



kompetenznetze.de
Networks of Competence in Germany

Optical technologies

VDI Technologiezentrum

In cooperation with

DAAD Deutscher Akademischer Austausch Dienst
German Academic Exchange Service

Invest in Germany



AN INITIATIVE OF THE



Federal Ministry
of Education
and Research

Editorial

Published by

Managing office kompetenznetze.de
VDI Technologiezentrum GmbH
Department for Basic Issues of Research,
Technology and Innovation
Graf-Recke-Str. 84
D-40239 Düsseldorf

Phone: +49 (0)211 6214-639

Fax: +49 (0)211 6214-168

eMail: info@kompetenznetze.de

Internet: www.kompetenznetze.de

kompetenznetze.de is an initiative
of the Federal Ministry
of Education and Research (BMBF).

Our thanks to all authors and
network coordinators for their kind
contributions of written content,
pictures and illustrations.

June 2005

Concept

Managing office kompetenznetze.de

Coordinating editors

VDI Technologiezentrum GmbH, Düsseldorf
Dr. Anja Lutz

Translated by

Burton, Van Iersel & Whitney GmbH,
München

Layout

verb, agentur für kommunikationsdesign gmbh,
Essen

Printed by

WAZ, Druck GmbH & Co. KG,
Duisburg-Neumühl

Orders

In writing to the
Federal Ministry of Education
and Research (BMBF)
Postfach 30 02 35
D-53182 Bonn

Or by

Phone: +49 (0)1805 2623-02

Fax: +49 (0)1805 2623-03

(0.12 €/ min from the German fixed network)

eMail: books@bmbf.bund.de

Internet: www.bmbf.de

kompetenznetze.de
Networks of Competence in Germany

Optical technologies

Words of Welcome

Networks of Competence for optical technologies – your powerful innovation partners



Light can do much more than illuminating homes and offices. The applications of optical technologies are far more varied and have by no means yet been exhausted. Examples include the scanners in supermarket checkouts, the lasers used by the automobile industry for precise and efficient welding, the optical imaging techniques employed in medicine to screen for tumors, and the painless treatment of dental caries.

With their broad range of potential applications and unequalled efficiency, optical technologies serve as a driving force in the economy and in the job market. Germany has already taken the lead in many areas of optical technology, and has every hope of generating further advances in this field. Around 16 percent of jobs in the German manufacturing industry are directly or indirectly dependent on optical technologies, which corresponds to approximately one million members of the national workforce. The annual turnover of 23 billion euros produced by German companies in 2003 and the two-digit growth rate in international sales achieved in 2004 underline the significance of the optical technologies sector to the German industrial economy.

The Federal Ministry of Education and Research (BMBF) actively supports the development of optical technologies in Germany through its funding policy. In order to promote the use of optical technologies in as many applications as possible, the BMBF initiated an industry-led strategy process in 1999/2000 to structure this area of the economy. The funding program "Optical Technology – Made in Germany" was launched in the spring of 2002. Under this program, roughly 280 million euros in research grants will be made available by the BMBF through to 2007. In the European Research Area (ERA) too, laser technology and optical engineering are destined to play a formative role. Optical technologies already feature prominently in all

six priority areas of the 6th EU Framework Programme (FP6), owing to their importance as a cross-cutting, enabling discipline. As plans advance for the forthcoming 7th EU Framework Programme (FP7), many research organizations and industrial associations in Germany and Europe are pressing for the greater integration of optical technologies as the cornerstone of a coherent European research strategy.

In addition to its efforts to promote new technologies with a pronounced knock-on effect in terms of economic growth and employment, the BMBF's latest funding program for optical technologies includes specific measures to support Networks of Competence. The aim of establishing such networks is to create durable structures capable of sustaining an innovation system in a particular field of innovation. Competence Networks are the ideal platform from which to launch innovation projects. By pooling the resources and expertise of a wide range of players in industry and science, they facilitate the development of advanced technologies and sophisticated service applications. Special mention deserves to be made of the ten regional networks belonging to the kompetenznetze.de initiative, in which meanwhile a total of more than 400 companies, mostly SMEs, are now playing an active role. These networks are as follows:

- Optence e.V. – Network of Competence for Optical Technologies Hesse/Rhineland-Palatinate
 - Photonics BW e.V. – Competence Network for Optical Technologies in Baden-Württemberg
 - bayern photonics e.V. – Bavarian Competence Network for Optical Technologies
 - Laser Technology Region Nuremberg
 - Image Processing Thuringia
- If any of these reports of the networks has awoken your curiosity, you can find further information at www.kompetenznetze.de. The kompetenznetze.de initiative launched by the < Ministry of Education and Research offers leading Competence Networks the opportunity to present their activities to an international audience. The initiative also provides support to the networks through knowledge-sharing workshops, by making initial contact to potential international partners, and by representing the networks in external relations activities.

Edelgard Bulmahn
*Federal Minister
of Education and Research*

- OpTecBB e.V. – Network of Competence for Optical Technologies in Berlin-Brandenburg
- PhotonicNet GmbH – Competence Network for Optical Technologies in Lower Saxony
- OpTech-Net e.V. – Network for Optical and Optoelectronic Technologies and Systems (Nordrhein-Westfalen)
- PhotonAix e.V. – Competence Network for Optical Technologies and Systems in Aachen
- OptoNet e.V. – The Thuringian Network of Competence in the field of Optical Technology

Partner for innovation, investment and education in Germany

kompetenznetze.de is an initiative of the German Federal Ministry of Education and Research (BMBF), conceived as an instrument for the marketing of selected Competence Networks in Germany. Its purpose-designed Web site presents Competence Networks with exceptional outreach and a high potential for innovation and value creation. As a partner for innovation, investment, and education, kompetenznetze.de is a useful resource and communication platform for those seeking information or collaborative partners in Germany, from anywhere in the world.

CONTACT

Managing office
kompetenznetze.de
VDI Technologiezentrum GmbH
Graf-Recke-Str. 84
D-40239 Düsseldorf
Phone: +49 (0)211 6214-639
eMail: info@kompetenznetze.de

Germany offers rich resources in the future's most prominent fields of innovation which, besides optical technologies, also include such fields as biomaterials, biotechnology, power engineering, industrial manufacturing, Information Technology, materials science, medical engineering, microsystems, nanotechnology and environmental technology. It is the home to many Networks of Competence whose work attracts worldwide interest, and radiating to all points of the globe. An initiative of the German Federal Ministry of Education and Research (BMBF), kompetenznetze.de altogether presents profiles of over 100 Competence Networks in 18 fields of innovation, each chosen on the basis of rigorous selection criteria. *kompetenznetze.de* sees itself as an exclusive club whose members are required to prove their eligibility by meeting a demanding set of standards: the ability to innovate, a dynamic business strategy, a flexible attitude to cooperation that includes ongoing collaboration with partners in science, industry, education, and (financial) services, and an international reputation. Outstanding networks can apply to join the initiative. A committee of experts offers its recommendations on those to be accepted. Once accepted, the network bears sole responsibility for the accuracy and updating of information presented on the site. These principles have enabled *kompetenznetze.de* to become quickly established and be recognized as a guarantee of quality.

Information and communication services

The Competence Networks are presented by means of standard profiles containing concise, informative texts, diagrams and photos describing their specialist expertise, their partners, and their range of activities. These profiles are accompanied by a wealth of complementary information on the fields of innovation in which they operate, described in terms of their significance to R&D strategy as a whole, but also with respect to market trends and educational opportunities. Portraits are also given of

the (currently) 33 regions in which the Competence Networks are based. A continual process of monitoring and evaluation is implemented as part of the initiative, to ensure that the content published by the networks meets the highest standards of quality and always remains up-to-date. Sections highlighting recent innovations achieved by the networks and the range of services they offer give a clear indication of the capacity of each Competence Network. Addresses are provided for direct contact with all of the participating groups. Searches can also be made in the accompanying database, e.g. to find potential collaboration partners.

Workshops and other events provide the opportunity to discuss innovation and investment with experts and to exchange experience in network management.

International cooperation

Our international activities are focused on finding suitable cooperation partners and opening up contacts. We have set up partnerships with a number of European countries. One example is France where, together with DATAR, the French regional development agency, we are helping to promote cooperation between countries and regions, including the establishment of a shared, Internet-based contact exchange, and maintaining close ties with local initiatives. *kompetenznetze.de* also appears regularly at public events and trade fairs. Lighthouse projects illustrate the opportunities offered by cross-border cooperation, and serve as an example for the implementation of such partnerships. As an important sideline, *kompetenznetze.de* takes part in political dialog on a national and international level. We provide expert advice for the European Trend Chart on Innovation and are engaged in discussions on the use of cross-border regional networks as a funding instrument, for instance with Norway and Sweden. There is even a growing export trade in the creation and management of Competence Networks. Lithuania, for example, is being helped to set up its own Competence Networks under an EU-sponsored project. Such support is

greatly appreciated by newly acceded EU member states, who in this way can be fully involved in the process of European integration.

Everyone can benefit from *kompetenznetze.de*

kompetenznetze.de is a location marketing tool used actively by a large number of companies, research institutes, university research departments, technology transfer agencies and investment firms to bring their skills and achievements to the attention of a wider audience. What more can be said than to extend a warm welcome to:

www.kompetenznetze.de

Our online services

- **Network portraits including innovation highlights, contact addresses**
- **Fields of innovation, including market trends and educational opportunities, research policy and innovation strategies, innovation highlights**
- **Innovative regions of Germany, regional contact addresses**
- **News channel and calendar of events, also with e-mail subscription**
- **Useful information on network programs throughout the world**
- **Service section including study reports and other information material, useful Web links, references to current literature, a press service, and a print-on-demand function**

Contents

6 Feature

15 Networks of Competence in Germany

Portraits of Networks of Competence

- 16 OpTecBB e.V. –
Network of Competence for Optical Technologies in Berlin-Brandenburg
- 18 PhotonicNet GmbH –
Competence Network for Optical Technologies in Lower Saxony
- 20 OpTech-Net e.V. –
Network for Optical and Optoelectronic Technologies and Systems (Nordrhein-Westfalen)
- 22 PhotonAix e.V. –
Competence Network for Optical Technologies and Systems in Aachen
- 24 OptoNet e.V. –
The Thuringian Network of Competence in the field of Optical Technology
- 26 Optence e.V. –
Network of Competence for Optical Technologies Hesse/Rhineland-Palatinate
- 28 Photonics BW e.V. –
Competence Network for Optical Technologies in Baden-Württemberg
- 30 bayern photonics e.V. –
Bavarian Competence Network for Optical Technologies
- 32 Laser Technology Region Nuremberg
- 34 Image Processing Thuringia

36 Conducting research in Germany

38 Important links

Optical technologies: brilliant prospects for Germany

Functioning as seedbeds for cooperative ventures, Competence Networks in the field of optical technologies combine the expertise of all network participants from science and industry. Many noteworthy innovations derived from the exploitation of light as a tool carry the "Made in Germany" label.

Germany's long-standing tradition of technological achievement in optical technologies reads like a success story, with names like Fraunhofer, Zeiss, Schott, Leitz, Voigtländer and Rodenstock. A quantum leap in the truest sense was achieved with the advent of modern laser technology, the cornerstone for which had already been laid by the theories of Albert Einstein: he discovered that photons can stimulate atoms, which in turn emit more photons. The principle governing the basic functionality of lasers was thus discovered, but it would be several decades before Theodor Harold Maiman built the first laser in 1960.

Today, all principles and methods through which light is generated, modified, and especially utilized are combined in the field of optical technologies. But enough of the theory – in a practical sense, everyday life without the use of light as a tool is hard to imagine anymore: fiber-optic networks, data storage, microelectronics, biotechnology, space exploration and utilization, laser welding – photons are always in the picture. Optical technologies set the pace for an abundance of technological developments and have a preeminent cross-cutting character, because they are an enabling technology on two fronts: Many new products and technologies are based on optical principles, and many products can only be produced cost-effectively through the use of optical technologies. For these reasons,

experts from industry, science and government agree that the 21st century belongs to the photon. "Optical technology does in fact serve an overarching pacesetting function that is indispensable to modern industrial society," confirms Professor Gerd Litfin, chairman of Linos AG in Göttingen, which produces optical components and systems.

This is especially true in Germany, which is still well ahead of the pack in the technical exploitation of light. Rapid translation of a concept into a technology suitable for industry is par for the course for "Made in Germany" laser innovations. But researchers and engineers above all find strength in unity: Ten Competence Networks distributed across Germany pack scientific and industrial competence in this field into a formidable surge of innovation, bringing together capable partners in industry, research and education, as well as the finance and consulting sector. The result is world-class products. Along with the kompetenznetze.de initiative, OptecNet Deutschland e.V., a federation of nine regional optical technologies Competence Networks (eight of which are also members of kompetenznetze.de), takes on a supporting role in the organization of knowledge transfer between the networks and the promotion of innovations.



Lasers are used to cut almost everything, from organic materials to 30-mm thick steel, even diamonds. Shown here are automobile components being cut by robots with a diode-pumped solid-state laser.
© ROFIN-SINAR Laser GmbH



Fuel atomization in a modern gasoline-powered engine
© Volkswagen AG

Optical technologies – basis for mobility

Anyone buying a new product these days, such as a car, has little idea of the extent to which light had a hand in its creation: Focused into powerful laser beams, light can cut or weld the sheet metal and steel used to make the car as if it were child's play. Injector nozzles and fuel filters are drilled using lasers, camshafts and fans are tempered with lasers, optical distance meters are used to improve active safety measures, and optical exhaust analysis in modern engine manufacturing reduces the environmental impact of pollutants.

The application of laser technology in production is regarded as a German specialty. Swiss consulting firm Optech Consulting, which specializes in the laser technology field, predicts a yearly average growth rate in the global market for laser materials processing systems of 13 percent from 2003 to 2010. This prognosis is good news indeed for Germany, because German laser manufacturers are the international leaders in this field: 40 percent of the beam sources used worldwide in materials processing and 25 percent of laser systems already come from Germany.

Light as a tool

In the area of metalworking with light, the laser makes full use of its advantages over conventional methods: laser beams are exceptionally controllable and operate without physical contact and with a high degree of precision. This saves industrial companies both time and money in sheet metal work. Two German companies – Rofin-Sonar, based in Hamburg (a member of **HansePhotonik** and **bayern photonics**) and Trumpf in Ditzingen (member of the **Photonics Baden-Württemberg (BW)** Network of Competence) – are world leaders in high-power solid-state lasers: The largest of the Trumpf-produced heavyweights has a power rating of up to 40 kilowatts.

Trumpf recently introduced laser remote welding, a novel technique for the automobile industry that could revolutionize autobody welding and assembly work. In this joining process, the focused beam of a CO₂ laser is precisely guided across the workpiece with the assistance of mirror actuators – which eliminates the need for moving robotic machinery. A second technique, remote “welding on the fly,” involves routing the laser beam through a robot-controlled scanner. In a body welding and assembly case study, remote welding yielded a 30-percent reduction in capital equipment expenditure and a 60-

percent reduction in cycle times as compared to conventional spot welding.

