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LASER TECHNOLOGY LIVE

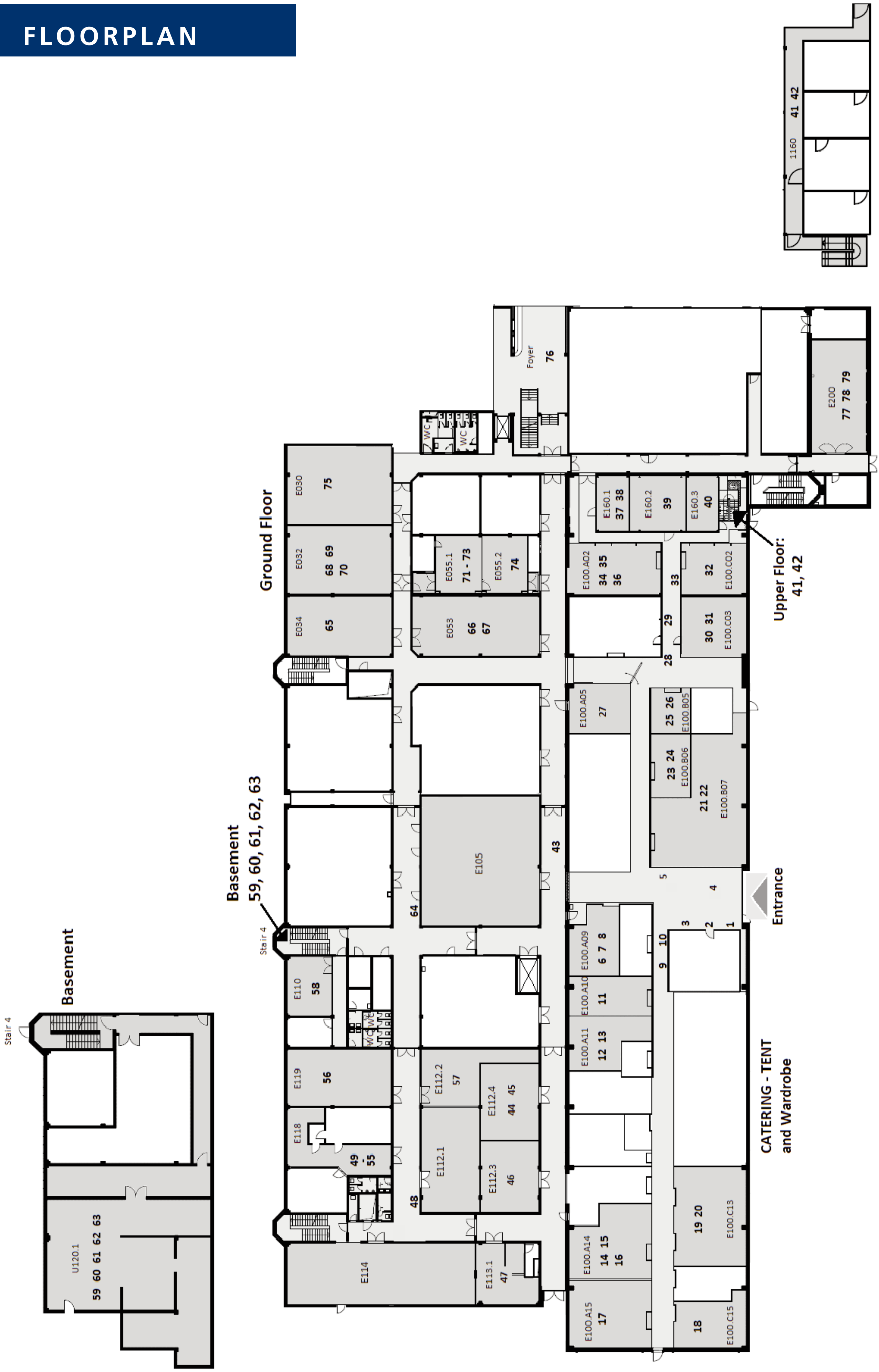
AKL'12 PRESENTATIONS AT FRAUNHOFER ILT AND APPLICATION CENTER

- **WEDNESDAY, MAY 9, 2012**
  14:30 - 16:30
- **FRIDAY, MAY 11, 2012**
  14:30 - 17:30

Fraunhofer
ILT

CONTENT – LASER TECHNOLOGY LIVE

FLOORPLAN



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E160.2

Cutting of Thin Glass

Laser micro-processing of thin glass is a rising business. Especially as flat-panel displays e. g. used in modern multimedia cell phones are a still rising market new technologies for machining of those thin glasses are needed.
Therefore in the next years and already now exists a vast demand for fast, efficient and highly qualitative manufacturing processes for thin glass sheets which include for example cutting and drilling of thin glass sheets. Laser processing especially with ultra-short pulse lasers is a promising solution.
The main focus on the processes is a fast and crack free ablation of the glass. To achieve a deep understanding of the process of ultra-short-pulsed laser ablation of dielectrics, the whole process is investigated including modeling and process diagnostics.

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CUTTING

BOOTH 23

E100.B06

High Speed Processing

For the development of cutting and welding processes Fraunhofer ILT uses a dynamic 2D-machine with 5 g acceleration and 300 m/min maximum speed. Due to a fixed working head/moved work piece, the machine is predestined for versatile diagnostics in high speed process development.
High speed laser processing is a key factor in the production chain of light weight components based on either fiber reinforced plastics (FRP) or high strength steel. Both materials are mechanically difficult to cut. Laser cutting is an attractive alternative to blanking or milling due to the fast, wear-free and flexible features of the laser process.
When cutting and welding automotive steel, a high processing speed and flexibility improves the economic efficiency. A cutting speed of 100 m/min in 1 mm thick steel can be achieved with 4 kW laser power.
When processing FRP material in high speed processes, the desired effect is the reduction of thermal load of the material. As in processes which employ ultra-short pulsed laser radiation, a short interaction time minimizes the heat affected zone.

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E100.B05

CO_2 Laser Cutting - Concepts for embedding Cognition and Self-Optimization

The flat-bed laser cutting machine Trumpf TruLaser 5030 is installed at the Fraunhofer ILT as a business case within the Cluster of Excellence at RWTH Aachen University. For the research on Technology Enablers for Self-Optimization, the machine is equipped with an optical sensor system that allows coaxial observation of the process. Current works focus on the acquisition of information about the running process and the control of the process in order to enhance quality and productivity of the manufacturing system. Meta-modeling is used for visualization of correlations between setting parameters and processing result and for embedding part of this knowledge into the machine. The three partners, Fraunhofer ILT / Chair LLT and NLD jointly develop a system that implements such functions for fast set-up and determination of errors. One central part of this system is the compensation of focus-shift by process control.

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BOOTH 26

CUTTING

E100.B05

Cutting of Fiber reinforced Plastics

The reduction of cycle times for the production of fiber reinforced plastic (FRP) components is one of the priority objectives to push a wide-spread use of FRP components in mass production. FRP materials with a thermoplastic matrix are one approach to reach this goal. In contrast to thermoset materials, thermoplastic reinforced material is moldable, can be remolten for joining and allows automated process chains including processes such as tape laying / tape winding or 3D fiber spraying. Laser processes are involved throughout the process chain for cutting precursor material, for consolidation, cutting and trimming of parts or for joining and significantly contribute to increase automation and flexibility.

Laser cut automotive parts are presented, either cut with a CO_2 laser or with a fiber laser.

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BOOTH 43

NEXT TO GATE TO E100

Laser Processing Heads for Cutting and Welding

Laserfact GmbH develops, produces and delivers beam tools for flexible manufacturing with lasers. The aim of Laserfact is the provision of laser processing heads which perform extremely reliably, efficiently and flexibly in industrial laser applications. By using sophisticated optics and nozzle design combined with solid engineering the products of Laserfact achieve optimum performance with striking simplicity in construction, operation and application. Laserfact supplies beam tools for laser cutting and laser welding with CO_2 lasers and solid-state lasers.
A specialty of Laserfact are combi-heads for flexible laser cutting and laser welding of sheet metal components without changing heads. A combi-head allows software-controlled process change on demand and with it significant cost savings regarding investment and operation.

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BOOTH 68

JOINING

E032

Laserwelding of Copper and Steel for Battery Modules

Lithium-ion battery cells are currently the most promising technology for energy storage in e-mobility. The cost-efficient production of energy storage is a key technology for this rapidly growing industry. The laser beam welding can make a major contribution for flexible and reliable joints. Because of price and availability the so called 18650 cells can be used, which are primarily built in notebook computers and power tools. Since these cells have a small capacity in comparison to large-sized cells, so they must be connected in parallel to form larger cells. In this case a copper terminal is welded to a nickel-plated low alloy steel can of the cell in an overlap configuration. The can is the negative pole of the cell. The joint must be achieved without a full penetration of the approximately 0.25 mm thick steel. This is carried out using spatial light modulation, which enables a controlled weld depth.

