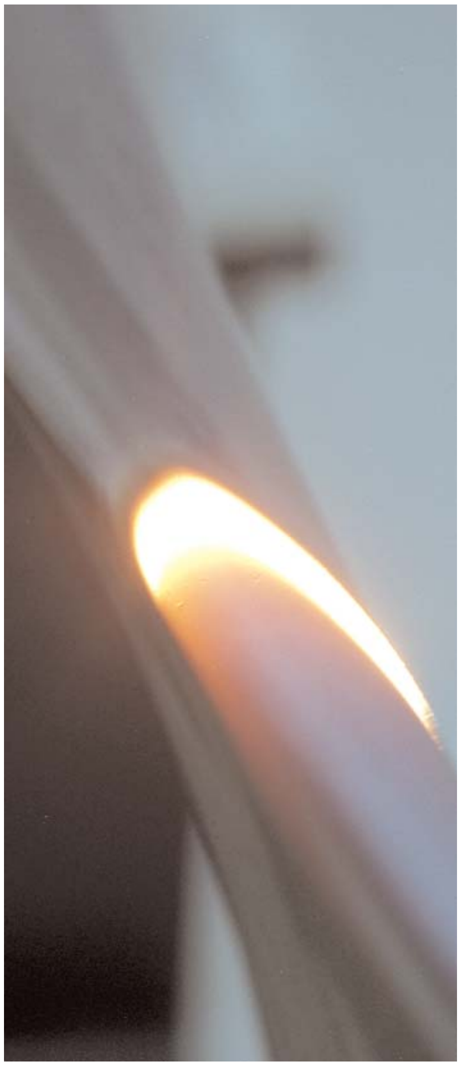
Fraunhofer Institut Werkstoff- und Strahltechnik

Annual Report 2007



Internet: www.iws.fraunhofer.de

Fraunhofer Institut Werkstoff- und Strahltechnik

Annual Report 2007

CERTIFICATE

ISO 9001:2000

DEKRA Certification

hereby certifies that the company

Fraunhofer Institut Werkstoff- und Strahltechnik

Fraunhofer Institut für Werkstoff- und Strahltechnik

Business field:
Management and Infrastructure, PVD- /Nanotechnology, CVD Thin Film Technology, Thermal Coating, Joining & Surface Treatment, Ablation and Cutting

Location:
Winterbergstraße 28 * D-01277 Dresden

has successfully implemented the above mentioned quality management system according to the standard (12/2000) and applies it effectively. The conformity was inspected during the certification audit documented in audit report no. A0605389. This certificate is only valid in connection with the successful performance of the surveillance audits.

Date of the first certification:	30.12.1997	Date of the last certification:	24.01.2007
This certificate is valid until:	23.01.2010	Certificate registration no.:	91297819/4 duplicate
Last audit day:	12.01.2007		

DEKRA Certification GmbH
Stuttgart, 24.01.2007

QMS-TGA-ZM-05-91-00

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Preface

The year 2007 was characterized by the benefits of the long awaited economic boom as well as investments in almost all areas. In particular the demand for new technologies clearly increased. Once again the Fraunhofer IWS benefited from an increase in research and development contracts from industrial customers.

We were able to raise industrial revenues by about 10 % to almost eight million Euros. This success is on the one hand stimulated by the economic upswing but it also reflects the trust that our industrial customers place in our work.

In 2007 the federal and state governments attributed greater importance to supporting research and development efforts. In this area IWS revenues raised by more than 10 %. Some of the projects only started in 2007, and as a result we anticipate a marked increase in public funding for 2008.

In September 2007 we performed a technology audit. Top-ranking representatives from science and industry analyzed the institute's development, structure, organization, technology areas and strategy. For all these areas the auditors arrived at an extraordinarily positive assessment and thus emphasized the strategic orientation of the IWS.

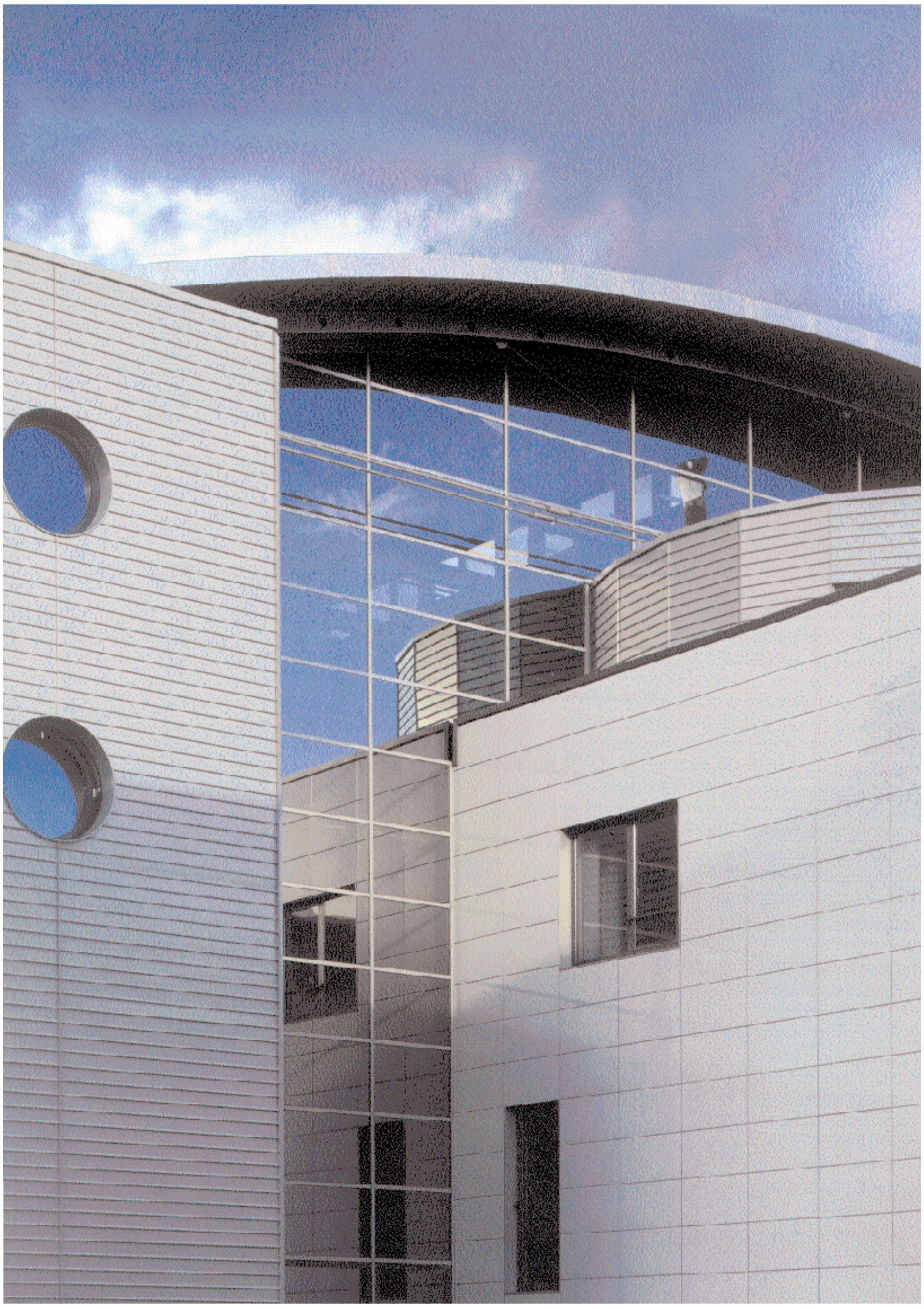
We are in particular proud of a number of highlights, which we will briefly describe on the following pages. Arguably the most spectacular result was the scientific and technical development of the remote cutting of metallic materials, which caused a worldwide sensation.

As in previous years we commercialized several new technologies in the research areas of surface technology and joining. Within our innovation cluster "nano for production" we were able to start up the first pilot systems.

Overall, the year 2007 was characterized by a noticeable growth. The number of employees increased by about 10 %. A further extension of the institute is planned for 2008 and 2009.

After such a successful year, we are now optimistically and enthusiastically moving forward into 2008.

A mind capable of discovering an idea will find the means to implement it.
Raymond Hull



Fraunhofer-Institut für
Werkstoff- und Strahltechnik IWS

Fraunhofer Institute for
Material and Beam Technology IWS

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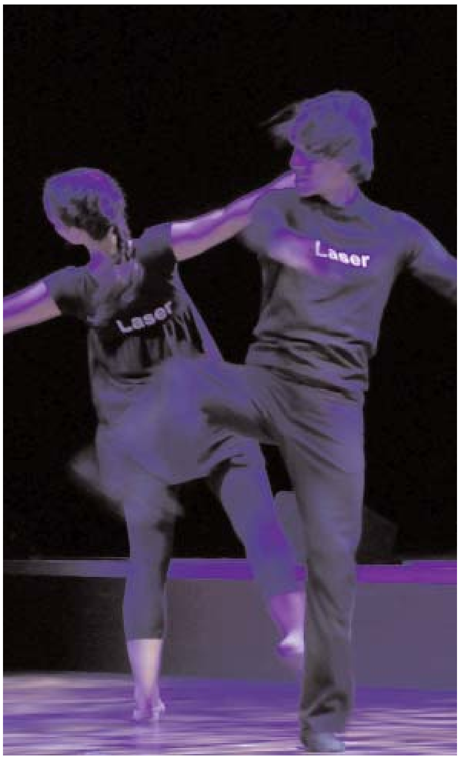
The signing of the Memorandum of Understanding between the TU Wroclaw and the Fraunhofer IWS Dresden

Strategic research collaboration established with the TU Wroclaw

On December 18th Prof. Edward Chlebus, director of the institute of production engineering and management at the Technical University in Wroclaw, and Prof. Eckhard Beyer, executive director of the Fraunhofer IWS, signed an agreement for the institutes to cooperate in the areas of laser- and nanotechnologies.

As a first step the institutes plan collaboration in the areas of research and development by exchanging scientists. In the mid-term the collaboration aims at establishing a research center with modern equipment.



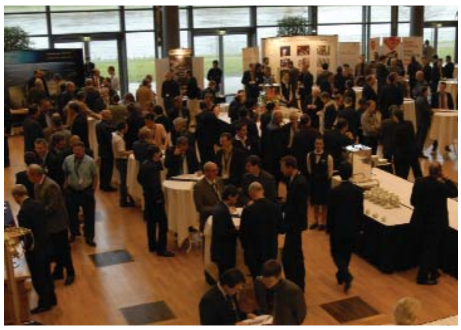
A spectacular dance show opened the 3rd international workshop on fiber lasers in the Congress Center Dresden

3rd international workshop "Fiber Laser"

For the third time the Fraunhofer IWS in Dresden organized the international workshop on fiber lasers. The event took place on November 14th and 15th 2007 in the Congress Center, Dresden. The participation of 350 visitors and exhibitors demonstrated the successful establishment of an attractive scientific event in the area of fiber lasers and their applications.

25 presentations addressed laser systems, components, technologies and current research topics. Over recent years research and development efforts made steady progress while simultaneously the number of fiber laser applications noticeably increased.

Of great interest were the technical exhibition and the demonstration of the latest laser technologies at the Fraunhofer IWS Dresden.



Technical exhibition at the 3rd international workshop on fiber lasers in the Congress Center Dresden

High power diode laser integration in lathes

The Bosch-Rexroth AG manufactures high precision hydraulic components to minimize distortions, it proved beneficial to use laser beam hardening. It is in particular efficient to use the laser beam hardening process directly in the CNC lathe. That way the preprocessing, hardening and finishing steps can be performed in a direct process sequence on one and the same machine. Engineers at the Fraunhofer IWS developed a solution to integrate a fiber coupled high power diode laser in up to four processing machines. An intelligent switch distributes the laser automatically to the processing machines. The switch automatically controls the timing to accommodate different cycle times for processing various parts on the different machines. The process ensures an optimal utilization of machine and laser time.

Integration of the laser beam hardening process in a lathe, example: hydraulic components for Bosch-Rexroth

Cutting of airbags using remote technology

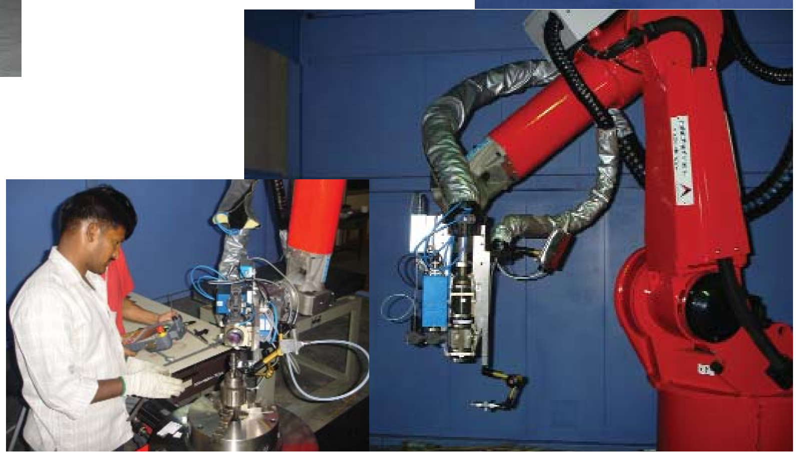
Together with the company Held Systems Deutschland GmbH, the Fraunhofer IWS Dresden developed a new generation of compact, flexible and highly productive airbag laser cutting machines. The advantages include the consistent quality of the inlay cut in the moving and up to 3 m wide materials and the higher throughput compared the conventional multilayer cut. Several systems were delivered to airbag manufacturers in China, Mexico, and Poland in 2007.

Laser system "Contilas 2500" for airbag fabrication

Combination system for laser beam hardening and buildup welding for an Indian research institute

In 2007, the ALOtec Dresden GmbH ordered a robot based laser system for hardening and buildup welding processes using a 6 kW diode laser from the Fraunhofer IWS. The system was ordered for ARCI research institute located in Hyderabad, India. Fraunhofer IWS engineers supported the technology transfer and introduced their Indian colleagues to developing processes using this technology. The laser system is equipped with components for temperature controlled laser hardening and with the extended CAD/CAM software module DCAM with robot simulation and offline programming option.

In addition, the institute provided powder nozzles and powder feeding technology for laser buildup welding. A total of 11 process adapted powder nozzles were delivered to customers in four countries in 2007 alone. Meanwhile a total of 60 powder nozzles have been shipped to research institutions and industrial manufacturing setups.

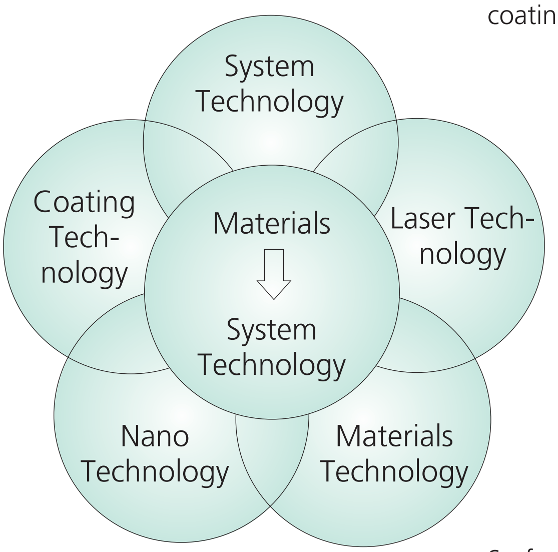


Robot based laser system for the Indian research institute ARCI

Our Mission: We solve our customer's problems and consider projects as successful if our customers are earning money with the developed solution

Short portrait

The research and development work at the Fraunhofer Institute for Material and Beam Technology (IWS) is based on our substantial expertise in materials- and nanotechnologies combined with the resources for comprehensive materials analysis and characterization. The specialty and competitive advantage of the Fraunhofer IWS lies in the combination of this fundamental expertise with its far reaching experiences and resources in the areas of coating and laser technologies.



Activity areas of the Fraunhofer IWS Dresden

Surface and coating technologies increasingly involve plasma processes. Therefore the institute developed a core competence area in plasma coating processes, which includes atmospheric pressure plasma sources and plasma CVD reactors.

In the area of laser technologies, the IWS focuses on laser materials processing and the development of laser specific system solutions.

To fulfill our mission to develop new technologies for industrial customers and to support them during the technology transfer, we developed a core competence in the area of system technologies.

Laser and surface technologies are production technologies. A central element of production technologies is materials. Materials are constantly developed and improved. Materials science plays an important role in macro processing. Similarly, nanotechnology is of fundamental importance to thin film coating technologies. In both areas the institute created new and extended upon existing core competences. Due to the close cooperation with equipment and system manufacturers, the IWS is in the position to offer "one stop solutions" to our customers. In general these solutions rely on novel concepts, which are based on an overall systems and process approach that also considers materials and workpiece behavior. The steady expansion of IWS equipment resources guarantees an effective and high-level project performance utilizing the latest technologies available.

Business fields

The IWS business fields are joining, cutting, and surface technologies. In particular are the following areas:

- joining,
- removal and cutting,
- surface technologies consisting of
  - surface layer technologies,
  - thermal coating technologies,
  - PVD vacuum coating technologies,
  - CVD atmospheric pressure coating technologies.

The business field "Surface Technologies" primarily addresses wear and corrosion protection, optical and decorative coatings, other functional coatings as well as the removal, structuring and repair of surfaces.

Our core competences:

Laser materials processing

- high speed cutting of thick metal sheets
- cutting and welding of plastics and other non-metals
- development of welding processes for hard-to-weld materials
- laser hybrid technologies such as
  - laser induction welding
  - laser induction remelting
  - plasma TIG or MIG assisted laser welding
- laser and plasma powder buildup welding
- laser surface layer hardening, alloying, and remelting as well as short-term heat treatment
- removal and cleaning
- process monitoring and control

Plasma coating processes

- plasma, flame, and HVOF spraying
- atmospheric pressure plasma assisted CVD (microwave and arc jet plasmas)
- plasma etching
- development and adaptation of plasma sources
- vacuum arc processes
- precision coating processes (magnetron and ion beam sputtering)
- laser arc processes as hybrid technology

Materials science, nanotechnology

- properties analysis of surface treated, coated and welded materials and parts
- failure and damage analysis
- optical spectroscopic characterization of surfaces and coatings down to the nanometer
- mechanical tribological characterization
- thermoshock testing of high temperature materials
- coating thickness and E-modulus measurements of nm to µm coatings

Systems technology

- utilization of the process know-how to develop, design and build components, equipment and systems that can be integrated in manufacturing lines including software components
- laser system solutions for cutting, welding, coating and surface refinement
- development of process monitoring and control systems
- process focused prototype development of coating systems or their core modules
- components for PVD and CVD systems
- atmospheric pressure plasma assisted CVD sources
- measurement systems for the characterization of coatings and the non-destructive part testing using laser acoustic and spectroscopic methods
- systems for the spectroscopic monitoring of gas mixtures
- software and control techniques

Process simulation

The IWS develops complete modules to simulate:

- thermal hardening and laser hardening,
- laser welding,
- laser powder buildup welding,
- vacuum arc coating,
- gas and plasma flow dynamics in CVD reactors,
- optical properties of nano layer systems.

The simulation results are used for process optimization. We also use additional commercially available simulation modules.

Business fields / Core services	Laser materials processing	Plasma coating processes	Materials / Nanotechnology	System technology	Process simulation
Removal / Cutting	□		▫	■	▫
Joining	■		■	■	□
Surface treatment	□	▫	□	■	□
Thermal coating	□	■	□	□	□
PVD - Vacuum coating technology		■	■	□	▫
CVD - Atmospheric coating technology		□	□	▫	□

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Equipment

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 beam sources

several CO_2 lasers, up to 8 kW

TEA and sealed-off CO_2 laser

several Nd:YAG lasers up to 4.4 kW cw (diode pumped) and 1 kW pm

Nd:YAG laser (1064, 532, 355 nm) with pulse lengths in the ns range

Nd:YAG laser with OPO (400-700 nm)

mobile Nd:YAG laser for surface structuring

transportable Nd:YAG laser (250 mJ, 8 ns, max. 20 Hz) with an articulated arm, beam transmission, and zoom optics for outdoor cleaning work

several high power diode lasers 1 - 6 kW

several fiber lasers, up to 8 kW cw

fiber laser (16 mJ pm, 20 W cw)

excimer laser (193 nm and 248 nm)

Handling systems

3D double gantry system, 22 axes with 3D processing heads, speeds of up to 40 m min^{-1}, working space 10 x 3 x 1.5 m^3

several CNC laser processing systems with up to 8 axes, speeds of up to 20 m min^{-1}, working space 4 x 3 x 1.5 m^3

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

2D and 3D milling machines with retrofitted laser and plasma powder buildup welding

laser system for the simultaneous processing with two cooperating robots, swivel unit and two fiber coupled 6 kW diode lasers

2D cutting system with linear direct drive (max. 300 m min^{-1} feed rate)

3D cutting system with two processing optics (synchronous and tandem processing)

2D and 3D cutting head systems for CO_2, Nd:YAG and fiber lasers

two laser processing stations with industrial robots

several precision systems with up to 8 CNC axes in combination with several laser beam sources

micro structuring systems with excimer lasers (193 nm and 248 nm)

Coating systems

vacuum arc coating systems (laser arc, pulsed high current arc, direct current arc, magnetic filter)

deposition systems for ultra precision multilayers based on ion beam sputtering and magnetron sputtering

combination coating system, electron beam (40 kW) and high current arc

laser PVD coating system (Nd:YAG, excimer, TEA-CO_2-laser) in high vacuum and ultra high vacuum

systems for vacuum and atmospheric pressure plasma spraying (VPS, APS, LAAPS) and for high velocity flame spraying (HVOF) with robot handling

systems for the plasma assisted CVD at atmospheric pressure

system for plasma etching at atmospheric pressure

test stand for atmospheric pressure plasma sources (linear dc arc discharge)

Special components

static and flexible dynamic beam shaping systems for laser powers of up to 10 kW

remote processing optics for CO_2, Nd:YAG and fiber lasers with working areas of up to 1 x 1 m^2

CNC or sensor controlled wire feeder for laser welding and coating

mobile MF and HF induction sources (4 - 20 kHz, 100 - 400 kHz)

modular powder nozzle system COAXn for laser beam buildup welding

process monitoring systems for thermal spraying, laser beam buildup welding, laser welding and cutting

software package DCAM for the offline programming of robots and CNC systems

sensor systems for the 3D geometry scanning (automatic teach in) for laser processing of parts (online and offline contour tracing)

beam diagnosis systems for CO_2, Nd:YAG and fiber lasers

LOMPOC-Pro + EMAqs-camera

measurement system for high speed process analysis (4 channel high speed image intensifying camera)

UV / VIS-, FTIR and NIR diode laser process spectrometer for the in-situ analysis of process gases and plasmas

Measurement devices

equipment for the analysis of material microstructures including preparation techniques:
- metallography
- transmission electron microscopy
- scanning electron microscopy

equipment for materials testing:
- servo hydraulic testing machine
- mechanical strain / compression testing machine
- computer assisted micro hardness tester
- resonance fatigue tester
- flat bending torsion system
- several wear testers (abrasive, cavitational, oscillating in sliding contact)
- salt spray fog test

laser acoustic tester for the determination of the E-modulus of coatings

laser shock measurement system with high speed pyrometer

equipment for analyzing surfaces and coatings:
- scanning atomic force microscope (AFM)
- EUV reflectometer
- fully automated spectral ellipsometer (270 - 1700 nm)
- UV-VIS spectrometer
- raman micro spectrometer
- FTIR-NIR spectrometer
- FTIR spectrometer, FTIR microscope
- registering indenter
- scratch tester
- roughness measurement equipment
- tribometer
- intrinsic stress measurement equipment

X-ray diffractometer (CuKα, MoKα)

particle counter (CPC + SMPS) and nano spectral analyzer

optical 3D coordinate measurement system

Robot system with 6 kW laser for laser buildup welding

Laser scanning microscope LSM Pascal 5 for high precision characterization and analysis of surfaces in the micro and nano meter range

Laboratory for the fabrication of single wall carbon nanotubes

Organization and contacts

External Project Groups

CCL - USA
Prof. J. Asmussen
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Laser Applications
C. Bratt
Coating Technology
Dr. T. Schülke

DOC
Dr. A. Zwick
phone: 0231/ 84 43 512

Executive Director Prof. Dr. E. Beyer

Deputy Director Dr. A. Leson
Deputy Director Dr. A. Techel
Assistant Mrs. R. Weinberg
phone: +49 (0) 351 / 2583-420

Infrastructure

Administration, Technical Support, Marketing
Dr. A. Techel
ext.: 473

Surface Engineering and Coatings

PVD- and Nanotechnology
Dr. A. Leson
ext.: 317

- **X-Ray and EUV Optics** – Dr. S. Braun, ext.: 432
- **Carbon Coatings** – Dr. V. Weihnacht, ext.: 247
- **Carbon Nanotubes and Particles** – Dr. O. Jost, ext.: 477
- **PVD Coatings** – Dr. O. Zimmer, ext.: 257

CVD Thin Film Technology
Dr. V. Hopfe
ext.: 402

- **Atmospheric and in-line CVD** – Dr. I. Dani, ext.: 405
- **Process Monitoring** – Dr. W. Grählert, ext.: 406

Thermal Coating
Dr. G. Stehr
ext.: 003

- **Thermal Spraying** – Dr. L. Berger, ext.: 330
- **Cladding** – Dr. S. Nowotny, ext.: 241

Laser Materials Processing

Joining and Surface Treatment
Prof. Dr. B. Brenner
ext.: 207

- **Welding** – Dr. J. Standfuß, ext.: 212
- **Bonding** – Dr. I. Jansen, phone: +49 (0)351/ 46 33 5210
- **Surface Treatment** – Dr. S. Bonß, ext.: 201
- **Materials Characterization** – Dr. B. Winderlich, ext.: 224

Ablation and Cutting
Dr. L. Morgenthal
ext.: 322

- **Laser Cutting** – Dr. T. Himmer, ext.: 238
- **Micro-processing** – Dr. U. Klotzbach, ext.: 252

Network Nano
Dr. O. Zimmer, ext.: 257
Dr. A. Leson, ext.: 317

Innovation Cluster 'nano for production'
Dr. A. Leson, ext.: 317

Fiber Laser and Scanner Technology
Dr. L. Morgenthal, ext.: 322

Network Laser LiFt
Dr. S. Bonß, ext.: 201
C. Zellbeck, ext.: 332

Chair for Laser and Surface Technology

Lehrstuhl Laser- und Oberflächentechnik LOT

Prof. Dr. E. Beyer
Deputy Prof. Dr. U. Günther
Assistant Mrs. J. Petermann
phone: +49 (0) 351 / 46 33 1993

Guest companies located at Fraunhofer IWS:

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

Connection to the University of Technology (TU Dresden)

Chair for Laser and Surface Technology

During 2007, 34 colleagues were employed in the university department. The third party revenues yielded more than 1.0 million euros.