Copper-aluminum laser beam microwelding

“Less than 50 percent of the application potential for lasers in materials processing has been realized thus far,” declares Arnold Mayer of Optech Consulting. A development by the Bavarian Laser Center, a member of the **bayern photonics** Network of Competence and coordinator of the **Laser Technology Region Nuremberg** Network of Competence, has added a further contribution to the list of uses for light beams. Laser beam microwelding for the process-reliable, durable joining of copper and aluminum – a metal bond that has proven problematic in the past – was advanced to production readiness at the center. The quality of the joints was significantly improved through optimized process control and optimal selection of filler metals for the coating process. The newly developed process is of particular interest for applications in automotive and high-performance electronics, where the use of this type of material is steadily gaining significance. According to Peter Wirth, CEO of Rofin-Sinar, the leading manufacturer of laser processing plant, this is just one of the factors that demonstrate how “industrial

laser technology has become a decisive factor in decisions to invest in Germany.”

Light testing procedure improves tire quality

Another important application of light technology has been considerably advanced by the Fraunhofer Institute for Integrated Circuits IIS. Each individual automobile tire is still tested by the manufacturer in a time-consuming process before leaving the factory. The downside to this approach is that mechanical or electrical testing methods can only examine a single narrow track per tire revolution, which means that defects outside the measurement track can be easily overlooked. Furthermore, the process rejects many tires that are actually intact, which necessitates cost-intensive manual re-inspection. Using the light-section method, also called Sheet of Light Imaging or SOL, a first-ever successful test consistently rejected all defective tires from a batch of 84,000. This reduced the reject pile to an impressive 0.06 percent. To achieve this, the new SOL method projects an 8-cm laser line onto the tire, which is recorded with a digital camera. The Fraunhofer IIS, a **bayern photonics** member institute, developed a software application called TireChecker that evaluates the digital camera data, which it uses to detect bulges and other deformations to an accuracy of 0.02 mm – 30 times better than the usual tire-industry tolerance values.



The optical sensor by Corrsys-Datron precisely measures chassis dynamics.
© CORRSYS-DATRON Sensorsysteme GmbH

Photons measure speed

But tire quality is not the only critical factor in road traffic safety. Precise speed measurement in order to ensure the optimal functionality of control systems such as ABS and EPS is also an important safety issue. Vehicle speed is typically still measured through tire rotation, but this method often yields false measurements due to poor grip and sliding of the tires. Corrsys-Datron has developed a method

to measure vehicle speed employing an optical sensor directly above the road surface, which eliminates tire skid as a source of false readings. In the not-too-distant future, these kinds of sensor will also be able to measure road conditions and differentiate between dry, wet and icy surfaces. This technology functions so reliably that it can now also be employed to measure rail vehicle speed.

Robots “see” with the help of image processing

The automobile manufacturing industry relies on high-quality automated series production. The robots used on the production line must be able to reliably recognize which parts they are grabbing, bolting or welding together during assembly. Industrial image processing helps them do just that, using computers to analyze the data from digital cameras and transmit the appropriate signals to the robots. The Gesellschaft für Bild- und Signalverarbeitung mbH (GBS) and Henkel & Roth GmbH have developed a quality-assurance and production-control imaging and analysis system for automatic assembly manufacturing in the automobile industry and the required monitoring of process steps in assembly cells. GBS is a member of the **Image Processing Thuringia** Network of Competence, a confederation of around 25 companies and 15 research institutes.

Language barrier between robots and image processing systems eliminated

VITRONIC, a member of the Optence Network of Competence, is also contributing to improving the interaction between the cameras, image recognition systems and robots used by a wide variety of manufacturers: Working alongside additional partners within the framework of a BMBF collaborative project entitled ARIKT (Adaptive Robotic Inspection of Complex Parts), the company developed a novel



LASER

World of Photonics

global
business
in light



Maximize business. Utilize know-how. 365 days a year.

LASER. World of Photonics is the leading trade fair for optical technologies. Together with the World of Photonics Congress, which is held at the same time, it is the international summit event for research, science and industry in the heart of Europe. The things that make it unique:

- Quality and quantity of contacts
- Comprehensive, application-oriented product portfolio with complete range of solutions for the industry
- Extremely international
- Professional business environment
- Exchange of knowledge at the highest level
- Global acceptance and high level of satisfaction among exhibitors and visitors alike

Above all, the structured index of photonics companies and valuable news at the Internet portal www.global-electronics.net will help you promote professional business and know-how 365 days a year.

An added advantage: the trade-fair center in Munich, the gateway to new growth markets in Central and Eastern Europe.

Laser. World of Photonics awaits you. Contact us now and find out how you can participate!

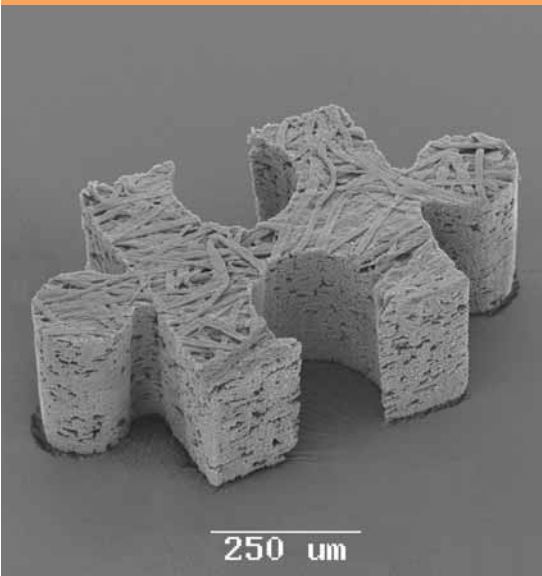
Hotline: (+49 89) 9 49-1 14 68

Fax: (+49 89) 9 49-1 14 69

info@laser.de

www.global-electronics.net/laser

New Munich Trade Fair Centre



Femtosecond lasers can cut out puzzle pieces the size of dust particles. All 100 pieces of this puzzle fit in a space of 5 mm².

© Laser Zentrum Hannover e.V.

optical measurement system for inspecting components with complex shapes and free-form surfaces. This makes it possible for the first time to easily combine diverse measurement systems comprising cameras, image recognition systems and robots from a wide array of manufacturers without having to reprogram and re-calibrate the tools each time. The advantage: significantly shorter development cycles and improved product quality for image processing systems and robots.

Light boosts the performance of microchips and raises the speed limit on the information superhighway

The entertainment media of tomorrow promise to be even smaller, lighter and more powerful. But the market for mobile entertainment electronics could not even have been created in the first place if it were not for advances in laser micromaterials processing that facilitated a significant increase in the circuit density of printed circuit boards in electronic devices such as mobile phones, CD players and computers. Without the latest high-power laser beam sources and materials processing methods, which currently make it possible to drill up to 1000 holes per minute with a diameter of less than 100 μm , the increasing demands of consumers could never be met.

The "Aachen lamp" – light for the next generation of chips

Moore's Law asserts that the processing power of computer chips doubles about every 18 months. To further increase the number of transistors and conductor paths on microchips, which makes it possible to manufacture the advanced microprocessors needed for the next generation of PCs, exposure techniques are needed that enable the tiny structures on silicon wafers to be further miniaturized. Until recently, these optical lithography techniques were limited to a wavelength of around 50 nanometers. Future generations of chips will require 13.5 nanometers, but the photolithographic production of such delicate conductor paths is far beyond the capabilities of currently implemented light sources. To fill this gap, light sources and processing systems for extreme ultraviolet light (EUV) are needed. Researchers from the Chair for Laser Technology at RWTH Aachen, Philips Extrem UV GmbH and two members of the **PhotonAix** Network of Competence, the Fraunhofer Institute for Laser Technology ILT and AIXUV GmbH, jointly developed an EUV gas discharge lamp for this application. The source for the "Aachen lamp" is an extremely high-temperature plasma generated through hollow cathode gas discharge.

Zippering along the data highway at the speed of light

But chips are not the only technology getting faster all the time. Today, larger and larger volumes of data must be transported with ever-increasing speed over longer distances. The storage, visualization and transmission of a volume of data that is growing exponentially around the world would hardly be feasible without optical technologies. Optical data communication using a novel technology called VCSEL (Vertical Cavity Surface Emitting Laser) enables low-cost, universally-available high-speed communication. Because VCSEL diodes are cheaper

to manufacture than conventional distributed-feedback and fiber-pigtail laser diodes, they are increasingly being implemented as emitters for high-bitrate data transmission.



Fiber-optic cable can already transmit data at speeds of up to 7 terabits per second.

© Getty Images GmbH

Medicine and biophotonics – light for life

Light can do more than speed data along the information superhighway – it also harbors the potential to diagnose and prevent the causes of illness, or gently heal them at an early stage. Modern optical diagnosis support systems enable early detection of cases of skin cancer, which can spare the patient from needing an operation. But light is also employed directly in gentle healing procedures: lasers are used to correct instances of ametropia in ophthalmology, painlessly remove decayed tooth material in dentistry, and remove bothersome spider veins in cosmetic surgery. Because of the significant role played by biophotonics in healthcare, the BMBF established the "Biophotonics" funding initiative, endowing it with a budget of 25 million euros for 2005.

Research in Germany

www.campus-germany.de

Benefit from Germany's excellent research landscape

- > efficient and highly-differentiated science and research system
- > state-of-the-art scientific infrastructure and equipment
- > highly qualified scientists and researchers, technicians and laboratory staff
- > close interlinking of large-scale research facilities with European and worldwide partners
- > high level of internationalisation and cooperation

Do research in a country traditionally strong in sciences

- > inventions, knowledge and understanding produced by German scientists represent milestones in science and research and form a basis for modern technologies (e.g. X-ray, Braun tube, electric motor, Otto engine, Plexiglas, GMR, MP3 format)

Gain from the innovative force of German research

- > German scientists, research institutes and industry are among the world leaders in nanotechnology, environmental research, neurosciences and biotechnology, biomedicine and medical engineering, automotive engineering, microsystems engineering, optical technologies, and process engineering
- > almost one quarter of all European patents are based on developments made by German scientists; in nanotechnology Germany is No.1

Experience Germany – the country in the heart of Europe

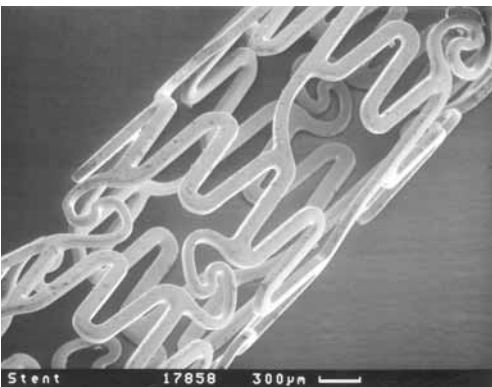
- > Germany certainly is worth discovering, offering a wide range of landscapes, plenty of leisure activities, a high standard of living, friendly people and so much more...

Germany invites researchers from all over the world to come and experience doing research in a research landscape designed for excellence

DAAD

Deutscher Akademischer Austausch Dienst
German Academic Exchange Service

Kennedyallee 50 • 53175 Bonn
P.O.B. 20 04 04 • 53134 Bonn
Deutschland / Germany
www.daad.de



Laser-structured stents allow blood to flow again through constricted vessels.
© Laser Zentrum Hannover e.V.

"Plastic lasers" will one day play a key role in the life sciences sector, for example in gene and protein analysis. Partners in the **PhotonicNet** Network of Competence of Lower Saxony have for the first time succeeded in manufacturing a low-cost organic semiconductor laser for such applications, which emits light in the ultraviolet range of the spectrum. Jointly manufactured by TU Braunschweig and the Physikalisch Technische Bundesanstalt (PTB) on plastic film, the organic UV lasers emit light pulses with a power rating of up to 6.8 watts. This is sufficient to stimulate clearly visible light emissions in the biofluorescence markers typically employed in this field. A key aspect of this technology is that the wavelengths of the new laser source can be precisely adjusted to allow a particular dye to optimally absorb the light. This capability will make fluorescence analysis considerably more efficient.

Early detection of arthritis using laser light

Until recently, inflammatory rheumatism could only be accurately diagnosed with magnetic resonance imaging (MRI), which is less than suitable as a routine procedure because of the high cost involved. Scientists at the Charité-Universitätsmedizin Berlin Institute for Medical Physics and Laser Medicine and from Laser and Medicine Technology GmbH in Berlin – a member of the **OpTec-Berlin-Brandenburg** Network of Competence – have recently succeeded in developing an alternative low-cost optical tomography procedure for the diagnosis of arthritis. The new optical light-scatter tomography method uses laser beams in the near infrared range to scan one of the patient's finger joints – a procedure that is less stressful for the patient – the results of which are evaluated in a computer. The technique is based on the fact that infrared laser light easily penetrates a healthy finger joint. Rheumatism in finger joints can be detected early using this gentle diagnosis technique, and the progress of treatment can be reliably monitored.

PETRA looks deep into protein crystals

Along with human genes, expanding the knowledge base on proteins stands at the top of the wish list of every researcher in the world. But in order to shed light on the three-dimensional atomic structure of the tiny protein crystals, molecular biologists need hair-thin, ultra-brilliant X-ray light beams to produce crystal-clear images of the configuration of the atoms. The PETRA particle accelerator at DESY (Deutsche Elektronen-Synchrotron), a member of the **HansePhotonik** Network of Competence, will provide this capability. In July 2007, upgrade work will begin to convert PETRA into the world's most powerful storage-ring X-ray radiation source, PETRA III, which will commence user operations in 2009. PETRA III will deliver intense, sharply focused X-ray light with an exceptional level of brilliance. There exists a significant need for the protein analysis procedures that will be made possible by this development. Potential applications include development of new drugs that target the exact site where pathogens attack.

Luminescent plastic: OLEDs reduce energy costs

"This is what the future of display technology looks like," says Dr. Bernhard Stapp, setting a miniature television on top of his office desk in Regensburg. Only a few centimeters tall, the set could fit on top of a credit card, and supports a separate, thin display showing a film of scenes from Paris. "I'm not saying displays of the future will be this small, but rather that they will be this thin and brilliantly lit," adds Stapp, head of research and development at Osram Opto Semiconductors (**bayern photonics**). As the film plays, Stapp rotates the TV. In contrast to currently popular liquid crystal displays (LCD), which are only clearly visible from the front, this display exhibits excellent contrast, clarity and brilliance

Next-generation lighting:
high-efficiency white OLEDs
© Philips



from any viewing angle. The new screen also responds up to 1000 times faster to rapid movements in the picture - so no more blurred soccer balls during the match. It is made primarily of semiconducting plastic, with a radiant layer much thinner than a human hair. This type of display uses OLEDs (Organic Light Emitting Diodes), which are also clearly visible in direct sunlight and, being self-luminescent, do not require any type of backlighting: When voltage is applied to the ultra-thin, organic layers, they emit light. OLEDs consume little power, which makes them ideal for compact, portable electronic devices. Small, mostly monochrome OLED displays are now being used in products such as cell phones, car stereos, PDAs, digital cameras, dashboards, washing machines and electric razors. An additional advantage is that the flexible luminescent plastic film can be molded into different shapes. Jörg Amelung, a photophysicist at the Fraunhofer Institute for Photonic Microsystems (IPMS), describes the potential range of applications for OLEDs in the most glowing terms: Someday

entire films could be seen playing on T-shirts, cars, or vases. Egg warmers could display the latest news during breakfast. OLEDs could also be capable of revolutionizing the home: For example, living rooms might be decorated with millimeter-thin video wallpaper that can change colors but also serve as a display screen. OLED-coated refrigerator doors are another possibility, as are windows or car windshields that can either be transparent or act as a monitor. But OLEDs with high lighting efficiency are also suitable for energy-saving lighting and indicator lamps: Modern traffic signals and car brake lights equipped with LEDs in place of conventional lamps are not only cheaper, they also enhance traffic safety through higher visibility and shorter response times.

