

# Photonics in Baden-Württemberg

THE LIGHT OF THE FUTURE -  
RESEARCH POTENTIAL IN OPTICAL TECHNOLOGIES

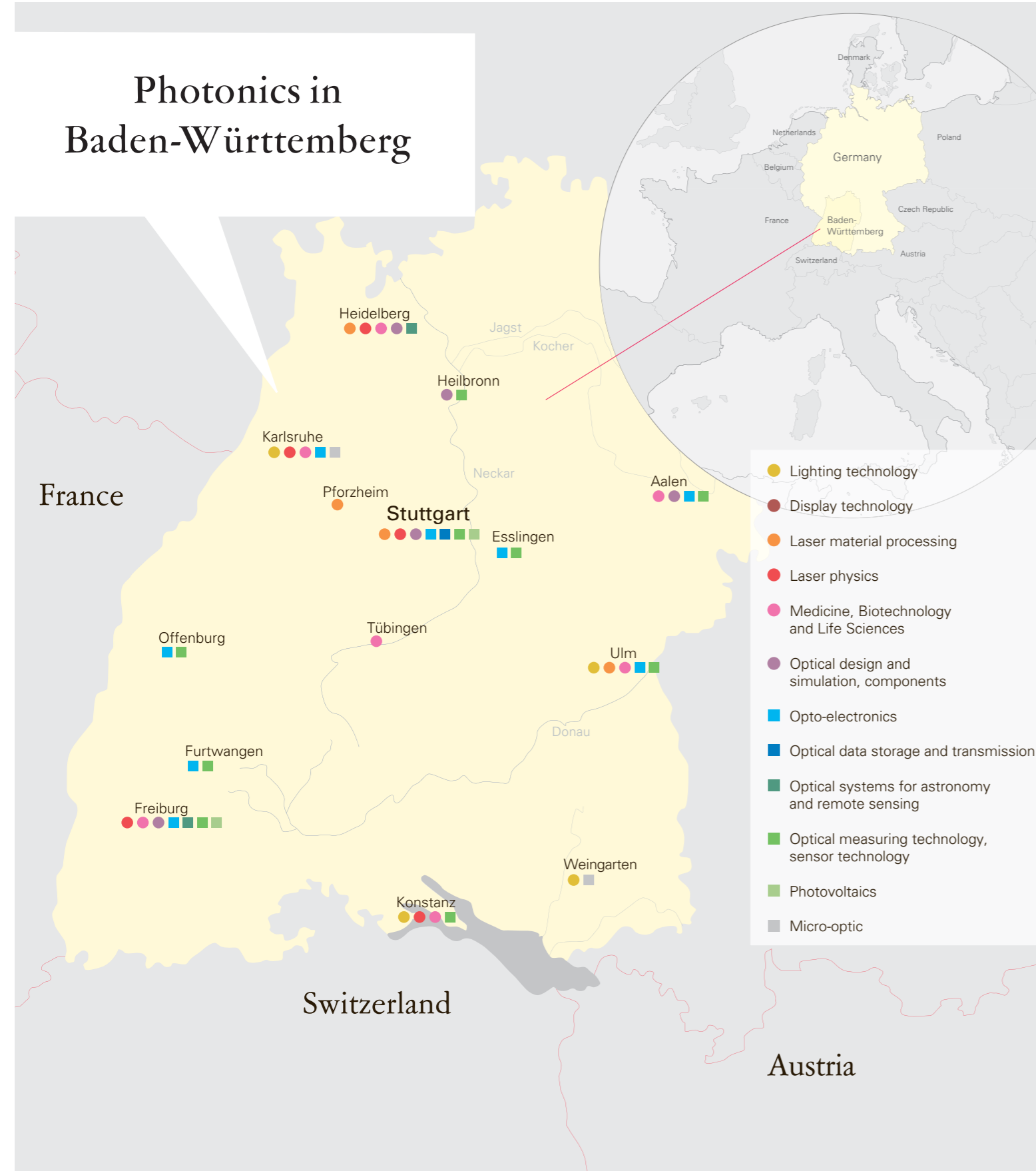


Baden-Württemberg

The German Southwest.