The department of laser and surface technology is the driving component of the institute for surface and manufacturing technology 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
- ablation technology

The following courses were offered:
- Prof. Beyer: Manufacturing technology II
- Prof. Beyer: Laser basics / laser system technology
- Prof. Beyer: Plasmas in manufacturing technology
- Prof. Beyer: Rapid prototyping
- Prof. Beyer: Laser robotic, lasertronic
- Dr. Leson: Nanotechnology
- Prof. Schultrich: Thin film technology
- Prof Günther: Micro and finish processing

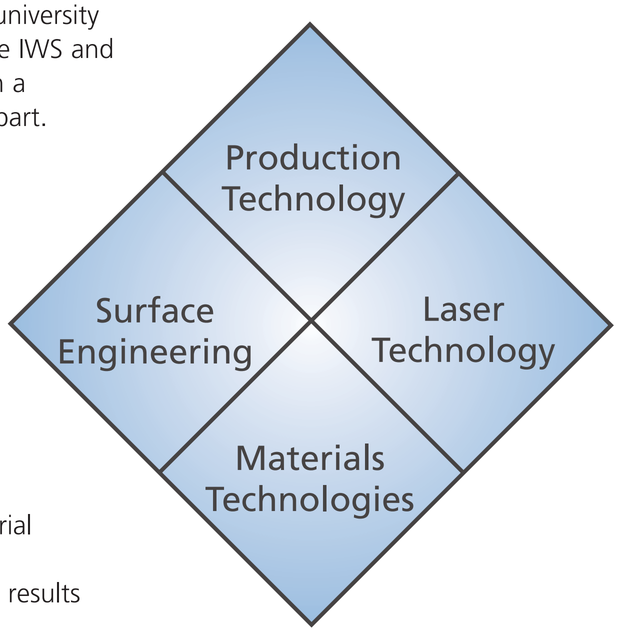
Lehrstuhl
Laser- und Oberflächentechnik LOT

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

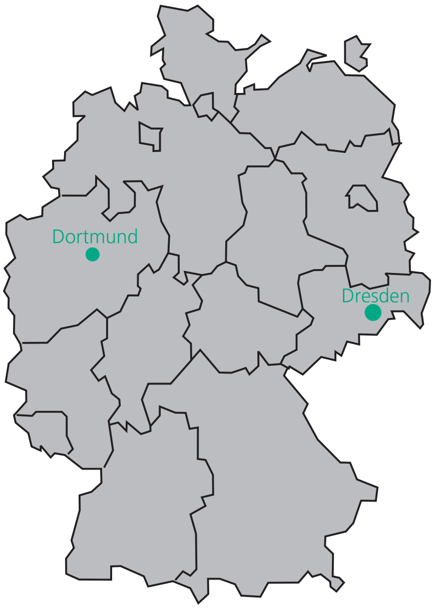


CD for laser technology course

CD for plasmas in manufacturing technology course

Industrial project group at the Dortmunder OberflächenCentrum (**DOC**) at the ThyssenKrupp Stahl AG

Dr. Axel Zwick
Manager of the project group
at DOC in Dortmund
phone: +49 (0) 231-844-3512



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

The DOC is the largest research and development center in the area of surface treatments for sheet steel in Europe. 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). At only half the layer thickness, these new coatings combine the very good corrosion protective properties of proven zinc coatings with a substantially improved laser weldability.

In addition hybrid and combination processes have been developed. Of special note are the hybrid welding of high strength steel components and the combination processes of cleaning and welding and welding and post galvanizing.

Beyond this the Fraunhofer project group offers in its 1,100 m^2 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. Coating systems are being developed with additional corrosion protection.

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 novel compact 8 kW solid-state laser with high beam quality, it becomes possible to perform process development as well as "trouble shooting" directly on site at the industrial customer production facility.

Facility of the Dortmunder OberflächenCentrum

www.iws.fraunhofer.de/doc

Fraunhofer Center for Coatings and Laser Applications (**CCL**)

Prof. Jes Asmussen
Center Director
CCL / USA
phone: +1-517-355 4620

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 led by Craig Bratt.

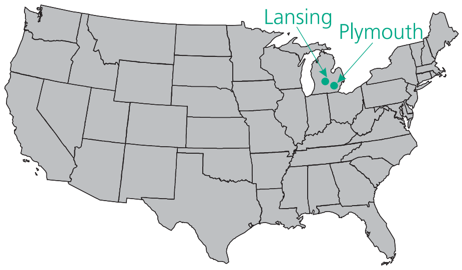
Coating Technology Division

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).

Laser Applications Division

The location's proximity to the city of Detroit led to a close cooperation with the American automotive industry. The group performed numerous laser-welding projects, especially to join powertrain components such as differentials, transmissions, and drive shafts. A technology to laser-MIG weld high-tensile car body steels was developed. Additional highlights were:

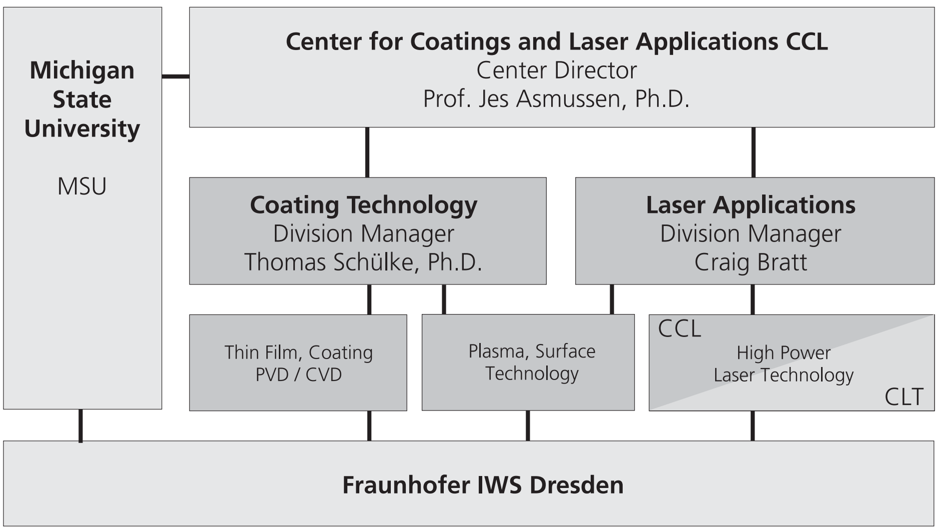
- development of a wear resistant coating for drilling equipment, deposited by laser deposition welding,
- laser welding of titanium structures or aerospace applications.



www.ccl.fraunhofer.org

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

Building of CCL in East Lansing, Michigan



Nanotechnology competence center

Project coordination

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www.iws.fraunhofer.de

Prince Alexander von Sachsen during the Nanotech Tokyo 2007

Nanotechnology competence center "Ultrathin Functional Films"

Nanotechnology belongs to the key technologies of the 21st century. Already today there are products ready for the market. Examples include computer hard disk drives and read / write heads for data storage, which are coated with layers only a few nanometer thick. Another example is the scanning electron microscope that makes the world of atoms and molecules visible. Ultrathin films are a key element of nanotechnology.

Since September of 1998, 51 companies, 10 university institutes, 22 research institutions and 5 associations, who bundled their know-how and formed a resources network, jointly pursue the persistent development of industrial application opportunities. The Fraunhofer IWS coordinates this effort, which is recognized by the German Federal Ministry for Education and Research as a national competence center for ultrathin functional films.

In February 2007, a group of nine competence centers with a focus in nanotechnology joined forces by forming the "Working group of nanotechnology competence centers in Germany (AGeNT-D)". The participating centers are located across Germany and jointly cover the entire area of different nanotechnologies.

Stefan Gallon was sent by the German embassy in Japan as an emissary for the economy. The photo shows him (center) in conversation with Karin Heidenreich and Dr. Andreas Leson during the Nanotech Tokyo 2007

Participation of the nanotechnology competence center Dresden at the Nanotech fair 2007 in Tokyo

The world's largest nanotechnology fair was the "Nanotech Tokyo 2007", which was held from February 21st to 23rd 2007. The nanotechnology competence center supported the Economic Development Corporation of the Free State of Saxony during the representation of the state at the fair.

The 49,000 visitors during the three days marked a new participation record. For the second time the Federal Ministry for Education and Research supported a joint exhibition for German nanotechnology companies. In addition, several events took place such as the topical seminar "Highlights of the latest German nanotechnology in Saxony".

Nanotechnology forum in Tokyo, October 3rd 2007

In October 2007, Prof. Dr. Georg Milbradt, Minister President of the State of Saxony, led a delegation of representatives to Japan in order to advertise the advantages of Saxony as a high technology location for potential investments. The delegation visited many companies including the research center of NTT. A highlight was the nanotechnology forum, which was held on October 3rd in Tokyo. Minister President Milbradt opened the event. The innovation cluster "nano for production" of the Fraunhofer-Gesellschaft sets a clear emphasis on the State of Saxony and thus several lectures were presented at the forum.

Nanotechnology innovation cluster "nano for production"

Nanotechnology innovation cluster "nano for production"

All industrial segments, from the automotive to the medical industry, can benefit from nanotechnology. In Germany, entrepreneurs and researchers cooperate with the goal to accelerate the transfer of nanotechnology research results to products and applications. Dresden, home to many high tech companies, is also a very attractive site for nanotechnology related research and industry. On November 27th 2006 the Fraunhofer Institute for Material and Beam Technology established the innovation cluster "nano for production". The cluster combines a total of 20 nanotechnology focused industry partners and research institutions mostly from Saxony. The goal of the innovation cluster is to drive nanotechnology developments from basic research to the threshold of industrial implementation and thus to create the opportunity for successful commercialization. The collaboration works on developing and testing essential elements of nano production technologies and on making them accessible to a broader user base. The effort also addresses the high demand for information about nanotechnology and nano production.

At the core of the innovation cluster are particularly promising research and development topics, which are being developed as technology platforms. These three platforms are:

Platform nano particles
Potential applications for nano powders and nano tubes include, for example, transparent ceramics and artificial muscles.

Platform nano coatings
Nano coatings are of outstanding importance for optical applications (i.e. X-ray mirrors, heat insulating glass), for tribological coatings and for micro systems technologies.

Platform nano structures
Nanostructure surface can be used to increase the efficiency of solar cells or for data storage applications.

Fraunhofer innovations cluster: Symposium on September 4th, 2007, in Berlin

The support of cluster initiatives is a central part of the high tech strategy of Germany's federal government labeled "Pact for Research and Innovation". Supported by the federal Ministry for Education and Research and the state governments, the Fraunhofer-Gesellschaft assumed the responsibility to design and establish Fraunhofer innovation clusters. A meeting to comprehensively discuss the previous experiences with this model for the first time was held on September 4th 2007 at the Academy of Sciences in Berlin-Brandenburg. The model was considered to be an effective instrument to strengthen innovative resources as well as to increase the tempo of innovation.

The innovation cluster "nano for production" participated at the exhibition demonstrating atmospheric pressure plasma technologies for the continuous processing of crystalline solar cells.

Project coordination

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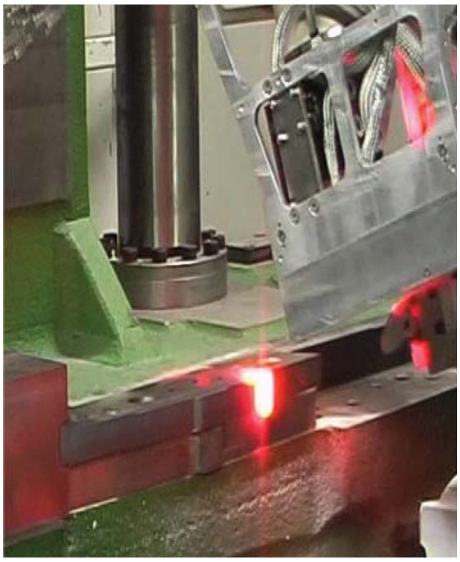
Prof. Bullinger, the president of the Fraunhofer-Gesellschaft, in conversation with Prof. Beyer and Dr. Leson

Laser integration in production technology
Initiative LiFt

Minister Wolfgang Tiefensee (left) presents the award for project LiFt, which was selected in the competition "Industry meets science", to Prof. Eckhard Beyer, executive director of the Fraunhofer IWS



Integration of a laser module in a milling machine for the hardening of large tools

The initiative

The Federal Ministry for Transport, Building and Urban Affairs (BMVBS) represents the federal government in technology transfer matters in the new states in Germany. The ministry explores new approaches to improve the transfer of scientific and technical innovations to industrial applications and solicited a competition "Industry meets science". The initiative **LiFt** was selected as one of the competition's winners out of 157 submitted applications.

Project goal

The goal of the **LiFt** initiative is to establish sustainable functional structures for the technology transfer from science to manufacturing in the area of laser materials processing. The initiative focuses on the collaboration of Saxony's laser process technology developers with machine and system builders as well as end users.

The systematic utilization of the resources in laser materials processing opens the following possibilities:

- cost reduction by reducing the process chains,
- increased efficiency of the manufacturing processes and products,
- equipping the products with a new unique selling characteristics at the highest level of technology.

Concept

In the end the possibilities of integrating laser technology into production technology is always defined by the technical and economic situation of a specific application. For example:

- There is a possibility of direct integration into a machine for mechanical processing if the cycle time of the laser treatment step is short compared to the mechanical processing. In some circumstances it is even possible to use one laser sequentially in several machines.
- Integration into the production flow in parallel to the cycle time if the cycle times of the laser processing step is comparable to the time needed for mechanical processing.

Both examples provide the opportunity for continuous inline processing and potentially can replace complex batch processes for example in furnaces or cleaning systems.

Implementation

Market analysis and feasibility studies are employed to collect information on various implementations of laser technologies. The data will then be analyzed to evaluate if the specific implementations are suitable for other application scenarios.

The spectrum of fabricated parts of a manufacturer is analyzed to assess whether these could benefit from laser integration. For example, laser integration may enable a more efficient production or a higher level of precision.

In parallel, it is evaluated jointly with the equipment manufacturer whether the integration of a laser into a machine is technically feasible and economically beneficial.

It is important to early identify and overcome potential barriers that could limit the commercialization of new technologies and to minimize the risks of introducing them.

Advantages through developing competences

- Industrial manufacturing process chains can benefit from laser integration if they consist of fabrication steps involving mechanical and thermal processing. In these situations the integration of laser material processing steps can reduce the manufacturing time and costs.

- For the machine and system manufacturers there is the opportunity to offer new products with the unique selling point of "integrated laser materials processing", which reflects the highest technological and efficiency level of their products.

- The participating research institutions have developed numerous laser materials processing technologies. These become accessible to the users and give new impulses to modernize manufacturing processes.

- The collaborative structure behind **LiFt** enables the sustainable, systematic and broad range technology transfer of laser material processing research to industry.

The project is funded by the Federal Ministry for Transport, Building and Urban Affairs (contract number 03WWSN019).

Project coordination

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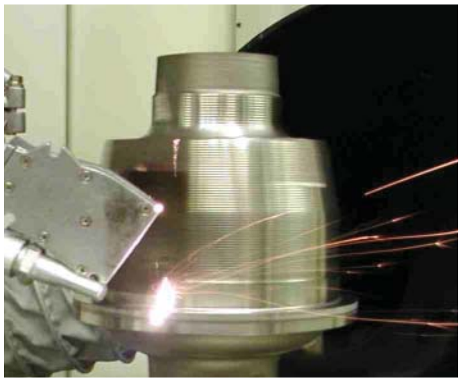
Laser system for the laser beam cleaning and welding in an industrial application



Industrial implementation of a laser beam cleaning step for the preparation of a subsequent welding process. The setup eliminates traditional cleaning steps.

Process chain reduction due to laser beam welding with additives and replacement of bolted connections, left: sample parts, right: laser welding process

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 2007 the employees are divided up as follows:

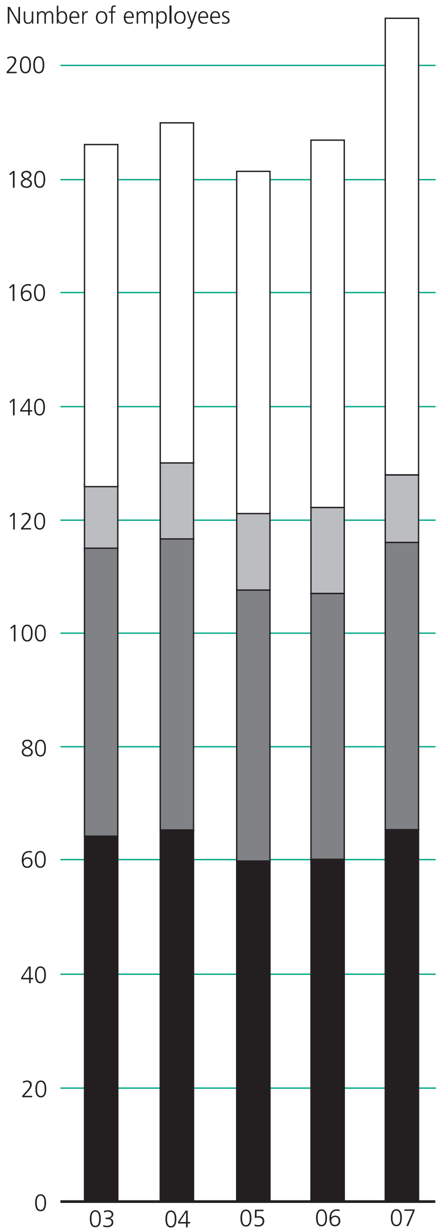
Employees of Fraunhofer IWS

	Number
Staff	**116**
- scientists	65
- technical staff	43
- administrative staff	8
Apprentices	**12**
Research assistants	**80**
Employees CCL USA	**12**
Total	**220**

Employees of Chair for Laser and Surface Technology of TU Dresden

	Number
Staff	**34**
- scientists	28
- technical staff	5
- administrative staff	1
Research assistants	**9**
Total	**43**

Building	**8400 m²**
- processing technology areas	2000 m²
- lab space, workshops	3070 m²
- office space	2630 m²
- conference rooms, seminar rooms etc.	700 m²
Technology area at the DOC (Dortmund)	**1100 m²**



Budget and revenue 2007 (preliminary*)

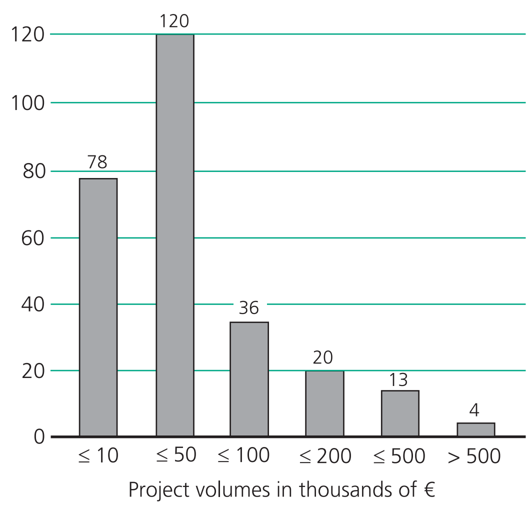
	million €	%
Operational costs and investments 2007	**17.7**	
Budget	**14.8**	
- personnel costs	7.1	
- other expenses	7.7	
Investment	**2.9**	

	million €	%
Revenue 2007	**17.7**	
Revenue operations	**14.8**	
- industrial revenues	7.7	52
- revenues of public funded projects	3.1	21
- base funding IWS	4.0	27
Revenue investment	**2.9**	
- industrial revenues	0.1	
- revenues of public funded projects	0.9	
- base funding IWS	1.3	
- strategic investment	0.6	

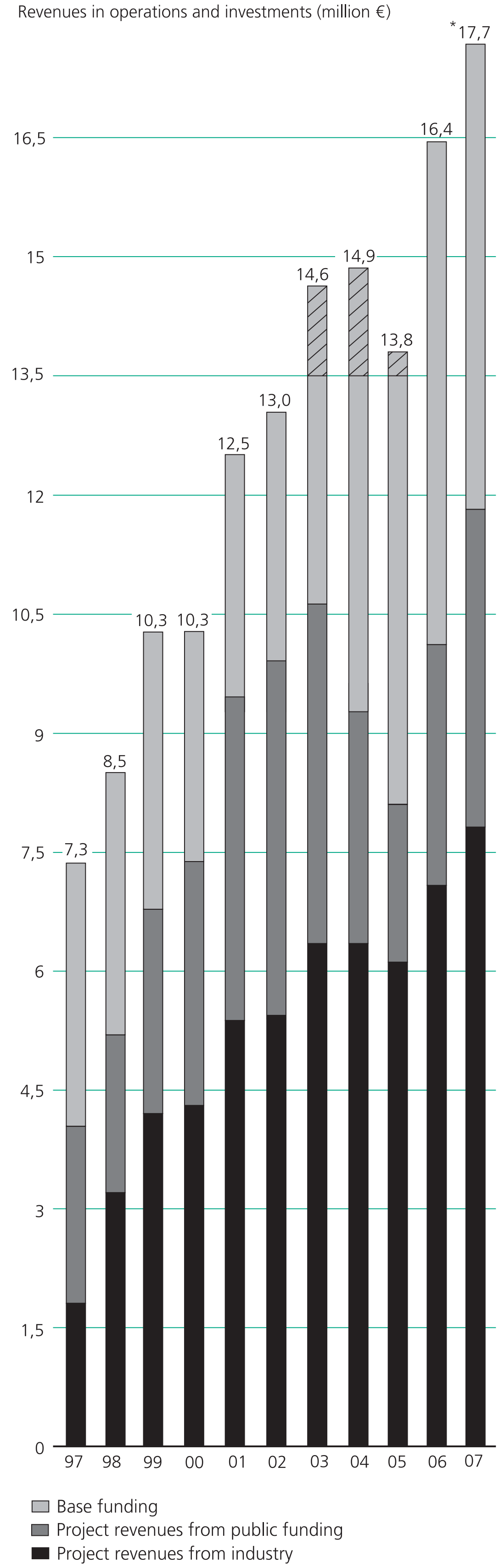
Projects

In 2007, IWS handled 271 projects. The distribution of the projects with respect to their volume is shown in the graphic below. One hundred twenty of the projects were for 10 to 50 T€ (thousands of euro), for example.

Number of projects



Revenues in operations and investments (million €)



Board of trustees

The advisory committee supports and offers consultation to the Fraunhofer IWS. Members of the advisory committee in 2007:

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

R. Bartl, Dr.
Manufacturing management of Siemens AG Transportation Systems

I. Bey, Dr.
Manager of the Research Center Karlsruhe (project performing institution) and the production and manufacturing technologies section at the Research Center Karlsruhe GmbH

S. Clobes, Ms.
Manager of the production systems and technologies department at the Federal Ministry for Education and Research (curator until April 2007)

D. Fischer, Mr.
General manager EMAG Leipzig Machine Factory GmbH

U. Jaroni, Dr.
Member of the board of directors - automotive division - ThyssenKrupp Steel AG

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

H. Kokenge, Prof.
President of the Dresden University of Technology
(curator since January 2007)

T. G. Krug, Dr.
Managing director Hauzer Techno Coating BV, Niederlande
(curator since January 2007)

P. G. Nothnagel, Mr.
Saxony Ministry of Economic Affairs and Labor

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

W. Pompe, Prof. Dr.
Dresden University of Technology

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

The 17th committee meeting took place on February 08, 2007, at Fraunhofer IWS in Dresden.

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. A. Techel	Deputy director Head of administration
Prof. Dr. B. Brenner	Department head
Dr. V. Hopfe	Department head
Dr. L. Morgenthal	Department head
Dr. G. C. Stehr	Department head

Guests are:

Prof. Dr. U. Günther	Agent of the chair / university
Dr. U. Klotzbach	Office manager VOP

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 2007 were:
- Prof. Dr. E. Beyer
- Dr. S. Bonß

The Fraunhofer-Gesellschaft

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration. The organization also accepts commissions 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.

Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: Through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. They do so by promoting innovation, accelerating technological progress, improving the acceptance of new technologies, and not least by disseminating their knowledge and helping to train the urgently needed future generation of scientists and engineers.

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. Students working at the Fraunhofer Institutes have excellent prospects of starting and developing a career in industry by virtue of the practical training and experience they have acquired.