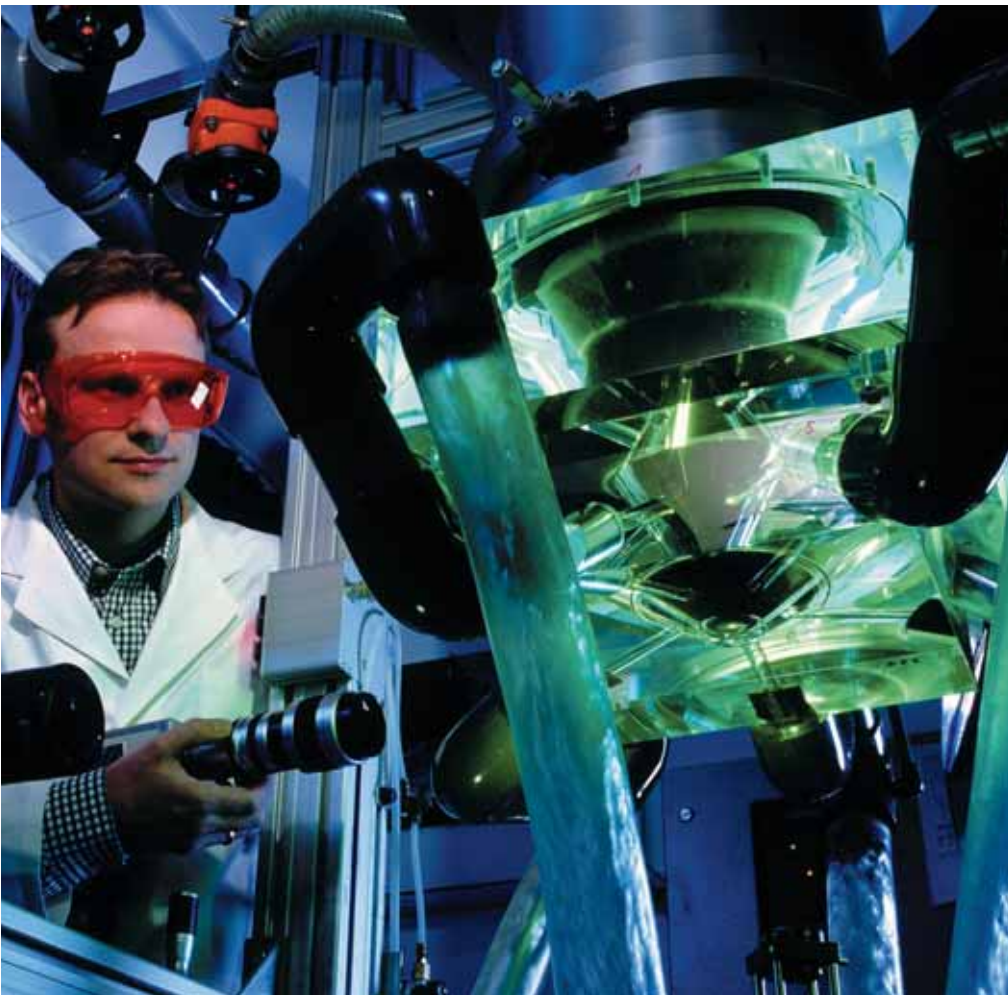
"Germany occupies a world-leading position in OLED manufacturing techniques and research and development," exults project manager Jörg Winkler of the VDMA display forum. To further expand the country's activities in this new research field and maintain international

competitiveness, the BMBF intends to make 100 million euros in funding available over the next five years within the framework of the broadly defined "OLED 2015" research and development initiative.

German researchers and developers are also significantly involved in OLED technology progress being made at the European level: 12 of the 24 partners in the EU project OLLA (high-brightness Organic Light emitting diodes for ICT & Lighting Applications) launched in late 2004 are from Germany. Osram-Organic Semiconductors, Aixtron AG and Covion GmbH, members of the OpTech-Net Network of Competence in North Rhine-Westphalia, are among the project partners who will be working on the development of high-efficiency white LEDs until 2008. OLEDs of this type will supplant light bulbs and neon tubes in the next ten to fifteen years, bathing offices and homes around the world in pleasing diffused light.

Optical metrology and sensor technology keeps the environment clean

Optical technologies can also be of service to the environment: Contaminated sites and soil and water pollution can be monitored more accurately, quickly and cost-effectively using optical fluorescence spectroscopy than with conventional methods.



Researchers at the Bosch company employ optical laser methods and enlarged transparent models to analyse air and fuel flows within ducting components. Such analyses indicate how the product can be optimized to further improve combustion. © Bosch

Using "Teramobil" to examine the atmosphere

Another critical factor in maintaining the quality of the environment is the ability to precisely determine the ozone concentration in various layers of the atmosphere. Researchers at Friedrich Schiller University in Jena – a member of the Thuringian **OptoNet** Network of Competence – have developed a portable high-powered laser for this purpose. "Teramobil" is a mobile terawatt laser system which can be employed to accurately determine ozone concentration levels in different layers of the atmosphere. The principle at work behind this application: The laser beams, which are otherwise mostly invisible, convert to white light in the atmosphere. The transportable high-powered laser could also be used to help convict environmental lawbreakers or obtain new fundamental insights into the chemical composition of the atmosphere. For developing this innovative technology in the area of ultraoptics, the Jena laser physicists received the 2005 Thuringian Research Prize for applied research.

Here in Germany, the possibilities arising from the focus on optical technologies provides impetus for innovation and economic growth in virtually all branches of industry. The opportunities created by light technology must be sustained, further expanded and exploited in order to facilitate both an upturn in the German economy and employment growth. Competence Networks make a significant contribution towards achieving these common goals through the nationwide networking of all of their participating partners.

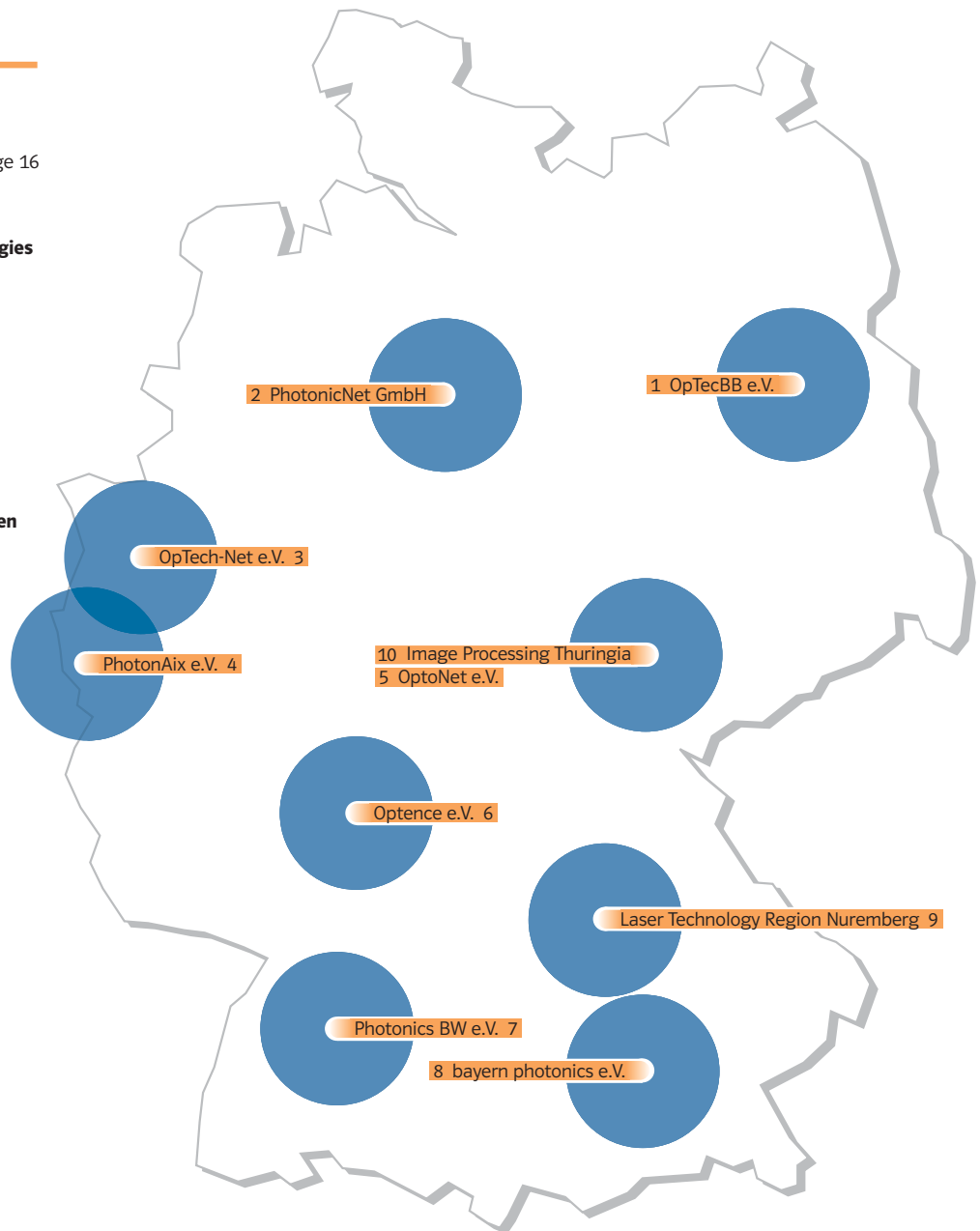
Silke Kramprich,
OptecNet Deutschland e.V.

Competence Networks for optical technologies in Germany



Optical technologies

- 1 **OpTecBB e.V. - Network of Competence for Optical Technologies in Berlin-Brandenburg** ◉ Page 16
▲ Berlin
- 2 **PhotonicNet GmbH - Competence Network for Optical Technologies in Lower Saxony** ◉ Page 18
▲ Hanover
- 3 **OpTech-Net e.V. - Network for Optical and Optoelectronic Technologies and Systems (Nordrhein-Westfalen)** ◉ Page 20
▲ Duisburg
- 4 **PhotonAix e.V. - Competence Network for Optical Technologies and Systems in Aachen**
◉ Page 22
▲ Aachen
- 5 **OptoNet e.V. - The Thuringian Network of Competence in the field of Optical Technology**
◉ Page 24
▲ Jena
- 6 **Optence e.V. - Network of Competence for Optical Technologies Hesse/Rhineland-Palatinate**
◉ Page 26
▲ Frankfurt/Main
- 7 **Photonics BW e.V. - Competence Network for Optical Technologies in Baden-Württemberg** ◉ Page 28
▲ Oberkochen
- 8 **bayern photonics e.V. - Bavarian Competence Network for Optical Technologies** ◉ Page 30
▲ Munich
- 9 **Laser Technology Region Nuremberg**
◉ Page 32
▲ Nuremberg
- 10 **Image Processing Thuringia** ◉ Page 34
▲ Jena



▲ Region of the managing office of the Network of Competence

Abbreviations

- AIF = German Federation of Industrial Cooperative Research Associations „Otto von Guericke“
- BMBF = Federal Ministry of Education and Research
- BMWA = Federal Ministry of Economics and Labour
- EU = European Union

The purpose of the infrastructural activity of these Competence Networks is to optimize the conditions for bringing potential users and researchers in the field of optical technologies together. The Networks of Competence will efficiently focus knowledge of their members and convert it into

industrial development. Other tasks of the Competence Networks include in particular activities related to training and continuing education, collaboration on issues concerning standardization and regulations, consulting and support of would-be entrepreneurs and public-relations work.

**Objectives**

OpTecBB's goal is to rapidly and efficiently promote the widespread development of optical technologies and thus to strengthen the region's economy.

Members of the network

- 44 SMEs
- 6 major enterprises
- 23 research institutes
- 4 universities
- 2 universities of applied sciences
- 2 technology foundations
- 1 bank
- 1 financial provider
- 3 service providers
- 2 private individuals

**C O N T A C T**

Dr. Bernd Weidner (Managing Director)

Phone: +49 (0)30 63921720

Fax: +49 (0)30 63921729

eMail: optecbb@optecbb.de

**OpTecBB e.V.
Rudower Chaussee 25
D-12489 Berlin**

www.optecbb.de

www.kompetenznetze.de/optecbb-en

Focus of activities

The region's strength in optical technologies, based on the existing knowledge base and resources, is mainly oriented towards the following areas of technology:

- Biomedical optics
 - Optical technologies for transportation and space
 - Optical technologies for the Internet
 - UV and X-ray technologies
- plus, on a more general, crosscutting level:
- training and education in optical technologies.

The region of Berlin-Brandenburg is also well endowed with research and manufacturing capacity in laser technology, optical components, lighting engineering and ophthalmic optics.

OpTecBB encourages scientific research and industrial applications, and furthers interdisciplinary collaboration and joint innovative projects by

- providing a forum for dialog
- initiating, mediating and coordinating collaborative ventures
- organizing and managing events such as strategy workshops
- public relations, Internet site
- supporting the creation of alliances
- consulting on funding programs
- assisting with the introduction of photonics as a new discipline in university education.

International activities

In an international context, OpTecBB strives to raise the region's profile as a strongly performing location in optics and photonics, and thereby to attract new companies and collaboration partners to the area, and to help its members secure access to new markets. Activities include organized visits to and appearances at trade fairs, such as the annual ECOC. By maintaining contacts with other regions and networks, OpTecBB enables its members to forge closer ties with other companies and organizations. OpTecBB has links with networks in Paris, Ottawa, Montreal and Tucson. Members of OpTecBB also participate in major trade shows such as Laser München and Photonics West by exhibiting jointly under the banner of OptecNet Deutschland.

Projects

The members of the network collaborate on numerous research and development projects.

An important aspect of this collaboration is that, by pooling a wide range of different experience and knowledge, it becomes possible to anticipate future technological developments and assess their potential for commercialization. In the focal field of UV and X-ray technologies, a group of more than 10 companies and research institutes has prepared a "Technological roadmap for X-ray material and structure analysis", which takes up international trends and evaluates their specific potential for the region of Berlin-Brandenburg.

Innovation highlight

Manufacture of lightweight mirrors

The BERLINER GLAS Group offers innovative processes to reduce the weight and thermal expansion of mirror mounts. This can be of considerable advantage in spaceflight applications, or in dynamic systems or lithography.

With their optimized balance between weight and rigidity, the lightweight structures are easier to handle when positioning large-sized mirrors. They also demand less stability on the part of mounting brackets and positioning elements, which overall leads to significant cost savings when compared with large-dimensioned mirror mounts that do not have a lightweight structure.

BERLINER GLAS employs two decisive technologies for the construction of lightweight mirrors. The structures can be machined out of a single block of material, achieving a weight reduction in the order of 70% - 80% and a high degree of precision. But closed structures cannot be built this way. The second technology relates to the joining of discrete, structured components. High-quality mirror surfaces have to undergo optical polishing. In the case of lightweight structures, this can lead to the so-called "print-through effect", in which the rib structure appears on the surface. This defect needs to be corrected. BERLINER GLAS has many years of experience in deterministic correction methods such as mechanical polishing, ion-beam etching and magnetorheological polishing.