# Photonics in Baden-Württemberg



## Content

- 4** Baden-Württemberg's research potential in the optical technologies field
- 5-9** Research at Universities  
 Universität Freiburg | Universität Heidelberg | Universität Karlsruhe (TH) | Universität Konstanz | Universität Stuttgart | Universität Ulm
- 10-11** Universities of Applied Sciences  
 Aalen University of Applied Sciences | Esslingen University of Applied Sciences | Konstanz University of Applied Sciences | Furtwangen University of Applied Sciences | Heilbronn University of Applied Sciences | Offenburg University of Applied Sciences | Ravensburg-Weingarten University of Applied Sciences
- 12-15** Non-university research  
 Max-Planck-Gesellschaft: MPI for Astronomy, MPI for Medical Research | Helmholtz-Gemeinschaft: German Aerospace Center (DLR), Forschungszentrum Karlsruhe (FZK) | Fraunhofer-Gesellschaft: Fraunhofer Institute for Applied Solid State Physics (IAF), Fraunhofer Institute for Physical Measurement Techniques (IPM), Fraunhofer Institute of Solar Energy Systems (ISE) | Leibniz-Gemeinschaft: Kiepenheuer Institute of Solar Physics (KIS) | Forschungsgesellschaft für Strahlwerkzeuge (FGSW)
- 16** Contract research institutes  
 Institut für Mikroelektronik Stuttgart (IMS CHIPS) | Institute of Laser Technologies in Medicine and Metrology (ILM) | Zentrum für Sonnenenergie- und Wasserstoff-Forschung (ZSW)
- 17** Optical technologies competence network  
 Photonics BW competence network
- 18-19** Technology transfer centres  
 Steinbeis Foundation for Economic Promotion | Steinbeis Transfer Centres



## Baden-Württemberg's research potential in the optical technologies field

Optical technologies are among the key technologies of the 21st century. With their potential for innovation and their huge significance for economic and technological development, optical technologies serve as an indicator for a region's future viability.

Baden-Württemberg, one of Europe's leading high tech regions, occupies a top position in the optical technologies sector. World leading companies such as **Carl Zeiss, TRUMPF, Sick, Richard Wolf, Karl Storz** and **Polytec** have their headquarters here. There are also many small and medium-sized companies that serve an ever-growing market with innovative products and services.

Today about 40 % of all laser beam sources and about 25 % of all laser systems in world wide use already come from Baden-Württemberg.

Baden-Württemberg has a long tradition of pioneering research and innovation in this field. The mathematician and astronomer **Johannes Kepler** (\*1571 †1630), born in present-day Weil der Stadt near Stuttgart, is also synonymous with groundbreaking inventions in optics. One of his most important works was the Dioptrice, which laid the foundations of optical science. Thanks to his profound understanding of light refraction and image formation, Kepler was able to explain short-sightedness and the effect of a magnifying glass or spectacles. In the 19th century, two physicists, **Gustav Kirch-**

**hoff** (\*1824 †1887) and **Hermann von Helmholtz** (\*1821 †1894) who taught in Heidelberg, were pioneers in the field of optics. Helmholtz established physiological optics and acoustics, while Kirchhoff became a protagonist of mathematical optics.

The significance of optical technologies as "enabling technologies" is acknowledged in the region, and appropriate structural conditions are assured by future-oriented support. Important examples include the establishment of the Center for Applied Photonics in Konstanz and the Optical Technologies research programme established by the Landesstiftung Baden-Württemberg gGmbH.

The Photonics BW e.V. competence network links research, development and production in the optical technologies sector in Baden-Württemberg, creating structures that promote innovation.

University and non-university research institutions in the region possess outstanding research potential and offer excellent study programmes as well as qualified doctoral opportunities in the optical technologies sector.

This publication is designed to provide readers with an overview of the research institutions in Baden-Württemberg and their main areas of specialisation within the optical technologies sector.



## Research at Universities

### Universität Freiburg

Top-level university since 2007



Founded in 1457, the **Universität Freiburg** is one of the oldest German universities and one of the nation's leading research institutions.

[www.uni-freiburg.de](http://www.uni-freiburg.de)

At the **Institute of Physics**, research is also performed in the field of optical physics. The Department of Molecular and Optical Physics specialises in negative ions in strong laser fields, cold atoms or triatomic hydrogen.

[www.mathphys.uni-freiburg.de/physik](http://www.mathphys.uni-freiburg.de/physik)

The **Department of Microsystems Engineering (IMTEK)** has research groups working on all aspects of Microsystems, including optical technologies.

[www.imtek.uni-freiburg.de](http://www.imtek.uni-freiburg.de)

The **Laboratory for Micro-optics at IMTEK** concentrates on the design and production of innovative, highly advanced micro-optic components, opto-mechanical assembly and connection techniques as well as the development of photonic systems.

[www.imtek.de/micro-optics](http://www.imtek.de/micro-optics)

The **Laboratory for Photonic Measuring Technology at IMTEK** deals with systems in the field of nano- and biophotonics. These include innovative microscopy techniques for examining biochemically functionalised surfaces and living cells.

[www.imtek.de/pmt/](http://www.imtek.de/pmt/)

### Universität Heidelberg

Top-level university since 2007



The **Universität Heidelberg** features a wide research spectrum, enjoying a leading position in many areas.

[www.uni-heidelberg.de](http://www.uni-heidelberg.de)

The **Centre for Astronomy (ZAH)** engages in basic research in the field of astronomy and astrophysics and in the education of young scientists.

[www.zah.uni-hd.de](http://www.zah.uni-hd.de)

The **Königstuhl State Observatory**, which is part of ZAH, cooperates with several task groups in the development of instruments for Earth-based observatories and space telescope. In the aerospace sector, the observatory has developed instruments for several space shuttle missions. Over the next three years, the observatory will also carry out a solar experiment at the International Space Station.