At present, the Fraunhofer-Gesellschaft maintains more than 80 research units, including 56 Fraunhofer Institutes, at 40 different locations in Germany. The majority of the 13,000 staff are qualified scientists and engineers, who work with an annual research budget of 1.3 billion euros. Of this sum, more than 1 billion euros is generated through contract research. Two thirds of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Only one third is contributed by the German federal and Länder governments in the form of institutional funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

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 is a recognized non-profit organization which takes its name from Joseph von Fraunhofer (1787-1826), the illustrious Munich researcher, inventor and entrepreneur.

VOP

Fraunhofer Verbund Oberflächentechnik und Photonik

The institutes of the Fraunhofer-Gesellschaft have organized themselves into seven research alliances, each specializing in a specific area of technology, in order to promote collaboration in related disciplines and offer customers a unique source of coordinated joint services.

Participating Fraunhofer institutes

Applied Optics and Precision Engineering IOF
www.iof.fraunhofer.de

Electron Beam and Plasma Technology FEP
www.fep.fraunhofer.de

Laser Technology ILT
www.ilt.fraunhofer.de

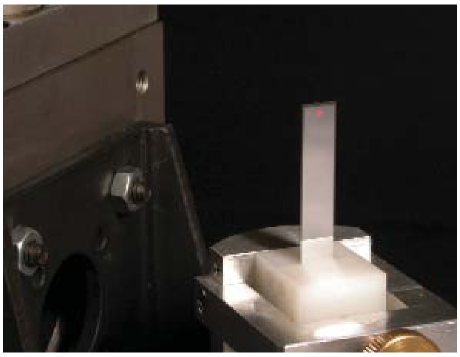
Physical Measurement Techniques IPM
www.ipm.fraunhofer.de

Surface Engineering and Thin Films IST
www.ist.fraunhofer.de

Material and Beam Technology IWS
www.iws.fraunhofer.de

Fraunhofer Surface Technology and Photonics Alliance

Surface technology and photonics are two of the core competences of the Fraunhofer-Gesellschaft. The former is of essential importance in the manufacture of optical and optoelectronic components and products. The latter, and laser technology in general, is becoming increasingly common in production processes and metrology in connection with surface engineering. They are both key technologies, being employed to a growing extent in a variety of applications, including production systems, optical sensors, information and communication technology, and biomedical engineering.

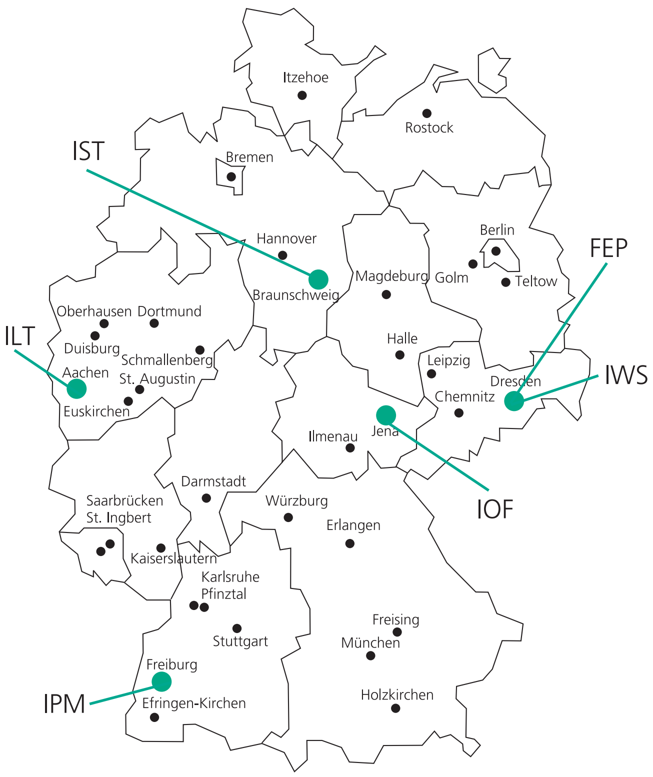


Core competences	FEP Dresden	ILT Aachen	IOF Jena	IPM Freiburg	IST Braunschweig	IWS Dresden
Coating and surface engineering	●	●	●	●	●	●
Beam sources	●	●	●	●		
Micro and nano technology		●	●	●	●	●
Materials treatment	●	●			●	●
Optical measurement techniques		●	●	●	●	●

top: Fraunhofer FEP
middle: Fraunhofer IPM
bottom: Fraunhofer ILT

In order to coordinate the targeted application of their expertise and define joint strategy plans, six Fraunhofer Institutes employing a total of around 1080 staff and working with a budget of €86 million have joined forces in the Fraunhofer Surface Technology and Photonics Alliance (VOP). The core competences of the alliance lie in the development of thin-film systems and coating processes for a wide variety of applications, surface functionalization, the development of laser sources and micro-optical and precision-engineered systems, materials processing and optical metrology.

In the immediate future, the alliance intends to focus its research activities on the advanced development of innovative laser sources such as fiber lasers and to nurture the industrial deployment of terahertz technologies.



Chairman of the alliance:

Prof. Dr. Eckhard Beyer

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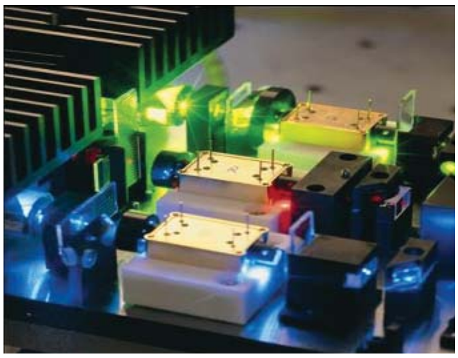
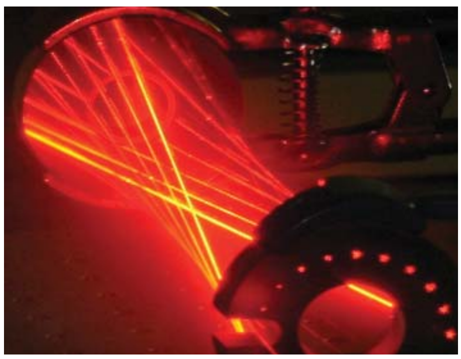
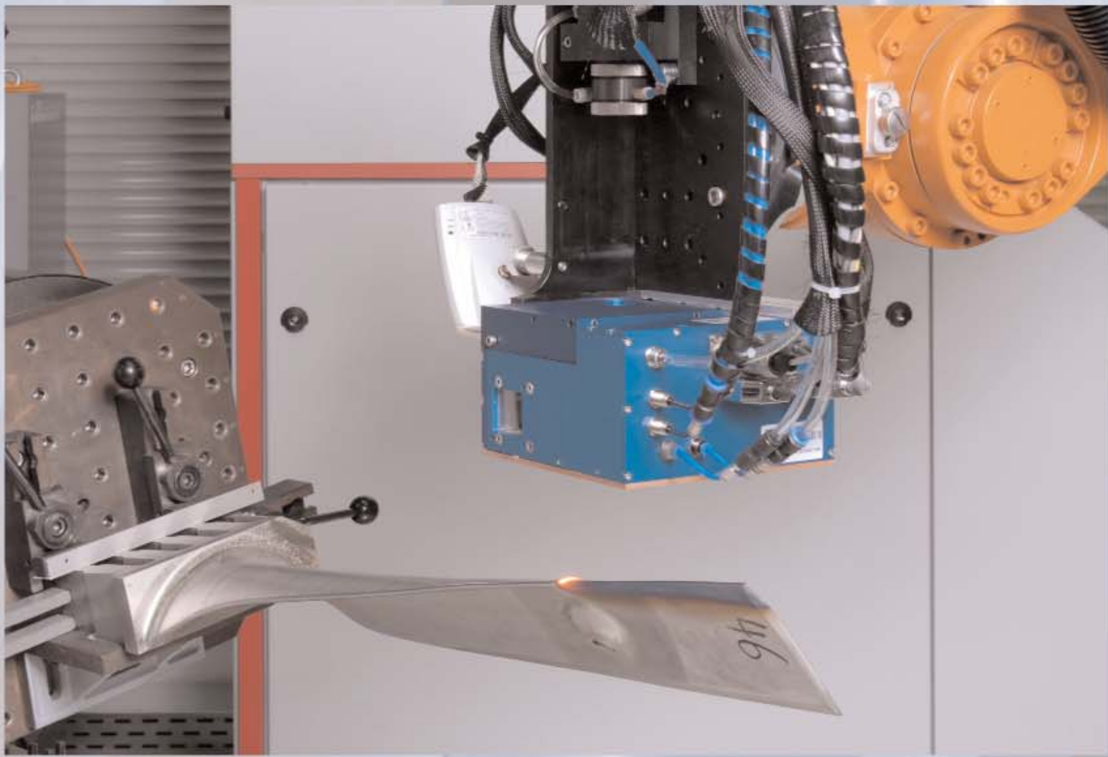




top: Fraunhofer IST
middle: Fraunhofer IOF
bottom: Fraunhofer IWS



Editor: Your department decided to tackle the challenge of welding hard-to-weld materials. Can you report any progress?

Prof. Brenner: We advanced our activities in this area in several directions. In the field of process engineering we developed several new technologies based on the high beam quality of fiber lasers. These new processes have substantial industrial application potential.

For example, one of the newly developed laser processes combines in one setting the initial removal of hard and soft surface contamination layers from areas that subsequently will be welded using the same laser and welding additives. The combination process enables a substantial cost saving since it avoids the need for additional hard turning process steps.

Another potentially interesting fiber laser welding process was developed to join cast iron and steel with no additive at previously impossible speeds. The further development of the weldability of mixed materials will be a focus in 2008 as well.

The third process is interesting for companies in the metal processing industry like the KMU. They would like to weld sheets thicker than 15 mm but cannot invest in lasers with powers of 10 or more kW. With a 4 kW fiber laser it is possible to make very narrow and up to 50 mm deep welding seams.

A completely new approach was used to develop a process to fabricate bimetal semi-finished products from conventionally impossible to weld materials. The process is based on inductively assisted laser roll cladding. As an example, we treated a bimetal strip made from curable tool steel and construction steel. Important process advantages could be demonstrated. As a result we are looking to extend the process to other material combinations such as steel / titanium, titanium / aluminum or similar.

The development of these sophisticated welding processes requires highly flexible and modern systems technology. An important milestone was therefore the installation and commissioning of a new laser beam welding system. This system was designed to accommodate a flexible and reproducible integration of additional modules such as a delivery system for welding additives, a heat treatment component, an integrated part cleaning unit and a plasma spectroscopy based quality control module.

Editor: Speaking of system technology - what is you strategy in this area?

Prof. Brenner: In the area of surface technologies we face the situation that there are no process related system technology components commercially available. Therefore we are increasingly developing our own process specific system components in house. Successful achievements in this area are the flexible beam-shaping unit with integrated temperature control, a novel laser light protection screen and new and very fast temperature measurement and regulation controllers. The latter are now being commercialized for a laser beam soldering process of solar cells. And of course, we build numerous unique testing setups for internal development.

The beginning of all science
is the amazement
that all things are how they are.
Aristoteles

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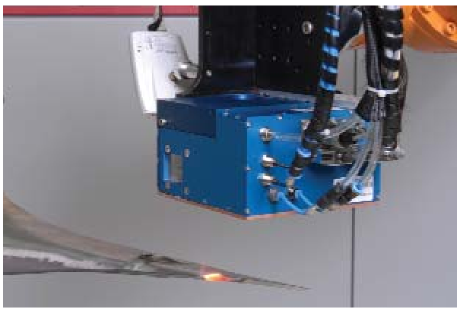
Optimized technologies for the hardening of steel components through laser and / or induction

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.



Laser beam hardening of a steam turbine blade using the dynamic beam shaping unit "LASSY"

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Team leader welding
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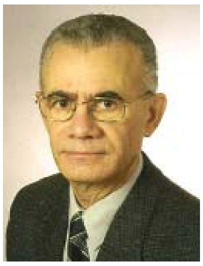
Welding of hard to weld materials

Laser welding is a modern welding process that is widely utilized in industry, especially in mass production. Such welding with a laser using an 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 an 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.

Completely laser welded integral structure for aircraft fuselages in closed profile design (demonstrator)



further information:
www.iws.fraunhofer.de/projekte/001/e_pro001.html
www.iws.fraunhofer.de/branchen/bra01/e_bra01.html

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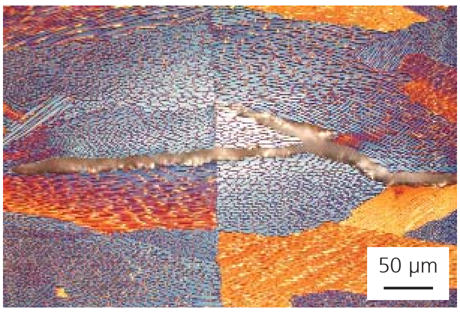
Complex materials and component characterization

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.



Micro structure of a welding seam in an austenitic steel after a hot crack test

Surface pretreatment and constructive adhesive bonding

An adhesive bonding process includes a step to treat the mating surfaces of the parts prior to applying the adhesive. The goal is to achieve good wetting of these surfaces with the adhesive and thus to generate a high strength bond. We are using primarily plasma and laser technologies in this area. The surfaces and the bonded compounds are then being characterized by contact angle, roughness and thickness measurements, optical microscopy, SEM / EDX and spectroscopic methods. A new direction is to integrate carbon nanotubes into the adhesives, which can increase the bonding strength and / or provide electrical conductivity to the compounds.
We offer the following services:

- pretreatment of mating surfaces and characterization of the surfaces,
- constructive adhesive bonding of various materials,
- measuring the bonding strength and aging behavior of adhesive bonds.

Adhesively bonded glass element

Example of projects 2007

Laser beam hardening - Manufacturing integration enables streamlined processes

Task

Laser beam hardening is a very efficient process to preferentially treat those localized surface areas on parts that are actually experiencing mechanical loading conditions, wear and other influences. The over the past years increasing availability of high power diode lasers and related system technology developments helped to establish laser beam hardening as a complementary technology to the classic hardening methods. The process is like many other heat treatment processes primarily applied in a separate step outside of the main production flow. However, in order to reduce time and costs, manufacturers prefer a continuous part flow without the need for additional logistics and storage. The laser beam hardening process is very suitable to be integrated into process chain. The task for the Fraunhofer IWS is to design an optimized process flow with integrated laser technology based on the analysis of the entire production process of a manufacturer.

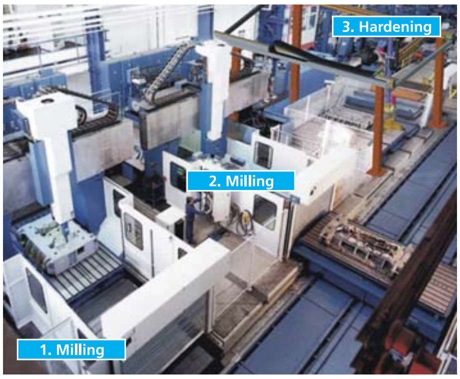


Fig. 1: Photomontage, the gantry system for hardening is integrated with a system of milling machines

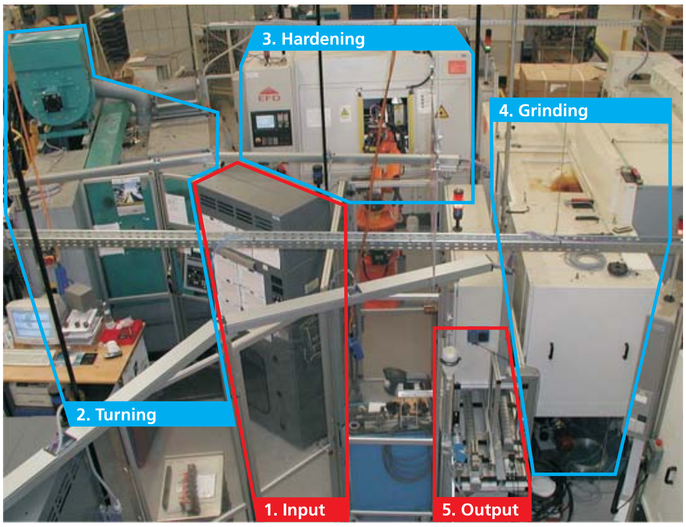


Fig. 2: Manufacturing cell for turbocharger shafts at Borg Warner Turbosystems GmbH in Kirchheimbolanden

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Solution

The particular manufacturing conditions determine how to integrate the laser beam hardening into the productions flow. The production of individual parts and small quantities frequently requires the highest flexibility. On the other hand, a high volume production scenario aims primarily at minimizing costs. Overall there are many different requirements and as such possible laser integration opportunities are equally myriad. A 6-axes gantry machine or a robot-based system with a working area to accommodate the entire manufactured part spectrum will be rather loosely integrated. A less flexible and high degree of integration can be found on machines that have been adapted for a single purpose treatment of specific parts or those that are directly integrated into a lathe or milling machine.

Examples

Gantry systems are, for example, recommended for the manufacturing of large tools. In such a setup the gantry system is integrated and connects via palette changers to several milling machines. Fig. 1 shows a photomontage of such an arrangement. The implementation of such a system is currently being planned for an auto manufacturer.

The integration into a manufacturing cell has been accomplished for Borg Warner Turbosystems GmbH in Kirchheimbolanden. In this application example the laser is used to partially harden the bearing areas of turbocharger shafts for utility vehicles (Fig. 2).

Generally it is possible to integrate a high power diode laser directly into a tool changer in a turning / milling center. The precision is very high as a result, because the different processes can be performed sequentially within one and the same setup of the parts.

Novel laser protection screen for lasers of highest brightness

Task

Novel high power lasers, fiber lasers and disk lasers with highest beam quality enable new application areas in materials processing. Simultaneously they require novel concepts for laser safety. Conventional passive protection screens are not suitable, in particular from an cost standpoint.

Active laser protection screens are a suitable solution. The sensors are integrated inside a cavity wall and respond in the event of laser irradiation to the subsequent pressure change or adventitious light. However, this principle always destroys the wall element. In addition it is difficult or impossible to accommodate the type of design changes that laser system manufacturers and operators frequently desire.

Solution

A novel concept of a laser protection screen is based on the principle of a large area thermistor. Such a wall element consists of an interlayer with thermistor properties that is electrically connected to two electrically conductive layers. The thermistor materials are, for example, metal oxides such as Al_2O_3. The basic material property that is used is the extreme dependence of the specific electrical resistance from the temperature (Fig. 1). If the laser beam hits the wall element it locally heats up. The heating causes the electrical resistance to change, which is relatively easy to detect and independent from the wavelength of the laser light (Fig. 2). Depending on the power density of the laser radiation, the laser is shut off before it destroys the wall element.

Results

The fabrication of such a wall element can be done in different ways. In addition to the adhesive bonding of two steel sheets we explored spraying and varnishing techniques. The application of thin layers allows the fabrication of lightweight wall elements as well as complex 3D shapes and freely formed surfaces. Panel sizes of 2 x 2 m^2 represent no problem due to the cost effective manufacturing process.

Depending on the panel size, it is possible to detect small as well as large area heating. It is also possible to detect mechanical damage that is not caused by laser light, for example. The technology enables to design cost effective enclosures and housings for laser systems with high demands on design as well as modular systems.

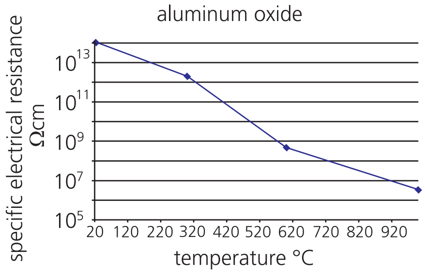

Fig. 1: Temperature dependence of the specific electrical resistance of aluminum oxide

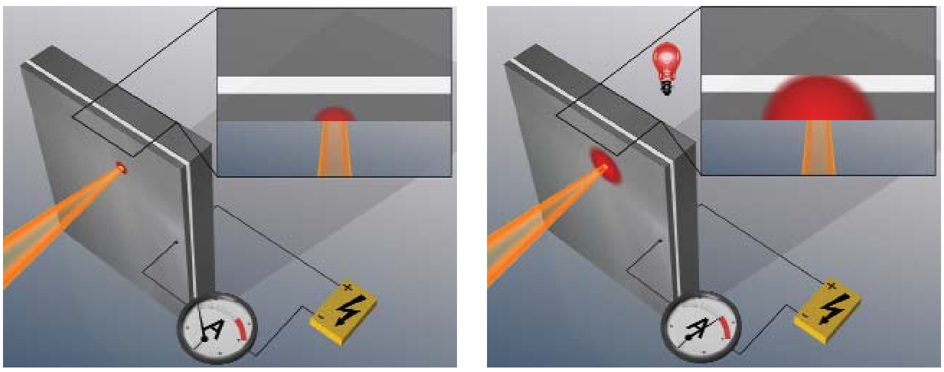

Fig. 2: Schematic representation of the novel laser protection wall, left: the laser beam hits the wall, right: the thermistor detects the laser radiation

Contact

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Crack free laser beam welding with removal of case hardened and nitrided layers

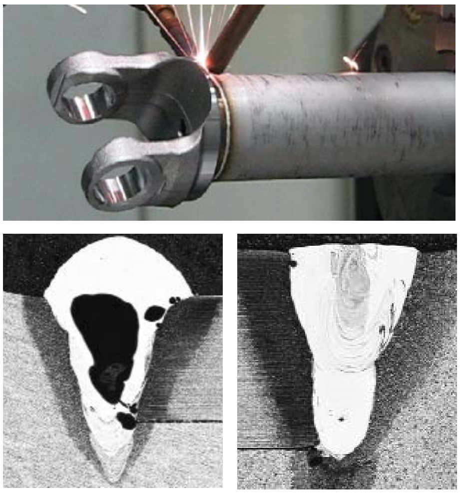

Fig. 1: Laser welded part with nitrided steering tube (top) and cross sections of welding seams
left: the nitrided layer was not removed,
right: the nitrided layer was removed by laser

Fig. 2: Carbo-nitrided part after combined removal and welding process

Contact

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Task

Today laser beam welding is the standard welding process for automotive powertrain components with rotational symmetry due to its low heat load and the high process speeds. When in use these powertrain components face high mechanical loads and wear. They are typically made from hard-to-weld materials such as low-alloyed case hardening or heat-treatable steels. To ensure the wear resistance of the component, these steels are case hardened, nitrided or otherwise surface treated.

These modified surfaces negatively influence the welding seam formation and thus substantially increase the processing time and production costs. In the past it was therefore necessary to either mask the mating welding areas to exclude them from the surface treatment or to later remove the treated surface volume prior to welding. The latter required extra process steps such as hard turning or grinding. In addition it was obligatory prior to the laser welding process to remove any remaining corrosion protective layer.

The goal is to markedly reduce part costs by saving processing steps.

Solution

Material adapted filler wires are used to alloy the welding seams of parts that were case hardened. In some circumstances the increase in hardness in the heat-affected zone (HAZ) of the materials can be substantial, which increases the risk of crack formation. Therefore it may be useful to combine the welding process with a heat treatment.

In the case of nitrided surfaces, problems during welding occur from outgassing nitrogen, which causes the formation of pores in the melt. Nitrided layers are therefore removed by pulsed laser ablation. Simultaneously this step is used to generate a specific contour of the welding areas, as this is required for the use of welding additives. The material adapted filler wires are designed to dissolve more nitrogen. Fig. 1 provides a comparison of welding seam qualities as they can be achieved with and without this process.

In addition to laser removal, carbonitrided or nitro-carburized surfaces require an integrated heat treatment. The risk of cracking has to be reduced due the hardness increase in the HAZ as a result of the high carbon content. Fig. 2 shows a very well formed welding seam surface and a high quality welding seam cross-section.

Results

- welding without mechanical pretreatment of the mating welding surfaces in one setup
- application of one and the same laser for removal as well as welding
- generation of crack free welding seams, improve weldability of critical material combinations
- cutting of process steps and thus reduction of time and costs

Laser beam welded patchwork structures - innovative solutions for automotive body making

Task

Metal parts in automotive manufacturing are required to constantly increase their mechanical strength and stiffness and simultaneously reduce their weight. This trend inevitably leads to new material and design concepts trying to adapt the utilization of materials to the realistic loading conditions.

The patchwork concept offers a novel approach to locally optimize parts. The principle is based on minimizing the metal sheet thickness wherever possible, while reinforcing the basic blank with additional smaller patch sheets to accommodate for higher local mechanical loads. As opposed to other known processes here, the joining occurs when the sheets are still flat. The forming process is applied after the sheets have been welded into a patch compound. The development goal is to optimize the manufacturing process as well as the load bearing capacity of the parts as a function of the shape of the patch sheet as well as the formability of the patch compound.

Solution

In collaboration with Fraunhofer IWU, basic investigations were performed to analyze the process steps design, laser beam welding and hydro forming. FE analysis and verifying experimentation was employed to identify patch geometries and patch edge formation to avoid catastrophic material failures during the forming process (Fig. 1).

The laser remote welding technology is an effective method to adapt the patch shape and seam contours to the expected loads. The high strength seam guarantees the safe transfer of the forming forces and a flawless part function. In the case of high strength sheet metals it is possible to significantly improve the ductility of the seam by using an integrated heat treatment process. This makes it possible to optimize the seam properties for forming processes.

Results

We analyzed the manufacturing process steps of design, laser beam welding and hydro forming and showed created necessary conditions to benefit from the advantages of the laser patchwork technology. These are in particular:

- saving of process steps (forming of individual sheets, joining of curved sheets),
- reduced requirements for blank tailoring and positioning,
- manufacturability of structures with high load bearing capacity at minimized weight.