*Lightweight structure:
Lightweight mirror mount, hexagonal mirror,
373 mm diagonal, 26 mm structural depth,
cells with 2 mm walls.
© Berliner Glas*



PhotonicNet

Competence Network for **Optical Technologies**

Objectives

Seedbed for interdisciplinary cooperation in the field of optical technologies

- Accelerating innovation processes through mediation and coordination
- Concentrating specialist skills and reinforcing regional strengths
- Supporting the creation of new businesses
- Education and training initiatives
- Communication and information-sharing
- Public representation

Members of the network

- 16 SMEs
- 7 large corporations
- 6 research institutes
- 6 universities
- 2 organizations (technology transfer and business development)



CONTACT

Dr. Hans-Jürgen Hartmann
(Managing Director)

Phone: +49 (0)511 277-1640

Fax: +49 (0)511 277-1650

eMail: hartmann@photonicnet.de

PhotonicNet GmbH
Kompetenznetz Optische Technologien
Garbsener Landstr. 10
D-30419 Hannover

www.photonicnet.de

www.kompetenznetze.de/
photonicnet-en

Focus of activities

PhotonicNet is a working partnership of members from industry, research and education, who share the aim of leveraging the huge innovative potential offered by optical technologies. The presence in the same region of internationally recognized optics companies and major users such as the automobile and steel industries, and a closely meshed infrastructure of excellent research and manufacturing facilities, come together to create synergy effects that make this region an outstandingly attractive location for companies in the field of optical precision engineering.

Core competencies in the network:

- Light sources and concepts
- Optical components, coatings, micro-optics
- Information and Communication Technologies
- Micro- and macromaterial processing
- Test and measurement systems, sensors, metrology
- Life sciences, biophotonics
- Training and education

PhotonicNet provides a structured environment in which this partnership can be intensified on a long-term, stable basis:

The network receives considerable support from the BMBF and the Land of Lower Saxony.

International activities

PhotonicNet has strong ties with the Scottish Optoelectronics Association (SOA) in Edinburgh, which offers many interesting openings for collaboration in the field of biophotonics.

Other international activities are organized through OptecNet Deutschland, the central association representing all regional optics networks at national and international level. These joint activities include trade show exhibits (Photonics West, Laser, Optatec), visits by foreign delegations, and professional trips to many parts of the world.

Projects

SPOTLITE – Beating the resolution barrier in light microscopy

- *Support from:*
EU (NEST project)
- *Members of PhotonicNet involved:*
Max Planck Institute for Biophysical Chemistry (coordinator)

The aim of SPOTLITE is to overcome the (diffraction) limitations of the light microscope and increase its resolution from half a μm to a few nanometers, and to do so using conventional light sources rather than complex laser systems. Cell biologists can use a “nanoscope” to view structural details of living cells in 3D and real time, at a previously unobtainable resolution. Other applications are envisaged in lithography (chip fabrication) and optical data storage.

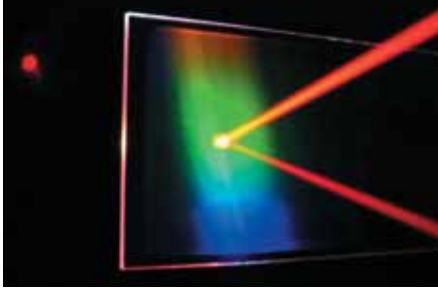


Printed polymer electronics manufactured using low-cost roll-to-roll processes © Fraunhofer Institute for Reliability and Microintegration, Munich

PolyApply – Polymer electronics off the roll

- *Support from:*
EU (Integrated Project)
- *Members of PhotonicNet involved:*
Institut für Hochfrequenztechnik, TU Braunschweig

The project will create a new generation of smart, ambient intelligent devices capable of integrating a range of electronic functions, including computation, sensing, and information storage, into a wide range of materials, even flexible or paper products such as consumer-goods packaging. The focus of the project is to devel-



Grating-waveguide structure allowing almost 100% reflection of the incoming light
© Laser Laboratorium Göttingen e.V.

op low-cost applications for ambient intelligence that provide multiple means of communicating with the environment and can be integrated into an overall network in everyday life.

MOBA - Micro-Optical Biochip Analysis

- *Support from:*
BMBF (collaborative project)
- *Members of PhotonicNet involved:*
TU Braunschweig

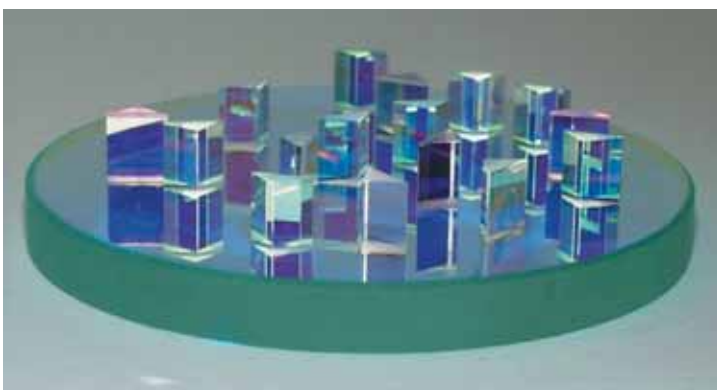
Development of a versatile device for the rapid analysis of biochips using a variety of optical techniques, such as fluorescence activation or the novel terahertz spectroscopy.

Areas of use: Matching of medication by means of gene analysis (DNA binding reaction), telemedicine, bioweapons detection.

InProGlas - Thermally based smoothing process for aspherical optics

- *Support from:*
BMBF (collaborative project)
- *Members of PhotonicNet involved:*
Laser Zentrum Hannover (coord.),
Leica Camera,
LINOS Photonics

Heating optical glass throughout its volume in a high-frequency beam source enables the surface of the glass to be smoothed under low stress in a downstream laser process. A non-contact measuring system records temperature, glass surface and glass surface temperature. The novel smoothing process is chiefly intended for use with complex glass surfaces.



Prism components for frequency conversion
© Laser Zentrum Hannover e.V.

SPOT - Super-mirror for modern optics

- *Support from:*
BMW (InnoNet project)
- *Members of PhotonicNet involved:*
Laser Laboratorium Göttingen (coord.),
Lambda Physik,
Laseroptik Garbsen

Development of a novel, ultra-reflective mirror for short spectral wavelengths, based on grating-waveguide structures. This is hoped to significantly raise the efficiency of laser applications in the UV range of the spectrum.

INTION - Integrative ion process for modern optics

- *Support from:*
BMW (InnoNet project)
- *Members of PhotonicNet involved:*
Laseroptik Garbsen,
Laser Zentrum Hannover,
LINOS Photonics,
LISA Laser

New process concepts for the manufacture of thin-film products with improved property profiles.

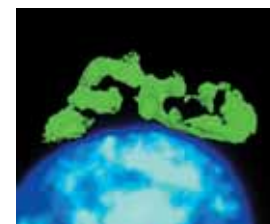
- Firmly adhering, mechanically strong coating systems for ophthalmology and laser beam protection
- Optical coating systems for laser systems
- Complex, highly stable, optical functional coatings for precision optics

Innovation highlights

Highlight 1

First commercial 4Pi confocal microscope

This novel microscope produces images of substantially improved sharpness. The 4Pi technology was developed by Leica Microsystems together with the working group led by Prof. Dr. Stefan Hell, Director of the Max Planck Institute for Biophysical Chemistry in Göttingen. The reduced size of the focal light spot makes it possible for the first time to resolve structures in living cells down to a diameter of 100 nm.



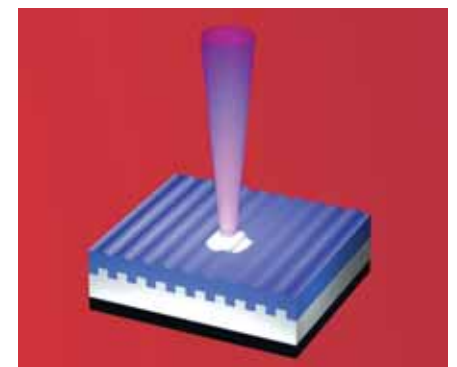
Golgi apparatus (green - 4Pi) and nucleus (blue - confocal) of a living cell
© MPI Biophysikalische Chemie, Dr. A. Egner

Highlight 2

Organic UV semiconductor laser

Various areas of the life sciences, such as gene and protein analysis, require photon sources that can be manufactured at very low cost. The organic UV laser made by TU Braunschweig in collaboration with the Physikalisch-Technische Bundesanstalt, based on polymer film, emits pulsed light with a power of up to 6.8 watts. The laser can be tuned to wavelengths in the range of 377.7 - 395 nanometers.

Organic solid-state laser (concept)
© TU Braunschweig, IHF



**Objectives**

The goal of the network is to support and promote optical and optoelectronic technologies. OpTech-Net e.V. functions as a

- communications platform for advancing strategic cooperative ventures
- broker, initiator and coordinator of new projects and alliances between the scientific and business communities, with the aim of accelerating the time-to-market of innovative products through networking.

Members of the network

- 23 SMEs
- 2 major corporations
- 2 research institutes
- 7 universities
- 4 private individuals

**C O N T A C T**

Dipl.-Ing. Dirk Kalinowski
(Managing Director)

Phone: +49 (0)203 3794658

Fax: +49 (0)203 3792409

eMail: info@optech-net.de

OpTech-Net e.V.
Lotharstr. 55
D-47057 Duisburg

www.optech-net.de

www.kompetenznetze.de/optech-net-en

Focus of activities

Optical technologies as a whole represent the key technology of the 21st century. Though regionally anchored, OpTech-Net is a nationally active association for linking business, science and education communities in this field. The ongoing activities that facilitate the exchange of ideas and information between these three areas include:

- Networking
- Initiation of cooperative ventures
- Knowledge transfer
- Specialist group activities
- Technology marketing
- Public relations

The network derives its focal areas of professional specialization from members' fields of activity. These areas are currently:

- Optical communications technology
- Display, signaling and lighting technology
- Sensors and metrology
- Optics, micro-optics and assembly and interconnection technology
- Materials
- LED technology

International activities

OpTech-Net e.V. is a member of the International Coalition of Optoelectronics Industry Associations (ICOIA), in which 10 optical and optoelectronics industry networks from around the world have banded together for the purpose of regularly discussing developments and trends in the field.

The Competence Network also participates in the community exhibition stands set up each year by Optecnet Deutschland e.V. at the Photonics West trade show in the USA, which gives member companies of the various Competence Networks the opportunity to present their products and break into new markets.

Projects

The members of the network participate in a variety of collaborative projects. The venture described below, an EU-funded collaborative project in the area of optical communications technology involving two members and two foreign partners, serves as one example:

Optical phase shift keying with synchronous demodulation

Since July 2004, a project jointly conducted by the *University of Paderborn* and three companies - CeLight in Israel, Photline Technologies in Besançon, France and *Innovative Processing AG (IPAG)* in Duisburg, Germany - has been operating with support from the European Commission within the scope of the Sixth Framework Programme. With a total of 1.7 million euros in funding through to June 2007, the project aims to develop "Key Components for Synchronous Optical Quadrature Phase Shift Keying Transmission".

This innovative modulation/demodulation scheme - given the abbreviated project designation "synQPSK" - can be combined with additional polarization multiplexing to achieve four times the information capacity of conventional data transmission methods. Existing wavelength multiplex systems, designed for channel data rates of 10 Gbit/s, can be set up for 40 Gb/s per channel using this approach. Specific advantages over 40 Gb/s time multiplex transmission are increased tolerances as compared with chromatic dispersion and polarization mode dispersion, and higher receiver sensitivity, which makes it possible to use existing fiber-optic cables and optical amplifiers, along with the rest of the system. Additionally, the frequency selectivity inherent in this method allows tighter packing of wavelength multiplex channels, thus permitting a further increase in transmission capacity.



Figure: The first electronic LED media facade to be installed can be seen at T-Mobile in Bonn (Germany)

From a technical standpoint, this project requires an optical super-heterodyne receiver in which a local laser is used for down-converting the optical fields into the baseband. Whereas earlier synQPSK work required highly specialized lasers with linewidths in the lower kHz range, the current project aims to achieve synQPSK using standard DFB lasers. The most significant project developments will be a QPSK modulator, an optical 90° hybrid co-packaged with balanced photoreceivers, SiGe and CMOS microelectronic circuits for processing the signals received, and a 4x10.7-Gb/s test bed for validating these components.

It is hoped that synQPSK technology will facilitate further growth in data transmission capacity that is both evolutionary and, compared with other strategies, more economical.

<http://ont.upb.de/synQPSK/>

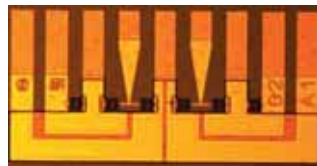


Figure: Realised component for synQPSK transmission.

Innovation highlights

Highlight 1

Transparent LED media facade

The Lumino LED media facade combines normally incongruous elements in a way that distinguishes it from any other LED display system in the world.

It is the first full-color, video-capable outdoor facade display that neither alters the building's architecture nor compromises the view from within the building or from without.

The scale, form and contour of the LED media facade can be customized for individual needs. The presentation design possibilities are virtually endless.

www.lumino.de

Highlight 2

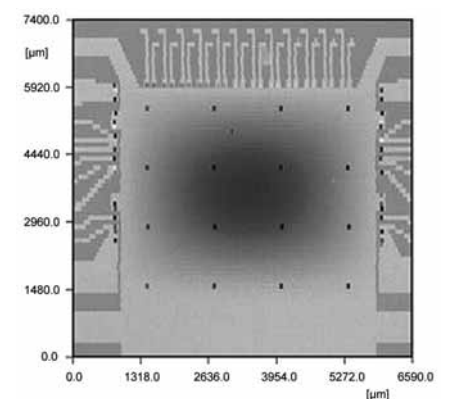
Gross and fine leak testing at the wafer level for hermetically encapsulated MEMS devices

MEMS devices and many types of electronic and photonic components require the protection of hermetic packaging to ensure reliability. Leak testing for small form factor modules has traditionally been very challenging from a technological standpoint, as well as cost-intensive. The new patented Optical Leak Test Station makes it possible to conduct gross and fine leak testing in a single pass for a full wafer with encapsulated devices and to identify leaks for each individual package on the wafer. A small membrane is integrated on each package - an optical sensor measures the deflection of the membrane as a function of time and pressure to detect potential leaks.