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BOOTH 69

JOINING

E032

Laserwelding of Copper using Green Wavelength

One research focus of the micro joining group at Fraunhofer ILT is on welding of various copper materials with thicknesses below 1 mm. The stability of the welding process and resulting seam defects on the one hand and the influence of joint geometry on the other are the main topics. The use of high brilliance beam sources such as fiber and disk lasers in the infrared range as well as use of a frequency-doubled laser source in the green wavelength range is under investigation. Also spatial and temporal power modulation is implemented for stabilizing the melt pool. In addition to the modulation methods the use of green laser radiation is investigated for welding. The advantages are an increased absorption in cold copper materials and due to the high beam quality provided by the source a smaller spot and therefore a higher intensity. The laser source is a prototype built by a project partner for the project CuBriLas.

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BOOTH 21

E100.B07

Practical Laser Solutions for Cutting and Welding in Sheet Metal Solutions

Laser beam welding renders new application and new design solutions in sheet metal construction possible. Combined with laser beam cutting flexibility of production can be maximized. New ways of design are approach utilizing the specific properties of both processes. The parts on display show a bunch of applications. Pipe fittings can be welded using direct programming from calculation of the cylinder sections and subsequent cutting and welding on the same track in one set-up. Production welding of sandwich structures is facilitated by combining overlap and stake welds. A number of material can be processed including mild steels with up to 0.35 % carbon, stainless steels, titanium alloys, nickel base alloys, as well as copper and bronze. Recently developed are welding processes for aluminide-base alloys, martensitic stainless steels, and dissimilar materials. Sheet thickness range from small and mid section range in standard sheet metal construction to heavy sections with up to 20 mm, e.g. for parts for chemical equipment, shipbuilding, and structural components.

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JOINING

BOOTH 24

E100.B06

Scanner Welding of Battery Contacts with Fiber Lasers

Lithium-ion batteries are at the time the most potential technology for energy storage in electro mobility. The cost efficient production of energy storage is key requirement. To construct appropriate battery packs the separate cells have to be electrically interconnected. In contrast to bolted connections, substance to substance bonds between conductors by laser welding have the advantage of a much lower electrical resistance and therefore an increase in efficiency. Laser scanner welding enables a flexible beam positioning, a low energy load, as well as minimized positioning and lower cycle times.

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E118

Coaxial Laser Brazing Head

Laser brazing has been established as a widely used joining technology in the automotive and electronics industry, particularly in car body manufacturing, due to its specific advantages. Until now only laser brazing heads with lateral brazing-wire feeding have been deployed for industrial manufacturing. In general the brazing wire is arranged so that it is fed from the forward direction. During the process this direction has to be maintained through constant reorientation of the brazing head. This leads to a loss of productivity, reduced quality, extensive programming of controlling axes and difficulties in brazing complex shapes, especially with radii less than 10 mm. For those reasons a brazing head with coaxial wire feeding in combination with a ring shaped laser beam would be of great advantage. The exhibited laser brazing head features such a coaxial ring-shaped laser beam distribution with coaxial wire feeding and integrated coaxial process control. This enables the brazing head to be used independent of direction and without constant reorientation.

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BOOTH 30

E100.C03

Improved Performance of Hot-Stamped Ultra-High-Strength Steel Parts by Local Heat Treatment using a High Power Diode Laser

Ultra-high-strength steels are widely used in the automotive industry. They allow a reduction of weight and improve crash-behavior. A state of the art process for ultra-high-strength steel parts is hot-stamping of boron alloyed steels, producing fully martensitic microstructures in the final part. Although hot-stamped parts offer fair ultimate strain, higher ultimate strain may be required in critical zones to improve crash behavior and joining.
A way to increase ultimate strain in a desired zone is local softening by laser heat treatment. Non-treated areas retain their strength. The process is temperature controlled, using a fiber-coupled high-power diode laser with a maximum laser power of 12 kW and a zoom-optics with a rectangular beam profile and top hat intensity distribution.

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SURFACE TREATMENT

BOOTH 59

U120.1

Optic Manufacturing by Laser Polishing and Laser Form Correction

The current state of the development of a laser based process chain for manufacturing fused silica optics is presented. This process chain is currently under development and focuses on the fabrication of highly individualized, non-spherical optics, since conventional manufacturing methods tend to be comparatively slow and expensive in this field.

In a first step fused silica is ablated with laser radiation to produce the geometry of the optics. A subsequent laser polishing step reduces the surface roughness and a third step uses micro ablation to remove the last remaining redundant material. Although the process chain is still under development, the ablation of fused silica already reaches ablation rates above 20 mm^3/s. The second step, the laser polishing, reduces the roughness significantly. The micro-roughness is already suitable for optics but the form accuracy is still insufficient. Therefore the third processing step is under development to optimize the form accuracy.

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BOOTH 60

SURFACE TREATMENT

U120.1

Machine Tool for Laser Polishing

Together with Maschinenfabrik Arnold and S&F Systemtechnik Fraunhofer ILT developed a machine tool for laser polishing of complex shaped 3D parts made from metals. The machine tool as well as examples of laser polished parts from tool and mould making and medical engineering will be shown.
Polishing of metals with laser radiation is a new method for the automated polishing of 3D surfaces. A thin surface layer is molten and the material flows from the peaks to the valleys. The main characteristics are:

- High level of automation
- Short machining time especially in comparison to manual polishing
- No pollutive impacts from grinding and polishing wastes and chemicals
- Polishing of grained and micro-structured surfaces without damaging the structures
- Generation of a user-definable and localized surface roughness
- Small micro roughness as the surface solidifies out of the liquid phase

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BOOTH 65

SURFACE TREATMENT

E034

Laser Interference Patterning of Large Areas

Functionalization of surfaces with nanostructures for selectively influencing its properties deliver many possible applications in a wide field of different markets. While stochastic nanostructures can be created by various rather inexpensive methods and even on large areas, is the creation of deterministic nanostructures expensive and often limited to small areas.
Multi-Beam-Interference (MBI) allows to directly enhance surfaces with periodical structures with a size from 100 to 5000 nm in one process step. It is relative material independent and can be applied on most polymers and metals. Normally a "spot-by-spot"-approach is used to structure areas larger than diameter of the overlapping laser beams which has the disadvantage of a high process time. To overcome this handicap we like to present you a new approach with a continuous movement along a symmetry axis of interference intensity distribution. It allows a huge decrease in process time and more homogenous structuring of large areas.

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BOOTH 61

U120.1

Structuring of Design Surfaces by Laser Remelting

The surface of a part or product strongly influences its properties and functions, like abrasion resistance, haptics as well as the visual impression. Therefore, many plastic parts have structured surfaces such as leather textures on car dashboards. Usually these structures are manufactured in the injection mould by photochemical etching which is a time consuming and expensive process.
A totally new approach to structuring metallic surfaces with laser radiation is structuring by remelting. In this process no material is removed but reallocated while molten. The innovation of structuring by remelting is the totally new active principle (remelting) in comparison to the conventional structuring by photochemical etching or the structuring by laser ablation (removal). The advantages of structuring by laser remelting are up to 10 times shorter processing times compared to laser ablation, the avoidance of post processing steps and the possibility of totally new surface appearances with multiple gloss levels.

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SURFACE TREATMENT

BOOTH 32

E100.C02

Micro Cladding of Gold Contacts

Parts which involve electric contact during operation such as metal switches for mobile phones or bipolar plates for fuel cells are conventionally electroplated with gold to reduce resistivity A novel laser-based method which involves laser cladding gold contact spots can spare up to 90 % of gold with no loss of electric properties. Gold powder with a particle size around 10 µm is cladded onto a metal substrate (e.g. stainless steel, nickel-based alloy) producing a contact spot with height and diameter below 100 µm. The spot is metallurgical bonded to the substrate with a low dilution to keep the electric conductivity. To improve the deposition rate of gold spots a multi-spot optic is investigated which allows the simultaneous cladding of 22 spots.

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E100.A11

Advanced Material Concepts for Wear Protection by Laser Cladding

Besides the deposition of conventional wear protection materials laser cladding offers the possibility to create tailored materials on the surface. Multi-layer laser cladding is a technology to produce metal based graded materials. The graded materials are formed in-situ layer by layer with a continuous change of composition of the additive materials in each layer. For example such layers can combine fatigue strength with wear resistance. Another concept is the production of compound materials with a ductile metal matrix and embedded hard phases (e.g. carbides) to improve wear properties. The addition of nano particles is another approach which is aimed at grain refinement to improve ductility as well as hardness and strength.