Fig. 1: Formed model part with optimized patch and welding seam contour

Fig. 2: Demonstrator: engine hood with edge relaxed patch

Demonstrators were designed according to load specification, laser welded at high quality and successfully formed. As an example we manufactured a model engine hood with a patch to reinforce the lock area (Fig. 2).

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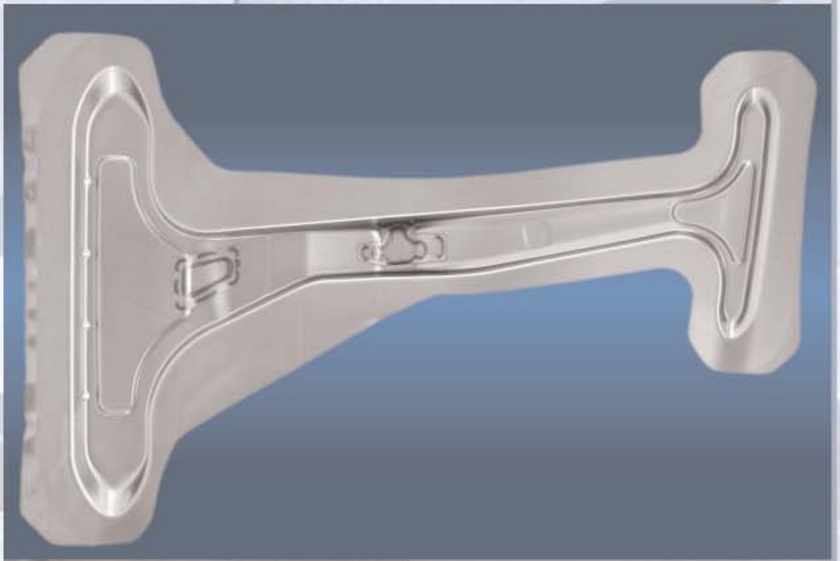
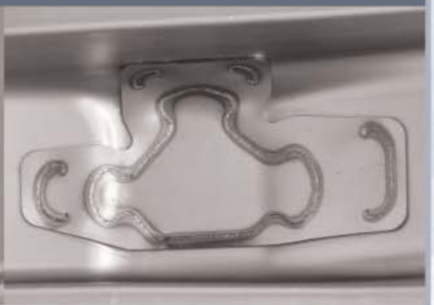
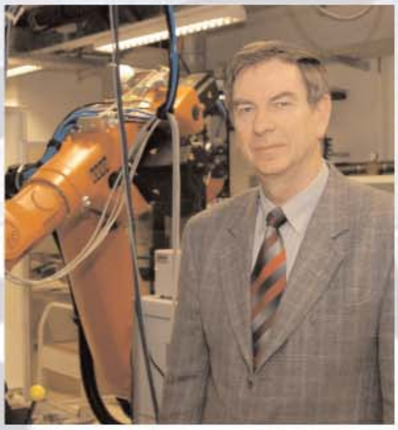




R&D-offer: Laser ablation and cutting, system engineering



Editor: What are the new results in the field of cutting with fiber lasers?

Dr. Morgenthal: Last year I commented that the fiber laser emerged as an interesting addition to the group of lasers, which are especially suitable for cutting. These lasers uniquely combine the highest beam quality and powers in the kilowatt range with the solid-state laser wavelength, which is well absorbed by metals. For the first time it was possible to perform laser beam cutting as an ablating process on metals without the need for additional gases. This opens the possibility to apply remote cutting technology with the goal to significantly reduce the cycle time for cutting blanks from thin metal sheets.

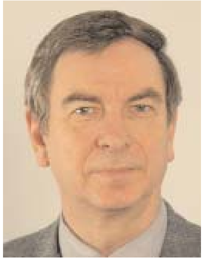
Editor: How about technology transfers in the field of laser beam cutting?

Dr. Morgenthal: The keyword "remote technology" is in terms of laser materials processing usually associated with laser beam welding. That's why we are especially happy that we, together with our partners, were able to transfer a remote technology based laser cutting solution to industry. This development elevated the precutting of airbag components to a new technology level. The disadvantages of the conventional multilayer cut are avoided while quality and productivity improved. I believe that the three systems that we installed in 2007 clearly demonstrate the success.

Editor: How important is the fiber laser for micro machining?

Dr. Morgenthal: In the field of laser micro machining we benefited from the interdisciplinary innovation thrust of the biotechnology field. We focused our research on bio and medical system technologies. In this field we combine our core expertise of laser micro technology in various ways with materials science, surface technologies and electronics. The combination of biological and technical components in a hybrid system yields new solutions such as lab-on-a-chip systems. An important resource for this work is IWS' pool of high quality equipment including micro machining lasers, which are increasingly replaced by fiber lasers.

He who does not aim for the stars
will not even make it
up to the church tower.
Patrick Swayze



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Examples of projects 2007

further information:
www.iws.fraunhofer.de/projekte/005/e_pro005.html
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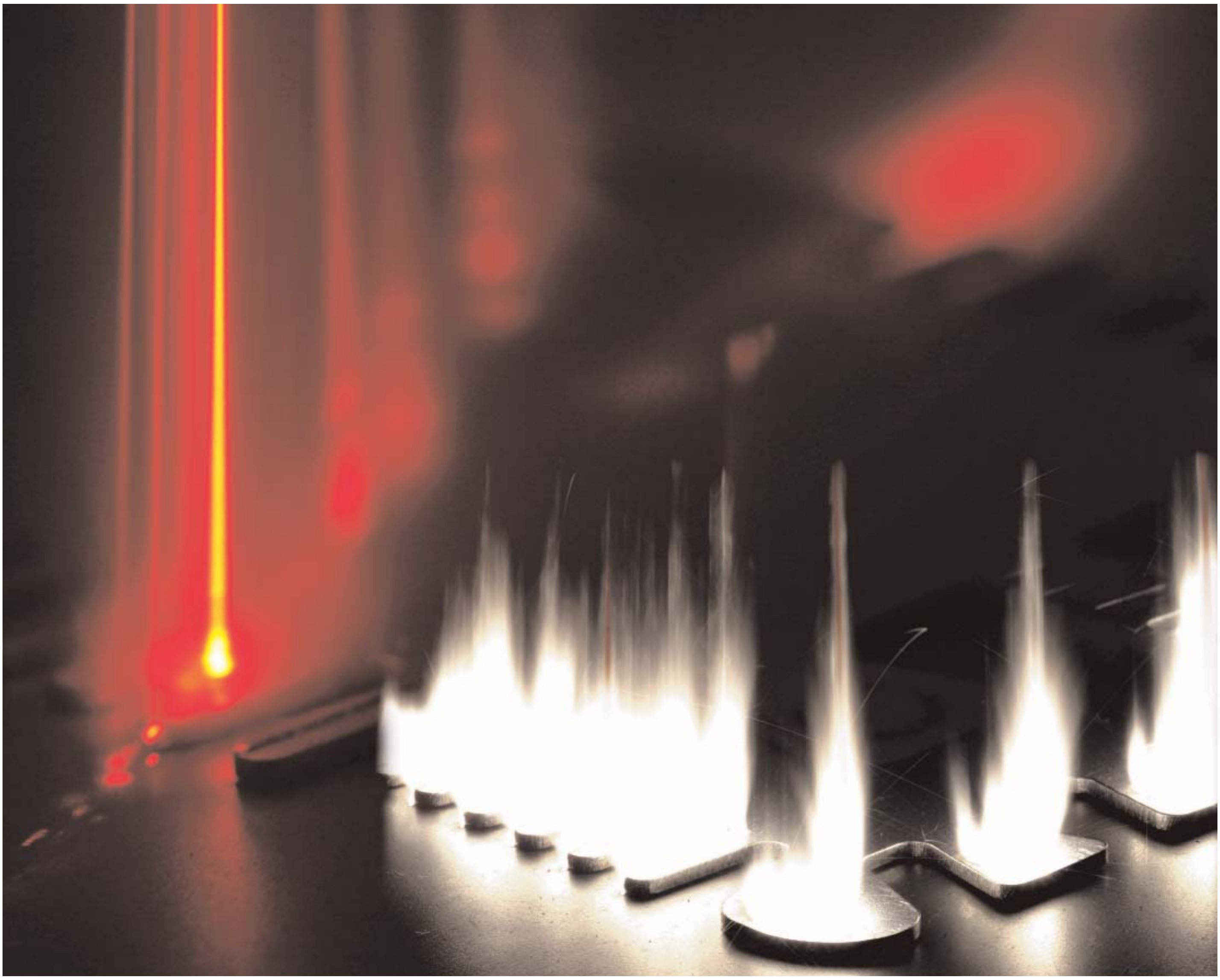
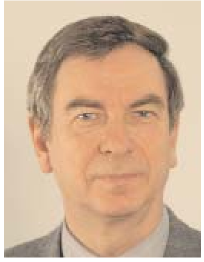
www.iws.fraunhofer.de/branchen/bra06/e_bra06.html





Dr. Thomas Himmer
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Cutting technology

The IWS is equipped with CO_2 and solid-state lasers, and especially fiber lasers, in a wide range of powers and beam qualities, which can be used for cutting of all materials that are used in modern manufacturing.

Research topics include the development of technologies to optimize process and cycle timing. We are using highly dynamic 2D and 3D cutting machines with direct linear drives as well as modern robots. Aside from using commercial processing optics we also apply internally developed scanner systems for remote processing.

We offer:
- technology and system development, testing, and optimization,
- comparison tests,
- feasibility studies with prototype manufacturing.

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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, fiber and Nd:YAG lasers,
- micro drilling with high aspect ratios and different bore geometries,
- cleaning with laser technology.

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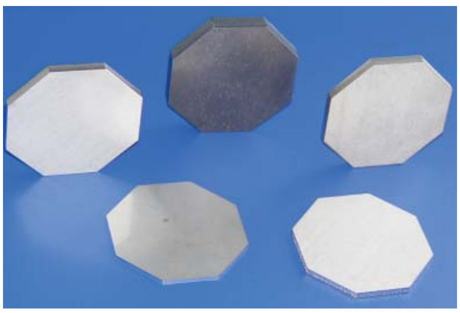
System engineering and laser processing

New or further developed and more powerful technologies in laser materials processing frequently require new system technologies or components in order to optimally use them. In cases where this system technology is not yet commercially available, we offer the development, testing, prototyping, and demonstration of these solutions. For example:
- processing optics with enhance functionality, such as high speed and / or precision beam scanning for remote processing,
- control technology and CAD / CAM tools for remote and on the fly processing,
- system technology and software for online process monitoring and control.



Laser beam cutting with fiber lasers

Mobile system for the anti-slip preparation of natural stones

Scanner optics for fiber laser HF-SAO1.06(2D)

Cutting with fiber lasers

Task

A task in laser materials processing is the cutting of thick-walled parts. The fiber laser is a relatively new beam source. There is not a lot of application experience. Therefore the Fraunhofer IWS recently increased efforts to investigate the cutting process with fiber lasers in greater detail. The goal is to develop economically attractive, high quality solutions for cutting tasks that can be offered to our customers.

Solution

The fiber laser parameters were experimentally investigated and optimized to cut stainless steel, construction steel and aluminum. Edge quality, surface quality and burr height were analyzed.

Additional research goals included the development of strategies to increase the cutting speed and cut quality. New nozzle geometries were developed and tested.

Results

Conventional laser cutting is performed with CO_2 lasers. Compared to these machines the fiber laser has a ten fold lower wavelength. Therefore it can be better focused, which leads to an improved absorption on metal surfaces. Subsequently the fiber laser offers the potential to significantly increase the cutting performance of metallic materials if compared to CO_2 lasers. At material thicknesses in the millimeter range it was possible to double the cutting speed while laser powers and cut quality remained equal. By optimizing the process parameters it is possible to achieve good quality of the cutting edges on almost all materials (Fig. 2 and 3). Our current research aims at the further reduction of the cutting edge roughness.

Fiber lasers offer an excellent cutting performance and quality. In addition they are three times more energy efficient than CO_2 lasers. Fiber lasers may soon take over the market for laser beam cutting of metallic materials.

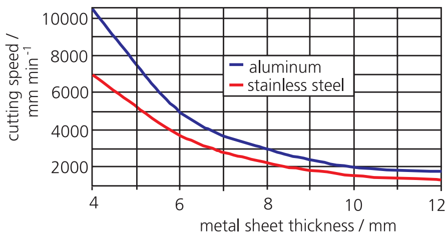


Fig. 1: Cutting speeds for cutting of different materials using a fiber laser (YLR4000)

CO_2 laser
P = 5 kW
v = 550 mm min^{-1}

Fiber laser
P = 4 kW
v = 450 mm min^{-1}

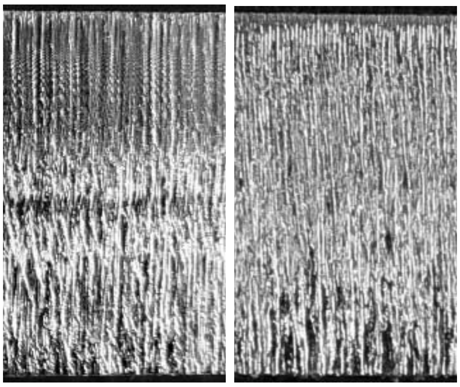


Fig. 2: Cutting edge quality of 15 mm thick stainless steel samples after cutting with CO_2 and fiber lasers

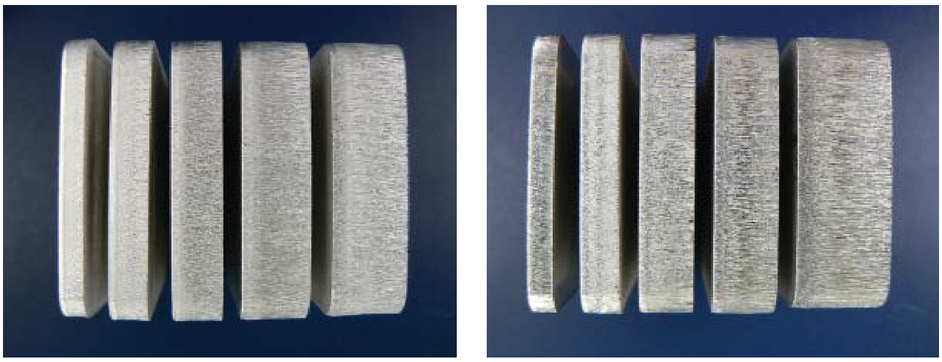


Fig. 3: Cutting edge quality of aluminum, (left: material thickness 4 - 12 mm) and stainless steel samples (right: material thickness 4 - 15 mm)

Contact

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Terahertz radiation reveals the secrets of art objects

Task

The structure, composition and damage of art objects should be carefully analyzed prior to restoration attempts. These evaluations usually require nondestructive techniques.

In the past it was common to treat wooden or textile art objects with pesticides such as Lindane or pentachlorophenol C_6Cl_5OH (PCP) to protect them from insects and funguses. Today it is known that these substances are highly toxic. Therefore a restoration should remove them if possible. However, the nondestructive verification of the presence of these substances is very difficult.

Solution

In cooperation with Fraunhofer IPM the IWS researchers investigated the application of the thus far seldom-used THz radiation to analyze the components of art objects. The measurement principle is based on THz time-domain spectroscopy (THz-TDS) and was developed to test for Lindane and PCP.

The same experimental equipment was applied to scan a painting sample along a measurement grid. At every data point the technique records the time dependence of the electrical field of the THz pulse. Then the THz spectrum of data is analyzed for characteristic fingerprints, which may reveal the identity of the radiated substances.

Results

Fig. 1 shows the THz spectrum of the fungicide PCP. The absorption lines are characteristic for this substance and are caused by vibrations of polar molecule groups. This way the substance can be uniquely identified.

To better visualize the THz-TDC scan data of the entire painting sample they are combined to a sequence of false color images as shown in Fig. 2. The false color representation of the individual images shows the electrical field distribution E(x, y, ω). These were calculated via Fourier transformation of the measured THz pulse time behavior. The sequence of the images does not represent the time development but the frequency dependence of the electrical field. This method allows for a very fast analysis of the distribution of substances across the image area. The THz image sequence visually combines the information about paint composition and thickness while the actual contents of the painting is only schematically visible.

The further analysis of the data requires more detailed information about the spectra of paint pigments. This is accomplished by reference measurements on known substances. Instead of using the transmitted radiation it is also possible to detect the reflected radiation. Individual paint layers of a painting can be analyzed by using runtime measurements of the THz pulses.

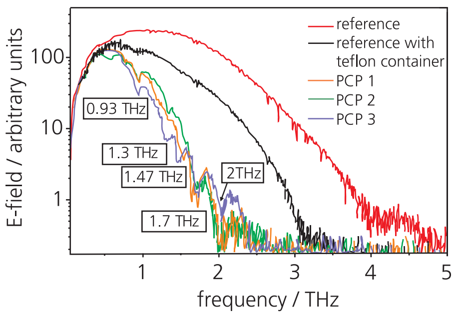

Fig. 1: THz spectrum of the fungicide PCP

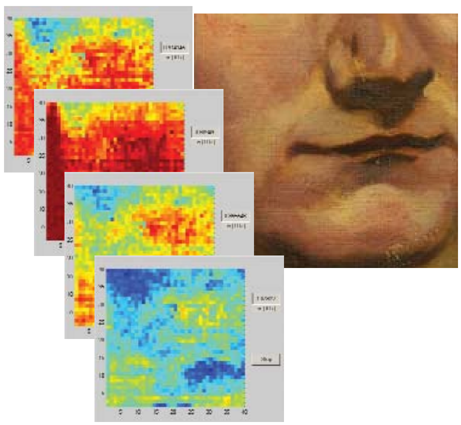

Fig. 2: THz-DS scan of a painting sample, left: individual images of a E(x,y,ω) sequence, right: photograph

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R&D-offer: Thermal coating

Editor: In the 2006 annual report interview you elaborated on the new strategic orientation of your department. Which components of this concept were you able to implement in 2007?

Dr. Stehr: The strategic direction of our department was laid out as follows:

1. tailored multifunctional property profiles of thermal coatings,
2. nano structure coating materials and systems,
3. novel system technology with complete system integration,
4. new application areas for thermal coatings.

We are very much delighted to report on progress in each one of those areas. There are initial but also some remarkable results. For example, we already developed multifunctional property profiles by using highly loadable friction optimized multilayer coatings. We also made important progress developing nano structured thermal spray coatings by using the process of suspension spraying.

To implement a direction independent laser buildup welding process, we turned around the coaxial principle, as you know it. The split laser beam is aimed at the centrically fed material. Using additive materials in the form of a wire allows for an almost 100 % utilization.

Editor: You are also working on improving the productivity of the laser buildup welding process using powder materials. What can you tell us about this?

Dr. Stehr: We developed the novel wide beam nozzle COAX11, which we exhibited live at the Euromold 2007 tradeshow. Customers from the tool and die making as well as automotive industries were able to see a laser buildup welding process producing a 17 mm wide and 75 mm long track in only 10 s. This deposition rate is approaching those of plasma powder buildup welding processes while simultaneously having the benefits of a much smaller heat affected zone and better controllability. There is even more possible with this technology and we are very intensively working on the further development of the system.

Editor: You mentioned the Euromold. There you received lots of attention for another development from your department …

Dr. Stehr: Yes, our completely integrated laser buildup process in a robot based handling system received lots of attention. We managed to integrate the simulation of the entire robot kinematics for laser buildup welding into our offline programming system DCAMx. The entire robot control process can be done on a PC. This includes all actual motions, accelerations, axis stops and especially the important collision checks. The coating system is available for processes while offline programming is performed.

Editor: What highlights can we expect in 2008?

Dr. Stehr: I cannot reveal too much at this point. However, I recommend that you visit us at the Lasys tradeshow from March 4th - 6th 2008 in Stuttgart. There we will exhibit our competence and new developments in integrating laser buildup welding processes into CNC based handling systems.

*Today's progress moves so rapidly.
Someone might just explain
how utterly impossible it is
to do a particular thing
while someone else
interrupts the first person to announce
that the very thing has just been done.*

Albert Einstein

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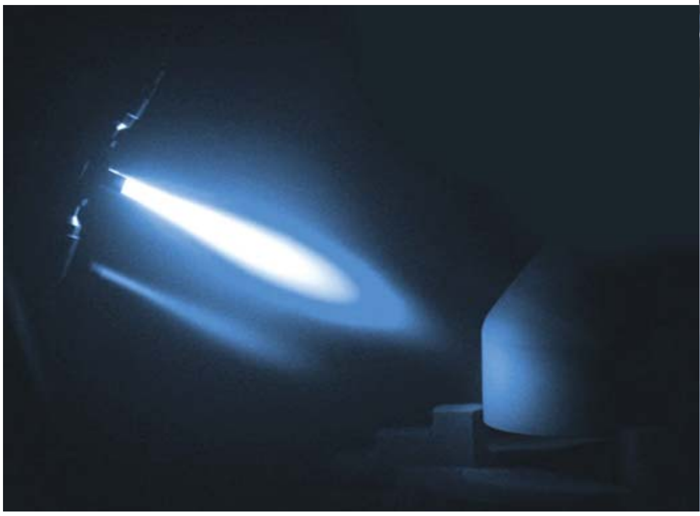
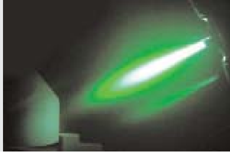
Examples of projects 2007

further information:
www.iws.fraunhofer.de/branchen/bra09/e_bra09.html
www.iws.fraunhofer.de/projekte/1-17/e_pro1-17.html





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Wear protection and functional coatings

The atmospheric (APS) as well as vacuum (VPS) plasma spray and flame spray processes 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.

Plasma spraying of a shaft

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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.

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

FLEXILAS: A new beam tool for the direction independent buildup welding with central wire feeding

Task

Laser beam buildup welding uses additive materials in form of solid and core-wires to accommodate the requirements of various applications. New methods of wire feeding are being developed to meet the requirements for accessibility, and material properties and precision. For the conventional powder material delivery we have established solutions in the form of coaxial laser processing heads. However, the introduction of lateral wire feeding faces the known restrictions of being dependent on the feeding direction.

Within the BMBF funded research program FLEXILAS we developed the fundamental principle of a new laser manufacturing process, which is designed for centrical wire feeding and therefore independent on the direction.

Solution

A special optics first splits the beam and then focuses its components into a circular focal spot on the surface of the substrate. The separated location of the split beams allows the placement of a wire nozzle so that the material can be delivered into the melt directly through the center of the laser beam. Therefore wire materials can now be fed for welding and soldering processes independent on the direction of the processing head.

Results

Two prototypes of processing heads are now available as a result of the development and the collaborations with industrial partners. Their compact design integrates the laser optical components, the feeder nozzles for the welding material, the inert gas supply and the cooling water.

These processing heads weld contours with constant track geometry. Uniform welding conditions can be achieved even in other than downhand positions. To fabricate the structure as shown in Fig. 2 we used SG2 welding wire with a diameter of 1.0 mm. With a laser power of 1 kW (Nd:YAG) and a spot diameter of 1.4 mm we achieved welding speeds of 1.7 m min^{-1}.

The stability of the welding process and the constant weld track cross section are remarkable considering the rough direction changes as well as the steep axes accelerations during the free contour motions that were necessary to weld this structure. An important process parameter is the dynamics of the wire feed. Here is potential for further development. Besides wires, it is also possible to process powders this way with improve material utilization.

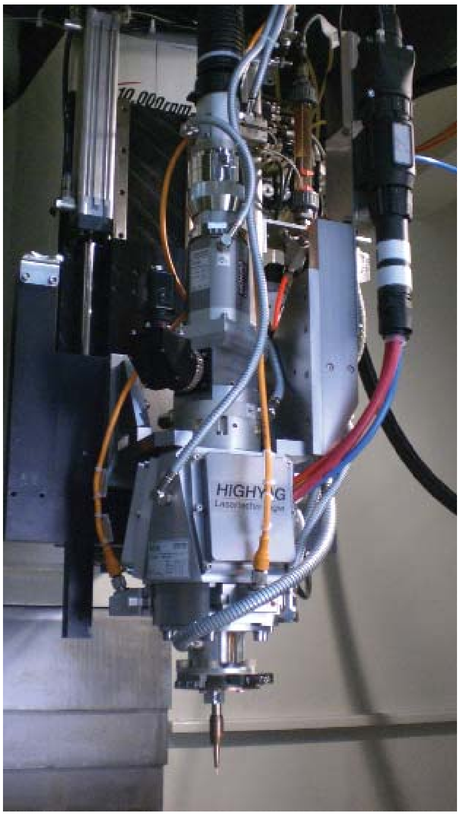

Fig. 1: Beam splitter optics: three beam system (HighYAG)

Fig. 2: Laser contour buildup weld with centrical wire feed (1.3 mm track width)

This research and development project was sponsored by the BMBF with the framework program "Research for tomorrow's manufacturing" (contract number 02PD2134)

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Nanostructured thermally sprayed coatings using suspension spraying

Task

We commonly use agglomerated powders or wires as materials to produce thermally sprayed coatings. The particle sizes of the granulated powders are typically in the range of 10 - 45 µm and they can be produced by various agglomeration methods. The application of sintering and melting processes during the agglomeration of the powders makes it difficult to elaborate nanostructured powders, which makes it even more difficult to produce nanostructured coatings from them. An alternative approach is to use suspensions of fine and nanostructured powders instead.

Funded by the Alexander-von-Humboldt Research Fellowship and a European research project we developed modified atmospheric plasma spraying (APS) and high velocity oxygen fuel spraying (HVOF) processes that utilize suspensions. Both processes are now established at the Fraunhofer IWS.