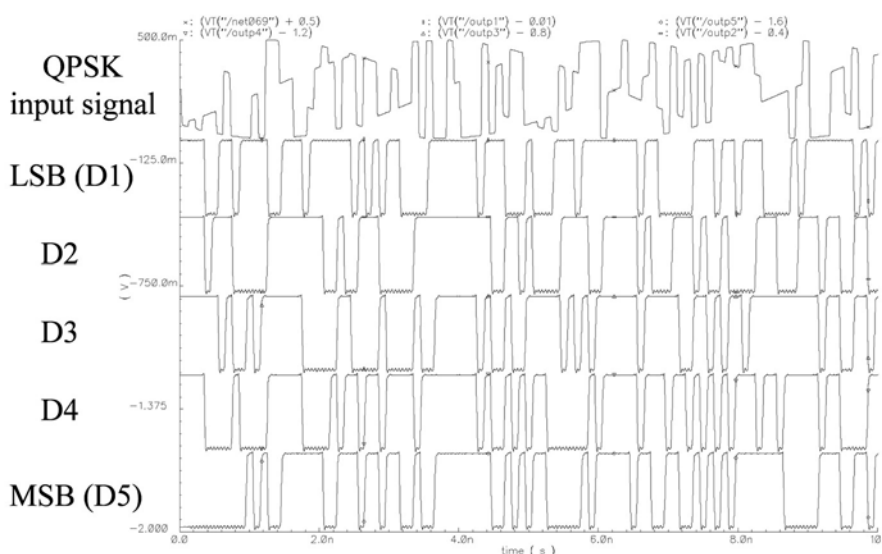
www.nanofocus.de

www.hymite.com

Figure: Membrane deflection indicates that the package has no gross leaks.



ADC output with QPSK input signal (10 Gsample/s)



**Objectives**

PhotonAix pursues the goal of sustainably promoting research and innovation in optical technologies in the Aachen region.

Members of the network

- 16 SMEs
- 1 large company
- 1 university
- 2 research institutes
- 3 consulting and service agencies

**CONTACT**

Christian Hinke (Managing Director)

Phone: +49 (0)241 8906 352

Fax: +49 (0)241 8906 121

eMail: hinke@photonaix.de

**PhotonAix e.V.
Kompetenznetz Optische Technologien
Steinbachstr. 15
D-52074 Aachen**

www.photonaix.de

www.kompetenznetze.de/photonaix-en

Focus of activities

PhotonAix promotes research and innovation through the following activities:

- Support for regional cluster-building
- Initiation and coordination of joint projects
- Support for marketing and public relations activities
- Promotion of training and education programs
- Support for startups
- Consulting on sponsorship opportunities
- Supporting and assisting the formulation of regional, national and European research policy

The thematic focus of the network encompasses the application of optical technologies in production - including the fields of life science and nanotechnology - and the development of corresponding components and systems. Highlights include:

- Laser materials processing
- Beam source development
- Optical metrology
- Optical technologies in micro- and nanotechnology
- Design, simulation and manufacturing of optical components
- Optical technologies in medical devices and biotechnology
- Training and consulting

From laser materials processing to biophotonics to applications in transport and space, the full spectrum of the production-engineering applications of optical technologies is represented in PhotonAix. The main activities and services offered include regional technology and industry marketing, consulting services for startups, technology management, training and education initiatives, and rigorous promotion of communication efforts within the regional network. The close interconnection of the region's diverse competencies yields practical and timely solutions to problems and faster translation of research results into market-ready products.

Alongside the joint appearance of the Optical Technologies Competence Networks at Optatec in Frankfurt, a visit paid by research minister Edelgard Bulmahn to the PhotonAix stand at the "Technology Day" event in Düsseldorf was among the top highlights of 2004. PhotonAix chairman Professor Poprawe illustrated the close cooperation among PhotonAix members in the area of training and education for the minister through the examples of Fraunhofer ILT and startup company Edgewave GmbH.

Minister Edelgard Bulmahn visits the PhotonAix stand at "Technology Day" (2004) in Düsseldorf





Plasma light source for the extreme ultraviolet
© Fraunhofer ILT

Innovation highlight

The Fraunhofer Institute for Laser Technology ILT, the Chair for Laser Technology at RWTH Aachen, AIXUV GmbH – all PhotonAix members – and Philips Extrem UV GmbH were honored with the science prize of the Donors' Association for the Promotion of Sciences and Humanities in Germany, which carries a 50,000-euro endowment. The team of collaborating partners from science and industry won the award for their especially productive, close cooperation on the development of a new *EUV (extreme ultraviolet) lithography process*. This technique is suitable for manufacturing exceptionally small semiconductor structures, which are in demand for the chips used in ever more powerful PCs.

Ever since the earliest days of semiconductor manufacturing, chips have been made using a light exposure process. To fit more transistors onto a chip, the already tiny structures on the silicon wafers must be made successively smaller. Conventional optical lithography processes can go no farther than about 50 nanometers. The EUV lithography method achieves an extraordinary technological leap forward by employing radiation with a wavelength of only 13.5 nanometers. Because the extreme ultraviolet light used is absorbed by all materials – even air – the entire lithography process must take place in a vacuum. This technology now features on the roadmap of all semiconductor manufacturers, including INTEL, and involves the development of completely new light sources, optical components and photoresists.

For their EUV light source, the Aachen researchers working with the team assembled by Dr. Willi Neff employ an extremely hot plasma generated using hollow cathode gas discharge. An international comparative study revealed that the "Aachen lamp" achieved the best performance. The groundwork for the patented concept was carried out between 1997 and 2000 at the Fraunhofer ILT and the RWTH Chair for Laser Technology. In 2000, Dr. Rainer Lebert founded a spin-off company, AIXUV, which manufactures and markets compact EUV lab sources for use in research and EUV systems for metrology and quality control.

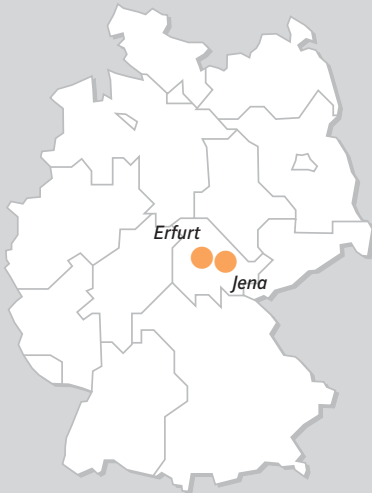
**Objectives**

Supporting the growth of optical technologies by

- pooling regional strengths
- preserving and creating employment
- developing future-oriented technologies
- ensuring faster, more efficient transfer of complex technologies to manufacturing
- developing products and services with unique selling points
- supporting training and education

Members of the network

- 46 SMEs
- 2 large corporations
- 5 research institutes
- 4 universities and other training establishments
- 3 banks & venture capital firms
- 1 technology development agency

**C O N T A C T**

Dr. Klaus Schindler
(Managing Director)

Phone: +49 (0)361 789 23 21
(Erfurt office)

Phone: +49 (0)3641 30 92 16
(Jena office)

Fax: +49 (0)361 789 23 69

OptoNet e.V.
Kompetenznetz Optische Technologien
Mainzerhofstr. 10
D-99084 Erfurt

Schillerstr. 1
D-07745 Jena

www.optonet-jena.de

www.kompetenznetze.de/optonet-en

Focus of activities

The larger companies and many small and medium-sized enterprises (SMEs) in the Competence Network offer advanced technologies for optical and optoelectronic components and systems. Their expertise is complemented by numerous highly reputed educational and research establishments, rounding out the profile of the Jena-Erfurt-Gera-Ilmenau region with its long tradition as a center of the optics industry.

The network members are experienced in the following specialist fields:

- Fundamental research in optical technologies
- Data visualization
- Optical surfaces and coatings
- Optical data processing and test and measurement systems
- Active optical fibers and fiber sensors
- Image processing
- Design of optical systems
- Optical precision machining
- Laser technology

The network's main activities are:**Marketing and communication**

OptoNet promotes its members through press releases, printed publications, the Internet, a competence database, and a newsletter. To promote internal communication, the network holds regular "cluster" meetings hosted by various members.

Cooperation exchange

The five OptoNet working groups, composed of specialists in the fields of optoelectronics, image processing, optical coatings, hybrid optical systems and laser technology, play a special role in the establishment of new cooperative ventures. The meanwhile traditional workshops held in conjunction with the regional research community attract an impressive number of participants from all over Germany and abroad.

Training and education

In addition to lending its support to numerous local educational and training events, OptoNet is particularly active in efforts to build up a skilled supply of qualified workers in the region, and organizes special events for school students, teachers and the general public.

Developing international relations

OptoNet has already forged close ties to other European optics networks, including OpticsValley in France and OpticForum in Wales. Another measure of the extent of its international activities is the network's participation in a variety of collaborative EU projects with partners in France, the UK, Finland and Poland.

Innovation highlights

Highlight 1 New automated optical test instrument (AOI)

The Thuringian firm GÖPEL electronic GmbH has developed an entirely new hardware and software platform for its optical printed-circuit-board (PCB) inspection systems.

The new range of systems is built around a scaleable modular photographic sensor that can be equipped with a selection of recording modules with capacities ranging from one to four mega-pixels. To increase the scope of testing, the user can add additional cameras and configure the system to test THT components, inspect colors, carry out 3D measurements or conduct tests with oblique-angle scanning.

The system sets new standards by achieving particularly high testing speeds, reduced debugging times, minimum pseudo error rates and extremely high reliability in terms of fault detection.

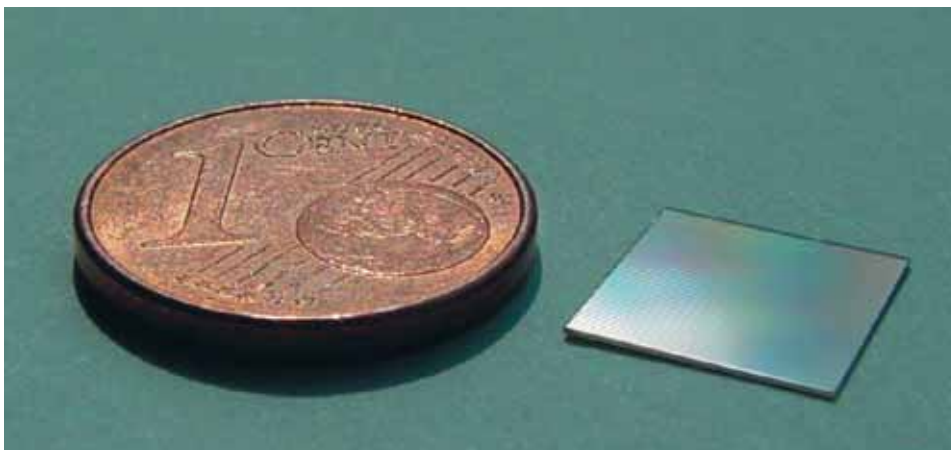


OptiCon Advanced Line
© Göpel electronic GmbH

Highlight 2 Ultra-flat image recording system

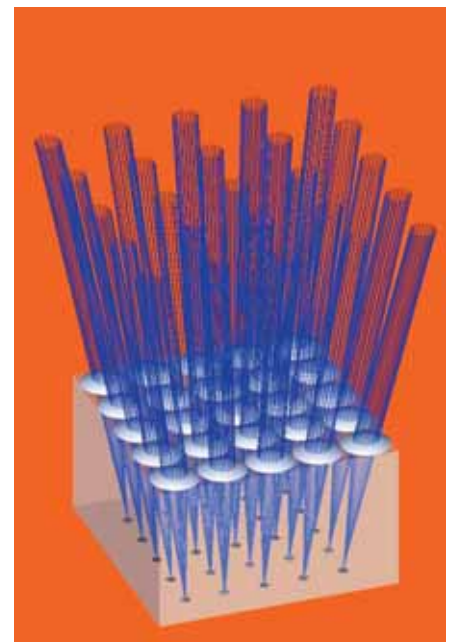
Researchers at the Fraunhofer Institute for Applied Optics and Precision Engineering (IOF) in Jena have succeeded in developing a novel image recording system based on the same principles as the compound eye of an insect. It is built in an extremely flat format, only roughly 0.2 mm high, and consists of an array of several hundred or even a thousand separate lenses. Each lens records a tiny portion of the overall image but, owing to their great number and the fact that they are aligned in a curved arrangement, together they produce a relatively wide picture. New micro-optical manufacturing techniques borrowed from the semiconductor industry are used to create accurately dimensioned, identical arrays of lenses and to fabricate them on silicon wafers as thin, monolithic image recording devices.

The potential applications of the "compound-eye camera" are many and varied, especially in situations where space is limited or where a camera needs to be installed as discreetly as possible. One possibility would be to install the camera inside cars to monitor the driver's eye movements and trigger a warning if the driver shows signs of falling asleep at the wheel. The camera is so thin that it could also be incorporated in chip cards for use in biometric identification of the owner.



The camera chip in comparison with a one cent piece.
© Fraunhofer IOF

Principle of compound eye camera - each optical channel of the device looks into a different direction so that each lenslet captures a different image point of the object.
© Fraunhofer IOF





Kompetenznetz
Optische Technologien
Hessen / Rheinland-Pfalz

Objectives

- Sustainable promotion of optical technologies in Hessen/Rhineland-Palatinate
- Promotion of regional cooperative ventures
- Strengthening of the industry
- Establishment of a communications platform
- Support for implementation of innovative business concepts
- Representation of member interests in government and public relations efforts
- Support for education and training in the field of optical technologies

Members of the network

- 24 SMEs
- 7 major enterprises
- 2 research institutes
- 12 universities of applied sciences
- 2 service companies (technology transfer/business development)



CONTACT

André Noack (Managing Director)

Phone: +49 (0)6732 935-122

Fax: +49 (0)6732 935-123

eMail: noack@optence.de

Optence e.V.

Kompetenznetz Optische Technologien

Ober-Saulheimer-Str. 6

D-55286 Wörrstadt

www.optence.de

www.kompetenznetze.de/optence-en

Focus of activities

There are a number of innovative companies, colleges and universities in the Hesse/Rhineland-Palatinate region that are active in the field of optics, which gives the area an impressive research and development potential.

Core competencies within the network

- Optical systems
- Optical metrology
- Laser technologies
- Image processing
- Diffractive and adaptive optics
- Micro- and integrated optics
- Coating technologies
- Liquid crystals
- Light sources
- New materials
- Sensor technology
- Training and education

Activities of the Competence Network

Optence establishes efficient communication structures between members, with the goal of accelerating cooperative ventures and strengthening the optical industry in the region in a sustainable fashion.

• Work groups:

In work groups, which serve as the network's central forum for innovation, specific topics of research are addressed in a goal-oriented manner by a manageable number of participants. The meetings provide a setting for socializing with users and external consultants, and also give participants the opportunity to find partners for cooperative ventures and create synergistic relationships.

• Marketing and communication:

Public forums such as the annual "Optical Technology Forum" in Wetzlar help increase public awareness of the world of optical technologies. Community stands at trade fairs provide members with a cost-effective opportunity to reach a national and international audience.

• Contract fulfillment and project management:

Optence can provide help when members or customers have a need for additional qualified staff or know-how, and is prepared on request to actively accompany their projects through to fulfillment. Together with its partners, Optence offers competent R&D services in virtually all areas of modern optics, including the search for production partners.

• Startup consulting:

Support for entrepreneurs in creating business plans, providing contacts, and help with obtaining venture capital and funding.

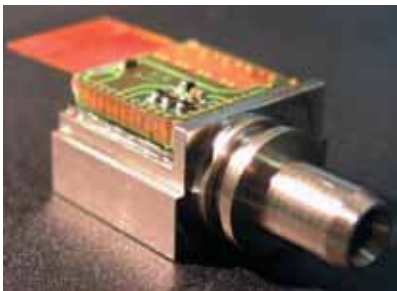
Optence is funded by the Federal Ministry of Education and Research.