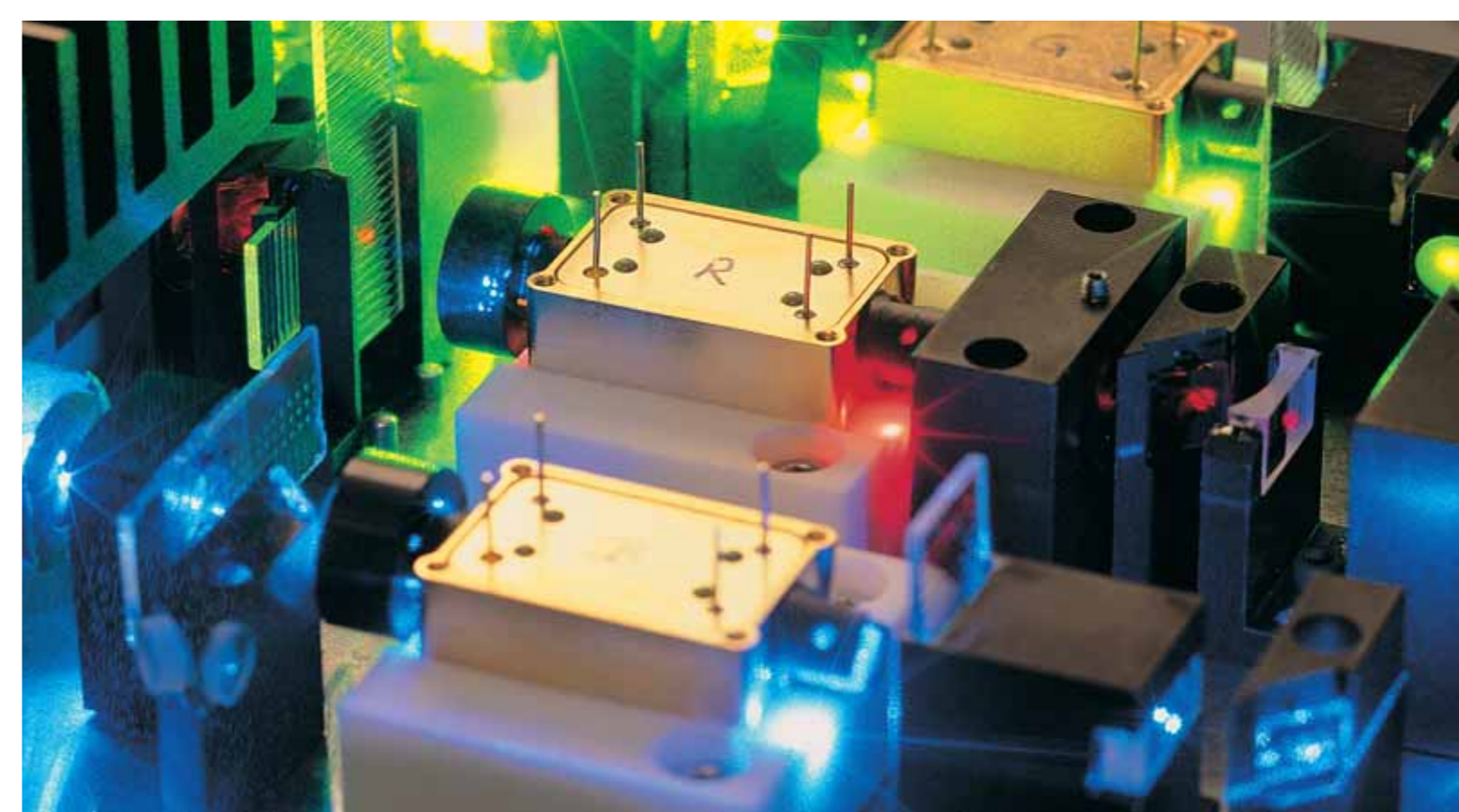
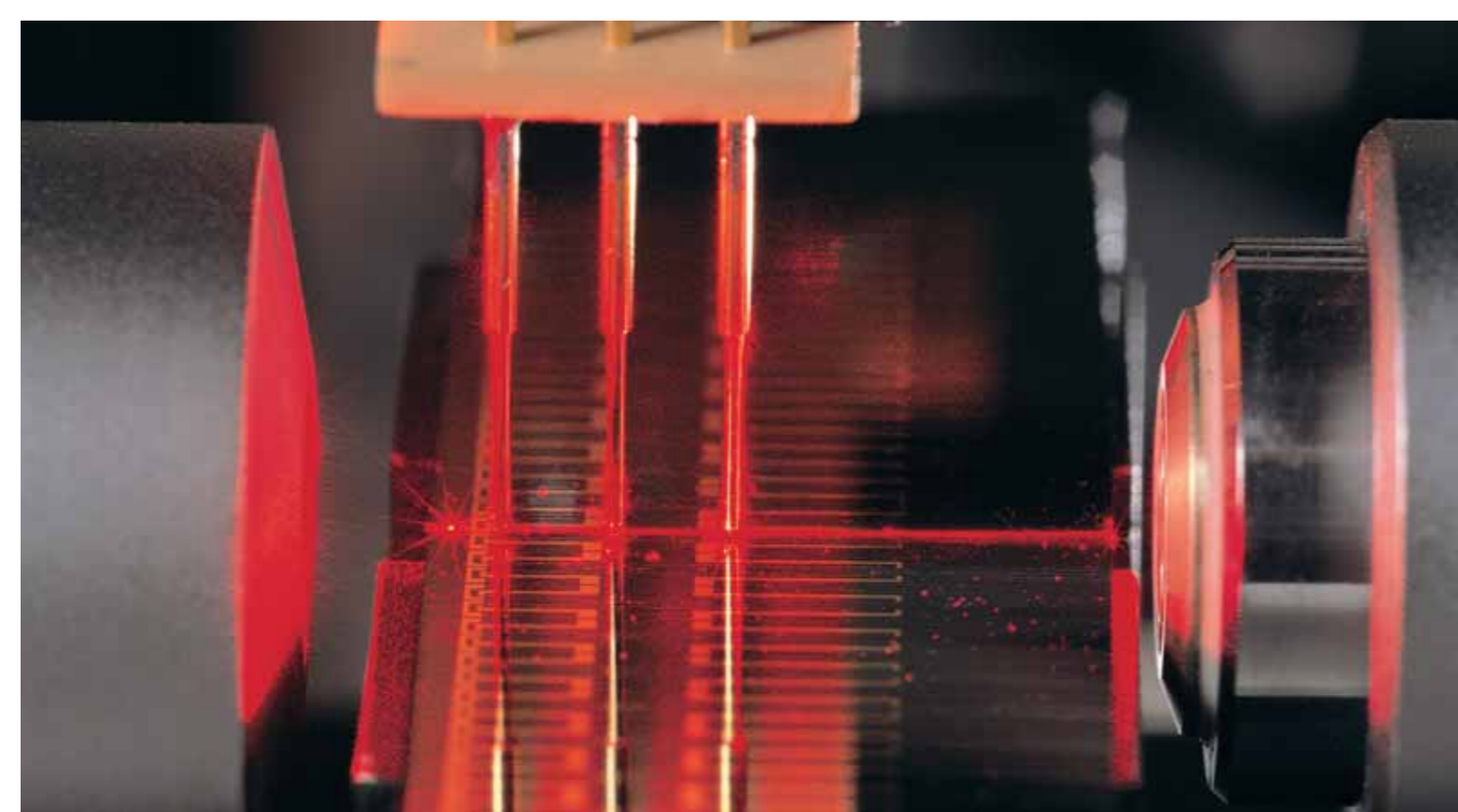
[www.zah.uni-hd.de](http://www.zah.uni-hd.de)