Solution

The thermal spraying of suspensions requires a modification of existing systems including the development of suitable suspension delivery systems. The preparation of stable suspensions proves an additional challenge.

A first series of experiments aimed at generating titanium oxide and aluminum oxide coatings from alcoholic and aqueous suspensions. Titanium oxide coatings have multifunctional characteristics and are of technical interest due to their photocatalytic, electrical and tribological properties. The photocatalytic properties come to the fore with respect to suspension spray coatings. In the case of aluminum oxide the electrical and wear properties are significant.

Results

Suitable suspensions were prepared for both materials and the existing spraying system was modified accordingly. A special suspension delivery and injection technology was developed (Fig. 2). By varying the deposition parameters coatings were fabricated with different microstructure. The alcoholic suspensions yielded porous coatings whereas the aqueous suspensions also produced high-density layers. Fig. 1 shows the example of a titanium oxide coating.

Of special interest is the fact that the phase composition of suspension sprayed coatings differs greatly from coatings that have been produced with conventional powders. In the case of titanium oxide the coatings consist of the photocatalytically more active phase anatase. It is even advantageous for photocatalytic applications if the coating is somewhat porous. In the case of aluminum oxide this new process effectively decreases the typical phase transformation from the α phase (corundum) to the γ phase of aluminum oxide. This implies the opportunity for the development of electrically insulating layers.

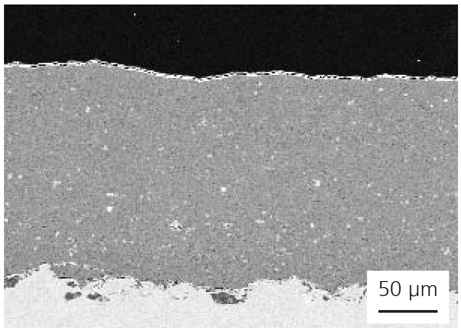

Fig. 1: Dense titanium oxide coating produced by high velocity oxygen fuel spraying (HVOF) from an aqueous suspension

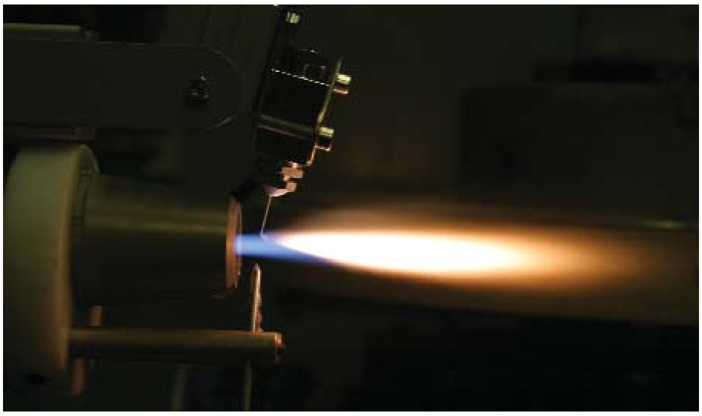

Fig. 2: HVOF flame jet with external injection of an alcoholic suspension

Contact

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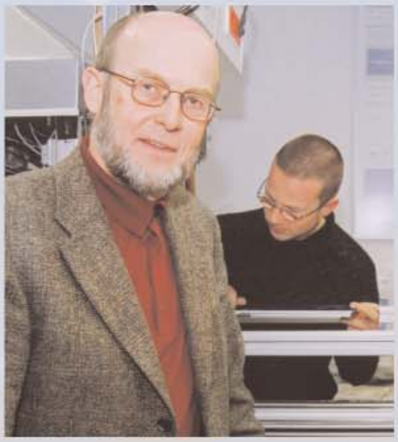
R&D-offer: CVD thin film technology



Editor: Publications from your department are increasingly addressing the area of photovoltaics. Is it even possible to keep pace in this highly dynamic field of technology development?

Dr. Hopfe: We see ourselves as newcomers in the area of solar energy generation using crystalline silicon. We bring the innovative technology approach of atmospheric pressure plasma technology to the table. In this area the IWS has a unique selling proposition and a technology development advantage of several years. The goal is to improve the costs and efficiency of solar cell manufacturing by using continuous atmospheric pressure plasma processes. Our plasma technology can coat, etch and texturize solar wafers at a very high throughput. Therefore the technology is relevant for future high volume production in this field.

It is true however, that this area is very dynamic. We have prepared ourselves by increasing our personnel resources as well as accelerating the implementation of a prototype system for industrially relevant investigations. Thanks to the cooperation with worldwide leading solar cell manufacturers we are now in the position to get immediate industrial feedback on our developments.

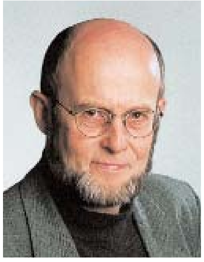
Editor: The term "prototype system" is more frequently used in your department?

Dr. Hopfe: That indeed reflects the main activities in the department over the past months. Initially we had to provide the infrastructure. Last year we opened our "CVD technology laboratory" and an additional development laboratory for diode laser sensor technology. These activities vastly improved the conditions to setup industrially relevant prototype systems. But let us return to the question of systems engineering. We have developed the resources and the engineering know how to plan, design and build plasma sources, CVD reactors and etching machines as well as optical sensors. In addition to the latest commercial development tools we are also using simulation techniques to model the thermo-fluid dynamics of gases, to simulate the optical behavior of multilayer coatings and of complex optical paths. The assembly of our designs is mostly done in cooperation with qualified mechanical engineering companies in the Dresden area. Last year we built and implemented two machines to coat and etch solar wafers, one machine for the plasma CVD of cylindrical machine components and a system to produce carbon nanotubes.

Editor: Your process sensors are recently using "gas tomography", which sounds a little exotic …

Dr. Hopfe: On the contrary, these are addressing practical issues brought up by our customers. We work on techniques to detect the gas distributions in technical plants and reactors. Our highly selective gas sensor technique is based on diode laser spectroscopy in combination with tomographic analysis algorithms. After several seconds of data collection the system produces three dimensional concentration distributions of selected gas species. The data are used to monitor and control the running processes.

Innovation starts in the head
with a bold idea
and the courage to take the risk.
Björn Engholm



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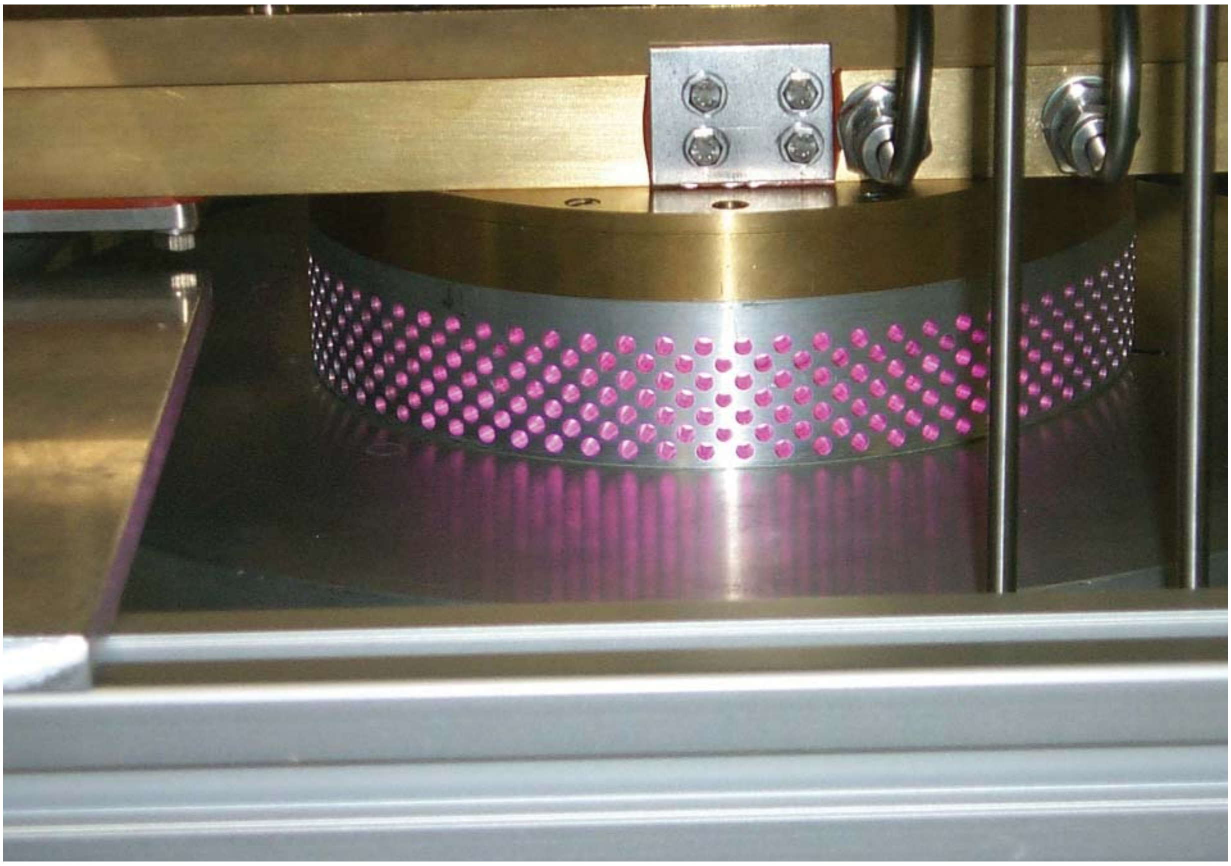
Examples of projects 2007

further information:
www.iws.fraunhofer.de/projekte/1-27/e_pro1-27.html
www.iws.fraunhofer.de/projekte/1-28/e_pro1-28.html



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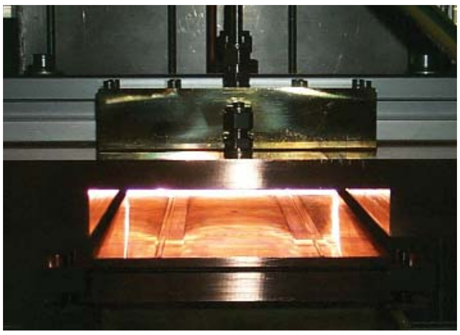
Plasma enhanced CVD processes at atmospheric pressure

Plasma enhanced chemical vapor deposition processes at atmospheric pressure produce large area and high quality functional coatings without the need for costly vacuum systems. The processes can continuously coat at high deposition rates on temperature sensitive (i.e. special steels, lightweight metals, glasses and plastics) flat as well as slightly curved materials. At the Fraunhofer IWS we develop prototype inline reactors for the synthesis of oxide and non-oxide coatings as well as plasma chemical etching processes at atmospheric pressure. The optimization of the reactor design is based on experimental results and thermo-fluid dynamic simulations. The modular reactor design promotes a cost efficient adaptation of the processes to new applications and coating materials.



View of the coating area of the ArcJet-PECVD system

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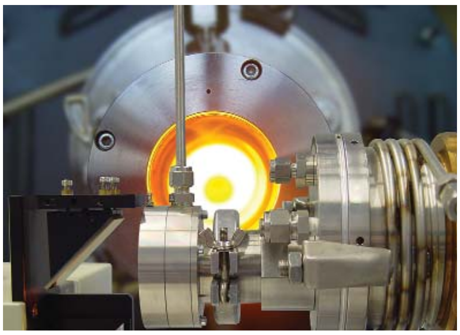
Process monitoring

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.



FTIR monitoring of high temperature processes

Atmospheric pressure plasma processes for cost reduction in silicon photovoltaics

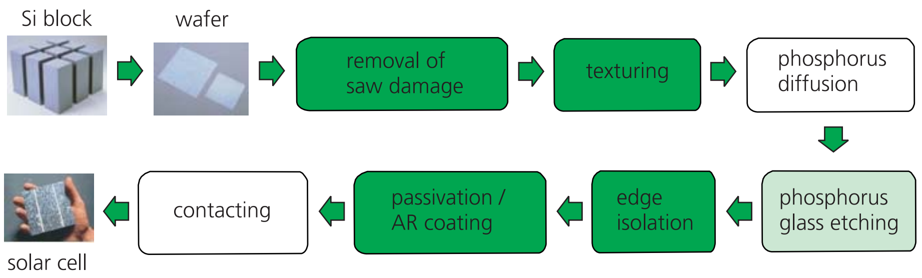


Fig. 1: Schematic representation of the production flow of crystalline solar cells (green: thus far investigated process steps, light green: additional possibilities for AP-PECVD applications)

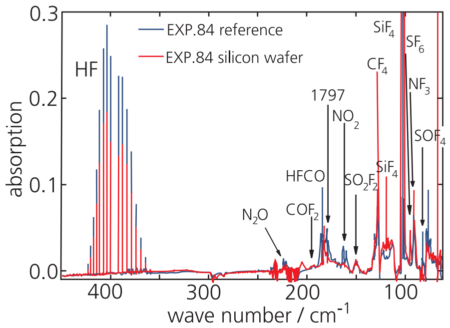


Fig. 2: FTIR spectrum of the exhaust gases during the etching of silicon with NF_3. (blue: reference, only graphite substrate holder in etching zone, red: silicon wafer in etching zone)

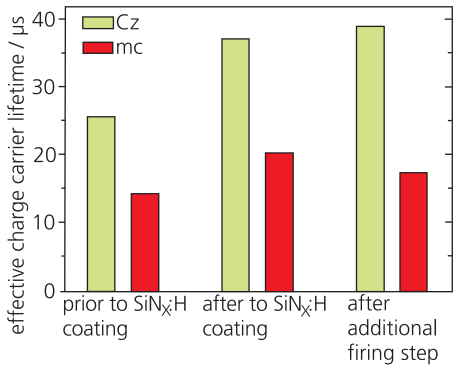


Fig. 3: Charge carrier lifetime measurements on mono and multi crystalline silicon wafers prior to and after atmospheric pressure SiN_x:H coating

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Task

The standard technology for the manufacturing of crystalline solar cells relies for most of its etching steps on wet chemical processes. The application of an antireflective surface coating is performed by plasma enhanced chemical vapor depositions (PECVD) in vacuum. The combination of these very different processes generates high costs, which is in particular driven by the high level of robot utilization. The implementation of an inline production process for solar wafer could provide substantial cost advantages combined with an increase in productivity.

At the IWS we develop continuous plasma etch and deposition processes at atmospheric pressure, which can be combined into an inline system for nonstop processing (Fig. 1).

Solution

The atmospheric pressure plasma is used to dissociate and activate gases for both etch and deposition processes. The activation of fluorine containing etch gases (i.e. SF_6, NF_3) occurs in a direct current arc discharge which covers the entire width of the wafer (120 mm). Etch process byproducts (mostly SiF_3) are volatile and thus easily escape from the surface. The plasma chemical deposition of SiN_x:H coatings on solar wafers is based on a 2.45 GHz microwave-excited atmospheric plasma discharge (working width 156 mm), which dissociates precursors such as silane and NH_3.

Results

After sawing, the wafer surfaces contain defects and contaminations. Those are removed by SF_6 etching (process step "saw damage etch removal"). The static etch rate is up to 0.95 µm m min^{-1}.

By carefully selecting the etch gases and the exposure time it was possible to simultaneously generate a tailored surface structuring on the front side of the solar wafers. The so generated nanostructure reduced the surface reflection of the wafer to 10 %. The utilization of the etch gas NH_3 was measured by FTIR gas phase spectroscopy (Fig. 2) to be 71 %. The edge isolation of the wafer is accomplished by plasma chemical etching of the backside with NF_3 or SF_6. The so produced wafers were tested under industrial conditions and in all cases delivered higher efficiencies than the wet chemically etched reference wafers.

Another important performance criterion is the passivation stability of the SiN_x:H coatings. A first test was performed measuring the charge carrier lifetime of the coatings on mono (Cz) and multi crystalline (mc) Si wafers. In both cases the applied coating led to an effective increase in charge carrier lifetime (Fig. 3).

Atmospheric pressure plasma technology for the fabrication of photocatalytically active TiO_2 coatings

Task

Photocatalytically active surfaces are increasingly gaining importance for example for self-cleaning windows and facade elements or self sterilizing wall panels in hospitals and to clean the air in aircraft cabins.

Organic contaminations are in the presence of oxygen completely oxidized. The reaction products are carbon dioxide, water and minerals. Titanium dioxide (anatase) is a semi conductive material with a band gap of 3.2 eV requiring a wavelength of less than 388 nm to initiate a reaction. Besides the self-cleaning effect the surface is also more hydrophilic. Therefore water forms a thin film on the surface rather than droplets and the surface cannot fog up.

Currently large area photocatalytically active titanium dioxide coatings can only be produced by wet chemical, vacuum or thermal processes (at temperatures above 650 °C). The goal is to optimize the low temperature atmospheric pressure plasma process for synthesizing these coatings.

Solution

At the Fraunhofer IWS we develop atmospheric pressure coating processes and inline reactor technology for large area applications. For the deposition of TiO_2 layers microwave plasma enhanced chemical vapor deposition is the process of choice (Fig. 1). The process offers the advantages of a large area and continuous deposition process without the need for expensive vacuum systems. The process can also be used to coat temperature sensitive materials, such as tempered steels, aluminum and preformed glass. The coating thickness is in the range from 30 - 50 nm and the films exhibit excellent adhesion and conform coverage.

Results

A TiO_2 film that has been deposited at 250 °C is initially amorphous and only minimally photocatalytically active. A plasma post treatment (PPT) transforms the coating into the anatase phase (Fig. 3). To evaluate the photocatalytic activity of the atmospheric pressure plasma enhanced CVD coatings we measured the degradation rate of stearic acid. The coatings show a comparable activity as it is found for commercial surfaces produced with high temperature processes (Tab. 1).

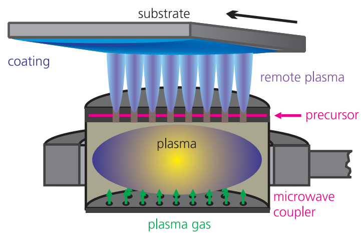

Fig. 1: Principle of the continuous atmospheric pressure microwave PECVD process

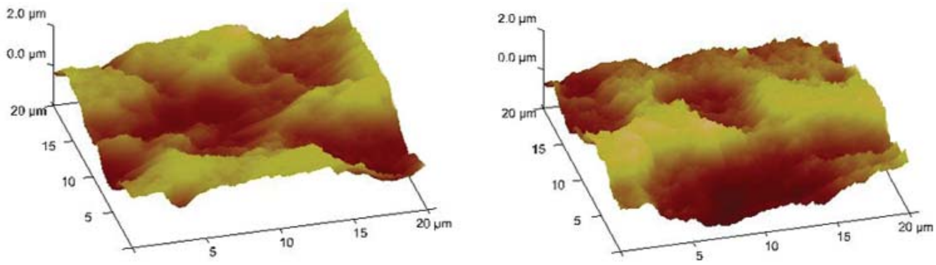

Fig. 2: AFM images: anodic oxidized aluminum sheet metal (left), coated with TiO_2 (right)

layer materials	degradation rate of stearic acid [nm h^{-1}]
SG bioclean	14.9
Pilkington active	8.2
stainless steel + TiO_2	1.4
stainless steel + SiO_2 + TiO_2	5.3
stainless steel + SiO_2 + TiO_2 (PPT)	13.5

Tab. 1: Degradation rate of stearic acid for various TiO_2 coated substrates, SiO_2 serves as a diffusion barrier

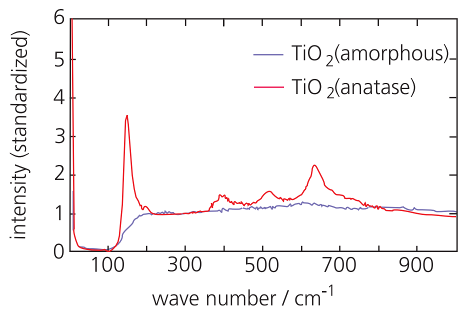

Fig. 3: Raman spectra of deposited (blue) and plasma post treated TiO_2 coatings (red)

Contact

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R&D-offer: PVD- and Nanotechnology

Editor: Right at the beginning of 2007 your department faced a substantial reorganization and restructuring. What was the reason and are there advantages?

Dr. Leson: The most important reason was the retirement of Prof. Schultrich. It offered the opportunity to combine the departments for PVD thin film technology and EUV / X-ray optics. Synergies can now be even better utilized than before since both departments contributed a substantial know how in various complementary deposition technologies. The result benefits our customers.

Editor: Which special developments and trends were important in 2007?

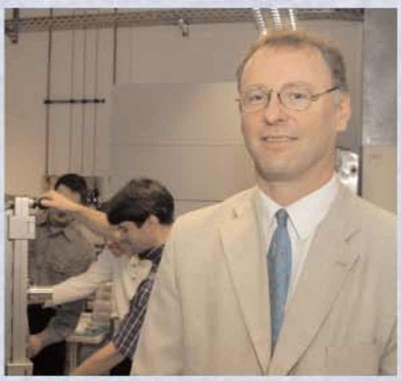
Dr. Leson: A good example is our laser based deposition process for the coating of inner diameter surfaces. In the past this technology was primarily used to deposit thermal barrier layers. We are now using it very successfully to synthesize optical coatings in particular for short wavelength applications. As such it was possible by using this process to significantly increase the efficiency of EUV collectors. Within a BMBF project we are also evaluating ion beam technology for the ultra precise processing of substrates for X-ray optics to achieve a new quality level.

Editor: The synthesis of superhard amorphous carbon coatings is a central topic for many groups in the field of PVD thin film technology. What is your competitive advantage?

Dr. Leson: With our technologies we produce ta-C coatings. The advantages of these materials compared to the classic a-C:H coatings become more and more evident. The ta-C coatings are two to three times as hard and exhibit advantageous friction properties with great potential for future applications. Our Diamor® films demonstrated excellent results for dry forming of aluminum. With the Laser-Arc modules we now have a system technology that is ready for the industrial environment and we working aggressively on its commercialization.

Editor: Is the additional development potential for the Diamor® coatings?

Dr. Leson: Absolutely. We are intensively working on an innovative filtering technique to produce very smooth laser arc coatings. In addition we intend to exploit the great potential of non-tribological Diamor® applications.



The future belongs to those who recognize opportunities before they become obvious
Theodore Levitt

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Fabrication and characterization of nanometer precision coatings

Nanometer single layer and multilayer coatings are used in EUV and X-ray optics for beam shaping and monochromator applications. For the deposition of metallic and dielectric coatings we use magnetron and ion beam sputter deposition as well as pulse laser deposition. The coating systems are characterized by:

- highest thickness precision,
- smallest roughness,
- high chemical purity,
- excellent lateral homogeneity,
- very good reproducibility.

In addition to the development and fabrications of precision coatings, we are offering our long-term experience in characterizing and modeling of nanometer coatings. The following technologies are available in our laboratory:

- X-ray reflectometry,
- EUV reflectometry,
- X-ray diffractometry,
- residual stress measurements.

Mirrors with reflective coating

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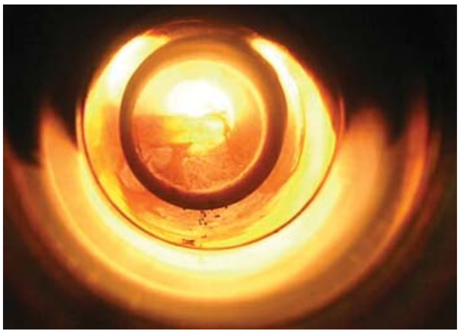
Carbon nanotubes

Carbon nanotubes show a number of interesting properties such as high strength, very good thermal and electrical conductivity, and interesting optical properties. Only small quantities of carbon nanotubes added to composite materials can open completely new functionalities for the matrix material while simultaneously maintaining the conventional matrix properties and keeping established production lines unchanged.

At Fraunhofer IWS we developed a novel process for the synthesis of high-quality single wall carbon nanotubes with a very narrow property spectrum. We are currently up-scaling the process. For the development of composite materials with special properties we are offering carbon nanotubes in different qualities and processing stages. The development of composite materials can be supported by modeling and extensive characterization.



Arc synthesis of filaments made of carbon nanotubes

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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.

further information:
www.iws.fraunhofer.de/branchen/bra07/e_bra07.html
www.iws.fraunhofer.de/projekte/1-22/e_pro1-22.html

Examples of projects 2007

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

Carbon based single and multilayer coatings for X-ray and neutron optics

Task

Carbon is of great interest for X-ray optical coating applications because of its low and edge free absorption over a wide spectral range. Current vacuum coating technology can be used to synthesize carbon films in various modifications, i.e. various X-ray optical densities. If it would be possible to reproducibly stack up chemically stable and smooth low density and high density carbon coatings, these could be used as highly reflective and simultaneously highly resolving X-ray mirrors.

Hydrogen free diamond-like carbon coatings (ta-C) are also of special interest for ultra cold neutron reflectors. The ta-C may potentially replace the conventionally used and highly toxic beryllium. The application requires very smooth ta-C coatings with the highest possible sp^3 contents over relatively large areas (typically several 100 cm^2).

Solution

Ion beam sputter deposition (IBSD) is particularly useful for the synthesis of high quality X-ray optical multilayer coatings. Compared to alternative vacuum coating techniques such as evaporation and magnetron sputtering the ion technique has the advantage of providing higher kinetic energies of the film forming particles. In the so-called "ion assist mode" an ion source operates in parallel to the primary sputter deposition process. Here it is possible to precisely adjust the film properties and to achieve very smooth surface. In the case of carbon single and multilayers the density and sp^3 content can be varied over a wide range by adjusting the primary and assisting ion parameters.