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BOOTH 40

DRILLING

E160.3

Drilling with Laser Radiation

Laser drilling enables the machining of different materials like steel, high-strength materials, multi layer systems, ceramics and plastics with high reproducibility and productivity. It offers an alternative manufacturing method to mechanical drilling, electric discharge machining (EDM), electro chemical machining as well as electron beam drilling.
Laser drilling is applicable for many manufacturing demands in industry due to the small achievable hole diameters, the high flexibility (e. g. different diameters and inclination angles) and the large attainable aspect ratios. By using new diode-pumped lasers such as fiber lasers it is possible to increase quality and productivity synchronic in comparison to state-of-the-art flash lamp-pumped Nd:YAG lasers.
Especially for the manufacturing of cooling holes in turbo engines parts drilling with laser radiation allows to machine multilayer systems (e. g. substrate, bond coat and thermal barrier coating) at acute inclination angles.

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BOOTH 37

E160.1

Laser-Beam Helical Drilling of High Quality Micro Holes

A large variety of modern components and products such as fuel injectors and spinning nozzles require holes drilled to very high standards with regard to roundness, diameter and aspect ratio. Laser-beam helical drilling has shown great promise to produce these high quality micro holes.
In helical drilling the laser beam is moved in rotation relative to the work piece.
In this case, the rotational movement is produced using a Dove prism, mounted in a high speed, hollow shaft motor. If the beam is shifted parallel to the optical axis, the outgoing beam moves on a circular path; if, however, it is tilted in front of the prism, the outgoing beam traces the shape a cone.
Helical drilling allows the production of exact cylindrical and round holes in the range of 50 µm as well as negatively tapered holes.

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MICRO TECHNOLOGY

BOOTH 58

E110

High Speed Micro Scanner for In-volume Selective Laser Etching

A modular prototype of a high speed micro scanner is demonstrated utilizing acousto-optical beam deflection, moving-magnet scanners and resonant scanners. Both high precision (focus radius 1 µm) and high speed (10 m/s even at focal length of 10 mm) are achieved. The high speed micro scanner will soon be made commercial available. Using high repetition rate lasers like fs fiber lasers and high power slab amplifiers (> 150 W) together with the new high speed micro scanner productive 3D modification is now possible with sub micrometer precision. High power fs-laser radiation (> 150 W) is scanned with high speed and used for rapid 3D micro modification of transparent materials. The laser modified material is selectively removed by wet chemical etching (in-volume selective laser etching - ISLE). Micro channels, 3D micro parts and shaped micro holes in glasses and sapphire are demonstrated for applications in medical diagnostics and mechanical engineering.

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E160.1

Functionalizing of Tool-Surfaces with ps-Lasers

Micro-and nano-structured surfaces in plastics are now found in many areas of everyday life. Many of these structures are inserted during the injection molding process with a structured tool inserts. These tool insert scan be made by using lasers with ultra short pulses. The use of ultrafast lasers offers the advantage of largely independency from the chosen material, so that e.g. hardened steel tools can be edited. Likewise, the geometry influencing melting deposits, which are obtained through the use of nanosecond lasers can be avoided to a large extent.
In another application, the melt-free structuring of mechanically stressed surfaces, offers a way of minimizing friction for example on components of internal combustion engines.

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1160

Laser Structuring with a sub ns-Microchip Laser

The ongoing miniaturization of products in fine mechanics, electronics, medical technology and sensor devices requires components with structure sizes in the micrometer range and accuracies with less than a micrometer. The laser ablation process provides an appropriate manufacturing technology for micro machining of metals, ceramics and polymers. Since focused laser beams provide ultra high intensities, laser ablation of hard materials like ceramics, tungsten carbide and diamond is possible with high accuracies. Using ultra short pulsed lasers in the femtosecond and picosecond range laser ablation is an ideal alternative to conventional processes like EDM. These laser sources are very expensive.
To overcome this bottle neck and to enlarge the ablation rate a microchip laser with a pulse duration of 600 ps is used. This pulse duration allows a combination of the high precision machining and a cost effective solution as microchip lasers are a much cheaper alternative.

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BOOTH 42

1160

Cost-Effective Laser System for Micro Manufacturing

The development of a small sized, integrable laser manufacturing system is one of the demanding requests of the EU-FP7 funded research project Polytubes. For the demonstrator applications, drilling processes with a borehole diameter of Ø 2 µm in polymeric materials, e.g. thin-walled tubes and sizing operations are requested. Actual commercial laser systems provide fast, contactless and precise micro processes but require wide installation space, are cost-intensive and often operate with focal sizes of several µm. The developed system consists of a remote controlled laser unit and of an additional inner handling unit for precise multi-axes positioning. The combination of a 600 ps-Microchip-Laser and sharp focusing allows high resolution processes above the ablation threshold of polymers, metals and ceramics. The processing parameters can be aligned to cutting, drilling or even ablation operations by an automated laser power control and vision assisted focal plane adjustment. According to material´s absorption the optical components can be customized to 375, 532 or 1064 nm.

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MICRO TECHNOLOGY

BOOTH 34

E100.A02

Glass Soldering by Laser Radiation

In industrial manufacturing glass solders are mainly applied in electro technology and electronics especially for the closure of electrode feed through and housing. The durability and the mechanical load of a glass solder joint depends on the mechanical stresses. Because of the problems with mechanical stresses the most joining processes require a temperature-time-profile which causes a thermal impact for the whole componentry. Often the required temperature sequence damages sensible components inside the housing by diffusion processes. Thus a soldering technology which works with reduced temperature input and a local heating is needed.

Glass soldering by laser radiation is an alternative to reduce the thermal input because of the localized energy absorption. The absorption of the laser radiation by the glass solder is an essential condition for a successful soldering process. By absorption the laser radiation the necessary temperature for a constant heating, melting and crack free soldering is achieved.

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E030

Laser Transmission Bonding

In the fabrication of hybrid micro-devices and systems consisting of different single components silicon is usually used as a base material. Conventionally these components are joined by bonding methods such as Silicon Direct Bonding and Anodic Bonding. The disadvantages of these joining methods are causing a high thermal stress and using the entire bond surface. As an alternative to these conventional areal bonding methods laser transmission bonding offers an unique opportunity to realize continuous selective bonding through a localized application. The exact energy deposition minimizes the heat affected zone and the thermal load of sensitive components can be reduced. Furthermore a locally selective joining is enabled.
At the Fraunhofer ILT a cw-thulium fiber laser and a galvanometer scanner are integrated in a commercial MaskAligner from Süss MicroTec. It allows the evaluation of the laser transmission bonding process on Wafer-Level using an industry-standard machine for various applications especially in Wafer-Level Packaging and 3D-Integration.

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BOOTH 70
MICRO TECHNOLOGY

E032

Microwelding of Bipolar Plates with Fiber Laser

Improvement of fuel cells is needed to reach higher performance and life circles for the adequate use in different applications. This can be achieved by design of special flow geometries of the flow field on both reagent sides. Therefore is the use of two different bipolar plates substantial. These parts of the fuel cell need to be mounted together, which is realized by laser beam welding. For this application a laser beam with excellent focusability is needed in order to achieve a small focus diameter (below 100 µm) in a large working area (216 x 216 mm²). This allows welding of thin bipolar plates (each 0.1 mm thick) with high welding speed up to 800 mm/s. The total welding seam length is about 3600 mm, so the production of a bipolar plate lasts for about 4 s. Through a proper shielding gas concept and the high welding speed seams without errors are achievable.

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BOOTH 28

HALLWAY IN FRONT OF E100.A03

Interactive Process Simulation for Laser Cutting

Laser cutting is an industrially established production technology. Nevertheless there is a great influence of dynamical processes on production quality regarding high cutting speeds assuring efficient facility utilization as well as for low cutting speeds, which are used to cut contours accurately.
For finding suitable control directives experimental diagnosis is found to be crucial. Physical modeling is therefore always based on experimental evidence.
Quality features such as surface roughness or adherent dross are caused by the dynamics of the process. The various process states and characteristic phenomena (e.g. evaporation, drop formation, gas flow) are visualized in a process simulation and have been experimentally validated.
The process simulation reproduces experimental details, observed by the diagnostic system and makes it possible to retrieve possible strategies to avoid defects like adherent dross.