The **Kirchhoff Institute of Physics** researches and teaches biomedical optics, applied optics, information processing and spectroscopy. Main focuses in photonics and laser physics include laser-matter interaction and short-pulse laser applications.

[www.kip.uni-heidelberg.de](http://www.kip.uni-heidelberg.de)

The **Chair of Optoelectronics** focuses on the development, production and characterisation of micro-optical components and systems. Main application areas for these components are optical information technology and medical technology. Current research is in the design of beam-forming optical components for semiconductor lasers. In the area of nanoscale optics, algorithms are developed for the vectorial calculation of field distributions.

[www.ziti.uni-heidelberg.de](http://www.ziti.uni-heidelberg.de)



**Universität Karlsruhe (TH)**

*Top-level university since 2006*



Universität Karlsruhe (TH) has been one of Germany's top-level universities since 2006. This success based mainly on three elements: the Karlsruhe School of Optics and Photonics (KSOP) as a graduate school for optical technologies, the Centre of Functional Nanostructures as an excellence cluster, and the Karlsruhe Institute of Technology (KIT) as a future-oriented concept.

[www.uni-karlsruhe.de](http://www.uni-karlsruhe.de)

The **Institute of Applied Physics (IAP)** works in the fields of nano photonics, photonic crystals, metamaterials, near-field optics, confocal microscopy, laser spectroscopy, ultra short-time spectroscopy, non-linear optics, semi-conductor optics, spin-optoelectronics, zinc oxide for ultraviolet optoelectronics and artificial light harvesting complexes. Dissertations and PhD theses acquired by students and scientists are based on a series of lectures within physics (degree) basic and main courses, in special lectures, main seminars and practicals. An exchange scheme exists with Heriot Watt University in Edinburgh, whereby one year's study in Scotland results in a "M.Phys. with honours in Optoelectronics and Lasers".

[www.apf.uni-karlsruhe.de](http://www.apf.uni-karlsruhe.de)

At the **Institute of Light Technology (LTI)**, scientists are engaged in the areas of light technology, optoelectronics, photonics and nanotechnology. This includes visual information technology and optoelectronics, electro optics and gas discharging as well as optical radiation technology.