Results

Fig. 1 shows the densities of individual carbon layers as a function of the primary ion type and energy as they were deposited on the IBSD system "IonSys 1600". The density can be adjusted between 2.0 - 2.7 g cm^{-3} and the films are very smooth with a surface roughness range of 0.10 - 0.15 nm RMS (AFM). For the carbon coatings with high densities we measured Young's modules of 400 - 450 GPa and estimated a corresponding sp^3 content of 50 - 55 %.

The IBDS system "IonSys 1600" was used to deposit several carbon based multilayer coatings for X-ray optics (e.g. Ni/C, Cr/C, C/C) and ta-C single layers. The coated substrate areas ranged up to 200 mm in diameter and 200 x 500 mm^2. The thickness variation over the entire coating surface was 0.1 %. Fig. 2 shows as an example a 500 x 100 mm^2 glass plate coated with a 250 nm ta-C film.

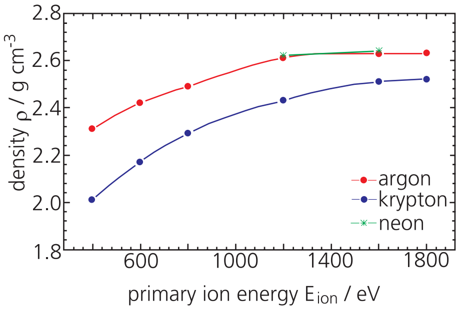

Fig. 1: Density of the carbon coatings as a function the primary ion parameters in an "IonSys 1600" system

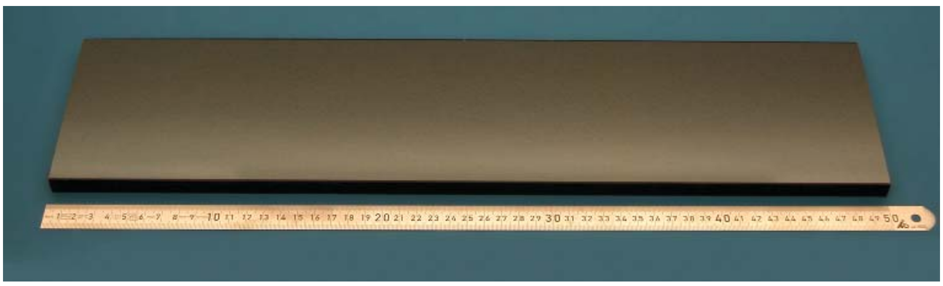

Fig. 2: DLC coated glass plate with dimensions of 500 x 100 mm^2


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Carbon nanotubes as a basis for new composite materials

Task

Carbon nanotubes are new nano materials with record-breaking physical, mechanical and electric properties. It is therefore desirable to use these extremely light, strong and conductive materials in composites. Carbon nanotube reinforced polymers, metals and ceramics can find applications in mechanically reinforced composite materials, lightweight materials, translucent electrodes, actuators, super capacitors, and nanoelectronics. These applications require larger quantities of nanotubes with precisely known properties. The cost effective manufacturing of semi-finished products also requires the modification or functionalization of the nanotubes and their processing in various matrix materials with the desired properties.

Solution

At the Fraunhofer IWS we are working on the implementation of the entire process flow from the synthesis of the carbon nanotubes to the fabrication of the semi-finished product. All necessary steps occur in one or two directly connected reactors within a closed system and take only a few minutes. Processing is controlled via inline monitoring. This level of system and process integration for the synthesis and modification of carbon nanotubes is worldwide unique. All process steps can be cost effectively combined and the nanotubes can be quickly adapted to the desired conditions, applications and products.

Results

We developed an arc-based gas phase process, which in the future will produce single-walled carbon nanotubes by the kg. In parallel we develop an oxidative concentration process for the nanotubes to remove side products in-situ directly after the synthesis. At the current level of optimization we achieve a yield of 80 %. These carbon nanotubes are dispersed into polymers and adhesives and adapted to model systems. For the coming years we plan further in-situ functionalization processes for the nanotubes directly during their synthesis.

Fig. 3: CNT synthesis laboratory

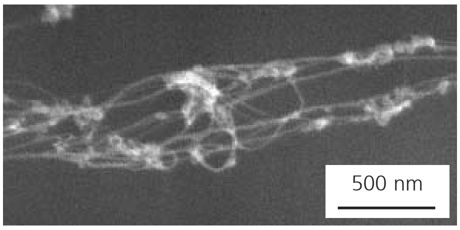

Fig. 1: Rope made from single-walled carbon nanotubes

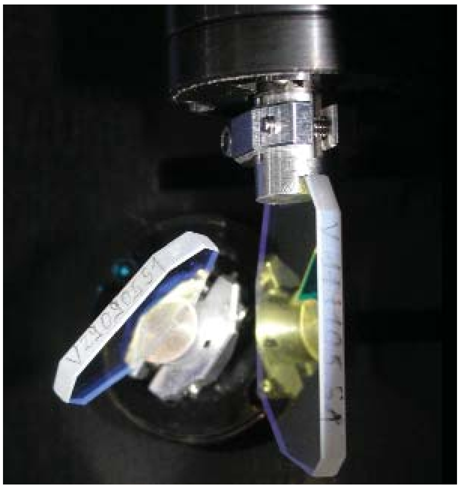

Fig. 2: Mirror scanner for the laser arc process to fabricate of single-walled carbon nanotubes

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Superhard carbon coatings with the potential for dry aluminum sheet forming

Task

The forming of aluminum sheets into readily usable parts demands high quality surfaces on the employed tooling. These tools are typically complex in shape and very expensive. Refining these surfaces with special coatings aims at improving the wear resistance of the tool, at reducing the sticking of material on the tool surface and at reducing the friction between tool surface and sheet. Despite all these efforts it is typically still necessary to use a lubricant during the process, which requires a subsequent expensive cleaning step to remove the lubrication residue from the parts.

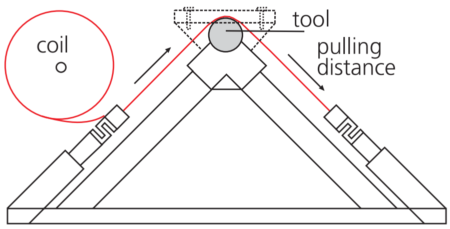


Fig. 1: Schematic representation of the strip drawing test (sheet marked in red)

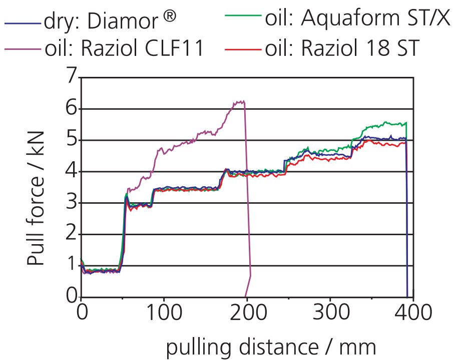
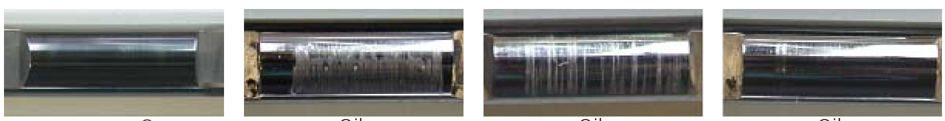


Fig. 2: Force progressions during the strip drawing test with AlMg5Mn sheets. Compared are uncoated tools with oils and a dry running Diamor® coated tool

Solution

A solution to this problem is to apply diamond-like carbon (DLC) coatings to the tool surface. The covalent bonding between the carbon atoms in such coatings shows little tendency to adhere to metals and causes low friction between the coated tool surface and the metal sheet. Under dry contact conditions the coefficient of friction is only about 0.1.



Diamor® dry | Oil: Raziol CLF 11 | Oil: Aquaform ST / X | Oil: Raziol 18 ST

Fig. 3: Tools after drawing tests with AlMg5Mn strips (compare Fig. 2)

Of particular importance for this application are ta-C coatings. They offer a hardness of about 5000 HV and thus a markedly increased wear resistance if compared to classic DLC coatings (ta-C = tetrahedrally bonded amorphous carbon). At the Fraunhofer IWS we produce these coatings under industrial conditions. They are marketed as Diamor® coatings and have proven their performance in numerous wear applications.

Recent investigations into the processing of aluminum showed that these coatings are not only beneficial from the standpoint of wear; they also demonstrated advantages over classic DLC coatings in terms of reducing the material's sticking and cold welding tendency.

These investigations were performed at the institute for manufacturing technology at the TU Dresden in form of metal strip drawing tests (Fig. 1). The materials used were the aluminum alloy AlMg5Mn as well as the particularly stick-prone alloy Al99.5. Compared were uncoated tools in combination with three typical lubricants and Diamor® coated tools without lubricant.

Results

The graph in Fig. 2 shows the pull force as a function of the pulled distance. Diamor® coated forming tools perform dry as well as uncoated tools in combination with high value drawing oils. Comparing the contact areas on the tools in Fig. 3 clearly shows cold welds on the surfaces of the uncoated material even tough they were wetted by drawing oil.

The dry running Diamor® coating does not show any cold welds. These investigations demonstrate that Diamor® coating provides the tool surface conditions for lubricant free aluminum sheet forming. These results were confirmed in industry based on coated rolls for the manufacturing of aluminum cables.

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Geometry memorizing coating structure for the fabrication of prototype casting molds and injection molding tools

Task

To remain competitive in a global economy, companies have to reduce the cycle time for the development of new products and employ innovative manufacturing processes. Under these time and cost pressures the efficient fabrication of prototypes and the cost effective low volume production of parts become increasingly important.

The goal of this project was to develop a tool and die making process for the rapid and cost effective manufacturing of casting molds and injection molding tools which are optimized for durability.

Solution

A layered material system consisting of a PVD functional coating, an APS support layer and a cast liner are used to take and memorize the shape of a positive model. This memorized shape is later made into the cavity of the forming tool. The positive model is fabricated by any of the rapid prototyping methods involving plastics. A functional plate (Fig. 1, left) was selected to demonstrate this new forming tool making process. The plate represents as spectrum of relevant applications, forming elements and materials.

The fabrication of a casting mold for the low volume manufacturing of the functional plate involves the following steps:

1. PVD coating of the prototype with a hard coating (e.g. TiAlN, 1 µm), after removal of the prototype the coating presents the functional surface of the casting mold,
2. deposition of a support layer (e.g. NiCrBSi + adhesion layer) using APS, thickness about 0.9 mm (Fig. 1, right),
3. application of a liner made of casting resin (Fig. 2),

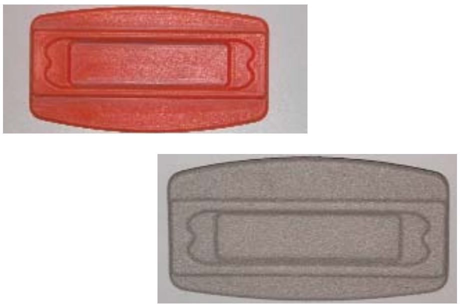

Fig. 1: Positive model:
left: PA functional plate,
right: coated with hard coating and support layer

4. fabrication of the shape memory by removing the prototype and finishing the tool form insert.

Results

The performance of the tool was evaluated based on its capability to release parts, based on the wear of the tool and the number parts formed, and based on the quality of the injection molded parts. 600 parts were manufactured after determining optimal injection parameters for the part material PP GF30, which contains 30 % glass fibers. The PP injection molded parts easily released from the mold and did not show any visual blemishes (Fig. 4). This efficient tool fabrication process is designed for the tool and die making industry. Using this process a toolmaker can quickly respond to changing customer requirements and wishes.

The project was performed in collaboration with the ITW Chemnitz and funded by the BMWi within the work group of industrial research associations "Otto von Guericke".

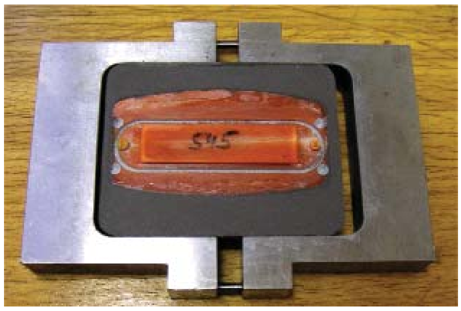

Fig. 2: Coating layers with liner in casting frame

Fig. 3: Completed tool insert after removal of the positive model and finishing

Fig. 4: Injection molded part, manufactured with the tool insert as shown in Fig. 3

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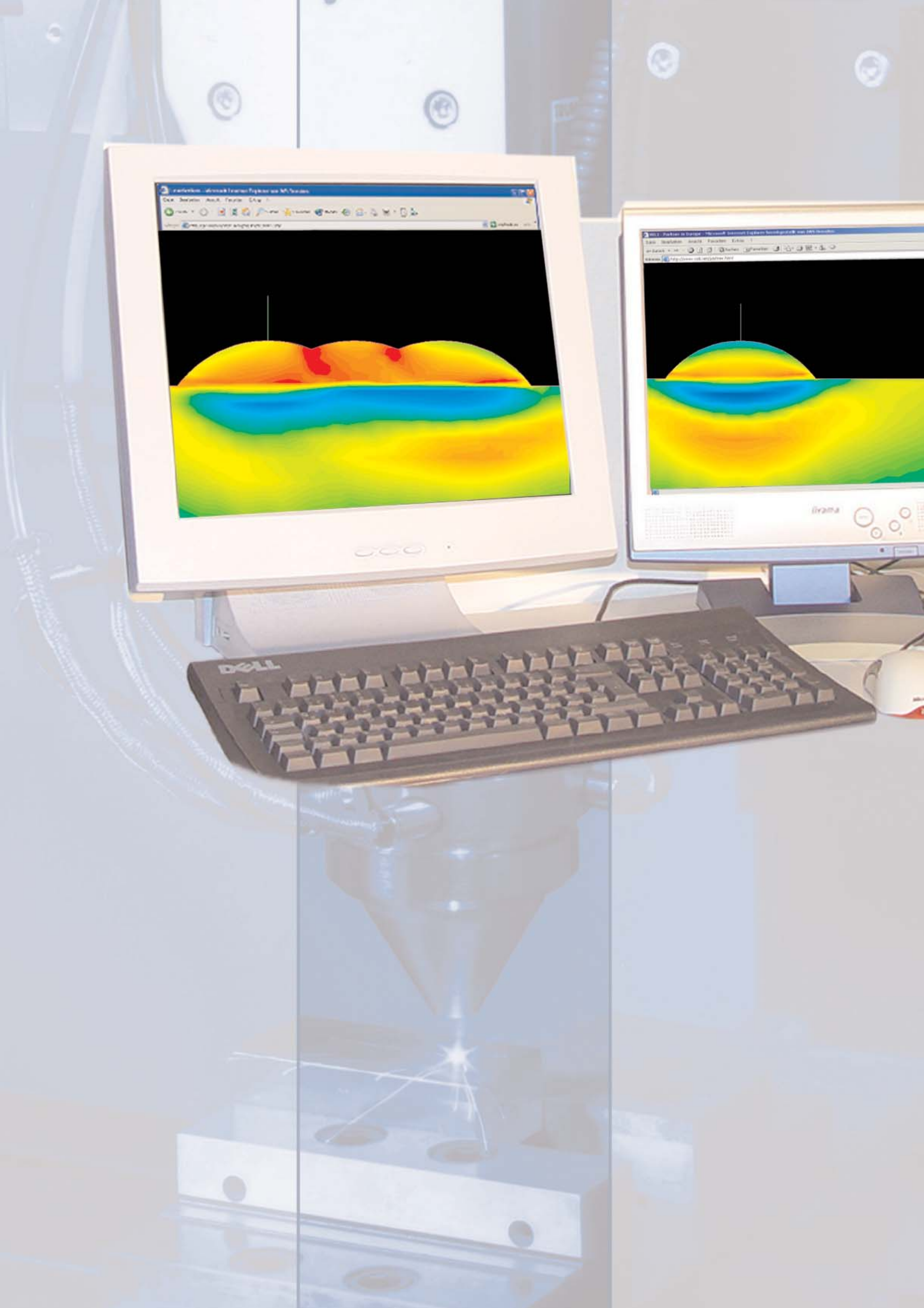
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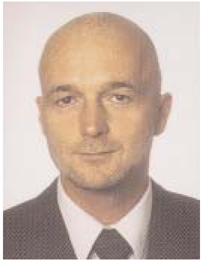
R&D-offer: Simulation and fundamentals



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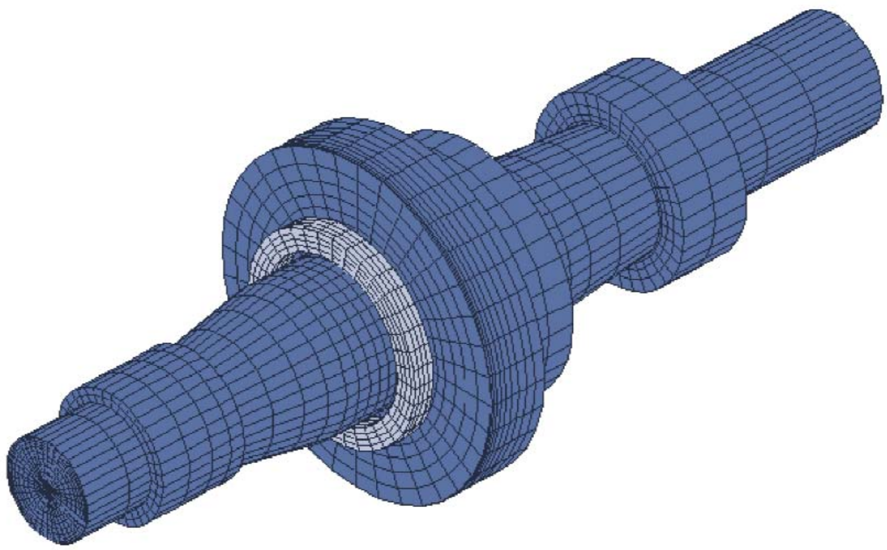
Example of projects 2007

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 the point of developing production capable software (e.g. laser hardening, laser cladding).

Model based estimates often make it easier to predict if, and by what means, it is possible to fulfill a detailed customer request. These models also help to find appropriate process windows. Analytical approximations as well as model experiments are also part of the IWS repertoire.

They serve to visualize basic physical processes during laser materials processing and make them accessible for a detailed analysis. An example of this is the modeling of the influence of electromagnetic fields on the convection in the melting bath. Using these methods in combination with experimental data helps to determine so far unknown materials parameters such as absorption coefficients of technical surfaces.



further information:
www.iws.fraunhofer.de/projekte/1-25/e_pro1-25.html

Control of the energy deposition during laser beam welding by oscillation techniques

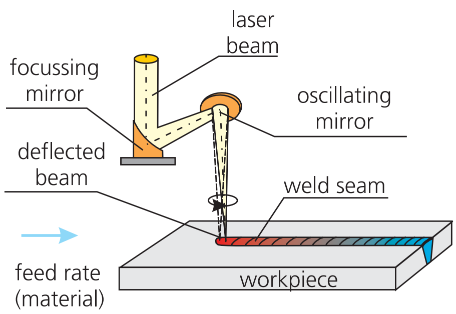


Fig. 1: Schematic diagram of the beam oscillation technique

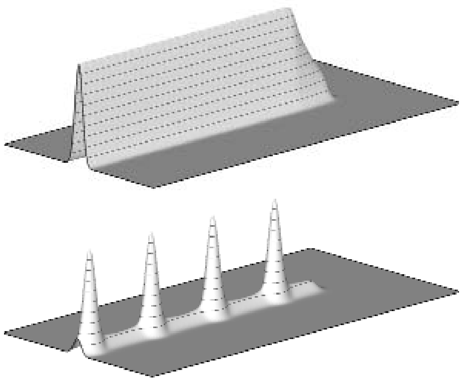


Fig. 2: Computed energy deposition for longitudinal oscillation with harmonic beam deflection, oscillation amplitude $A_x = 2$, $W_x = 1$ (upper) und $W_x = 8$ (bottom)

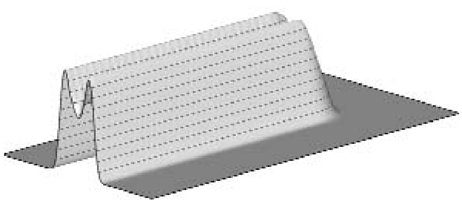


Fig. 3: Computed energy deposition for circular beam oscillation ($A_x = A_y = 2$, $W_x = 1$)

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Task

In recent years, some promising results about laser beam welding with forced beam oscillations were published. A characteristic feature of this technology is the purposeful beam manipulation by an oscillatory beam deflection in superposition to the commonly uniform feed rate of a conventional laser beam welding process. The implementation of this technique with an oscillating mirror in the optical path between laser and workpiece is schematically shown in Fig. 1. The setup allows the realization of different one- and two-dimensional oscillation patterns (e.g. lines, circles, ellipses and eight-shaped patterns). The application of oscillation techniques offers several possibilities to influence the energy deposition during the welding process. In such a way, the process behavior as well as the resulting properties of the weld can be favorably changed. However, the determination of optimal process conditions requires an appropriate understanding of the interactions among the relevant welding and oscillation parameters.

Solution

Manifold feasible process variants result as function of the oscillation regime (oscillation pattern, frequency and amplitude) and the chosen welding parameters (laser power, intensity distribution, welding speed). As a consequence, it is more effective to investigate the underlying relations and dependencies first by modeling than by time-consuming and expensive experiments. In a first approximation, the objectives of the modeling are focused on the mathematical description of the spatial and temporal motion of the laser spot and the computation of the resulting energy deposition as delivered by the laser beam.

Both phenomena can be described in dimensionless form as function of two quantities, i.e. the oscillation amplitudes A_x and A_y related to the focus radius r_0 and the oscillation parameter W_x that is defined to be

$$W_x = \frac{w_{ch}}{f \cdot r_0}$$

with the welding speed w_{ch} and the oscillation frequency f.

Results

Computed energy distributions for longitudinal harmonic oscillations are shown in Fig. 2. It is obvious that the uniformity of the energy deposition along the weld path strongly depends on the value of W_x ranging from a homogeneous energy deposition for $W_x = 1$ to a pulse-like energy deposition for $W_x = 8$.

Fig. 3 shows the resulting energy distribution for a circular oscillation pattern with $A_x = A_y = 2$ and $W_x = 1$. It can be seen that the largest amount of energy is deposited beside the weld line caused by the positions of the crossing points along the beam spot path, which are squeezed to the sides for small values of W_x. This phenomenon explains the practical experience that circular oscillations of the laser beam are well suited to increase the gap bridging ability in butt-welding applications provided the oscillation frequency is high enough to fulfill the condition $W_x = 1$.

Special events

April 26th, 2007
The IWS participated with the national "Girls day"

May 11th, 2007
Third alumni meeting of former Fraunhofer IWS and LOT TU Dresden colleagues

June 29th, 2007
The IWS participated at the "Long Night of Sciences" event of the state capital Dresden

July 22nd, 2007
Dresden's Fraunhofer institutes participate at the 50th open Sunday at the State Library of the Free State of Saxony / University Library (SLUB). The event was initiated by the us!b student foundation

September 25th - 26th, 2007
Technology audit at the Fraunhofer IWS Dresden

October 16th, 2007
German-British workshop "Technologies and Materials for Nanoelectronics" as part of the "V2008 Industry Exhibition and Workshop Week - Vacuum Coating and Plasma Surface Technology" (workshop organizer: Fraunhofer IWS)

October 16th, 2007
Forum "Metal casting process chains for prototype parts in alignment with series production" (organizers: Fraunhofer IWS Dresden and Company Coachulting, Dr. Geiger)

November 14th - 15th, 2007
3rd International workshop "Fiber Lasers" in the International Congress Center Dresden (organizers: Fraunhofer IWS and Fraunhofer IOF)

November 28th, 2007
Workshop of the nanotechnology innovation cluster "nano for production" as part of the Dresden Innovation Forum 2007 at the International Congress Center Dresden

Surface Engineering and Nanotechnology (SENT)

The Fraunhofer IWS in collaboration with Fraunhofer Technology Academy and the TU Dresden launched a series of continuing education courses addressing industrial thin film technology. These courses are offered as general lectures at the IWS and as special on-site packages for industrial customers.

January 23rd - 24th, 2007
"Industrial potential of thin film and nano film technology"

March 27th - 28th, 2007
"Processes for the deposition of thin films"

May 24th, 2007
"Gas phase deposition of thin films - overview and evaluation"

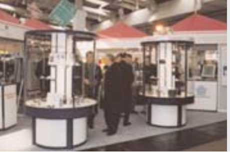
July 10th, 11th,17th,18th, 2007
"Processes for the deposition of thin films"

October 22nd, November 5th, 2007
"Optical thin film systems"

Girls day at the Fraunhofer IWS (April 26th, 2007)

Dresden's Fraunhofer institutes participate at the 50th open Sunday at SLUB

Dr. Hans Eggers (BMBF) during the opening speech of the 3rd International Workshop "Fiber Lasers" in the International Congress Center Dresden (November 14th - 15th, 2007)



Committees

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

Prof. E. Beyer:
Chairman of the Fraunhofer Surface Technology and Photonics Alliance VOP

Prof. E. Beyer:
Director of the Institute for Surface and Manufacturing Technology 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 Dresden discussion forum of economy and science

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

Prof. E. Beyer:
Member of the competence center "Aerospace Technology Saxony / Thuringia 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 (ELI)

Prof. E. Beyer:
Member of the review committee of the AiF

Prof. E. Beyer:
Member of the board of directors of the Laser Institute of America

Prof. E. Beyer:
Member of the board of stakeholders of the Technology Platform Photonics21

Prof. E. Beyer:
Member of the Society for Chemical Technology and Biotechnology e.V. (DECHEMA)

Prof. E. Beyer:
Member of the international advisory board of the Journal of Laser Applications (JLA)

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 Society for Chemical Technology and Biotechnology e.V. (DECHEMA)

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 Advisory Board of the magazine "NanoS"

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 International Expert Panel for the Nanomat-Program of Norway

Dr. A. Leson:
Board member of the working group of nanotechnology competence centers in Germany

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 program committee of the VDI scientific advisory board

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

Dr. A. Leson:
Member of the Board of the European Center for Micro and Nano Reliability e.V.