Innovation highlights

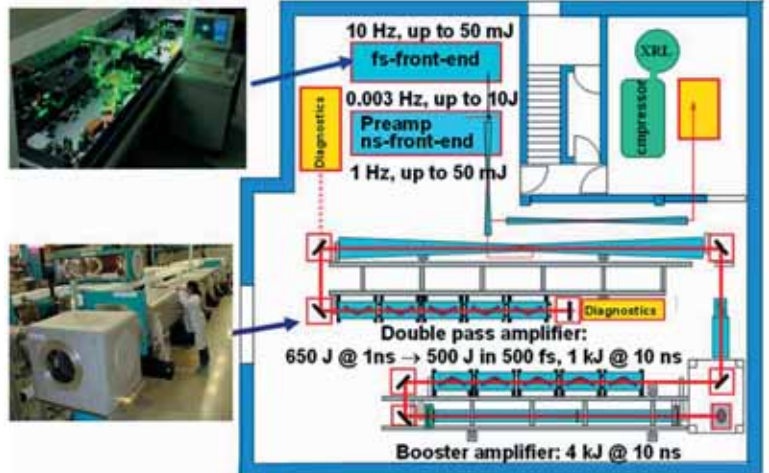
Highlight 1

First commercially available integrated optical CWDM ROSA (Receiver Optical Sub-Assembly)

Exceptionally cost-effective to manufacture, the integrated optical CWDM ROSA consists of a four-channel demultiplexer with an integrated receiver diode array and operates entirely without fiber connections. This approach yields the ability to integrate active and passive optical elements within a minimal amount of space, as is required for applications such as 10GB Ethernet transceivers with the X2 form factor. There are also numerous other applications in the areas of sensor technology or CWDM transceivers. Contact: www.cubeoptics.de



Optical layout of PHELIX



Highlight 2

PHELIX: Petawatt High-Energy Laser for Heavy-Ion Experiments – Germany's largest laser system

GSI Darmstadt is currently building a 1-kilojoule/1-petawatt (10^{15} W) Nd:glass laser system called PHELIX. The project is being carried out in close cooperation with Lawrence Livermore National Laboratory in the US and the Commissariat à l'Energie Atomique (CEA) in France. The PHELIX laser architecture is based on Nova and Phebus amplifiers with a diameter of 31.5 cm. PHELIX will combine a high-current, high-energy (GeV/u) heavy-ion beam with an intense laser beam – the first such system in the world. This innovation will open the door to a variety of fundamental scientific research opportunities in the fields of atomic physics, nuclear physics and plasma physics.

GSI PHELIX is a member of Lasernet / Laserlab Europe. Contact: www.gsi.de/phelix

Highlight 3

Optics for personal care

A newly developed optical sensor measures a person's individual UV sensitivity on face and body before a session on the tanning bed. The measured data are then used to calculate a personalized tanning program. The sensor is based on miniaturized plastic optics with an integrated optoelectronic sensor.

Contact: www.viaoptic.de



The heart of the tanning sensor is a highly precise photometric integrator made of plastic.



The sensor ready for use



Objectives

Promoting the advancement of optical technologies through research, development and application, training and education, marketing and public relations.

- Promoting three-way dialog between industry, science and government.
- Strengthening international competitiveness and building a sustainable future for the business economy of Baden-Württemberg.

Members of the network

- 13 SMEs
- 7 major enterprises
- 4 universities
- 5 advanced technical colleges
- 4 research institutes
- 5 agencies
(consulting and other services)
- 1 bank



CONTACT

Dr.-Ing. Andreas Ehrhardt (Director)

Phone: +49 (0)7364 202913

Fax: +49 (0)7364 204903

eMail: ehrhardt@photonicsbw.de

**Photonics BW e.V.
Competence Network for
Optical Technologies
Carl-Zeiss-Str. 1
D-73447 Oberkochen**

www.photonicsbw.de

**[www.kompetenznetze.de/
photonicsbw-en](http://www.kompetenznetze.de/photonicsbw-en)**

Focus of activities

Photonics BW represents the interests of developers, manufacturers and users in the field of optical technologies and serves as a central contact point.

The network's activities extend across many important areas of optical technologies, with a special focus on the needs of the most prominent sectors of industry in Baden-Württemberg:

- Laser materials processing
- Optical design and simulation
- Optical communications
- Optics in medicine and biotechnology
- Optical measurement techniques
- Training and consulting

Research, development and application

Forging links between science and industry is one of the fundamental aims of Photonics BW. The network has set up six working groups in which experts meet at regular intervals to share their knowledge and to discuss topical issues arising at the pre-competitive and non-commercial level of research. To support interdisciplinary working between the individual working groups, a "competence matrix" documenting the products and fields of expertise of the network members has been compiled and posted on the Photonics BW Web site.

Another important function of Photonics BW is its role as project administrator for the "Research in Optical Technologies" funding program on behalf of the „Landesstiftung Baden-Württemberg gGmbH" (Baden-Württemberg State Foundation). Photonics BW manages a total of 21 research projects sponsored under this program, which has covered a variety of topics relating to optical technologies in three successive competition rounds.

Training and consulting

Organization of seminars and workshops, participation in the mobile exhibition „Faszination Licht" and publishing detailed guides to study and training opportunities.

Marketing and public relations

Organization of special events and joint booths on international trade fairs and conferences, like LASER, OPTATEC and Photonics West; releasing publications.

International activities

Photonics BW participates in international activities as a member of the national association of regional Competence Networks in optical technologies, OptecNet Deutschland. It also cooperates directly with a photonics Competence Network in France.

Innovation highlight

The perfect laser for microprocessing

In microtechnology, thermal influences play a special role during processing. Laser beam sources for microprocessing have to exhibit special properties: diffraction limited beam quality, short pulses and the highest stability. TRUMPF has developed new solid-state lasers especially to meet these requirements. The TL Q laser series celebrates its premiere at the LASER fair 2005 in Munich.

In the field of microprocessing, laser light is primarily used for the precise removal of material. Pulsed Q-switched diode-pumped lasers are used for this purpose. TRUMPF has designed and developed a new laser series especially for microcutting, etching, drilling and structuring. According to the specifications, the fluctuation in output power is below one percent and the maximum angle deviation of the exit beam is under 10 mrad.

High pulse energies - high repetition rates

The average output of up to 30 W of the TRUMPF TL Q lasers with a so-called Q-switch, can be converted physically either into high pulse energies or high repetition rates. The specific application determines which pulse properties are best. TRUMPF therefore offers lasers with two different laser-active media. While the TL 20-1 LQ with YLF-rod offers particularly high pulse energies of up to 4 mJ at 4 kHz, the TL 35-1 VQ with Yttrium-Vanadat (YVO4)-rod achieves repetition rates of up to 200 kHz. Nevertheless, with 30 kHz, up to 1 mJ of pulse energy is available. The pulse widths are dependent on the pulse energy and are between 15 and 80 ns.

The output is regulated not by controlling the excitation, but rather from pulse-to-pulse outside the resonator. The overall opto-mechanical resonator system is therefore in a state of equilibrium during operation. In addition to power stability, some micro applications, such as drilling, require an additional exact round beam profile. The advantage of a symmetrical beam is its consistent power distribution without fluctuations, before, during and after the focal point. TRUMPF microprocessing lasers are

used in any application for which the benefits of touch-free, flexible and precise material ablation are evident.

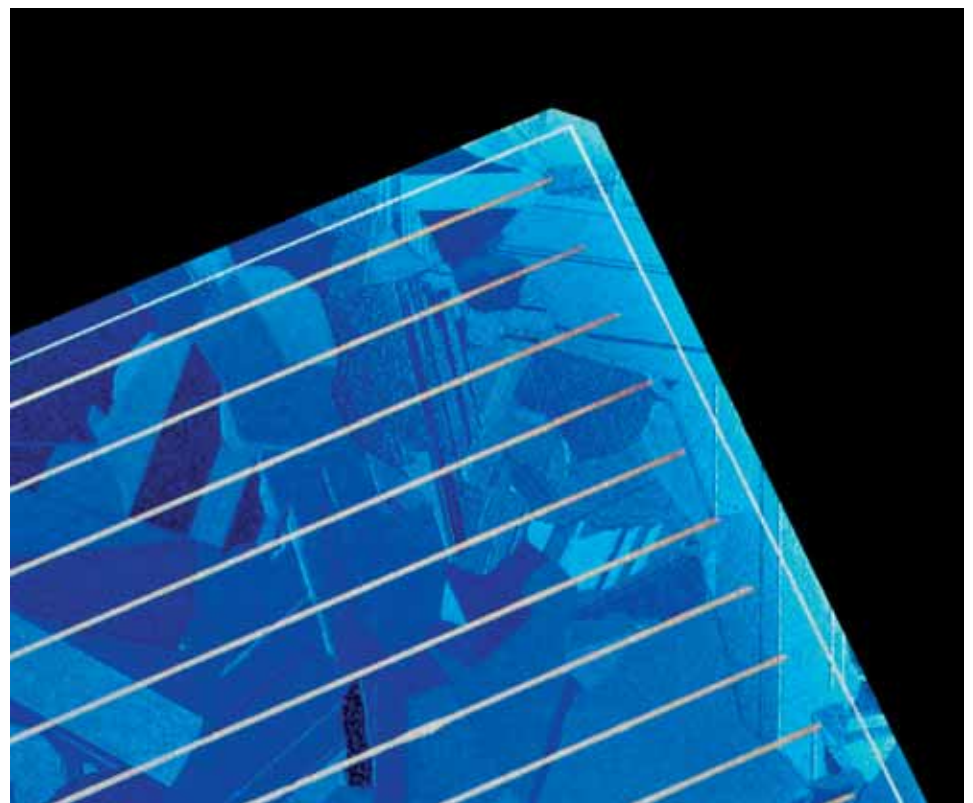
Laser ablation of semi-conductors, ceramics or steel

One example is the processing of crystalline silicon solar cells. In principle, they consist of one pn-transition in which the emitter is only a few nanometers thick. The production method causes a short circuit on the edges of the solar cells which reduces the available electric current. Up until now, this short-circuit has primarily been removed by means of machine grinding or by etching. In conjunction with scanner technology, the TRUMPF TL Q microprocessing lasers offer a new approach. The electric charge carriers are removed by vaporizing the material. About 50 to 70 mm wide grooves with depths of 5 to 10 mm are generated by the pulsed laser light along the edges of the solar cell. The individual pulses are very rapidly and precisely positioned by means of scanner optics. Thanks to the high repetition rate, these systems generate the

macroscopic overall lengths of the grooves in a short time.

The short pulses are also perfectly suited for drilling and structuring steel and hard metals. Thus, in 1 mm thick steel, it is possible to drill holes with diameters of between 50 and 200 µm at a tolerance of 1 µm. Also, microstructures are generated to improve the tribologic properties of sliding surfaces. The tribologic conditions in the contact zone define the workpiece quality and tool service lifetime in forming technology as well as precision cutting and punching tools. In combustion engines they affect the consumption of oil and fuel. This innovation was a development of common interest of pilot customers in the network.

Grooves along the edge of a multi-crystalline silicon solar cell.



**Objectives**

Excellent ideas need excellent contacts. This is where bayern photonics comes in: as a Competence Network for optical technologies, the network serves as a platform to promote cooperation between companies, research institutes and service organizations. This approach helps to strengthen Bavaria's position as a top region for optical technologies.

Members of the network

- 5 global players
- 27 SMEs
- 12 research institutes
- 6 service enterprises

**C O N T A C T****Dr. Horst Sickinger****Phone: +49 (0)8153 9536-87****Fax: +49 (0)8153 9536-98****eMail: info@bayern-photonics.de****bayern photonics e.V.****Argelsrieder Feld 22****D-82234 Oberpfaffenhofen****www.bayern-photonics.de****www.kompetenznetze.de/****bayern-photonics-en****Focus of activities**

- Initiation of cooperative ventures
- Career fairs
- Meetings of specialist working groups
- Organization of customized workshops and training seminars
- Project management
- Publications
- Promotion of training and education

All bayern photonics activities are related to the field of optical technologies. The amount of emphasis placed on specific areas is determined by our members.

Optics design, lighting technology, laser technology, micro-optical systems, biophotonics / life sciences, optics manufacturing, optical information and communication systems and optical testing and measurement are the fields most strongly represented at present.

Germany-wide networking in OptecNet Deutschland e.V. makes it possible to forcefully promote an effective vertical business marketing program and to leverage negotiating power at the political level.

In 2005, bayern photonics intends to expand the range of services on offer to its members and to set up additional specialist working groups.

Services offered:

Project management

We offer professional project consultation from start to finish, with concrete support in the following areas:

- Project structuring
- Support during the planning phase - definition of targets
- Achieving transparency on current project status
- Risk assessment
- Response to project disruptions
- Compilation of reports and journals
- Organization of project meetings

Taking advantage of these services allows the researchers to concentrate on their research without having to invest so much time dealing with administrative matters. Outsourcing of project management often leads to reduced overall project costs. We can also offer our members attractive discounts.

International activities

Although the primary role of bayern photonics is to serve as a regional network in Bavaria, the network also cultivates international contacts which have resulted in numerous cooperative alliances.

Examples:

- Québec Optics City – Canada
- LAS Laser Association – Russia

The Competence Networks for optical technologies also take part each year in the Photonics West trade show, where members have the opportunity to present their products to an international audience as part of a joint exhibit.

Project

Project in which our members are currently partners:

RIOS - Characterization, modeling and propagation of real light source radiation in optical systems

- *Support from:*
BMBF (collaborative project)
- *Project members of bayern photonics involved:*
Agfa-Gevaert AG,
Friedrich-Alexander University
Erlangen-Nürnberg, Chair for Optics,
LINOS Photonics GmbH & Co. KG

The goal of the project is to create a complete process chain that facilitates the comprehensive characterization, modeling and analysis of real light sources, as well as the simulation of the radiation field propagation of these light sources through complex optical systems. It explicitly encompasses the entire optical sequence, from source to detector/receiver and all practically occurring forms of radiation from UV to near infrared.

Innovation highlight

Several jointly developed products have emerged from cooperative alliances between network members.

SHS Autolab - jointly developed by AMICRA and OPTOCRAFT

The two cooperative partners, AMICRA Microtechnologies and OPTOCRAFT, first met at a working group organized by bayern photonics. This meeting ultimately led to the SHS Autolab automatic testing system for micro-optics. The first commercial system is shortly to be delivered to the customer.

SHS Autolab is designed to carry out complete final inspection of wafer-based micro-optics, but can also analyze individual elements. SHS Autolab is easy to use, fully automated, and features a short measurement cycle time per measured element. It also allows complete recording of the measurement results, with a data export interface for connection to downstream systems.



Laser Technology Region Nuremberg



Objectives

The Laser Technology Region Nuremberg network seeks to make it possible for companies to use the potential of the laser as a high-tech tool by means of application-oriented research, efficient knowledge transfer and individual services. In this context, training and development takes on an important role as an active form of knowledge transfer.