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MODELLING AND SIMULATION

BOOTH 33

HALLWAY IN FRONT OF E100.C02

Modelling and Simulation of Laser Keyhole Welding

Laser welding is a well established production technology, which in the industrial application is rated by productivity and product quality. Nevertheless there seems to be still a certain potential for a design optimization based on physical modeling and numerical simulation. The extension of suitable process domains by a modified process control is therefore based on a fundamental understanding of the physical processes occurring in laser welding applications.
An interactive process simulation for laser welding applications based on an approximative model has been developed, which resolves the form of the welding capillary and gives the dimensions of the weld pool in axial and azimuthal direction.
Whereas commercial tools for laser welding model a fictitious heat source according to experimental data like metallographic cross-sections, the process simulation gets the weld pool dimensions from the underlying physical processes like the diffusion of heat and the fresnel absorption on the capillary surface. It has been validated against experimental data.

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BOOTH 64

MODELLING AND SIMULATION

IN FRONT OF E105

Computational Photonics Engineering

When dealing with laser radiation in the field of material processing, laser measurement applications or in developing laser sources one is always faced with the problem of beam guiding and shaping. For the proper design of optical components and systems the use of numerical tools is most often inevitable. In some cases it is sufficient to treat the laser radiation in the geometrical limit taking laser beams as light rays. But often the coherence and small transverse dimensions of the laser beams make it necessary to consider the wave nature of laser radiation. Basically this means to solve Maxwell equations in some approximate form. The most widely used approximation is the paraxial approximation that leads to the solution of the Fresnel integral or equivalently the SVE-approximation of the Helmholtz equation. For wide angle beam propagation as is for example the case with high NA focusing other numerical methods have to be employed.

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BOOTH 77

SYSTEM TECHNOLOGY

E200

TCP-Seam Tracking

Industrial system for simultaneous TCP- and seam tracking is shown.
During longitudinal seam welding of pipes in industrial manufacturing plants, lacks of fusion often lead to production downtimes and returns. Lack of fusion in the weld seam that has not been identified can lead to a failure of the seam in further processing. The reason for the defect is a lateral shifting of the groove in relation to the laser beam, which can be caused by the pipe twisting, the joining edges being out of alignment, poor initial setting of the plant or of the seam-tracking sensor and shifting of the laser beam owing, for example, to thermal influence. While the first two effects can be controlled and corrected using conventional seam-tracking sensors and proper tracking, thermal effects result in a shifting of the beam within the beam guiding system. The principle suggests that this can be neither identified nor corrected by conventional seam tracking. So the aim is to ascertain the beam's position relative to the seam, in order to have the seam tracking correspond of the TCP.

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BOOTH 22

E100.B07

Process Monitoring and Control during Hybrid Laser-arc Welding

In current manufacturing, conventional arc welding processes, such as MIG/MAG and submerged arc welding, are mainly used to produce joints of metal sheets over a wide range of materials and wall thicknesses. Yet the manufacturers are facing problems like a low productivity and reliance on the skill of operators to change process parameters to maintain weld quality, particularly during changeovers, i.e., when material and/or wall thickness is changed. Hybrid laser-arc welding offers many advantages compared with conventional arc or laser welding. Producing deep penetration welds comparable with laser welds, and at the same time having an improved tolerance to joint fit-up when compared with laser welding. The coupling of the two processes - laser and electric arc welding – leads to an increased number of parameters and degrees of freedom, respectively. In the presented work a camera based coaxial monitoring system is employed to achieve controlled conditions for laser MIG/MAG hybrid welding processes.

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SYSTEM TECHNOLOGY

BOOTH 78

E200

Motion-Tracking for Process Control

Advances in beam delivery systems and laser sources allow higher processing speeds for manufacturing systems. Laser processes with high feed rates and small focus diameters operate in process regimes where a deviation in actual process parameters significantly influences quality. One important factor herein is the laser power per unit length coupled into the work piece, but most beam delivery systems provide insufficient or no information about the current velocity of the laser spot relative to the work piece.

Motion-tracking allows acquisition of this vital information. If implemented coaxially, it detects actual speed including all deviations from positioning of scanning mirrors and handling systems. In diagnostic mode, motion-tracking can be employed to track the real processing path in order to determine optimization potential in nc-programming. For industrial application and quality documentation, motion-tracking enables control of laser power amongst other setting parameters in order to ensure constant energy input for the laser process and therefore constant quality.

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BOOTH 06

SYSTEM TECHNOLOGY

E100.A09

Monitoring the Melt Pool Geometry at Laser Cladding

Laser cladding is used almost exclusively on complex geometries, durable and high-valued components, e.g. for stationary gas turbines and aero engines. These parts have to fulfill high safety standards and very high quality and documentation requirements. Understandably, process documentation, monitoring and control methods play an important role here. The CPC system (Coaxial Process Control) developed at the Fraunhofer ILT/LLT is adapted to the cladding process combined with a process illumination by High-Power LEDs. The aim is to extract quality-relevant process information in-situ whilst laser processing by monitoring the melt pool geometry as a robust process parameter. This information should interrupt defective processes in time to initiate corrective processing strategies, and fulfilling the relevant quality assurance documentation requirements (DIN ISO 9000 ff., VDA 6.1), e.g. for safety-relevant components.

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BOOTH 07

SYSTEM TECHNOLOGY

E100.A09

Measurement of the Powder Density Distribution for Powder Feed Nozzles

The Laser Metal Deposition has established as a technology for functionalization of surfaces, repair and modification of components as well as generation of new parts. The most important field of application is the manufacturing of tools and combustion engines, stationary gas turbines and aero engines. At the laser cladding process a filler material in form of a powder is melted using the laser beam and fused with the base material. Therefore the powder feeding into the melt pool is an important influencing variable for the result of the process. The powder efficiency, the oxidation by the ambient atmosphere and the roughness of the cladded layer are influenced by this parameter. For this reason there is a need for a characterization of the powder-gas-flow to assure the quality of the processing result. As a solution a measurement method has been developed that allows to scan the powder density distribution of the entire powder-gas-flow.

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SYSTEM TECHNOLOGY

BOOTH 08

E100.A09

Quality-Control-System for Laser Brazing

The setup of coaxially integrated quality control system for laser brazing is exposed. Two cameras are observing the process in different spectral regions. The first camera collects the reflected light of an external illumination while a second camera records the near-infrared spectral region. Hence, a real image and a distribution of the thermal radiation are generated. With the combined analysis of these two images it is possible to measure process parameters like brazing velocity, brazing time and process geometry. Moreover seam imperfections like pores, surface quality and the wetting behavior of the process can be detected while their emergence. As an additional time and money consuming off-line inspections is avoided by this system it is a useful application for industry where demands on seam quality are very high, e. g. in the automotive sector. The presented system provides the opportunity to monitor the whole brazing process: seam quality and process parameters are documented. Results and film material of a brazing process are shown in a presentation.

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SYSTEM TECHNOLOGY

BOOTH 79

E200

Polygon Scanner Applications

Latest developments in high power ps-lasers achieve new records regarding average laser power and pulse rate. Due to the high scanning speed of polygon scanners a low pulse overlap can be achieved for an optimal result in full utilization of the laser power. The new developed prototype of a polygon scanner based micro structuring machine has a scan field of 100 mm and a maximum scan speed of 330 m/s. Biggest challenges to be solved are the modulation of the laser beam with several megahertz synchronously to the laser pulses and the correspondingly adapted positioning of the laser beam on the work piece.
Areas of application include the large-scale structuring or laser treatment of different materials with high power ps-lasers. In addition to current applications of the system with ps-lasers, high-speed processes with cw lasers, such as the quasi-simultaneous soldering of solar cells or dicing of semiconductor wafers, are possible.

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BOOTH 47 — **LASER MEASUREMENT TECHNOLOGY**

E113.1

Inline Thickness Measurement of Plastic Films with OCT

Optical Coherence Tomography (OCT) is a technology based on an interferometric measurement principle. With OCT, distances, thicknesses or tomographic 3D images can be measured. The OCT sensor developed by Fraunhofer ILT uses infrared light to detect refractive index changes within a measuring range of 4.5 mm and with an optical resolution of 7 µm. The available dynamic range reaches up to 60 dB.
One application is the inline monitoring of multilayer plastic films during the production process. Increasing requirements upon packaging films are reflected technologically in an increase of functional layers of plastic films. Until now, an inline film inspection system detecting the single layers' thicknesses separately has not been available. In addition to better process control, the interferometric sensor will enable a control concept for individual film thicknesses to be implemented. By saving raw materials, companies can attain significant cost reductions and increase productivity.