Dr. A. Leson:
Member of the board of directors of the European Research Society "Thin Films" e.V. (EFDS)

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. G. C. Stehr:
Member of the scientific counsil and advisory board of AIF

Dr. G. C. Stehr:
Association of Thermal Sprayers e.V. (GTS)

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

IWS prizes in 2007

1. Best innovative product idea

   Sebastian Lipfert, Peter Gawlitza, Jürgen Schmidt
   "*Coating of EUV collectors*"

2. Best scientific technical performance

   Carl-Friedrich Meyer, Michael Leonhardt
   "*Magnetic filtering for laser arc processes*"

   Liliana Kotte, Sebastian Tschöcke
   "*Deposition of transparent and scratch resistant SiO_2 coatings using plasma assisted CVD at atmospheric pressure*"

3. Best scientific performance of a junior scientist

   Gunther Göbel, Stefan Schrauber
   "*High power laser joining of parts with difficult-to-weld surface layers or coatings in a mechanically joined state*"

   Kristian Schlegel, Matthias Lütke
   "*Laser punching - a method of remote processing*"

4. Best scientific student performance

   Matthias Leistner
   "*Optical spectroscopic investigation for the optimization of the manufacturing process for single wall carbon nanotubes*"

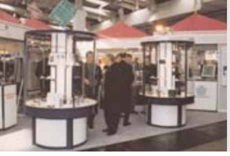
   Matthias Märcz
   "*Investigation of inline modification processes to optimize the synthesis of carbon nanotubes*"

5. Special award

   Karin Reinhardt, Uwe Gust
   "*as a special recognition for the extraordinary effort during the education of apprentices*"

S. Lipfert, P. Gawlitza and J. Schmidt are receiving the institute's award for the best innovative product idea

L. Kotte und S. Tschöcke are receiving the institute's award for the best scientific technical performance



Diplomarbeiten

F. Bartels
(Technische Universität Dresden)

"Einfluss von Schneidgasströmungen auf die Prozesssicherheit und Schneidqualität beim Faserlaserschneiden"

"The influence of cutting gas flows on process safety and cut quality during fiber laser cutting"

M. Dickert
(Hochschule für Technik und Wirtschaft Dresden (FH))

"Entwicklung eines optischen Sensors auf Basis der Laserdiodenspektroskopie LDS zur ortsaufgelösten Bestimmung von Gaskonzentrationen am Beispiel von NH_3"

"The development of an optical sensor based on diode laser spectroscopy LDS for the spatially resolved detection of gas concentrations using the example of NH_3"

G. Dietrich
(Technische Universität Dresden)

"Einfluss der Quellenparameter auf Dichte, E-Modul und Eigenspannung von diamantartigen Kohlenstoffschichten"

"The influence of the source parameters on the density, E modulus and intrinsic stresses of diamond-like carbon coatings"

P. Grabau
(Technische Universität Dresden)

"Elektrische Diagnose einer Long-Arc-Plasmaquelle zur Erhöhung der Prozesssicherheit und -zuverlässigkeit"

"The electrical diagnosis of a long arc plasma source to increase the process safety and reliability"

T. Großer
(Hochschule Mittweida (FH))

"Zerstörungsfreie Charakterisierung von thermisch gespritzten Schichten mittels des laserakustischen LAWave-Verfahrens"

"The nondestructive characterization of thermal sprayed coatings using the laser acoustic LAWave method"

F. Käppler
(Hochschule für Technik und Wirtschaft Dresden(FH))

"Entwicklung multifunktionaler Schichten im System von Titanoxid und Chromoxid beim thermischen Spritzen"

"The development of multifunctional coatings from titanium oxide and chromium oxide by thermal spraying"

T. Klotz
(Fachhochschule für Technik und Wirtschaft Berlin)

"Erfassung von Hochtemperatur- und Hochgeschwindigkeitsprozessen in der thermischen Spritztechnik"

"The acquisition of data from high temperature and high speed processes in the field of thermal spray technology"

M. Leistner
(Technische Universität Dresden)

"Optisch-spektroskopische Untersuchungen zur Optimierung des Herstellungsprozesses von Single Wall Carbon Nanotubes"

"Optical spectroscopic investigations to optimize the manufacturing processes of single-wall carbon nanotubes"

M. Märcz
(Technische Universität Dresden)

"Untersuchungen von in-line Modifikationsprozessen zur Optimierung der Kohlenstoffnanoröhrensynthese"

"Investigations of inline modification processes for the optimization of the synthesis of carbon nanotubes"

R. Neher
(Technische Universität Dresden)

"Optimale Steuerung von Laserhärteprozessen"

"Optimal control of laser hardening processes"

J. Roch
(Technische Universität Dresden)

"Aufbau und Test eines Versuchsstandes zur Evaluierung einer 10,5“ Atmosphärendruck-MW-Plasma-Quelle"

"Implementation and test of a test stand to evaluate a 10.5" atmospheric pressure MW plasma source"

M. Ruppert
(Technische Universität Dresden)

"Untersuchung des Einflusses der Anoden-Kathoden-Konfiguration und Parametern der laser-induzierten, gepulsten Bogenentladung auf die Abscheiderate und die Schichteigenschaften"

"The investigation of the influence of the anode cathode configuration and other parameters of the laser induced pulsed arc discharge on the deposition rate and coating properties"

K. Schlegel
(Westsächsische Hochschule Zwickau (FH))

"Prozessuntersuchungen zum Remote-Faserlaserschneiden ohne Schneidgasunterstützung"

"Process investigations for the remote fiber laser cutting without cutting gas support"

T. Schiefer
(Technische Universität Dresden)

"Laserbehandlung von Titan- und Stahllegierungen und Kombination mit einem automatisierten Klebstoffauftrag"

"Laser processing of titanium and steel alloys in combination with an automated adhesive application"

R. Schwach
(Westsächsische Hochschule Zwickau (FH))

"Nachbildung der physikalischen Eigenschaften optisch reaktiver Elemente"

"Emulation of the physical properties of optically reactive elements"

K. Sommer
(Westsächsische Hochschule Zwickau (FH))

"Charakterisierung der Zerstörschwellen von Reflexionsoptiken für gepulste Laserstrahlung"

"Characterization of the damage threshold of reflective optics for pulsed laser radiation"

J. Spatzier
(Technische Universität Dresden)

"Herstellung und Charakterisierung von karbidhaltigen Verschleißschutzschichten mittels Laser-Pulver-Auftragschweißen"

"Fabrication and characterization of carbide containing wear coatings made by laser powder buildup welding"

G. Stude
(Technische Universität Dresden)

"Über die Herstellung von Nanopartikeln und die Bewahrung ihrer Eigenschaften durch Core / Shell-Strukturen am Beispiel metallischer Nanopartikel"

"About the fabrication of nanoparticles and the preservation of their properties through core / shell structures using the example of metallic nanoparticles"

J. Werner
(Technische Universität Dresden)

"Herstellung von Antihaftschichten mittels Arc-Jet-PECVD bei Atmosphärendruck"

"Fabrication of nonstick coatings by arc-jet PECVD at atmospheric pressure"

S. Zschaler
(Berufsakademie Sachsen, Staatliche Studienakademie Dresden (BA))

"Entwicklung von Algorithmen zur Erzeugung von polygonalen Netzen am Beispiel ausgewählter geometrischer Körper unter Analyse aktueller CAD-Austauschformate"

"Development of algorithms for the generation of polygonal nets based on selected geometric shapes and the analysis of current CAD exchange formats"

Doctoral theses

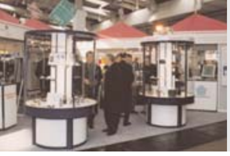
A. Benke
(Technische Universität Dresden)

"Aufbau nanoskopischer Netzwerke aus DNA und Bindeproteinen"

"Assembly of nanoscopic networks from DNA and binding proteins"

Stipends

F.-L. Toma
Docteur en Sciences pour l'Ingénieur
Humboldt-Stipend



Model of a single wall carbon nanotube at the tradeshow Nanotech Tokyo 2007

The Minister President of the State of Saxony, Prof. Dr. Georg Milbradt (center), and the state's Minister for Science, Dr. Eva-Maria Stange (left), visit the TU Dresden's Laser and Surface Technology exhibition booth at the Hannover Industry Tradeshow 2007

At the tradeshow booth during the Thermprocess 2007 in Düsseldorf IWS scientists present laser hardening processes using a high power diode laser and the dynamic beam shaping system "LASSY"

Partipcipation in fairs and exhibitions

Nanotech 2007 Tokyo, Japan, February 21^{st} - 23^{rd}, 2007

The Fraunhofer IWS Dresden and the nanotechnology competence center "Ultrathin Functional Films" participated at the world's largest nanotechnology tradeshow. At the "Nanotech Tokyo 2007" the institute exhibited for the second time at the booth of Saxony's Economic Development Corporation. 484 exhibitors participated in 3 exhibition halls. With 49,000 visitors (4000 more than 2006), the tradeshow registered a new record. The competence center was in particular involved in the preparation of the representation. Several members of the CC actively participated with lectures during several events related to the tradeshow.

Hannover Industry Fair 2007, April 16^{th} - 20^{th}, 2007

The IWS exhibition was setup at the 40 m^2 joint booth "SurfPlaNet", which was hosted by the VDI (Society of German Engineers) in exhibition hall 6. The IWS presented the latest results in the area of surface technologies. The integration of the laser arc module LAM400 into an industrial coating system FlexiCoat 1000® of Hauzer Techno Coating (NL) was shown. The laser arc module can be used to deposit wear resistant coatings (superhard amorphous carbon ta-C) on tools and components. The integrated system was handed over to an automotive supplier for the industrial application of ta-C coatings. This success represents a crucial step toward the commercialization of the institute's laser arc and carbon thin film technologies.

The IWS also presented at the show's supplier section "Subcontracting" in hall 5. The application of the latest generation of fiber lasers for materials processing was demonstrated with the example of laser beam hardening. This technology is particularly interesting for the precise localized hardening of precision components. Using scanner optics enables the hardening of larger areas as well.

Another exhibition was setup in hall 2. Here the institute participated jointly with the TU Dresden's laser and surface technologies section at the booth "Research for the future". The research results for the surface preparation in adhesive bonding processes were exhibited.

Thermprocess 2007, Düsseldorf, June 12^{th} - 16^{th}, 2007

The international specialized tradeshow for thermal processing technology THERMPROCESS takes place every four years in Düsseldorf. The fair is part of a group of tradeshows such as GIFA, METEC and Newcast. The IWS presented laser-hardening technologies, which are of particular interest to the tool making industry. The booth was located adjacent to our partner EFD Induction GmbH Freiburg. Due to the variety of different exhibitors we receive requests going beyond what was exhibited. This led to an active exchange of experiences.

Laser 2007 München, June 18^{th} - 21^{st}, 2007

Together with two other Fraunhofer institutes, the IWS exhibition was setup at a 221 m^2 joint Fraunhofer booth in hall B3. The guiding theme of the Fraunhofer exhibition was labeled "Tailored Light". A fiber laser system for laser materials processing was presented. Until only a few years ago it was

not possible to use fiber lasers for applications other than telecommunication and measurement devices due to the low power levels. Recent progress in the areas of fibers and optical waveguides as well as the development of powerful laser diodes for optical pumping opened new perspectives for the technology in many application fields. The demonstrated objective for IWS is to make these developments readily available to industrial customers.

In collaboration with industrial partners, IWS scientists build a special system for the show that can universally demonstrate various laser materials processing operations. During the Laser 2007 it was possible to show a laser cutting as well as a laser hardening process.

The IWS also presented at a Fraunhofer booth in hall B2. Here the exhibition focused on using fiber laser for micro materials processing.

Parts2clean 2007, Stuttgart, October 9th - 11th, 2007

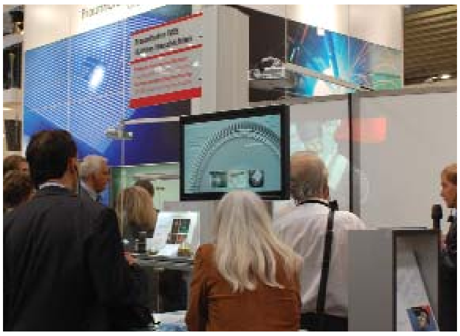
The IWS participated at the joint Fraunhofer Cleaning Technology Alliance booth. A solution to partially clean surfaces of parts with laser beams was presented. The special characteristics of this technology are the integration capability into the automated manufacturing flow, the short cycle time, the possibility to clean functional surfaces for the subsequent processing step in an already preassembled state and the solvent-free processing. The benefits of the technology were demonstrated by removing coolants, lubricants, preservatives and other residues from surfaces of edges to be subsequently joined by laser welding.

Industrial Exhibition & Workshop Week V2007 Dresden, October 16th - 18th, 2007

The "V2007 - Industrial Exhibition & Workshop Week: Vacuum Coatings and Plasma Surface Technologies" was a first time event. The Fraunhofer IWS Dresden was a co-organizer and participated with the following exhibits:
- atmospheric pressure plasma technologies for the continuous processing of crystalline solar cells,
- quality and process control of gases at highest sensitivity, stability and selectivity (trace-scout-sensor).

Euromold 2007, Frankfurt / M., December 5th - 8th, 2007

The IWS participated for 12th time at this tradeshow, which addresses model and tool making and casting technologies. The main attraction was the laser processing system that had been built by IWS scientists in collaboration with several industrial partners. A live performance demonstrated a laser coating process at the show. Robot systems are more and more used in manufacturing, therefore the demonstration showed a diode laser robot system performing precision buildup welding for fabrication and repair steps on tools. The unit was also equipped with the extended CAD/CAM software package DCAM. This package enables the programming of 3 and 5 axes CNC systems and can handle robot systems with simultaneously rotating or swiveling table and additional linear axis.



Presentation of laser beam cutting with fiber lasers during the guided press tour at the tradeshow Laser 2007 in München

Fraunhofer IWS presentation at the joint Fraunhofer booth at the Euromold

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[P02] E. Beyer, I. Jansen

"Verfahren zum hochfesten Kleben von Bauteilen"

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[P03] E. Beyer, P. Pfohl

"Vorrichtung und Verfahren zur Bearbeitung von Bauteilen"

Anmelde-Az.: DE 10 2007 017 363.8

[P04] E. Beyer, P. Pfohl

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[P05] B. Brenner, S. Bonß, F. Tietz, J. Hannweber, S. Kühn, U. Karsunke, M. Seifert

"Verfahren und Vorrichtung zum Randschichtenhärten formkomplizierter Bauteile"

Anmelde-Az.: PCT/EP2007/008787

[P06] B. Brenner, G. Göbel

"Verfahren und Vorrichtung zum rissfreien Schweißen, Reparaturschweißen oder Auftragschweißen heissrissanfälliger Werkstoffe"

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Anmelde-Az.: EP 07018361.1, US 11/856,789

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Anmelde-Az.: PCT/DE2007/001579

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[P11] T. Himmer, J. Hauptmann, L. Morgenthal

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Anmelde-Az.: DE 10 2007 002 437.3

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Anmelde-Az.: DE 10 2007 049 362.4

[P14] S. Kühn, S. Bretschneider, M. Melde, J. Hannweber

"Laserschutzwand für eine Umhausung bei Laserbearbeitungsanlagen"

Anmelde-Az.: DE 10 2007 038 780.8

[P15] S. Kühn, J. Hannweber, M. Melde, S. Bretschneider

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[L55] I. Jansen

"Lasereinsatz in der Klebtechnik"

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[L56] I. Jansen

"Application of the Laser Beam in the Bonding Technology"

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[L57] I. Jansen, H. Sieber

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[L58] R. Jäckel

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[L59] J. Kaspar, B. Brenner, A. Luft, F. Tietz

"Surface Age Hardening of a Precipitation Hardening Steel by Laser Solution Annealing and Subsequent Aging Treatment"

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[L62] A. Klotzbach, R. Gnann

"Processing Optics for Fiber Laser"

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[L67] A. Leson

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[L68] A. Leson

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[L69] E. Lopez, B. Dresler, G. Mäder, J. Roch, S. Krause, I. Dani, V. Hopfe

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[L70] F. Lusquinos, J. C. Conde, S. Bonß, A. Riveiro, F. Quintero, R. Comesana, J. Pou

"Theroretical and Experimental Analysis of High Power Diode Laser (HPDL) Hardening of AISI 1045 Steel"

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[L73] A. Mahrle, E. Beyer

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[L83] S. Saaro, L.-M. Berger, T. Naumann, M. Kašparova, F. Zahálka

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[L86] H.-J. Scheibe, V. Weihnacht, T. Stucky

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[L87] E. Schmalz, O. Zimmer

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"Microstructure of Advanced TiC- Based Coatings Prepared by Laser Cladding"

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[L98] F.-L . Toma, L.-M. Berger, T. Naumann, S. Langner

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"Spatially Heterogeneous Electrical and Electrochemical Properties of Hydrogen-Terminated Boron-Doped Nanocrystalline Diamond Thin Film Deposited from an Argon-Rich $CH_4/H_2/Ar/B_2H_6$ Source Gas Mixture"

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"Strategien zum beanspruchungsgerechten Fügen und Randschichtveredeln"

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"Application of Energy Dispersive X-Ray Diffraction for the Efficient Investigation of Internal Stresses in Thin Films"

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[T01] T. Abendroth, I. Dani, V. Hopfe

"Deposition of Titanium Dioxide Using a Microwave Plasma Enhanced CVD Process Working at Atmospheric Pressure"

16th European Conference on Vapor Deposition (EuroCVD-16), Den Haag (Scheveningen), Niederlande, 16.-21. September 2007,

[T02] M. Becker, T. Schuelke, D. Schneider, A. Leson

"LAwave - Measurement Technology for Quality Assurance"

EuroNanoForum, Düsseldorf, 19.-21. Juni 2007

[T03] L.-M. Berger

"IWS Thermal Spray Research - Processes, Materials and Developments"

National Research Council of Canada; Industrial Materials Institute, Boucherville, 11. Oktober 2007

[T04] L.-M. Berger, S. Saaro, T. Naumann, M. Kasparova, F. Zahalka

"Microstructure and Properties of HVOF-sprayed WC-(W,Cr)$_2$C-Ni Coatings"

EUROMAT 2007, Nürnberg, 10.-13. September 2007

[T05] L.-M. Berger, S. Saaro, T. Naumann, M. Wiener, V. Weihnacht, S. Thiele, J. Suchanek

"Microstructure and Properties of HVOF-Sprayed Chromium Alloyed WC-Co and WC-Ni Coatings"

3èmes Rencontres Internationales Projection Thermique (RIPT), Lille, 6.-7. Dezember 2007

[T06] L.-M. Berger, D. Schneider, T. Großer

"Non-Destructive Testing of Coatings by Surface Acoustic Waves"

ITSC 2007, Bejing, China, 15.-16. Mai 2007

[T07] L.-M. Berger, C.C. Stahr

"State and Perspectives of Thermally Sprayed Ceramic Coatings in the Al_2O_3-$Cr2O_3$-TiO_2 system"

Surface Modification Technologies XXI, Paris, 24.-26. September 2007

[T08] L.-M. Berger, M. Woydt, S. Saaro

"Comparison of Self-Mated Hardmetal Coatings Under Dry Sliding Conditions up to 600 °C"

ECOTRIB 2007: Proceedings of the Joint European Conference on Tribology and Final Conference of COST 532 Action: Triboscience and Tribotechnology, Ljubljana, Slovenia, 12.-15. Juni 2007

[T09] E. Beyer

"Industrial Applications of Fiber Lasers"

Industrial Workshop: Advanced Solid State Lasers: Status, Prospects and Applications, München, 20.-21. Juni 2007

[T10] S. Bonß

"Neues Anlagenkonzept zum beidseitig gleichzeitigen Laserstrahlhärten formkomplizierter Bauteile"

63. Kolloquium für Wärmebehandlung, Werkstofftechnik, Fertigungs- und Verfahrenstechnik, Wiesbaden, 10.-12. Oktober 2007

[T11] S. Bonß, J. Hannweber, S. Kühn, M. Seifert, F. Tietz, B. Brenner, E. Beyer

"Neues Anlagenkonzept zum beidseitig gleichzeitigen Laserstrahlhärten formkomplizierter Bauteile"

7. Industriefachtagung "Oberflächen- und Wärmebehandlungstechnik", 10. Werkstofftechnisches Kolloquium, Chemnitz, 27.-28.September 2007

[T12] S. Bonß, J. Hannweber, M. Seifert, U. Karsunke, B. Brenner, E. Beyer

"Integrated Heat Treatment - System for Precise Die Hardening in Automotive Industries"

ASM Heat Treating Society Conference & Exhibition, Detroit, USA, 17.-19. September 2007

[T13] S. Bonß, J. Hannweber, M. Seifert, S. Kühn, U. Karsunke, B. Brenner, E. Beyer

"Novel Machine System for Simultaneous Heat Treatment with Dynamic Beam Shaping"

11th Nordic Conference in Laser Processing of Materials, Lappeenranta, Finland, 20.-22. August 2007

[T14] S. Bonß, J. Hannweber, M. Seifert, F. Tietz, S. Kühn, U. Karsunke, B. Brenner, E. Beyer

"Novel Machine System for Simultaneous Heat Treatment with Dynamic Beam Shaping"

26th International Congress on Applications of Lasers & Electro-Optics (ICALEO 2007), Orlando (FL) USA, 29. Oktober - 01. November 2007

[T15] S. Braun

"Halbleiterlithographie der nächsten Generation: Reflexionsoptiken für extrem ultraviolette (EUV) Strahlung"

Praktikerseminar 2007, Dresden, 28. Juni 2007

[T16] S. Braun, P. Gawlitza, S. Lipfert, G. Dietrich, A. Leson

"Präzisionsbearbeitung und -beschichtung von Oberflächen mittels Ionenstrahltechnik"

KooperationsForum "Moderne Beschichtungs- und Oberflächentechnologien" Köln, 27. November 2007

[T17] S. Braun, P. Gawlitza, S. Lipfert, M. Menzel, S. Schädlich, A. Leson

"High-Precision Multilayer Coatings and Reflectometry for EUVL Optics"

EuroNanoForum, Düsseldorf, 19.-21. Juni 2007

[T18] **is** B. Brenner

"Neueste laserbasierte Fügeverfahren in Forschung und Industrie"

7. Dresdner Materialforschungstag des MFD, Dresden, 28. November 2007

[T19] B. Brenner, S. Bonß, J. Hannweber, F. Tietz, M. Seifert

"New Technologies for Industrial Laser Hardening - an Overview"

ASM Heat Treating Society Conference & Exhibition, Detroit, USA, 17.-19. September 2007

[T20] **is** B. Brenner, A. Jahn, J. Standfuß

"Induction Assisted Laser Welding Improves the Formability of Laser Welded Body Structures Made from High Strength Steels"

ALAW 2007, 15th Annual Automotive Laser Application Workshop, Plymouth, MI, USA, 18.-19. April 2007

[T21] F. Brückner, D. Lepski, E. Beyer

"Strain and Stress Histories in Laser Build-Up Welding - II. FEM Stress Calculations"

20th Meeting on Mathematical Modelling of Materials Processing with Lasers, Igls/Innsbruck (Austria), 17.-19. Januar 2007

[T22] F. Brückner, D. Lepski, E. Beyer

"FEM Calculations of Thermally Induced Stresses in Laser Cladded Coatings"

4th International WLT-Conference on Lasers in Manufacturing, München, 18.-21. Juni 2007

[T23] F. Brückner, D. Lepski, E. Beyer

"Simulation of Thermal Stress in Induction-Assisted Laser Cladding"

26th International Congress on Applications of Lasers & Electro-Optics (ICALEO 2007), Orlando (USA), 29. Oktober-1. November 2007

[T24] I. Dani, V. Hopfe

"SPECVD und plasmachemisches Ätzen bei Atmosphärendruck für kontinuierliche Prozesse"

13. Fachtagung Plasmatechnologie (PT 13), Bochum, 05.-07. März 2007

[T25] I. Dani, G. Mäder, S. Krause, B. Dresler, E. Lopez, S. Tschöcke, D. Linaschke, V. Hopfe

"Großflächige PECVD und plasmachemisches Ätzen bei Atmosphärendruck"

XIV. Workshop Plasmatechnik, Ilmenau, 21.-22. Juni 2007

[T26] I. Dani, S. Tschöcke, L. Kotte, G. Mäder, J. Roch, S. Krause, B. Dresler, V. Hopfe

"Kontinuierliche Großflächenbeschichtung durch Mikrowellen-PECVD bei Atmosphärendruck"

EFDS-Workshop "Plasmabehandlung und Plasma-CVD-Beschichtung bei Atmosphärendruck", Dresden, 25. April 2007

[T27] W. Danzer, T. Himmer, L. Morgenthal, M. Lütke, F. Bartels

"Schneiden mit Faserlasern"

3. Internationaler Workshop "Faserlaser", Dresden, 14.-15. November 2007, Tagungs-CD, ISBN-Nummer 978-3-8167-7506-5

[T28] D. Dittrich, B. Winderlich, B. Brenner

"Steps for the Improvement of Damage Tolerance Behaviour of Laser Beam Welded Skin-Skin-Joints for Aircraft Structures"