Members of the network

- 12 universities and research establishments
- 6 large corporations
- 11 SMEs
- 11 service enterprises (technology transfer and consulting)
- 7 financial service providers and venture capital agencies
- 4 economic development agencies



CONTACT

Dipl.-Ing. Hans-Joachim Krauß

Phone: +49 (0)9131 97790-0

Fax: +49 (0)9131 97790-11

eMail: info@blz.org

**Lasertechnik Region Nürnberg
c/o Bayerisches Laserzentrum gGmbH
Konrad-Zuse-Str. 2-6
D-91052 Erlangen**

www.blz.org

**www.kompetenznetze.de/
laser-technology-nuremberg**

Focus of activities

The Competence Network Laser Technology Region Nuremberg seeks to translate the many and varied possible applications of laser technology into tangible use. The work conducted by the network therefore covers the entire spectrum of laser machining, medical engineering, metrology and process engineering, as well as plant and system manufacture. The members of the network have developed special capabilities through research in sectors such as laser-beam plastic welding (1), rapid manufacturing (2), microjoining technology and automotive engineering. The products, processes, techniques and applications developed by the Competence Network are therefore relevant to a wide range of industrial sectors.

The efficient technology transfer of research into industrial application is one of the main goals of the Laser Technology Region Nuremberg network. It enables regional, national and international companies to benefit from expertise in the field of laser technology which the members of the network have developed, for example, in research projects and which they now pass on in the form of development work, engineering services, training and consultancy.

International activities

- Participation in joint international projects
- Exchange programs for scientists and students
- Organization of specialist international meetings and conferences (for example LANE 2004 – Laser Assisted Net Shape Engineering, Erlangen and LEF 2005 – Lasers in Electronics Production and Precision Engineering, Erlangen)
- Worldwide contacts to subject-related research establishments and enterprises

Projects

Hybrid welding of plastics (1)

- *Support from:*
AiF
- *Project members:*
Bayerisches Laserzentrum gGmbH,
Laserquipment AG
- *Thematic focus:*
Development of an innovative process combining laser transmission welding and radiant heat welding to create a hybrid welding process for plastic components.

In this cooperation project the company Laserquipment AG and the Bavarian Laser Center are developing a hybrid welding process which combines the advantages of laser transmission welding (see Fig. P1) with those of radiant heat welding. In this process the radiant heater only delivers as much energy as is required to cause a local temperature increase in the welding zone without reaching the melting temperature of the plastic. The energy required is provided by a focused laser beam which melts the plastic in a locally limited area, producing a narrow weld seam. Computer simulations and experimental tests show that by using this hybrid technology a volumetric heat increase in the upper plastic part is achieved during welding. This reduces the yield stress in the plastic and, in combination with suitable clamping devices, the thermal contact between the parts being joined is improved. The process can also be made suitable for use in joining together plastic components of large surface area and complex shape, as used in particular in automotive production.



Fig. P1
In the hybrid process,
laser transmission welding
is combined with
radiant heat welding.
© BLZ/Fuchs

ForWerkzeug Research Alliance – Subproject B1 (2)

- *Support from:*
Bayerische Forschungsstiftung
- *Project members:*
Bayerisches Laserzentrum gGmbH,
TRUMPF Werkzeugmaschinen
GmbH + Co. KG
- *Thematic focus:*
Technology integration for the manu-
facture of series tools by means of
metal-foil LOM

Over the past 10 years the requirements for the manufacture of tools have changed considerably. This is especially true in the case of tool-making by means of deep drawing and injection molding. The causes include the deployment of new materials and production methods, the introduction of platform concepts in the auto industry, and increasing efforts towards light-weight construction. In connection with global competition, shorter product life cycles, lower volumes and an increasing choice of different variants, these changes lead to new requirements which the tool manufacturers have to meet. Simple and cost-efficient tools with a reduced service life are often required within a short period.

Under this research project, the combina-

tion of selected rapid tooling techniques is being investigated for the manufacture of series tools to meet specific requirements. Owing to their ideally complementary characteristics, the project is focusing on NC milling, metal-blank and metal-foil LOM, which has been developed by the Bavarian Laser Center in cooperation with the Chair of Manufacturing Technology at the University of Erlangen-Nuremberg and TRUMPF Werkzeugmaschinen GmbH + Co. KG. At the forefront of these efforts is the integration of metal-foil LOM technology into tool manufacture. To this end, the reproducibility of geometries by means of metal-foil LOM is being studied and the resulting component properties identified. A further project goal is to combine the techniques involved in NC milling, metal-blank and metal-foil LOM for the manufacture of segmented, cost-optimized tools.

Innovation highlight

Laser droplet welding tool head

The laser droplet welding process (see Fig. IH 1) was developed in cooperation with network partners at the Bavarian Laser Center. In this innovative process, a thin metal wire is melted by means of laser pulses. The very small metal droplet which forms can be used, among other things, to combine incompatible materials with each other.

At the Bavarian Laser Center, a tool head (see Fig. IH 1b) has now been developed for this process which will make it possible to use laser droplet welding technology on an industrial scale. The process is suitable for welding filigree geometries, thin metallic coatings, heat-sensitive components and highly dissimilar parts geometries, without any negative effects on their mechanical and electrical properties.

Fig. IH 1
Laser droplet welding process
© BLZ/Fuchs



Fig. IH 1b
Droplet welding tool head
© BLZ



Image Processing Thuringia

Objectives

Image Processing Thuringia is a network with regional focus in the Ilmenau-Jena-Erfurt technology triangle that brings together companies, universities and non-university research institutes. Its key areas of activity are application-oriented research, development of optoelectronic components, and development of advanced methods and processes for image processing and analysis.

Members of the network

- 21 SMEs
- 3 large industrial companies
- 11 research institutes
- 2 universities
- 2 universities of applied sciences
- 2 business incubators



CONTACT

Privatdozent Dr.-Ing. habil. K.-H. Franke
(Spokesman)

Dipl.-Ing. I. Heinze (Contact)

Phone: +49 (0)3677 2010-300

Fax: +49 (0)3677 2010-302

eMail: karl-heinz.franke@tu-ilmenau.de

KN Bildverarbeitung Thüringen
Gustav-Kirchhoff-Str. 5
D-98693 Ilmenau

www.zbs-ilmenau.de

**www.kompetenznetze.de/
image-processing-thuringia**

Focus of activities

The Thuringian research program Image Processing, Pattern Recognition and Technical Vision Systems (BMTS) was created in 1997 on the initiative of the Thuringian Ministry of Science, Research and the Arts (TMWFK), TU Ilmenau and the Center for Image and Signal Processing.

The "Image Processing Thuringia" Competence Network was developed out of this program in the spirit of the BMBF „kompetenznetze.de“ concept. The main activities within the network are structuring and focusing the image processing landscape in Thuringia, ongoing development of information and communication networks, development and coordination of industrial and scientific contacts, and building of research alliances.

The spectrum of activities undertaken by the participants includes:

- Applied research in 2D system theory, image and signal processing, pattern recognition, computer graphics, light engineering, technical optics and neuroinformatics
- Development and production of optical, optoelectronic and electronic components for image processing
- Image processing software and customer-specific systems development
- Image-assisted quality assurance and inspection
- Image-assisted robotics and industrial automation
- Non-contact image-assisted geometric 2D and 3D metrology
- Spectral metrology, color image processing and analysis
- Multi-sensor methods and image fusion, including satellite image analysis
- University and postgraduate training and education

International activities

The network conducts international activities within the scope of various European projects (e.g. EUTIST IMV).

Projects

Monolithic Integrated Color Sensor (MICOS)

• Support from:

Thuringian Ministry of Economic Affairs, Technology and Labor

• Project members:

MAZeT GmbH, Jena,
Zentrum für Bild- und Signalverarbeitung (ZBS) e.V., Ilmenau,
MSO Jena Mikroschichtoptik GmbH, Jena,
Fraunhofer Institute for Applied Optics and Precision Engineering, Jena,
M+S Mikrotechnik & Sensorik GmbH, Jena,

The project pursues the goal of achieving on-chip integration of Si sensors and spectrally modified interference filters with lighting and special analysis electronics (including calibration).

The objective of these endeavors is to contribute to improvements in the industrial application of Si color and spectral sensors and expanding their fields of application.

- Establishment of mathematical principles for system-theory calculation of the transient response of a filter-based color analysis system and its application
- Testing of continuous electro-optical modeling of real Si photodiodes with integrated microoptical functional groups for wavelength selection and beam shaping
- Increasing the number of a sensor's spectrally sensitive photodiode elements to more than three spectral ranges and testing the effect of the solution on problems relevant to practical application (metamerism, basic spectral analysis, etc.)
- Testing of structured deposition and precision assembly of various bandpass filters on the photodiode surfaces
- Testing process compatibility of microelectronic and microoptical manufacturing steps

High-precision optoelectronic measuring systems for precision manufacturing (HOMS)

- *Support from:*
BMBF
- *Project members:*
Technical University of Ilmenau, PMS Institute, Ilmenau,
SIOS Messtechnik GmbH, Ilmenau,
Lehren- und Messgerätewerk
Schmalkalden GmbH,
Zentrum für Bild- und
Signalverarbeitung (ZBS) e.V., Ilmenau,
Mahr OKM Optische
Koordinatenmesstechnik GmbH, Jena,
4h-Jena engineering GmbH, Jena,
Gesellschaft für Fertigung und
Entwicklung e.V., Schmalkalden

The overall goal of the project is to investigate measurement principles and develop high-precision measurement systems for use in the manufacturing environment (in-process test and measurement). The aimed-for high level of precision places great demands on research and new development.

- Dimensioning of smooth gauges to an accuracy of 100 nm (diameter, shape, roundness). The measuring instruments required operate at a level of precision approximately one order of magnitude higher, e.g., in the range of around 10 nm.
- Dimensioning of screw thread gauges with extremely high accuracy (1 μ m) in all required thread parameters, monitoring of the overall profile.
- Dimensioning of relevant geometric 3D characteristics (e.g., flute, rake angle, clearance angle) of miniaturized cutting tools with an accuracy approaching 50 nm.
- Dimensioning of microelectronic and microtechnology components and assemblies in the measurement volume range 5x5x5 mm³ to 600x400x300 mm³, with an accuracy of 1 μ m to 100 μ m depending on measurement volume, adhering to shortest possible measurement times.



Innovation Highlight 1
Nanoscale measuring machine (0.1 nm resolution in 25 x 25 x 5 mm³) © TU Ilmenau

ENVILAND - Synergistic Usage of Optical and SAR Data

- *Support from:*
BMBF, German Aerospace Center
- *Project members:*
Jena-Optronik GmbH, Jena,
Friedrich Schiller University, Institute for Geography, Jena,
Friedrich-Wilhelms-University, Center for Remote Sensing on Land Applications, Bonn,
Zentrum für Bild- und
Signalverarbeitung (ZBS) e.V., Ilmenau,
DESOTRON Design Software
Elektronik GmbH, Sömmerda,

The overriding objective of the ENVILAND project is to develop methods for the integrative use of SAR and optical Earth observation instruments, with special emphasis on applications of surface mapping techniques, in particular for land cover. The mapping of land surface cover and the change dynamics of this parameter are of great importance to the investigation of scientific issues (carbon cycle, etc.) and for economic (sustainable utilization) and political (European inventory statistics) decision-making. ENVILAND will take up synergetic aspects of current Earth observation activities in Germany and deliver significant contributions to the development of scale-free, transferable, stable and economically feasible methods for analyzing remote sensing data for land cover issues.

ENVILAND relies primarily on data from the ASAR and MERIS instruments on board the European environmental satellite ENVISAT, which offers the first-ever opportunity in the field of Earth observation to analyze radar and optical data in a synergistic manner. This allows the advantages of the two methods to be combined more efficiently than in the past.



Innovation Highlight 2
Intelligent cameras and high-performance LEDs with focused beam optics in an assembly cell
© GBS mbH



Innovation Highlight 3
CONTOUR 2xx-8xx measuring system
© Hommelwerke GMBH

Innovation highlights

Highlight 1

3D nanomeasurement and positioning machines for large measurement ranges

Technical University of Ilmenau, SFB 622
Measurement systems with atomic-level resolution and comparatively huge measurement volumes play a key role in nanotechnology. The goal is to achieve 0.1 nm resolution and a measurement volume of 350 x 350 x 5 mm³.

Highlight 2

Image analysis for quality assurance and production control

Gesellschaft für Bild- und Signalverarbeitung mbH, Henkel & Roth GmbH
Automated component assembly in the automotive industry requires monitoring of the production steps in assembly cells.

Highlight 3

Shaft measurement systems

Hommelwerke GmbH
Ultra-precise non-contact measurement ensures quality of complex crankshafts and camshafts.

Dr.-Ing. Nicole Hilbrandt, DAAD

Conducting research in Germany

A highly developed university and research landscape plus innovative companies shape the scientific research system in Germany. The high quality of academic training "Made in Germany" is recognized worldwide. 100 and more research universities train 70% of the students in Germany. With more than 250,000 scientists and investigators working here, Germany is one of the leading "research nations".

Bringing research to life

The strengths of German research traditionally lie in mechanical engineering, chemistry, medicine, physics, mathematics and the humanities. German scientists and research institutes are world leaders in biomedicine and medical engineering, in environmental research and automotive engineering, and in engineering in general. However, German scientists and researchers also play their part in the world's top groups in the future fields of optical technologies, microsystems engineering, neurosciences, biotechnology and process engineering. In 2003, more than 13,000 German inventions were patented throughout Europe, meaning that almost one quarter of all European patents are based on developments made by German scientists. In the field of nanotechnology, Germany actually comes 1st.

Around 10% of all the Nobel Prizes ever awarded went to German scientists. In the past 15 years, the work of eight German researchers has been acknowledged in the form of a Nobel Prize. This places German third behind the United

Biotechnology is an emerging field of science and research. Nowhere else in Europe are as many Biotechnology companies to be found as in Germany.
© Bayer AG



States and Britain. A total of 27 German researchers have received the Nobel Prize in Chemistry, 22 in Physics, and 15 in Medicine/Physiology.

Innovative force and strong trademarks

Inventions, knowledge and understanding produced by German scientists represent milestones in science and research and form a basis for modern technologies:

- The discovery of X-rays paved the way for the use of computed tomography in medical diagnostics.
- The Braun Tube created the basis for the development of the television.
- The first programmable calculator – Z3 – was the forerunner to the present-day computer.
- The Haber-Bosch process is still considered today to be the most important and most economical way of producing ammonia. 90% of all fertilisers are made from ammonia.

Science and research and business and industry thus go hand in hand, and German companies successfully market numerous research findings by German scientists as innovative products. World-famous examples include products like Ferrari red, Aspirin, Adidas trainers, polymethyl methacrylate (perhaps better known as Plexiglas, Perspex or Lucite), as well as spark plugs, electric motors and the German car engine. GMR read heads for computer hard disks, liquid crystals for use in LCD technology, dirt-repelling paints with Lotus Effect, MP3 format and language recognition are all products with innovation.

"Qualified in Germany"

Germany has one of the best higher education systems in the world. 365 higher education institutions, of which 122 are universities and equivalent institutions plus 191 universities of applied sciences (Fachhochschulen). 42 higher education institutions are particularly strong in research. Building on the principle of the "unity of research and teaching", Germany's universities are not only teaching establishments for students, but also centers of top-flight scientific research. This would not be possible without

academics, researchers and scientists, research organizations and institutes, at home and abroad, engaging in intensive cooperation with each other. The universities are funded by the state (public) and by foundations. They also carry out externally funded research contracts (third-party or contract research) within the scope of appropriate agreements.