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BOOTH 18 — **LASER MEASUREMENT TECHNOLOGY**

E100.C15

Laser-based Material Identification and Sorting

Fast laser identification of materials is applied to sort different materials. Individual pieces of material are transported on a conveyor belt at a speed of 3 m/s and online analyzed by a laser beam. Within a few microseconds the laser carries out a multi-element analysis of the material. According to the result of the laser-spectroscopic analysis, the pieces are ejected into the appropriate fraction.
This technique can be used in various industrial applications. In the recycling industry a more detailed classification becomes increasingly important with increasing recycling rates. To produce a variety of alloys using a high fraction of recycled material, it is necessary not only to separate different metals, but also to fractionate different alloys of the same metal from the waste stream. Scrap aluminum is sorted as well as other light metals or high and low alloyed steel.
This online measurement technology can also be applied to characterize and sort streams of raw material, e.g. minerals and ores, and for mix-up inspection in a production line.

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BOOTH 56

E119

At-Wavelength EUV Defect Inspection

One of the most challenging requirements for the next generation extreme ultraviolet lithography (EUV) lithography at 13.5 nm or even 6.X nm is an extremely low amount of critically sized defects on mask and mask blanks for mass chip production. Fast and reliable defect inspection of such mask blanks is still a challenge. Here we present the current status of the development of our actinic Schwarzschild objective based microscope operating in dark field with EUV discharge produced plasma source.
For characterization of the microscope performance, several programmed defect structures – artificial pits and bumps were created on top of multilayer mirror surfaces and investigated both with EUV microscope and atomic force microscope. Sensitivity of actinic inspection to defects of different sizes in dark field mode without resolving the defects is under study. The dependency on defect shape, size and position in relation to the multilayer surface and its scattering signal are discussed together with results of a defect mapping algorithm.

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EUV- AND PLASMA TECHNOLOGY

BOOTH 57

E112.2

Nanopatterning with EUV Interference Lithography

Interference lithography (IL) with extreme ultraviolet (EUV) radiation is one of the most promising candidate technologies for resist patterns in the sub-20 nm range.
The distinct features of EUV light such as the short wavelength, allowing for resolutions within the range of a few nanometres in printing (down to $\lambda/4$), and its strong interaction with matter, which permits photochemical sensitivity, make it a promising candidate for future nanostructuring systems.
Utilizing the experience of Fraunhofer ILT with plasma sources of high intensity EUV radiation, the nanopatterning setup for EUV-IL was built in RWTH Aachen University (RWTH-TOS).
The setup is operating with up to 4" substrates, with a single illumination field size around 1000x1000 μm^2. The method is substrate-independent, allowing for great flexibility of the technique. Nanostructuring throughput is up to 10 times higher than e-beam patterning. Dense patterns with sub-10 nm resolution have been experimentally demonstrated.

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Freeform Optics for Illumination Applications

Traditional illumination optics based on apertures and imaging optical components are limited in terms of efficiency and compactness. These approaches depend on numerous optical components which make the alignment process complicated. By using freeform optics, all optical functions can be integrated into one component. The freeform optics transforms the input intensity distribution (e.g. given by an LED) into a desired output intensity distribution. At Fraunhofer ILT and Chair TOS, efficient algorithms have been developed to calculate the shape of freeform optics by the input and output intensity distributions. Within the BMBF funded project AUTOLIGHT, a segmented freeform optics has been developed that generates a fog light intensity distribution. By segmenting the surfaces of the freeform optics, the thickness of the optics can be limited, and the replication of polymer freeform optics is simplified. The fog light freeform lens as well as other freeform optics will be displayed.

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BOOTH 76

LASER AND LASER OPTICS

FOYER

High Brightness Diode Laser Modules

High power diode lasers are well established for pumping and materials processing due to their robustness and compactness. The major drawback of those sources based on conventional high power diode laser bars is their comparably low brightness. Current research performed at Fraunhofer ILT covers two innovative approaches: Firstly, 14 broad area single emitters are spatially and polarization multiplexed for high brightness fiber coupling. Secondly, spectrally stabilized diode laser bars are the key component for high power dense wavelength division multiplexing (HPDWDM) which allows scaling the brightness of diode laser systems to the level of solid state laser systems. Various diode laser modules will be displayed: high-reliability spaceborne fiber coupled diode laser modules, spatially multiplexed diode laser modules and wavelength stabilized diode laser bars.

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E053

An Automated Setup for Measuring Laser-induced Damage Thresholds

The Laser-induced damage thresholds (LIDT) of optical components are major design issues for the laser engineer as they limit efficiency and lifetime of many laser systems. Not only does the LIDT of an optical component depend on the laser parameters such as pulse duration, wavelength, beam profile, etc.; it is also closely linked to the production process and thus difficult to estimate.
This setup allows testing of optical components with respect to LIDT and qualification of batches of them for usage in volatile laser systems. It is conform with ISO 11254-2 and can be adapted to a large variety of laser parameters. A monitoring system detects damage of a test spot online and stops its irradiation. In this way, contamination of the test sample is prevented and more test spots can be placed on the test sample. Environmental conditions can be defined (vacuum with $p < 1e\text{-}5$ mbar or vented with process gas).

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LASER AND LASER OPTICS

BOOTH 19

E100.C13

Gain-switched Diode-pumped Fiber Lasers

Volume markets in micro materials processing such as laser marking, ablation and drilling require cost-efficient, pulsed beam sources with fundamental mode beam quality. Pulsed fiber lasers perfectly match these demands due to their high efficiency, simple construction and excellent beam quality.
Gain-switched fiber lasers offer a new approach, promising considerable cost saving. The fiber laser is built as an all-fiber-oscillator and the pulse is generated by temporal modulation of the pump diodes. The repetition rate ranges from about 20 kHz down to single-shot operation. Since the laser can also be run in continuous or in quasi-cw mode, it offers a great deal of versatility and minimal amplified spontaneous emission, even at low repetition rates.
An ytterbium-doped fiber is double-side pumped with 500 ns pulses. Pulse widths of about 40 ns and a peak power of up to 9 kW at 1080 nm with a single-mode beam quality can be achieved.

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E118

Automated Assembly of MicroLasers

Presented is a miniaturized solid state laser for marking applications, featuring novel assembly strategies to reduce size, cost and assembly effort. Design and setup have been laid out with future automation of the assembly in mind. Using a high precision robot the optical components of the laser system are directly placed on a planar substrate providing accurate positioning and alignment within few microns. No adjustable mounts for mirrors and lenses are necessary, greatly simplifying the setup.

Consisting of a Neodymium doped crystal, pumped with a fiber coupled diode laser, an electro-optical Q-switch for pulse generation and a beam expander the entire assembly is confined in a 100ml space and delivers 4W of continuous output power at 1.064 µm with an efficiency greater than 40 % at pulse lengths of 10 - 20 ns.

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BOOTH 52

LASER AND LASER OPTICS

E118

Qualification of Opto-mechanical Components for Applications in harsh Environment

Laser resonators and complex sequential amplifier and frequency converting setups require a high mechanical stability of the optical components. For example, typical tilt stability requirements of oscillator mirrors are in the range of a few µrad. For scientific applications the environmental laboratory conditions are quite stable regarding temperature, humidity, pressure, etc. and usually offer low vibrational loads. In industrial or scientific fields though, many laser applications demand stable laser operation in unstable environments. This is particularly the case in airborne or spaceborne LIDAR-lasers where frequency, pointing and power output stabilities have to be maintained at different environmental conditions and with inevitable vibrational noise and mechanical shocks (e.g. during handling). During development and qualification of opto-mechanical components and sub-assemblies, these are subjected to thermal tests, mechanical tests (vibration and shock) and experimental modal analysis (to determine resonance frequencies).

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BOOTH 05

HALLWAY IN FRONT OF E100.B07

Tunable Lasers & Frequency Converters for Output Wavelengths from UV to MIR

Converting laser radiation to new application specific wavelengths increases the possibilities of using modern solid-state, fiber and diode lasers in industry and research. By tailoring the combination of fundamental laser source and frequency converter, the Fraunhofer ILT develops efficient and cost-optimized beam sources for a wide variety of applications.
The output parameters of our customized lasers and frequency converters can provide laser wavelengths from UV to MIR, output power from the Milliwatt level up to multi-hundred Watts and all time regimes from CW operation to ultrafast pulses. Exhibits include exemplary oven designs for nonlinear crystals optimized for high power harmonic and parametrical generation, as well as compact packages of frequency converters for diode and fiber lasers and of a blue diode pumped green emitting Pr:YLF laser.