[www.lti.uni-karlsruhe.de](http://www.lti.uni-karlsruhe.de)

The establishment in 2006 of the **Karlsruhe School of Optics & Photonics (KSOP)** as a publicly funded project by the Deutsche Forschungsgemeinschaft (DFG) as part of the Excellence Initiative of the German federal and state governments overcame deficiencies regarding interdisciplinary education in the field of optical technologies. The research areas cover photonic materials and devices, advanced spectroscopy, biomedical photonics and optical systems.

Professors and young scientists from Universität Karlsruhe (TH) and KSOP partner institutions train international Master and Ph.D. students. During the 3-year Ph.D. programme, KSOP's interdisciplinary approach is broadened by project management and leadership courses. Currently, about 40 highly qualified young scientists successfully complete a postgraduate programme. In 2007, KSOP started the Master course in Optics and Photonics.

[www.ksop.de](http://www.ksop.de)

**Karlsruhe Institute of Technology (KIT)**



The **Karlsruhe Institute of Technology (KIT)** represents the merger of the Universität Karlsruhe (TH) with the Forschungszentrum Karlsruhe, which joined forces to achieve an unprecedented level of cooperation. KIT concentrates its research activities on the field of optics and photonics in several key areas. It brings together competences at the University's Department of Electrical Engineering and Information Technology. The Light Technology Institute (LTI) is developing a luminescent wall paper, the DFG-Centre for Functional Nanostructures and the Research Centre's Institute for Microstructure Technology are indicative of how the scientific capabilities and capacities of both institutions in the field of optic and photonics are bundled together.

[www.kit.edu](http://www.kit.edu)

**Universität Konstanz**

*Top-level university since 2007*

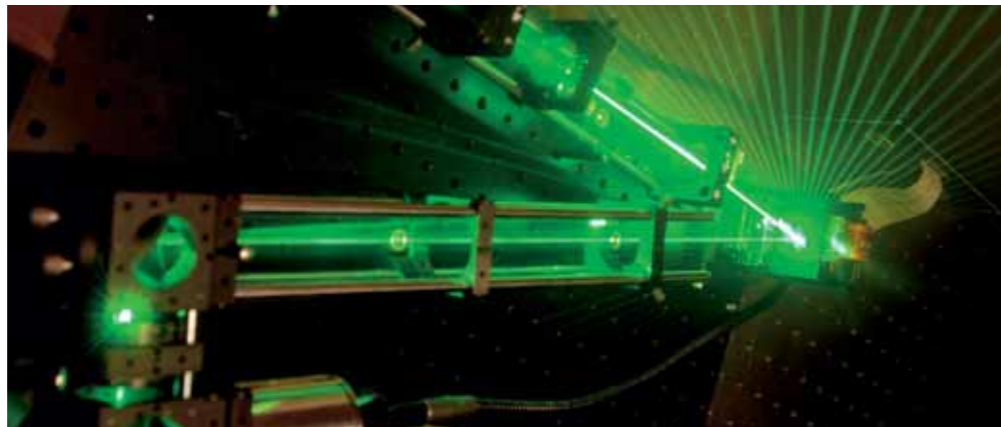
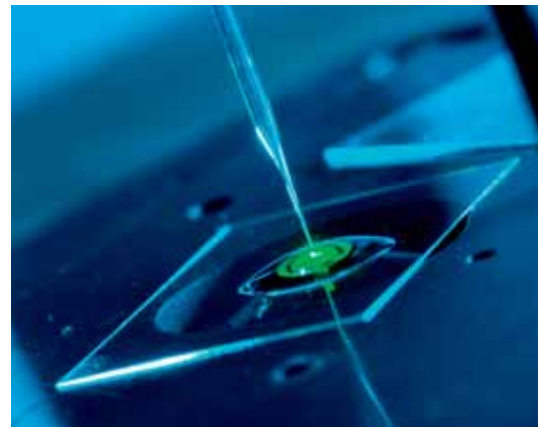
As the smallest institution that was ranked officially among top-level universities in Germany, Universität Konstanz defines itself as a highly efficient research site. Experimental and theoretical physics are taught in close cooperation. The undergraduate course

comprises the fundamentals of physics, including classic optics and atomic physics. On a graduate level, students have an interdisciplinary choice of photonics related lectures, seminars and laboratory.

[www.uni-konstanz.de](http://www.uni-konstanz.de)

The **Center for Applied Photonics (CAP)** is an interdisciplinary research platform of the Universität Konstanz that coordinates the activities of the natural sciences in the field of optical technologies. To assure the direct transfer of innovative concepts from basic research into the photonics industry, work groups in the departments of biology, chemistry, physics, psychology and materials sciences are closely networked. There is special emphasis on training young scientists for research and industry, with some 30 post graduates and some 30 degree students working at CAP on front-end projects. A seminar on Applied Photonics and annual CAP workshops allow an exchange of information internally and with colleagues from abroad.