Research in Germany

Germany has an efficient and highly differentiated science and research system. Besides the research universities, research is also actively performed by four efficient science and research organizations, further state (public) and private research centers plus around 260 specialized universities and universities of applied sciences. All in all, there are more than 750 state-financed research institutions in Germany, plus research and development centers run by industrial corporations.

The strengths of Germany's science and research system are

- the high-quality scientific infrastructure and equipment available to the research centers
- the well-qualified scientists and researchers, technicians and laboratory staff
- the close interlinking of large-scale research facilities with European and worldwide partners (ITER, ILL, ESRF, JET, SLAC)
- and a high level of internationalization.

The strengths of the German science and research system: According to Science Citation Index No. 3 worldwide (all disciplines); 277 triadic patents per million employees (far above EU and OECD averages).
© DAAD



The Fraunhofer Society

The Fraunhofer-Gesellschaft (FhG) – 80 research units, including 57 Fraunhofer Institutes – carries out applied research

of direct value to private and public enterprise and of wide benefit to society. Fraunhofer research ranges from next-generation internet, augmented reality and virtual factories through to mechatronics and energy technologies. Around 90 % of its research budget is acquired by contract research.

Max Planck Society

More than 4,000 scientists and scholars conduct projects at the 78 research institutes of the Max Planck Society (MPG). They perform basic research of the highest quality at the frontiers of knowledge, and provide competitive research conditions for excellent scientists from all over the world. The main research fields are biosciences, neurosciences, cognitive sciences, physics, chemistry, astronomy, geosciences, computer sciences, social and cultural sciences. Since 1948, 15 Max Planck Society researchers have been awarded a Nobel Prize.

Helmholtz Association

The Helmholtz Association of 15 national research centers develop and operate large-scale research facilities and the corresponding scientific infrastructure available to national and international research teams. For example, the German Electron Synchrotron, with its specialist focus on particle physics, and the Society for Heavy Ion Research (GSI) in Darmstadt offer the very best conditions for high-energy researchers. Helmholtz works in six research fields: energy, earth and environment, health, key technologies, structure of matter, and transport and space.

Leibniz Association

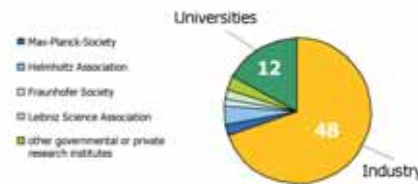
The 84 institutes of the Leibniz Association carry out demand-oriented and interdisciplinary research. Numerous cooperation agreements exist with industry, the public administration, and politics; the Leibniz Association also cooperates closely with universities. Research fields encompass the arts, humanities and education, economic and social sciences, life sciences, mathematics, natural sciences, engineering and environmental research.

Germany is building a science and research system that will guarantee more flexibility, greater liberty in terms of recruitment and pay scales, relaxed conditions for the granting of residence permits to non-native top-flight researchers and greater autonomy for research organizations and institutes. Cross-disciplinary structures of excellence are being established and funded. Examples include Competence Networks (Federal Ministry of Education and Research – BMBF), Centers of Excellence and Collaborative Research Centers (DFG), Innovative Regional Growth Cores (BMBF), plus other major research and development projects based on cooperation between industry and research institutes.

The total research budget in Germany is about 70 billion US\$. © DAAD

Research Investment in Germany

→ Total research investment: 70 Billion US \$



Private sector research and applied research and development

German companies are among the most innovative in Europe. At 66%, the proportion of industry-based and financed investments in research and development is particularly high. Environmental research is an example of successful technology transfer, as proven by the growing markets for renewable energies, from photovoltaics all the way through to wind energy. Companies cooperate particularly closely in the field of applied research, working together with globally operating Fraunhofer Institutes and the German Federation of Industrial Cooperative Research Associations "Otto von Guericke" (AIF).

International researchers in Germany

Germany offers international, highly qualified scientists and researchers outstanding working conditions in specific fields. Certain sectors of industry are looking for highly qualified foreign researchers who may, under certain conditions, immediately receive a residence permit.

In this context, highly qualified means, not least, academics, scientists and researchers with particular subject or specialist knowledge plus academic and research staff in key positions. In the field of research and development, in particular, the proportion of foreign staff is already very high at 8% to 10%. After graduating, foreign students can remain in Germany for up to one year to look for a job. Many opportunities are also open abroad for staff who gained experience in Germany. Numerous German companies maintain branches and subsidiaries all around the world.

Apply for research funding and fellowships

About 20,000 foreign researchers are supported by German funding organizations. A large number of scientists finance their stays in Germany by other means.

The key funding organizations are

- the *Alexander von Humboldt Foundation* (> 1,800 fellowships per year; some 100 Humboldt Associations in 60 countries, a network of 23,000 Humboldtians, including 35 Nobel Laureates) – www.avh.de
- the *German Academic Exchange Service* (DAAD) (the largest academic exchange organization in the world; a network of regional offices and study information centers; > 200 programs; > 30,000 scholarships per year) – www.daad.de
- the *German Research Foundation* (DFG; the central self-governing and funding organization of science and research; annual budget of around 1.3 billion euros; funds more than 20,000 research projects each year) – www.dfg.de

In Germany the ratio of PhD holders per million inhabitants is about twice as high as in the USA or the UK. © IU Bremen



Important links to optical technologies in Germany

Investment support

Invest in Germany

This federal agency offers services and assistance to promote Germany as a location for business and industry.

www.invest-in-germany.de

Information platforms

Optische Technologien

Central information platform for optical technologies and funding information by the BMBF project coordinator VDI Technologiezentrum GmbH (German only)

www.optischetechnologien.de

OptecNet Deutschland

The site of the Association of German Competence Networks for Optical Technologies provides a wealth of news, information and links related to optical technologies.

www.optecnet.de

Research funding and fellowships

German Academic Exchange Service (DAAD)

The DAAD is the largest academic exchange organization in the world. The DAAD promotes a young and international elite worldwide through more than 200 programs. Running a worldwide network of regional offices and study information centers, the DAAD guides and advises students, graduates, teachers, and scientists on their path to Germany.

www.daad.de

German Research Foundation (DFG)

The DFG is the central funding organization responsible for promoting research at universities and other publicly financed research institutions in Germany with an annual budget of nearly 1.5 billion euros. The DFG also advises parliaments and public authorities on questions relating to science and research, encourages international collaboration in science and the humanities, and supports the advance-

ment and training of young researchers.
www.dfg.de

Alexander von Humboldt Foundation (AvH)

The AvH is one of the most important research foundations for international scientists. Each year, the Alexander von Humboldt Foundation enables more than 1,800 researchers from all over the world to spend time researching in Germany. Together with around 100 Humboldt Associations in 60 countries, AvH maintains a network of some 23,000 fellows and alumni from all disciplines in 130 countries.

www.avh.de

Volkswagen Foundation

Volkswagen Foundation focuses its efforts on selected funding initiatives, such as thematic impetus, societal challenges and international focus.

www.volkswagen-stiftung.de

Federal funding programs (of relevance to optical technologies)

Förderprogramm Optische Technologien

Funding programs dedicated to optical technologies (German only)

www.bmbf.de/pub/foerderprogramm_optische_technologien.pdf

Funding Program Summary:

Optical Technology - Made in Germany

English summary of the optical technologies program

www.optischetechnologien.de/temp/download/OT_Englisch.pdf

Nanotechnology Conquers Markets

Nanotechnology framework program
www.bmbf.de/pub/nanotechnology_conquers_markets.pdf

Materials Innovations for Industry and Society - WING

Funding program dedicated to materials science

www.bmbf.de/pub/rahmenprogramm_wing_engl.pdf

IT Research 2006

Funding program dedicated to Information Technology

www.bmbf.de/pub/it-research_2006.pdf

Biotechnology - using and shaping its opportunities

Funding program dedicated to biotechnology

www.bmbf.de/pub/framework_programme_biotechnology-using_and_shaping_its_opportunities.pdf

Research initiatives

Caesar (Center of Advanced European studies and research)

Caesar, calling on financial resources from the German federal government and the state North Rhine Westphalia, is located in Bonn.

www.caesar.de

Fraunhofer-Gesellschaft

The Fraunhofer-Gesellschaft undertakes applied research. It maintains roughly 80 research units, including 58 Fraunhofer Institutes, at over 40 different locations throughout Germany. In the field of optical technologies, six Fraunhofer Institutes collaborate and form the Fraunhofer Surface Technology and Photonics Alliance (www.vop.fraunhofer.de).

www.fraunhofer.de

German Federation of Industrial Cooperative Research Associations "Otto von Guericke" (AiF)

The central concern of the AiF is the promotion of applied research and development (R&D) for the benefit of small and medium-sized enterprises (SMEs).

www.aif.de

Helmholtz Association

Community of 15 scientific-technical and biological-medical National Research Centers. These centers are tasked with pursuing long-term research goals on behalf of the state and society.

www.helmholtz.de

Leibniz Association

Several institutes belonging to Section D – mathematics, natural sciences, engineering – are active in optical technologies.

www.wgl.de

Max Planck Society

Society for basic research: Several Max-Planck-Institutes, such as the Institute of Quantum Optics (www.mpg.de), are active in optical technologies.

www.mpg.de

Regional research initiatives and networks**MST – Micro System Technology Initiative**

Initiative dedicated to promoting and enhancing micro system technology in Lower Saxony, sponsored by the Ministry for Economic Affairs, Employment and Transport (German only)

www.mst-niedersachsen.de

Photonics Valley East-Württemberg

Photonics cluster in East-Württemberg

www.photonic-valley.de

Forschungsprogramm „Optische Technologien 2002“

Funding program dedicated to optical technologies sponsored by the state of Baden-Württemberg (German only)

www.landesstiftung-bw.de/projekte/wissenschaft-php?id=167

MST – Förderprogramm Mikrosystemtechnik Bayern

Funding program dedicated to promoting and enhancing microsystems technology in Bavaria, sponsored by the Bavarian Ministry of Economic Affairs, Infrastructure, Transport and Technology (German only)

www.mst-bayern.de

Associations**DGaO**

The German Society of Applied Optics, the German branch of the European Optical Society (German only)

www.dgao.de

OptecNet Deutschland

Association of the German Competence Networks for Optical Technologies

www.optecnet.de

Spectaris

The German Industrial Association for Optical, Medical and Mechatronic Technologies

www.spectaris.de

VDMA (Verband Deutscher Maschinen- und Anlagenbau – German Engineering Federation)

The German Engineering Federation has set up a sector-specific division dedicated to lasers and laser systems for materials processing.

www.vdma.org

**Objectives**

- Strengthening the infrastructure in northern Germany through the planning, organization and promotion of network activities in R&D, applications, and training and education
- Representing the interests of its members through political lobbying and public-relations work

CONTACT

Dr. Hans-Heinrich Nölke
(Managing Director)

Phone: +49 (0)40 302349-30

Fax: +49 (0)40 302349-31

eMail: info@hansephotonik.de

HansePhotonik e.V.

Harburger Schlossstr. 6-12
D-21079 Hamburg

www.hansephotonik.de

Focus of activities

HansePhotonik brings together dynamic representatives of science and industry in northern Germany to create networks that extend horizontally across a wide range of fields of application and vertically from research to industrial application – because goal-oriented cooperation between capable teams spawns innovation.

The network's core competencies lie in the areas of:

- materials development for beam sources and optical materials
- laser systems and equipment
- laser material processing
- rapid manufacturing
- metrology, sensor technology and image processing
- diagnostic and therapeutic medical devices
- training and education

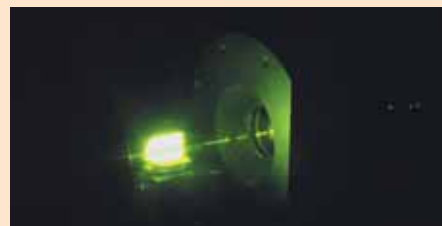
Concurrent with NORTEC 2006, a "Baltic round-table" gathering will be held in Hamburg with new EU member nations Estonia, Latvia, Lithuania and Poland for the purpose of promoting optical technologies in the Baltic Hanseatic region. In the spirit of Hanseatic traditions, this event will provide the starting point for a Baltic network established especially for the field of optical technologies.

Innovation highlight

Compact green erbium laser resonator with the light amplification laser crystal between the mirrors. The laser material (Er-doped yttrium-lithium-fluoride, Er:YLF) is excited using a two-stage absorption process in near infrared (non-visible light) and laser emission occurs in the green spectral range (up-conversion laser.) Both stages are resonant at the same wavelength, which makes it possible to excite the material using a single light source. This laser requires no additional non-linear crystals to generate the green light. It operates in continuous wave mode and can also be excited with conventional diode lasers at 970 nm. The crystal manufacturing and the first-ever successful development of this type of crystal laser were carried out at the Institute of Laser Physics of the University of Hamburg.

Photo Laser

© Institute of Laser Physics, University of Hamburg



Information – Communication – Cooperation



Portraits of the networks:

- ▶ full profiles of areas of competence
- ▶ outstanding innovation highlights
- ▶ strong partners
- ▶ an attractive range of services
- ▶ interactive maps of competence

Regional profiles:

- ▶ main thematic areas
- ▶ locally based networks

Information services:

- ▶ up-to-date news on innovation activities
- ▶ a diary of relevant events
- ▶ E-Mail subscription

International network programs:

- ▶ innovation brokerage
- ▶ sponsorship programs and activities

Direct access:

- ▶ to the competence networks
- ▶ and their partners in science, business and training

A huge quantity of relevant knowledge:

- ▶ links and references
- ▶ press service
- ▶ document-on-demand

Fields of innovation:

- ▶ R&D strategies
- ▶ market trends
- ▶ related training and education resources

- *Aerospace Technology*
- *Agrobusiness*
- *Bionics*
- *Biotechnology*
- *Education & Training*
- *Environmental Technology*
- *Genomics*
- *Information & Communication Technologies*
- *Manufacturing Technologies*
- *Maritime Technologies*
- *Materials Science*
- *Mechatronics / Microtechnologies*
- *Medical Engineering*
- *Medicine*
- *Nanotechnology*
- *Optical Technologies*
- *Power Engineering*
- *Traffic & Transportation*



www.kompetenznetze.de

Invest in Europe's Leading Economy



COMCONTOR.COM

Invest in Germany

***Invest in Germany* guides the investor to success in Germany's business environment.**

As the primary contact for companies considering expansion into Germany, *Invest in Germany* provides information about the German business environment and assistance in establishing connections with an extensive network of contacts in both the public and private sectors.

www.invest-in-germany.com

Invest in Germany GmbH, Anna-Louisa-Karsch-Straße 2, D-10178 Berlin, Tel.: +49 30 206 57-0, office@invest-in-germany.com

Invest in Germany, LLC, 345 Park Avenue - 15th floor, New York, NY 10154, USA, Tel.: +1 212-454-1905, rassmann@invest-in-germany.com

Invest in Germany, LLC, 200 South Wacker Drive, Chicago, IL 60606, USA, Tel.: +1 312 596-8503, bremer@invest-in-germany.com

Invest in Germany, LLC, 201 California Street, San Francisco, CA 94111, USA, Tel.: +1 415 248-1246, geiger@invest-in-germany.com

Invest in Germany