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LASER AND LASER OPTICS

BOOTH 44

E112.4

Pick & Align – Active Alignment of Optical Components

At the Fraunhofer Institute for Laser Technology ILT a soldering and mounting technique has been developed for high precision packaging. The specified environmental boundary conditions (e.g. a temperature range of -40 °C to +50 °C) and the required degrees of freedom for the alignment of the components have been taken into account for this technique.
In general the advantage of soldering compared to gluing is that there is no outgassing. In addition no flux is needed in our special process. The joining process allows multiple alignments by remelting the solder. The alignment is done in the liquid phase of the solder by a 6 axis manipulator with a step width in the nm range and a tilt in the arc second range. In a next step the optical components have to pass the environmental tests.
At the booth several results will be shown and the mounting process presented.

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BOOTH 45

LASER AND LASER OPTICS

E112.4

3D Absorption Measurements of Optics on a ppm Scale

Thermal properties of optical materials play a crucial role in the design and development of high-average-power lasers and optics. Temperature rise and gradients inside of optical elements, caused by absorption of laser radiation, can severely diminish the efficiency and beam quality of a laser (e.g. nonlinear frequency conversion, Faraday isolators). To achieve an optimum system performance, materials with low absorption have to be selected first. Secondly, the unavoidable thermal effects have to be taken into account for the optimized design. Both steps require a good knowledge of the absorption at optical surfaces and in the bulk.
With the Photothermal Commonpath Interferometer (PCI) we are capable of performing 3D absorption measurements with ppm sensitivity in the bulk and at the surface of numerous optical materials, e.g. TGG, LBO, BK7, fused silica and many more.

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BOOTH 53

LASER AND LASER OPTICS

E118

Electro-Optically Actuated Zoom-Lens

Progressive miniaturization and mass market orientation denote a challenge to the design of dynamic optical systems such as zoom-lenses. Two working principles can be identified: mechanical actuation and application of active optical components. Mechanical actuation changes the focal length of a zoom-lens system by varying the axial positions of optical elements. These systems are limited in speed and often require complex coupled movements. In contrast, active optical components change their optical properties by varying their physical structure by means of applying external electric signals. An example are liquid-lenses which vary their curvatures to change the refractive power. A simplified zoom-lens is presented with no moving elements. The change of focal length is achieved only by varying curvatures of targeted integrated electro-optically actuated lenses.

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BOOTH 54

E118

Active, Multi-Aperture Beam Integrator for Application matched CO_2 Material Processing

Laser applications such as material heat processing require uniform intensity distributions within the target zone. If the laser mode is not known or changes in time, the design of optical systems for beam homogenization is most challenging and often does not meet specific requirements. In this case beam integration systems are applied that integrate multi-aperture optical elements. Homogenization is done first by beam separation and second by superimposing shares of intensity. Such a system is presented. Its design is challenged both by the utilization of CO_2-laser radiation and the reconfiguration of the optical path to actively change the spot size in the target zone. Solely reflective materials are used, that enables the exclusive of hazardous infrared materials such as ZnSe. The targeted integration of electro-mechanical linear and rotating devices enables the continuous variation of the optical path. The change in spot size can be done independently in two directions.

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LASER AND LASER OPTICS

BOOTH 20

E100.C13

Laserstation for Inverse Glass Structuring

A station for glass structuring using the inverse ablation process has been set up at Fraunhofer ILT. The station consists of a multi-axis system with an integrated scanner and a 10 ns @ 532 nm laser. The laser beam is focused on the bottom of the glass component and a defined area is scanned with single laser pulses. After this step the ablation layer height is incremented. Thus the processing layer moves from the bottom to the top. In this way the wanted geometry is built up layer by layer.

With this process, geometries with a diameter of 500/800 µm and a depth of 80/120 mm have been demonstrated.

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BOOTH 67

LASER AND LASER OPTICS

E053

Development of Highly Stable and Compact Laser Systems for harsh Environment

Beside rugged industrial lasers for 24/7 production, especially lasers for airborne LIDAR applications have to withstand shocks, vibrations and temperature variations during transportation and flight. Furthermore, under these conditions these lasers have to emit stable single frequency pulses. In many flight applications on for example planes or helicopters volume and mass budgets are very limited. To meet these special requirements a highly stable and compact laser setup was developed. This comprises a structured monolithic baseplate and sub-components. The baseplate is designed to have a very high compactness, high eigen frequencies, a high bending moment, but low weight and volume. Also, all subcomponents were designed to withstand vibrational loads as well as temperature variations. This was experimentally validated with in-house test equipment.

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BOOTH 55

LASER AND LASER OPTICS

E118

Tailoring of Freeform Optical Surfaces for Highly Customized Illumination Applications

LED are becoming a light source of great importance, allowing very flexible beam shaping due to their limited spatial extent. Here, the techniques of classical optics design can no longer be applied as demands on target intensity distributions and optical efficiency are particularly high. It is thus required that new concepts be developed for the design of efficient and flexible optics.

Instead of classical lens geometries, general refracting or reflecting surfaces (freeform surfaces) are used in the optical design. Their shape is established using complex mathematical algorithms which are developed at Fraunhofer ILT.

LED systems for the uniform illumination of square and rectangular areas were designed. Additionally, the flexibility of this approach was demonstrated by creating arbitrary irradiance distributions in the target plane.

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BOOTH 29

HALLWAY NEXT TO E100.A03

Customized Electronics and Drivers for Laser Applications

Beratron is specialized in electronic solutions for laser applications. Our products ranges from small drivers for fiber-coupled diodes or superluminescence-diodes over TEC cooling solutions to high current 19 inch systems up to 500 A current. The products are build in a modular way and can be customized after your special needs. The modules include CW, QCW and pulse driver electronics for laser diodes and are equipped with various analogue or digital interfaces (e.g. EIA-232, CAN, USB, Ethernet …). Beratron also offer special trigger solutions (e.g. pulse-picking, frequency stabilized lasers) and customized laser control boards for complex laser systems. Applications are R&D, material processing, pumping, imaging, ranging, etc.

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LASER AND LASER OPTICS

BOOTH 17

E100.A15

Cooling Systems for Diode Laser made by Micro SLM

IQ evolution is specialized in Micro-SLM and cooling technologies, a rapid manufacturing procedure of three dimensional complex products made of metal powder

- Our products are micro cooler for high-power laser diodes, cooler for power electronics or LED as well as other complex 3D-structures

- Our micro coolers are leading f.e. to a significant increase in the lifetime of the laser bars compared to the current copper based cooling technology (the new materials used here are not exposed to corrosion and erosion)

- We have special know-how in the Selective Laser Melting process and machines as well as in using special materials, pure materials and custom made material compounds

- We are able to produce micro structures from 50 µm up

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BOOTH 48

LASER AND LASER OPTICS

IN FRONT OF E112.1

High Power Ultrafast Yb:Innoslab Amplifier

To transfer femtosecond technology from laboratory to industry, laser sources of high power and high repetition rate are essential. They have to combine sub-picosecond pulses and diffraction-limited beam quality for high precision and hundreds Watts of average output power and high repetition rates for high throughput. Ytterbium-doped laser crystals allow pulse durations from 100 fs to 1 ps. The presented Innoslab amplification platform based on Yb:YAG allows amplification to kW average power. The optical-optical efficiency of 55 % and the beam quality $M^2 < 1.5$ are outstanding for kW ultrafast lasers. At 10 - 1000 MHz repetition rate up to 100 µJ pulse energy are attainable without chirped pulse amplification (CPA). With CPA 100 mJ at > 10 kHz repetition rate are feasible. Due to the large beam cross section Innoslab amplifiers can sustain three orders of magnitude higher peak power than fiber amplifiers.

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WISSENSCHAFTSPREIS DES STIFTERVERBANDES 2012

BOOTH 46

NANO PROCESSING

E112.3

Nano- and Microstructuring with Micro Scanner

A high precision scanner and tightly focusing (NA> 0.3) are utilized together with a 1.5 W femtosecond fiber laser source to process transparent dielectrics. With this set up the fabrication of waveguides, in-volume marking and surface nanostructuring for different applications becomes productive.
Moreover the fast modification of sapphire and fused silica and subsequent etching are used to fabricate 3D microcomponents e.g. micromechanical devices, micro optics and microfluidic devices.

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BOOTH 62

U120.1

Laser-based Inline Production of Thin Wear-Protection Coatings out of Nanoparticulate Solutions

Wear-protection coatings are a powerful tool for improving the performance and lifetime as well as the application range of various components. Within the FunLas consortium ("FunLas – Functionalization of thin, nanoparticle-based layers on susceptible steel surfaces via brilliant diode laser radiation"), funded by the BMBF, the Fraunhofer ILT and partners have successfully developed a laser-based inline-coating process as a low-cost alternative to industrially established Physical Vapor Deposition (PVD) processes. The major challenge of this innovative coating process is the required thermal post-treatment of the printed nano-layers often applied on substrates with low thermal stability (e.g. hardened steel). Due to its exact local and temporal controllability, the laser process developed at the ILT enables the generation of the required high peak temperatures of > 1000 °C without affecting the substrate properties negatively.