[www.uni-konstanz.de/CAP](http://www.uni-konstanz.de/CAP)



## Universität Stuttgart



## Universität Stuttgart

At Universität Stuttgart, nine institutes demonstrate extensive expertise in optical technologies, and are devoted to basic research ranging from experimental quantum optics and the characterisation of new optical materials, to the production of optoelectronic components such as lasers and modern detectors.

[www.uni-stuttgart.de](http://www.uni-stuttgart.de)

The **Institut für Strahlwerkzeuge (IFSW)** is one of the leading laser research centres worldwide, specialising in a holistic research approach that covers every aspect from laser sources to their applications, and from fundamental investigations to industrial technology transfer: laser development and optics (diode-pumped solid-state lasers, optical elements), beam delivery and beam shaping (fibre optics, fibre lasers, integrated optics), process dynamics (process fundamentals, simulation and modelling, aerodynamic components), process development (macro and micro material processing, quality control). IFSW benefits from advanced laboratory equipment as well as an excellent infrastructure for application orientated research and development.

[www.ifsw.uni-stuttgart.de](http://www.ifsw.uni-stuttgart.de)

The **Institut für Elektrische und Optische Nachrichtentechnik (INT)** works at the front ends of electrical and optical data lines. The main activities are design and test of digital and analogue integrated circuits for information technology and telecommunications, especially in the field of photoreceivers and analogue/digital converters.

[www.uni-stuttgart.de/int](http://www.uni-stuttgart.de/int)

The **1. Physikalisches Institut PI 1** investigates the interaction of matter with THz radiation and materials with magnetic response in the optical domain.

[www.pi1.physik.uni-stuttgart.de](http://www.pi1.physik.uni-stuttgart.de)

The **3. Physikalisches Institut PI 3** investigates single molecules by optical spectroscopy and implements quantum information processing protocols using optically active defect centres in diamond.

[www.pi3.uni-stuttgart.de](http://www.pi3.uni-stuttgart.de)

The **4. Physikalisches Institut PI 4** develops white light lasers for ultrafast spectroscopy applications and investigates photonic metamaterials (1D, 2D, and 3D) with negative refraction, which are produced in an in-house cleanroom.

[www.pi4.uni-stuttgart.de](http://www.pi4.uni-stuttgart.de)

The **5. Physikalisches Institut PI 5** conducts research in the field of quantum and atom optics including atom lasers, atom interferometry, atom lithography and quantum information processing.

[www.pi5.uni-stuttgart.de](http://www.pi5.uni-stuttgart.de)

The **Institut für Halbleiteroptik und funktionelle Grenzflächen (IHFG)** develops single photon emitters and optoelectronics based on III-V Semiconductors, which are also grown in an in-house epitaxy-group.

[www.ihfg.uni-stuttgart.de](http://www.ihfg.uni-stuttgart.de)

The **Institut für Photogrammetrie's** research on image processing covers a further important field of optical technologies.

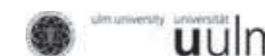
[www.ifp.uni-stuttgart.de](http://www.ifp.uni-stuttgart.de)

The **Institut für Technische Optik (ITO)** examines new optical principles and their implementation in individual sensors and measurement systems. This involves the design (ray- and rigorous wave-based), the manufacturing, the characterization and the application of modern optical components and strategies. The latter are based on a deep understanding of physical phenomena in the interaction of light with structures having dimensions down to the sub wavelength scale. Physical modelling, computer simulation and meas-

urement are three approaches which are combined systematically in the development of new measurement systems. A wide field of applications ranging from the nano to the macro scale are addressed within ITO's strong cooperations with leading industrial partners and within public funded research projects.

[www.uni-stuttgart.de/ito](http://www.uni-stuttgart.de/ito)

## Universität Ulm



The areas of research at Universität Ulm include quantum optics, innovative materials, nearfield microscopy, medical-optical systems, optoelectronic devices and their applications. Universität Ulm works closely with the Institute of Laser Technologies in Medicine and Metrology (ILM). As an independent contract research institute, the ILM is attached to Universität Ulm, and conducts research in the fields of photonics, biomedical optics and laser applications in medicine.

[www.uni-ulm.de](http://www.uni-ulm.de)