4th International WLT-Conference "Lasers in Manufacturing", München, 18.-22. Juni 2007

[T29] B. Dresler, St. Krause, I. Dani, V. Hopfe, M. Heintze, R. Möller, H. Wanka, A. Poruba, R. Barinka

"Atmospheric Pressure PECVD of Silicon Nitride for Passivation of Silicon Solar Cells"

22nd European Photovoltaic Solar Energy Conference and Exhibition, Milano, Italien, 3.-7.September 2007

[T30] J. Dubsky, P. Chraska, B. Kolman, C. C. Stahr, L.-M. Berger

"Formation of Corundum Phase in Plasma Sprayed Alumina Coatings"

The 16th International Federation for Heat Treatment and Surface Engineering (IFHTSE) Congress, Brisbane, Australia, 30. Oktober - 01. November 2007

[T31] V. Franke, U. Klotzbach, M. Panzner, R. Püschel

"Potentials of Fiber Laser Technology in Microfabrication"

Laser-based micro- and nanopackaging and assembly, San Jose, California, USA, 22.-24. Januar 2007

[T32] P. Gawlitza

"Ionenstrahlbeschichtung für EUV-Multischichtoptiken"

Statusseminar Litho 45/32nm, Bonn, 7. März 2007

[T33] P. Gawlitza, S. Braun, G. Dietrich, A. Leson, S. Lipfert

"Ionenstrahlsputtern zur Synthese von Präzisions-Multischichtoptiken"

Oberflächentech. mit Plasma- und Ionenstrahlprozessen, Mühlleiten, 13.-15. März 2007

[T34] P. Gawlitza, S. Braun, G. Dietrich, A. Leson, S. Lipfert

"Großflächige Präzisions-Ionstrahltechnik für die Optik-Verfahren und Anwendungen"

V2007, Dresden, 16.-18. Oktober 2007

[T35] G. Göbel, B. Brenner

"New Thermomechanical Approach to Overcome Hot Cracking in Laser Welding"

4th International WLT-Conference "Lasers in Manufacturing", München, 18.-22. Juni 2007

[T36] G. Göbel, B. Brenner, E. Beyer

"New Application Possibilities for Fiber Laser Welding"

26th International Congress on Applications of Lasers & Electro-Optics (ICALEO 2007), Orlando (FL) USA, 29.Oktober - 01.November 2007

[T37] G. Göbel, J. Standfuß, B. Brenner

"Extreme Narrow Gap Welding using Fiber Lasers"

3. Internationaler Workshop "Faserlaser", Dresden, 14.-15. November 2007

[T38] J. Hannweber, S. Kühn, M. Melde, S. Bretschneider

"A Novel Laser Protection Screen for High Power Laser"

3. Internationaler Workshop "Faserlaser", Dresden, 14.-15. November 2007

[T39] J. Hauptmann

"Application with Fiber Based UV Pico-Second Laser"

3. Internationaler Workshop "Faserlaser", Dresden, 14.-15. November 2007

[T40] P. Herwig, P. Pfohl, E. Beyer

"System Engineering for Laser Processing of Copper"

3. Internationaler Workshop "Faserlaser", Dresden, 14.-15. November 2007

[T41] P. Herwig, P. Pfohl, R. Imhoff, E. Beyer

"Processing of High Reflective Materials with High Brightness Lasers"

26th International Congress on Applications of Lasers & Electro-Optics (ICALEO 2007), Orlando (USA), 29. Oktober - 01. November 2007

[T42] T. Himmer, W. Danzer, L. Morgenthal, M. Lütke

"Cutting with Fiber Lasers"

3. Internationaler Workshop "Faserlaser", Dresden, 14.-15. November 2007

[T43] T. Himmer, L. Morgenthal, E. Beyer

"Application of High Quality Beam Sources in R&D Projects"

4th International WLT-Conference "Lasers in Manufacturing", München, 18.-22. Juni 2007

[T44] T. Himmer, T. Pinder, L. Morgenthal, E. Beyer

"High Brightness Lasers In Cutting Applications"

26th International Congress on Applications of Lasers and Electro-Optics (ICALEO 2007), Orlando, (USA), 29. Oktober - 01. November 2007

[T45] C. Hinüber, C. Kleemann, R. Friederichs, L. Haubold, H.-J. Scheibe, T. Schuelke, C. Boehlert, M.-J. Baumann

"Biocompatibility and Mechanical Properties of Diamond-like Coatings on Cobalt-Chromium-Molybdenum Steel and Titanium-Aluminum-Vanadium Biomedical Alloys"

VaPSE 2007, Hejnice, CZ 25.-27.Oktober 2007

[T46] V. Hopfe

"Atmosphärendruck-Plasma-CVD und -Plasmaätzen für kontinuierliche Großflächenprozesse"

OTTI-Seminar "Reinigen, Aktivieren und Beschichten mit Atmosphärendruck (AD)-Plasma", Regensburg, 19.-20. November.2007,

[T47] V. Hopfe, I. Dani, E. López, B. Dresler, H. Beese, M. Heintze, R. Moeller, H. Wanka

"Atmospheric Pressure Plasmas for Crystalline Silicon Solar Wafer Processing"

18th International Symposium on Plasma Chemistry (ISPC-18), Kyoto, Japan, 26.-31. August 2007

[T48] V. Hopfe, I. Dani, E. López, M. Heintze

"Atmospheric Pressure Plasma Enhanced Chemical Etching for Crystalline Silicon Solar Wafer Processing"

18th International Symposium on Plasma Chemistry (ISPC-18), Kyoto, Japan, 26.-31. August 2007

[T49] A. Jahn, S. Standfuß, B. Brenner, R. Mauermann, S. Menzel

"Formability Optimization of Laser Welded Patchwork Structures"

4th International WLT-Conference "Lasers in Manufacturing", München, 18.-22. Juni 2007

[T50] I. Jansen

"Oberflächenvorbehandlung von Glas und Metallen"

Innovationsforum Glas, Delo Industrieklebstoffe, Landsberg, 18. Januar 2007

[T51] I. Jansen

"Lasereinsatz in der Klebtechnik"

Dresdner Fügetechnisches Kolloquium, TU Dresden, 22.-23. März 2007

[T52] I. Jansen

"Application of the Laser Beam in the Bonding Technology"

InnoCarBody 2007, Bad Nauheim, 11.-12. Juni 2007

[T53] I. Jansen, H. Sieber

"Transparente Glas-Metall-Klebungen mit zähelastisch modifizierten Acrylaten"

21. International Symposium, Swiss Bonding 07, Rapperswill, Schweiz, 14.-16. Mai 2007

[T54] R. Jäckel, A. Leson

"Nanotechnologie-Kompetenzzentrum "Ultradünne funktionale Schichten" in Sachsen"

Erfahrungsaustausch mit Nanocluster Kansai-Gebiet, Japan, 19. Februar 2007

[T55] O. Jost

"Large-Scale Synthesis of Single-Walled Carbon Nanotubes with a Modified Arc-Discharge Technique"

EuroNanoForum, Düsseldorf, 19.-21. Juni 2007

[T56] O. Jost

"Informationsvortrag Nanotechnologie am Fraunhofer IWS Dresden"

Infotag des Deutschen Verbandes für Schweißen und verwandte Verfahren (DVS) Bezirksvorstand Berlin, Berlin, 28. November 2007

[T57] **is** O. Jost, A. Leson, E. Beyer

"Towards the Large-Scale Production of Single-Wall Carbon Nanotubes"

1st International Congress on Science and Technology in the Micro and Nano Scale (MiNaT-Congress), Stuttgart, 13.-15. Juni 2007

[T58] O. Jost, M.H. Ruemmeli, B. Büchner, W. Pompe, G. Eckstein

"Growth of Single-Walled Carbon Nanotubes by Redox Reactions in Solution"

Nanotube Konferenz IWEPNM 2007, Kirchberg (AT), 11.-17. März 2007

[T59] J. Kaspar, B. Brenner, A. Luft, F. Tietz

"Surface Age Hardening of a Precipitation Hardening Steel by Laser Solution Annealing and Subsequent Aging Treatment"

4th International WLT-Conference "Lasers in Manufacturing", München, 18.-22. Juni 2007

[T60] J. Kaspar, A. Luft, M. Will, S. Nolte

"SEM and TEM Investigation of the Ablation Mechanisms Involved in Ultrashort Pulsed Laser Drilling of Silicon"

4th International WLT-Conference "Lasers in Manufacturing", München, 18.-22. Juni 2007

[T61] R. Kunkel, A. Czegledi, H. Beese

"Measurement of Moisture Traces in Reactive Gases by a New Tunable Diode Laser Absorption System"

Pittcon 2007, Specialty Gases Session, Chicago, 28. Februar 2007

[T62] A. Klotzbach, R. Gnann

"Processing Optics for Fiber Laser"

3. Internationaler Workshop "Faserlaser", Dresden, 14.-15. November 2007

[T63] U. Klotzbach, V. Franke, F. Sonntag, L. Morgenthal, E. Beyer

"Requirements and Potentialities of Packaging for Bioreactors with LTCC and Polymer"

Conference "Laser-Based Micro- and Nanopackaging and Assembly" San Jose/California, 22.-24. Januar 2007

[T64] **is** A. Lange

"Modeling and Simulation of Laser Welding"

Seminar des Institutes für Analysis und Numerik, Uni Magdeburg, 2. März 2007

[T65] A. Lange

"Thermoelectric Currents in Weld Pools"

Deutsche Physikalische Gesellschaft-Frühjahrstagung 2007, Regensburg, 30. März 2007

[T66] A. Lange

"Thermoelectric Currents in Weld Pools"

Gesellschaft für Angewandte Mathematik und Mechanik 2007, Zürich, 20. Juli 2007

[T67] A. Lange

"Gezielte Strömungsbeeinflussung durch Magnetfelder in Schmelzbädern beim Laserstrahlschweißen"

Klausur Sonderforschungsbereich 609, Schmochtitz, 21. September 2007

[T68] **is** A. Lange

"Thermoelectric Currents in Laser Induced Weld Pools"

Fachseminar an der Fakultät Maschinenbau, TU Ilmenau, 19. Dezember 2007

[T69] D. Lepski, F. Brückner, E. Beyer

"Strain and Stress Histories in Laser Build-Up Welding - I. Heuristic Model"

20th Meeting on Mathematical Modelling of Materials Processing with Lasers, Igls / Innsbruck (Austria), 17.-19. Januar 2007

[T70] A. Leson

"Neue Werkstoffe für intelligente Produkte"

VDI-Expertenforum Energie- und materialeffiziente Produktion -Herausforderung und Chance für die deutsche Industrie, Dresden, 16. Februar 2007

[T71] A. Leson

"Nanotechnology in Saxony - Highlights and Recent Developments"

NanoTech 2007, Tokio, Japan, 21. Februar 2007

[T72] A. Leson

"Fraunhofer-Innovationscluster Nano for Production"

Fraunhofer -Innovationscluster Symposium, Berlin, 4. September 2007

[T73] A. Leson

"Superhard Nanostructured Carbon Coatings - Properties and Applications"

Nanotechnologieforum, sächs. Delegationsreise, Tokio, Japan, 3. Oktober 2007

[T74] A. Leson

"Superhard Nanostructured Carbon Coatings - Properties and Applications"

Nanotechnologieforum, sächs. Delegationsreise, Osaka, Japan, 5. Oktober 2007

[T75] A. Leson, M. Leonhardt, C. F. Meyer, H.-J. Scheibe, V. Weihnacht

"Deposition of Amorphous and Nanostructured Carbon Films - Process, Technology and Application"

NanoScience 2007, Lichtenwalde, 19. Oktober 2007

[T76] S. Lipfert, S. Braun, P. Gawlitza, A. Leson

"Reactive Nanometer Multilayers as Tailored Heat Sources for Joining Techniques"

Workshop Hybrid Nanostructured Materials, Prag (CZ), 5.-6. November 2007

[T77] E. López, H. Beese, G. Mäder, I. Dani, V. Hopfe, M. Heintze, R. Moeller, H. Wanka, M. Kirschmann, J. Frenck, A. Poruba, R. Barinka, H. Nussbaumer, R. Dahl

"New Developments in Plasma Enhanced Chemical Etching at Atmospheric Pressure for Crystalline Silicon Wafer Processing"

22nd European Photovoltaic Solar Energy Conference and Exhibition, Milano, Italien, 3.-7. September 2007

[T78] A. Mahrle, E. Beyer

"Mathematical Description of the Transient Energy Deposition in Laser Materials Processing with Forced Beam Oscillations"

20th Meeting on Mathematical Modelling of Materials Processing with Lasers, Igls / Innsbruck (Austria), 17.-19. Januar 2007

[T79] A. Mahrle, E. Beyer

"Simulation von Temperatur- und Geschwindigkeitsfeld in laserinduzierten Schmelzbädern"

TU Dresden, Workshop Strömungssimulation, Dresden, 29. Juni 2007

[T80] A. Mahrle, E. Beyer

"Modellierung, Simulation und rechnergestützte Prozessauslegung zum Wärmeleitungsschweißen mit Laserstrahlung"

Schweißtagung "Verfahrensgerechte Produkt- und Prozessgestaltung", Neu-Ulm, 17.-18. Oktober 2007

[T81] A. Mahrle, F. Kretzschmar, E. Beyer

"Control of the Energy Deposition during Laser Beam Welding by Oscillation Techniques"

4th International WLT-Conference on Lasers in Manufacturing, München, 18.-21. Juni 2007

[T82] A. Mahrle, F. Kretzschmar, E. Beyer

"Modeling and Simulation of the Energy Deposition in Laser Beam Welding with Oscillatory Beam Deflection"

26th International Congress on Applications of Lasers & Electro-Optics (ICALEO) 2007, Orlando (USA), 29. Oktober -1. November 2007

[T83] G. Mäder, E. Lopez, I. Dani, V. Hopfe

"Plasmaätzen von Solarwafern mit Linear-DC-Arc-Plasmaquellen"

EFDS-Workshop "Plasmabehandlung und Plasma-CVD-Beschichtung bei Atmosphärendruck", Dresden, 25. April 2007

[T84] G. Mäder, J. Roch, S. Krause, B. Dresler, S. Tschöcke, I. Dani, V. Hopfe

"Continuous Microwave Plasma Enhanced CVD at Atmospheric Pressure"

3rd International Congress on Cold Atmospheric Pressure Plasmas: Sources and Applications (CAPPSA 2007) Ghent, Belgien, 10.-13. Juli 2007

[T85] M. Märcz, M. Leistner, W. Grählert, I. Dani, V. Hopfe, S. Kaskel

"In-situ Monitoring of SW-CNT Synthesis using NIR Spectroscopy"

NanoSmat-2007, Algarve, Portugal, 9.-11. Juli 2007

[T86] S. Nowotny, S. Scharek, J. Ortner

"Repair of Local Erosion Damages by Laser Assisted Direct Metal Deposition (DMD)"

French-German Workshop on Erosion in Weapon Barrels, Dresden, 10.-11. Juli 2007

[T87] B. Polllakowski, B. Beckhoff, S. Braun, P. Gawlitza, F. Reinhardt, G. Ulm

"Zerstörungsfreie Speziation von vergrabenen TiO_x Nanoschichten"

PRORA 2007, Berlin, 15. November 2007

[T88] A. Roch

"Herstellung von einwandigen CNT auf der Basis des gepulsten Lichtbogens"

Institutsseminar, IOF TU Dresden, Januar 2007

[T89] S. Saaro, L.-M. Berger, T. Naumann, M. Kašparova, F. Zahálka

"Mikrostruktur und Eigenschaften von HVOF-gespritzten WC-(W,Cr)$_2$C-Ni Schichten"

7. Industriefachtagung "Oberflächen- und Wärmebehandlungs-technik" zum 10. Werkstofftechnischen Kolloquium in Chemnitz, 27.-28. September 2007

[T90] H.-J. Scheibe

"Gepulste Plasmen zur Herstellung nanostrukturierter Schichten und deren Anwendungen"

Gründerimpuls Dresden Nanotechnologie, Dresden, 10. Oktober 2007

[T91] H.-J. Scheibe

"Laser-Arc Process for Formation of Nano-Structured Carbon Films and Nano-Particles"

German-Britisch Workshop Technologies and Materials for Nanoelectronics, Dresden, 16. Oktober 2007

[T92] H.-J. Scheibe

"Laser-Arc Process for Formation of Nano-Structured Carbon Films and Nano-Particles"

VaPSE 2006, Hejnice, CZ, 25.-27. Oktober 2007

[T93] H.-J. Scheibe, M. Leonhardt, A. Leson, C.-F. Meyer, D. Doerwald, T. Krug

"Laser Induced Pulsed Arc Deposition - Laser-Arc: A Laboratory Proven ta-C Deposition Process on the Road for Industrial Application"

HIPIMS-Days, Sheffield, UK, 10.-11. Juli 2007

[T94] H.-J. Scheibe, T. Schuelke

"Laser-Arc System - Technology for ta-C Deposition"

SVC, Louisville, KY, USA, 29. April - 03.Mai 2007

[T95] D. Schneider, B. Schultrich

"Testing thin films and surfaces by the laser-acoustic test method Lawave"

MicroNanoReliability, Berlin, 2.-5. September 2007

[T96] C.C. Stahr, L.-M. Berger, S. Thiele

"Mikrostruktur und Eigenschaften thermisch gespritzter Schichten im System TiO_2-Cr_2O_3"

7. Industriefachtagung "Oberflächen- und Wärmebehandlungstechnik" zum 10. Werkstofftechnischen Kolloquium in Chemnitz, 27.-28. September 2007

[T97] C.C. Stahr, S. Saaro, L.-M. Berger, J. Dubsky, K. Neufuss

"About the Dependance of the Stabilization of α-Alumina on the Spray Process"

Global Coating Solutions: Proceedings of the 2007 International Thermal Spray Conference, Beijing, 14.-17. Mai 2007,

[T98] J. Standfuß, G. Göbel, E. Beyer

"Aspects of Fiber Laser Welding in Regard to Process, Applications and Economics"

Laser-ERFA-Møde, Odense, Dänemark, 13. September 2007

[T99] **is** J. Standfuß, G. Göbel, U. Stamm, B. Brenner

"Laser Welding of Dissimilar Materials in Powertrain Applications"

ALAW 2007, 15th Annual Automotive Laser Application Workshop, Plymouth, MI, USA, 18.-19. April 2007

[T100] F.-L. Toma, L.-M. Berger, T. Naumann, S. Langner

"Suspensionsgespritzte Al_2O_3-Schichten"

7. Industriefachtagung "Oberflächen- und Wärmebehandlungstechnik" zum 10. Werkstofftechnischen Kolloquium in Chemnitz, 27.-28. September 2007

[T101] F.-L. Toma, L.-M. Berger, T. Naumann, S. Langner

"Microstructure of Nanostructured Ceramic Coatings Obtained by Suspension Thermal Spraying"

3èmes Rencontres Internationales Projection Thermique (RIPT), Lille, 6.-7. Dezember 2007

[T102] F.-L. Toma, L.-M. Berger, T. Naumann, C.C. Stahr

"Elaboration and Characterisation of Suspension Plasma Sprayed Ceramic Coatings"

Surface Modification Technologies XXI, Paris, 24.-26. September 2007

[T103] F.-L. Toma, L.-M. Berger, C.C. Stahr, T. Naumann

"Ceramic Nanostructured Coatings Elaborated by Suspension Plasma Spraying"

EUROMAT 2007, Nürnberg, 10.-13. September 2007

[T104] F.-L. Toma, L.-M. Berger, C.C. Stahr, T. Naumann, S. Saaro

"Preparation and Characterization of Nanostructured Ceramic Coatings Obtained by Suspension Plasma Spraying"

10th International Conference for the European Ceramic Society, "Thermally Sprayed TiO_2 - Cr_2O_3 Coatings with Multifunctional Properties", 17.-21. Juni 2007

[T105] J. Vetter, O. Zimmer, H.-J. Scheibe, V. Weihnacht

"Types of cathodic vacuum arc sources and ist application potential"

ICMCTF 2007, San Diego, CA, USA, 23.-27. April 2007

[T106] V. Weihnacht

"Leistungssteigerung von Werkzeugen zur Aluminiumbearbeitung durch Beschichtung mit ta-C"

V2007, Dresden, 16.-18.Oktober 2007

[T107] **is** B. Winderlich, S. Bonß, B. Brenner, J. Standfuß

"Strategien zum beanspruchungsgerechten Fügen und Randschichtveredeln"

Steinbeiß-Symposium "Fertigung und Bauteileigenschaften", Stuttgart, 20. Juni 2007

[T108] O. Zimmer

"PVD-coating - A new solution for antistatic finishing of filter media"

EDANA Nonwovens Academy Leeds, Leeds, 29.-30. März 2007

[T109] O. Zimmer

Innovationscluster "Nano for Production"

Workshop "Innovationscluster Nano for production" im Rahmen des Dresdner Innovationsforums, Dresden, 28. November 2007

[T110] O. Zimmer, J. Berthold, P. Siemroth

"Filtered Vacuum Arc - technology for advanced applications"

HIPIMS-Days, Sheffield, UK, 10.-11. Juli 2007

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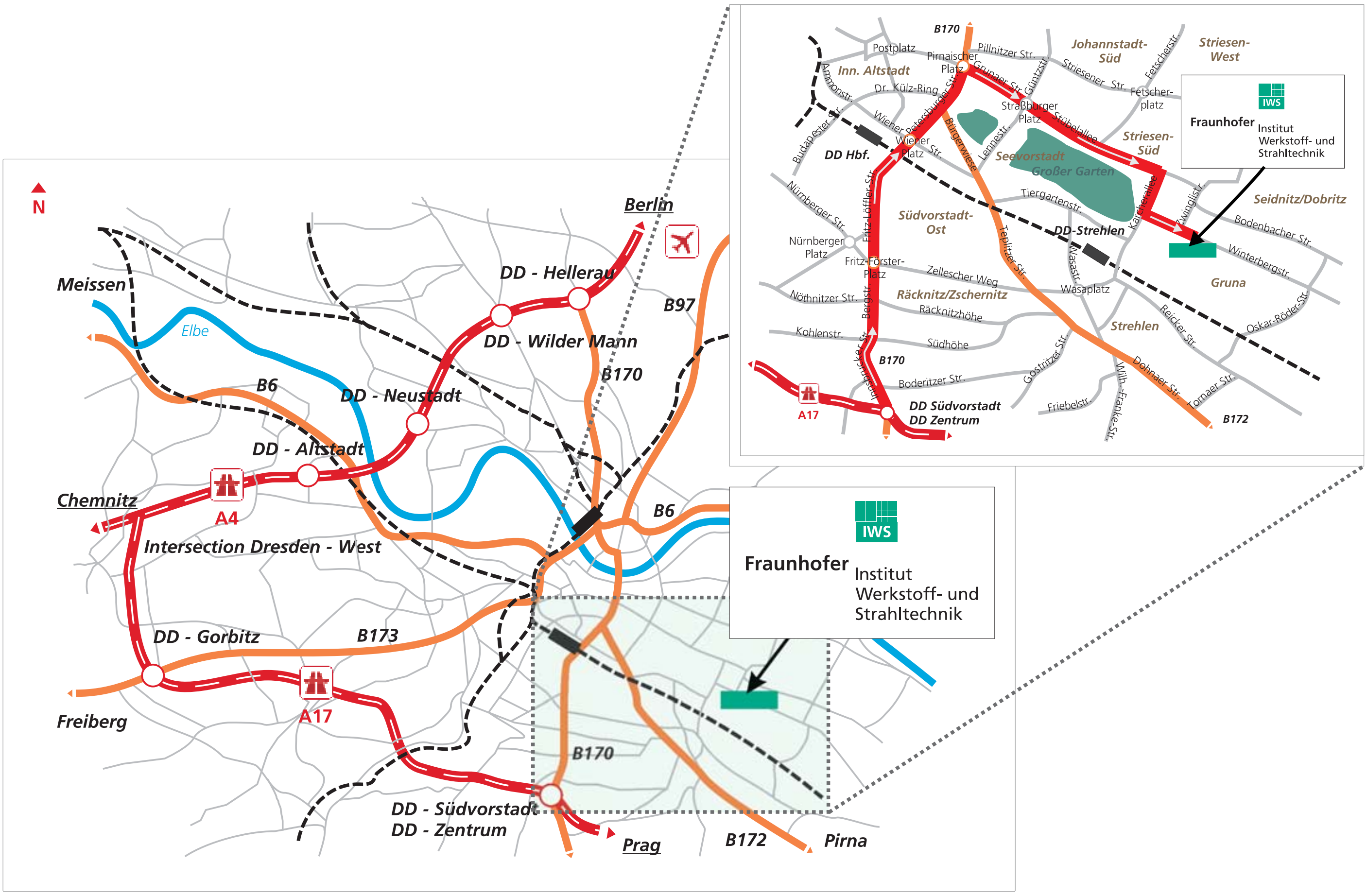

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- from Dresden main railway station take line #10 to Straßburger Platz
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- take Autobahn A4 or A13 to intersection Dresden-West, follow new Autobahn A17 to exit Südvorstadt / Zentrum
- follow road B170 in direction Stadtzentrum (city center) to Pirnaischer Platz (about 6 km)
- at Pirnaischer Platz turn right towards "Gruna / VW-Manufaktur"
- continue straight until the end of the "Großer Garten" (Great Garden) and then turn right onto Karcherallee
- at the next traffic light turn left onto Winterbergstraße and continue straight until IWS

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