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NANO PROCESSING

BOOTH 63

U120.1

Conductive Paths by Printing and Laser Processing of Nanoparticulate Solutions

Functional layers play a central role in electronic devices. Especially conductive structures (e.g. conductive paths or transparent conductive oxide coatings) on flexible and temperature sensitive substrates are of great interest in this field of application. Printing techniques show great potential due to resource-efficient, flexible and cheap application of structures only onto desired areas of the substrate. To reach the functional properties of the applied nanoparticulate materials heating steps are usually necessary. The replacement of conventional heating for drying, sintering and even partial melting or crystallization by laser treatment allows us to reach high temperatures in top layers with high temperature gradients so that even temperature sensitive substrates can be used.
High vacuum processes (CVD, PVD) and time and energy consuming thermal processes can be avoided by the combination of laser and printing processes.

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BOOTH 13

ADDITIVE MANUFACTURING

E100.A11

Additive Manufacturing by Laser Metal Deposition

Laser Metal Deposition (LMD) also known as laser cladding can be used as an additive manufacturing process by cladding layer upon layer. The result is a near net-shape component with almost 100% density and a property profile which meets the specifications of the used material, or even performs better due to the fine microstructure created by the high cooling rates during LMD. The size of the components is only limited by the handling system. In contrast to powder bed based technologies LMD offers the possibility to produce new material concepts e.g. gradient properties or build-up of lightweight hybrid components consisting of various alloys. Potential applications are the production of functional prototypes and small batch parts. LMD can also be used to modify components for a more individualized production when small numbers of derivatives are required.

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BOOTH 14

ADDITIVE MANUFACTURING

E100.A14

High Power Selective Laser Melting for Series Production

The Fraunhofer ILT developed Selective Laser Melting (SLM), an additive manufacturing technology which emerged from Rapid Prototyping and/or Rapid Tooling. SLM can be used to manufacture series-identical materials such as steel, aluminium-, titanium- and nickel-based alloys layer by layer according to a 3D-CAD volume model. This process enables the production of nearly unlimited complex geometries without the need for part-specific tooling or preproduction costs. According to the current state of the art SLM is used to manufacture functional prototypes and to build up final parts in small batches directly. For SLM to enter to enter series production with higher lot sizes, increased productivity is necessary. Therefore an SLM machine was completely redesigned and equipped with a 1 kW laser source. The aim is to identify process strategies corresponding to the material and geometry of the manufactured part with which the increased laser power can be converted into an increased productivity efficiently, while maintaining the requirements for constant component quality.

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INNOVATIONSPREIS 2011
DES LANDES NRW

BOOTH 15

E100.A14

Digital Photonic Production with Selective Laser Melting

Due to technology intrinsic advantages like lot-size-one capability and almost infinite freedom of design, AM was recently described as “the manufacturing technology that will change the world”. AM technologies are characterized by a fundamentally different relation of cost, lot size and geometric product complexity compared to conventional manufacturing processes.
Only the holistic development of AM production chains provides the full economic, ecologic and social benefit. The availability of AM specific new methods for manufacturing-technology-adapted, resource-adapted and functional-adapted product design will be a critical success factor for future AM applications.
New methods for AM specific product design, AM specific topology optimization and interactive product configuration tools are presented. Key elements of these methods are the systematic analysis and modeling of technology specific restrictions and capabilities, e.g. geometric features of Selective Laser Melting.

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ADDITIVE MANUFACTURING

BOOTH 16

E100.A14

Rapid Manufacturing of Parts out of Superalloys for the Energy and Aerospace Industry

The additive manufacturing technology Selective Laser Melting (SLM) is used for direct fabrication of functional metallic parts. Already established in the field of tool making, SLM has shown its capability to manufacture complex parts which resist high dynamic mechanical loads. Also offering low material consumption, this process is a great economic alternative to produce high value small-scale series, like for instance those found in gas turbines in the energy and aerospace industry. Currently, SLM only plays a minor role in the production of gas turbines, the main limitation being the processable materials. Used widely in this field, nickel and cobalt based superalloys offer great mechanical strength, and corrosion and oxidation resistance at high temperatures. The application of components within gas turbines and the complexity of such alloys require intensive process development in order to obtain similar properties as conventionally produced parts.

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INNOVATIONSPREIS 2011 DES LANDES NRW

BOOTH 27

ADDITIVE MANUFACTURING

E100.A05

Rapid Powder Switch for Laser Metal Deposition

During Laser Metal Deposition (LMD), the laser beam often has to be switched off and on when moving the processing head (optic and nozzle) to a new position. During this time, usually the powder gas feeding is not interrupted because the powder flow takes several seconds to stabilize after switching on. This leads to undesired powder losses. By using a rapid powder switch the powder gas flow can be switched off and on within 300 ms. Thus the powder losses are reduced to a minimum. The application of a rapid powder switch will be demonstrated during LMD of different metal alloys.

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AVIATION WEEK INNOVATION CHALLENGE 2012

BOOTH 31

ADDITIVE MANUFACTURING

E100.C03

Powder Feeding Nozzles for Laser Metal Deposition

One key component for Laser Metal Deposition LMD, also known as laser cladding, is the powder feeding head which provides the powder and the shielding gas for the process. The main demands in industry are flexibility, robustness and high powder efficiency. Fraunhofer ILT has developed various powder feeding heads for several industrial applications. This includes discrete and coaxial powder feed nozzles and a zoom optic which allows a flexible change of track width (developed together with Reis Lasertechnik). A special application is the cladding of inside surfaces. Fraunhofer ILT has developed different processing heads with integrated optic and powder feeding for cladding of inner surfaces. The design allows the cladding of inner surfaces starting from either 25mm or 50mm diameter upwards. These optics are presented here together with the company IXUN Lasertechnik.

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BOOTH 11

E100.A10

LaCAM3D - LMD CAM Software

Laser Metal Deposition (LMD), also known as laser cladding, is nowadays an established method for the repair of high added value components in several branches.

For the repair of complex surfaces by LMD a digital surface model of the area to be repaired is required. Distortion and defects of a worn component implies that the original CAD model from the design stage is no longer suitable for the representation of the part geometry. For this reason Fraunhofer ILT uses a laser profile scanner to measure the actual part geometry. The resulting point cloud is processed to a polygon mesh and imported in the LaCAM3D software developed by Fraunhofer ILT. In LaCAM3D tool paths for the LMD process are generated and connected depending on the welding strategy. Based on the tool paths machine specific NC code is generated.

The demonstration shows the acquisition of the actual part geometry, the tool path generation with the LaCAM3D software and the LMD processing of the part.

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FERCHAU INNOVATIONSPREIS 2011

ADDITIVE MANUFACTURING

BOOTH 04

ENTRANCE

Special Exhibit for Digital Photonic Production

Cheekbone implant with interconnected porous structure generated by Selective Laser Melting (3.5:1 scale model)

Laser additive manufacturing methods like Selective Laser Melting (SLM) allow for direct fabrication of complex individual structures according to CAD data. With respect to medical application, SLM enables the generation of customized implants with defined porosities. Interconnected porosities facilitate the growth of new bone tissue throughout the whole implant and therefore enhance biointegration. SLM can process metallic biomaterials and biodegradable polymeric or polymer/ceramic composite materials. This individualized cheekbone implant is originally made of biodegradable polylactic-acid.

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INNOVATIONSPREIS 2011 DES LANDES NRW

Laser Thin Film Patterning

Thin films and their applications are becoming an indispensable building block for future technologies and markets. Products like organic light-emitting diodes, thin and flexible displays and solar panels heavily rely on thin films with electronic, optical or other functionalities. The films which can consist of metals, insulators and semiconductors have thicknesses between nanometers and micrometers.
Beside deposition of such films, subsequent treatment is a fundamental step towards the final product. Laser patterning - the selective removal of layers without impact on the surrounding material - plays a key role in establishing thin film technologies in production. Laser patterning processes for industrial applications have to be precise, selective and gentle enough to allow high processing speeds on large formats while minimizing the loss of area and maintaining film functionality. Such processes are enabled by utilizing ultra-short pulse laser sources.