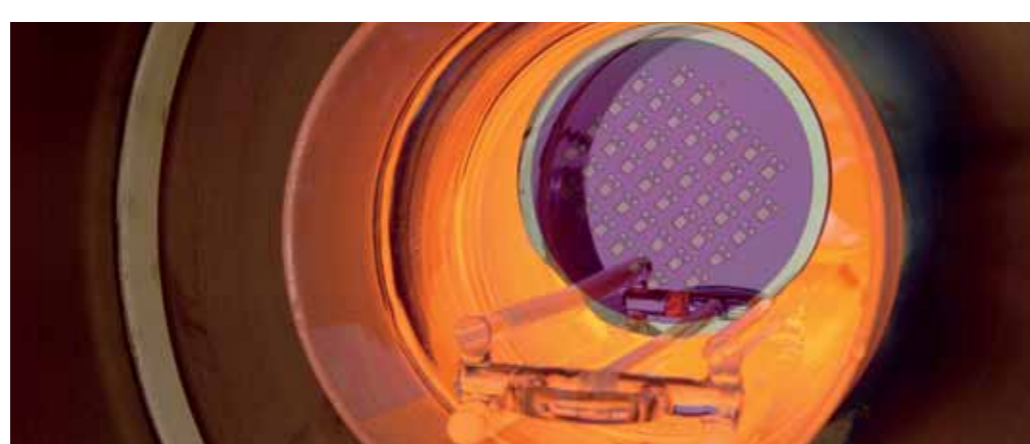
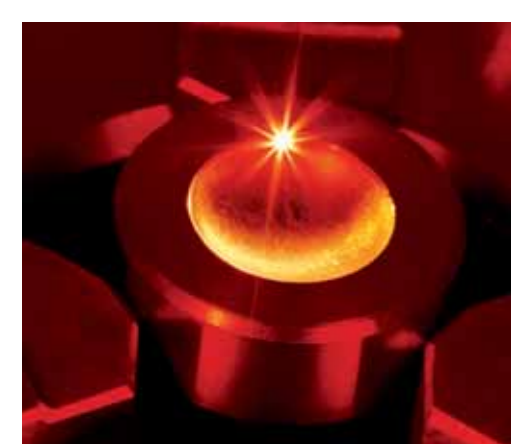
The **Institute of Optoelectronics** is investigating semiconductor-based light-emitting and laser diodes and their application in various fields including optical data transmission. The institute pursues basic research, as well as highly application-oriented research within

the framework of joint projects in close cooperation with major industrial partners.

[www.uni-ulm.de/opto](http://www.uni-ulm.de/opto)

Basic research at the **Institute of Quantum Physics** focuses on the development of new concepts for generating light and its characterisation, non-classic properties of photons, light-atom interactions and innovative measuring concepts for individual photons.

[www.physik.uni-ulm.de/quantum](http://www.physik.uni-ulm.de/quantum)



## Universities of Applied Sciences

### Aalen University of Applied Sciences



Research at the Center for Optical Technologies (ZOT) focuses on the development of new production processes for innovative optical components. Current ZOT activities concentrate on deterministic, economic surface processing of rotationally symmetric aspheres within the framework of the ASPHERO5 project, funded by the German Federal Ministry of Education and Research (BMBF) with partners from industry. The production of injection moulds for free-form plastic optics is researched within the framework of the Landesstiftung Baden-Württemberg's Sensoform project while production of free-form surfaces is conducted jointly with the Deggendorf University of Applied Sciences and various partners from industry. In its optoelectronics/laser technology Bachelor and research-oriented Master of Photonics degree courses, the ZOT offers lectures on the topics of optical technologies, fundamentals in optics, project management, materials and manufacturing processes in optoelectronics.

[www.htw-aalen.de/zot](http://www.htw-aalen.de/zot)

#### ZAFH PHOTON<sup>®</sup>

The New Dimensions in Photonic Processes **PHOTON<sup>®</sup>** Centre of Applied Research was established in February 2008 at Aalen University of Applied Sciences, in association with the Universities of Applied Sciences of Furtwangen, Konstanz, Mannheim, Offenburg and Reutlingen, the Universität Heidelberg and the Institute of Laser Technologies in Medicine and Metrology (ILM), Ulm as well as Photonics BW as a consulting partner. The goal of this cooperative effort is to achieve research results in multidimensional microscopy and photonic sensor systems.

[www.htw-aalen.de/iaf/laser.html](http://www.htw-aalen.de/iaf/laser.html)

### Esslingen University of Applied Sciences



The optical sciences are embedded in several faculties. In the automotive field, the optical testing methods are used for measuring chassis shape and vibration. Optical engineering and microoptics are taught as part of the curriculum in the bachelor programmes of Mechatronics / Precision Engineering and Microtechnology. Machine vision systems as basic elements of automation systems are integrated in the Mechatronics / Automation Systems bachelor programme.

[www.hs-esslingen.de](http://www.hs-esslingen.de)



### Konstanz University of Applied Sciences

Optics and Photonics at the University of Applied Sciences Konstanz are embedded in the research and teaching profile. Emphasis is on optical system technology where current projects are carried out in the field of optical quality assurance and metrology, imaging and image processing measurement systems and light engineering. The field optical systems is an integration of expertises of the three faculties mechanical and electrical engineering as well as informatics, where research and teaching projects for first and second degrees include collaborations with other universities and companies.

[www.htwg-konstanz.de](http://www.htwg-konstanz.de)

Teaching and research at the university are bundled in the innovative fields of photonics at the **Institute of Optical Systems Konstanz (IOS Konstanz)**. Current projects include the development of 3D-optical metrology and digitization systems, high accuracy optical profilometry, laser metrology for distance and tilt measurements, camera systems for inspection, spectroscopy and measuring systems for non-contact assurance technology in manufacturing processes form a research focus.