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BOOTH 36 SOLAR TECHNOLOGY
E100.A02

Laser Soldering in Photovoltaic Module Manufacturing

Photovoltaic is a key technology destined to play a major role in future energy supply concepts. To produce a solar module, the individual solar cells are connected in series by means of tin-plated copper ribbon connectors to form a string. The joining process is conventionally performed by soldering. The proof of principle of laser soldering has been demonstrated in numerous studies. Fraunhofer ILT is now equipped with an automated assembly machine that allows the laser soldering process to be evaluated under production conditions. The assembly machine is a Stringer TT 900 from Teamtechnik, which has the capacity to link together up to 900 cells per hour.
The modular design of the soldering station enables different laser sources and beam-shaping concepts to be tested for viability in a production environment. The fully automated assembly system enables laser-based joining and process monitoring processes to be investigated using industry-standard machines operating at typical industrial throughput rates.

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BOOTH 71

E055.1

Image Processing of Cell Morphology

High content screenings, e. g. multi-cellular assays, become more and more important for active ingredient development in pharmacology. Hence, tracking technologies for the screening of cell behavior are crucial for the understanding of the functional interaction between different cell types. Focus is the possibility to track the morphology of living cells with a highly variable shape. Finally the shape can be categorized and conclusions for the screenings can be drawn.
In cooperation with the Max Planck Institute for Molecular Biomedicine in Münster MPI-MBM and the Fraunhofer Institute for Manufacturing Engineering and Automation IPA, the Fraunhofer Institute for Laser Technology ILT will build up in-vivo-like structures artificially and analyze their behavior automatically.
The exhibition will present first results and current approaches for the detection of the cell morphology. In particular, the analysis of a sequence of images of fluorescence labeled cells, taken in defined time steps will be shown. The contour and the movement of each individual cell will be tracked.

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LIFE SCIENCE

BOOTH 74

E055.2

Laser Fixation of Wound Dressings

A persistent task in medical care is to deal with chronic wounds. The preferred treatment for extensive wounds is placing a tight dressing onto the entire area and to fix the dressing by using staples. A laser-based approach could avoid these injuries by fixing the dressing with protein glue. The glue is applied in liquid form and then cross-linked by near-infrared laser radiation. For that process the temperature has to kept in range between 55 – 70 °C for a few seconds.

For practical use a hand piece or applicator with an integrated temperature sensor is required. The surface temperature of the dressing is sensed by an infrared thermometer and the sensor signal is fed into the feedback loop of the laser's power controller. Thus the protein glue can be cured without overheating. When the protein glue changes from a liquid into a solid state, the scattering of the laser radiation increases and the optical penetration depth falls off. Then the laser wavelength can be switched to a less attanuated wavelength to fully cure the solder tissue interface.

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BOOTH 72

LIFE SCIENCE

E055.1

Material Design for Laser Lithography

The generation of artificial organs is a visionary idea in biomedical research. Realization depends on better understanding of materials, biomolecular interactions and systems engineering. For that reason the development of suitable materials and appropriate technologies are the main challenges in these efforts. The material class of biocompatible hydrogels, which fulfill most of the requirements for the use in human organisms, are combined with laser or light based technologies. Biomimetic structures can be built up which may replace human tissues in the future (3D-Biofabrication).
The combination of photo-curable hydrogels, based on thiol-ene chemistry, photo-initiator system and light processing is a promising approach for the construction of tissue-like structures. The Investigations of novel polymer systems and processes are done in the group Biotechnology and Laser Therapy.

The experimental setup and first achievements in material development are presented in our lab.

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BOOTH 73

LIFE SCIENCE

E055.1

Fluorescence-based Live Cell Imaging

Fluorescence microscopy is a powerful tool in Life Science. Not only high resolution pictures of stained samples, but also life images of fluorescence labeled cells allow insights into biological aspects.
At Fraunhofer ILT this is used for the analysis of cell behavior on laser patterned surfaces. These patterns can be of different shape (ripples, lines etc.) and sizes (from nano- to micrometer) and work as cell guiding structures. Live cell imaging allows, with a subsequent image processing, an insight into the effect of these structures on cell growth. For demonstration purpose we show fluorescence labeled bacteria in an Olympus IX81 fluorescence microscope.

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BOOTH 09

IN FRONT OF E100.C09

Cluster of Excellence »Integrative Production Technology for High-Wage Countries«

In the Cluster of Excellence »Integrative Production Technology for High-Wage Countries«, process engineers and materials scientists based in Aachen are developing new concepts and technologies offering a sustainable approach to industrial manufacturing. A total of 25 chairs and institutes of RWTH Aachen, together with the Fraunhofer Institutes for Laser Technology ILT and for Production Technology IPT, are working on this project, which in the first instance will run until the end of 2012. Funding of approx. 40 million euros has been granted to this Cluster of Excellence, an initiative that unites the largest number of research groups in Europe devoted to the objective of preserving manufacturing activities in high-wage countries. Within the Cluster of Excellence the following nine research groups are working in the field of laser technology and optics.

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EXCELLENCE NETWORKS

BOOTH 10

IN FRONT OF E100.C09

RWTH Aachen Campus

In the upcoming years, RWTH Aachen University will create one of the largest campus areas and one of the nationally and internationally most renown knowledge and science centers on an area of 2.5 square kilometers. The RWTH Aachen Campus will bundle knowledge, research, development and life in a new quality dimension. Sophisticated architecture and various facilities offer work and living quality on the highest level. Enterprises will have the possibility to settle on the Campus: for rent or in own buildings, in any size, from a 3-persons-office and limited projects up to long-term engagements with several hundred employees. As an outstanding feature, enterprises may enroll in the training and education programs of RWTH Aachen University. Research and Development will be organized in thematic clusters, representing the most important future-relevant topics. Up to 12 thematic clusters are planned and one of the starting clusters will be the Digital Photonic Production cluster.

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Chamber of Industry and Commerce Aachen (IHK Aachen)

The Aachen Chamber acts as a critical partner in political and administrative issues, as an independent practicing lawyer in the market and as a customer-oriented service provider for companies. As a decisive promoter of the Aachen economic region, it is concerned with improving commercial framework conditions and building up the competitive competence of the local economy.
A further important function lies in the performance of duties such as holding exam i-nations, calling in experts, monitoring cartel law and issuing foreign trade documents. Finally, the chamber offers its members concrete company-based services such as information about new legislation and developments, advice about starting up and safeguarding companies, arranging cooperation, foreign trade information, innovation and technology transfer as well as further training and seminar events.

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Fraunhofer Institute for Laser Technolgy ILT / Press Counter

With about 370 employees and more than 11.000 m^2 of usable floor space the Fraunhofer ILT is world-wide one of the leading development and contract research institutes of its specific field. In the technological area »lasers and optics« development activities are concentrated on innovative diode and solid state lasers for industrial use as well as design and assembly of optical components and systems. The technological area »laser material processing« offers solutions in cutting, ablation, drilling, welding, soldering, surface treatment and micro processing. The activities cover a wide range of applications from macro processing via micro processing up to nano structuring. In the area »medical technology and biophotonics« innovative procedures for therapeutic laser treatments and processes for the production of medical technology products, particularly for microsurgery techniques, are developed. In the area »laser measurement technology« processes and systems for inspection of surfaces, for chemical analysis and for testing geometrical accuracies are developed.

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BOOTH 02a

CENTRAL INFORMATION

ENTRANCE

AKL e.V. – Aix Laser People

Arbeitskreis Lasertechnik AKL e.V. is a registered non-profit association formed in 1990 by a group of companies and private individuals aiming to pool their experience and conduct joint public-relations activities in order to spread the use of laser technology in industry and promote the sharing of scientific ideas. The »Innovation Award Laser Technology« aims to reward excellent achievements in applied research and outstanding innovation in the field of laser technology and to shine a spotlight on their authors.

In 2012, around 100 laser experts and enthusiasts were signed up as active members of the AKL network. The association's activities include disseminating information on innovations in laser technology, organizing conferences and seminars, compiling educational material dealing with laser technology, stimulating the interest of future young scientists, and providing advice to industry and research scientists on questions relating to laser technology.

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BOOTH 02b

CENTRAL INFORMATION

ENTRANCE

ELI – European Laser Institute

Optical technology is taking an increasing hold on all domains of industry and science. Europe already possesses a strong position in this field by virtue of its numerous experts and excellent research and development facilities. Nevertheless, it has been realized that there is an urgent need to link the existing sources of know-how and expertise, and to enhance the performance of joint research activities.

Consequently, the European Laser Institute (ELI) has created an efficient platform bringing together the necessary competence and knowledge on optical technologies. By promoting technology transfer within Europe, ELI aims to enhance the international lead of European industry and research in the field of laser technology and photonics. By working in close collaboration with existing national and international organizations, the ELI network of industrial and academic research institutions helps to influence R&D policy on a national and European level.

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