[www.ios.htwg-konstanz.de](http://www.ios.htwg-konstanz.de)

### Furtwangen University of Applied Sciences



Microsystem technology is one of the strongest research focuses at the Institute of Applied Research. In particular, micro-optical-mechanical systems (MOEMS) are investigated. In MOEMS microtechnology is used to realize optical system. One example are actively focusing systems, where the core element is produced using microtechnical processes and can be implemented as an active-optical module for a multitude of focusing tasks including conventional free beam optics. Focusing is performed by a microtechnically produced chip that contains an electrostatically deformable diaphragm. Another area of development is gas sensing based on photonic bandgap fibres. Investigations are designed to assure that the results can be applied to various gas semiconductor combinations, particularly to the latest CO<sub>2</sub>-gas sensors.

[www.hs-furtwangen.de](http://www.hs-furtwangen.de)

### Heilbronn University of Applied Sciences



At Heilbronn University of Applied Sciences, optical technologies are incorporated in the mechatronics and microsystem technology sector. The focus is on optics design, in particular free-form surfaces, aspherical and tilted surfaces for imaging, illumination and optical measuring technology. Applied research, research transfer and contract development play a major role. A head-up display was developed, and a rotationally symmetric triangulation sensor for high precision, rugged distance measuring evolved within the framework of numerous industrial projects. The study course incorporates the fundamentals and applications of technical optics, laser technology, fibre optics, optoelectronics, image processing and optical production technology.

[www.hs-heilbronn.de](http://www.hs-heilbronn.de)

### Offenburg University of Applied Sciences



Optical technologies at the University of Applied Sciences in Offenburg are part of the electrical engineering and information technology sector, which maintains a close partnership in this field with the Université Louis Pasteur, Strasbourg. Research in optics is focused on optical sensors, fiber optics, optical communications, computer-generated holograms and 3-D-imaging. The University of Applied Sciences Offenburg is taking part in the research program ZAFH PHOTON. Within this project research in the area of optics is done in cooperation with other leading universities in Baden-Württemberg. Furthermore the University of Applied Sciences Offenburg is member of the Photonics BW competence network.

[www.hs-offenburg.de](http://www.hs-offenburg.de)

### Ravensburg-Weingarten



### University of Applied Sciences

Ravensburg-Weingarten University of Applied Sciences and the Interstate University of Applied Sciences of Technology Buchs (NTB), Switzerland offer engineers and physicists a joint masters degree course in optical system technology. Research activities are concentrated on the areas of microoptics, opto-mechanics and light technology. Work in the area of microoptics is focused on the simulation, production and characterisation of subwavelength grids. The incorporation of mechanical finite element analyses in wave and beam optics design is a further focus of research. Another area of expertise in light technology deals with the measuring and optical design of light sources and optical lighting systems, the characterisation and optimisation of spectral light properties, as well as the use of LEDs as new light sources, for example in medical technology.

[www.hs-weingarten.de](http://www.hs-weingarten.de)

## Non-university research

### MAX-PLANCK-GESELLSCHAFT



#### Max Planck Institute for Astronomy

The Max Planck Institute for Astronomy in Heidelberg currently comprises two scientific departments: one devoted to cosmology and the formation and evolution of galaxies, the other to the formation of stars and planets. The institute also houses strong instrumentation groups and is famous throughout the world as a centre of modern infrared instrumentation, specialising in the fields of adaptive optics and interferometry. Adaptive optics can be used to eliminate deterioration of the telescopic image caused by atmospheric turbulence in real time: a sharp image is created at the telescope's focal plane which previously had only been achieved in space, out of reach of interference from the Earth's atmosphere. In interferometry, two or more telescopes are switched together which makes exceptional demands on the precision of optical and mechanical components in the optical and infra-red spectral range. This leads to a hitherto unprecedented resolving power in these wavelength ranges, permitting for instance the clarification of the structure of protoplanetary disks and active galactic nuclei.

[www.mpia.de](http://www.mpia.de)

#### Max Planck Institute for Medical Research

The Biomedical Optics department at the Max Planck Institute for Medical Research in Heidelberg develops and applies new optical methods for biomedical research. Biological function often occurs in a complex tissue environment and must ultimately be studied in that context. Optical microscopy is virtually the only means by which living tissue can be studied with high spatial resolution. While the concept of optical microscopy per se is a rather dated one, going back centuries, a number of developments over the last several decades have led to a return of the light microscope to the

front-lines of biological research. This includes the development of efficient non-toxic fluorophores together with highly sensitive means of fluorescence detection, optical sectioning microscopy, photochemical activation (uncaging) of signal substances, and the discovery and subsequent optimisation of genetically encodable fluorophores (Green Fluorescent Protein and its variants).

[www.mpimf-heidelberg.mpg.de](http://www.mpimf-heidelberg.mpg.de)

### HELMHOLTZ-GEMEINSCHAFT



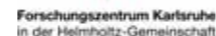
#### German Aerospace Center (DLR)



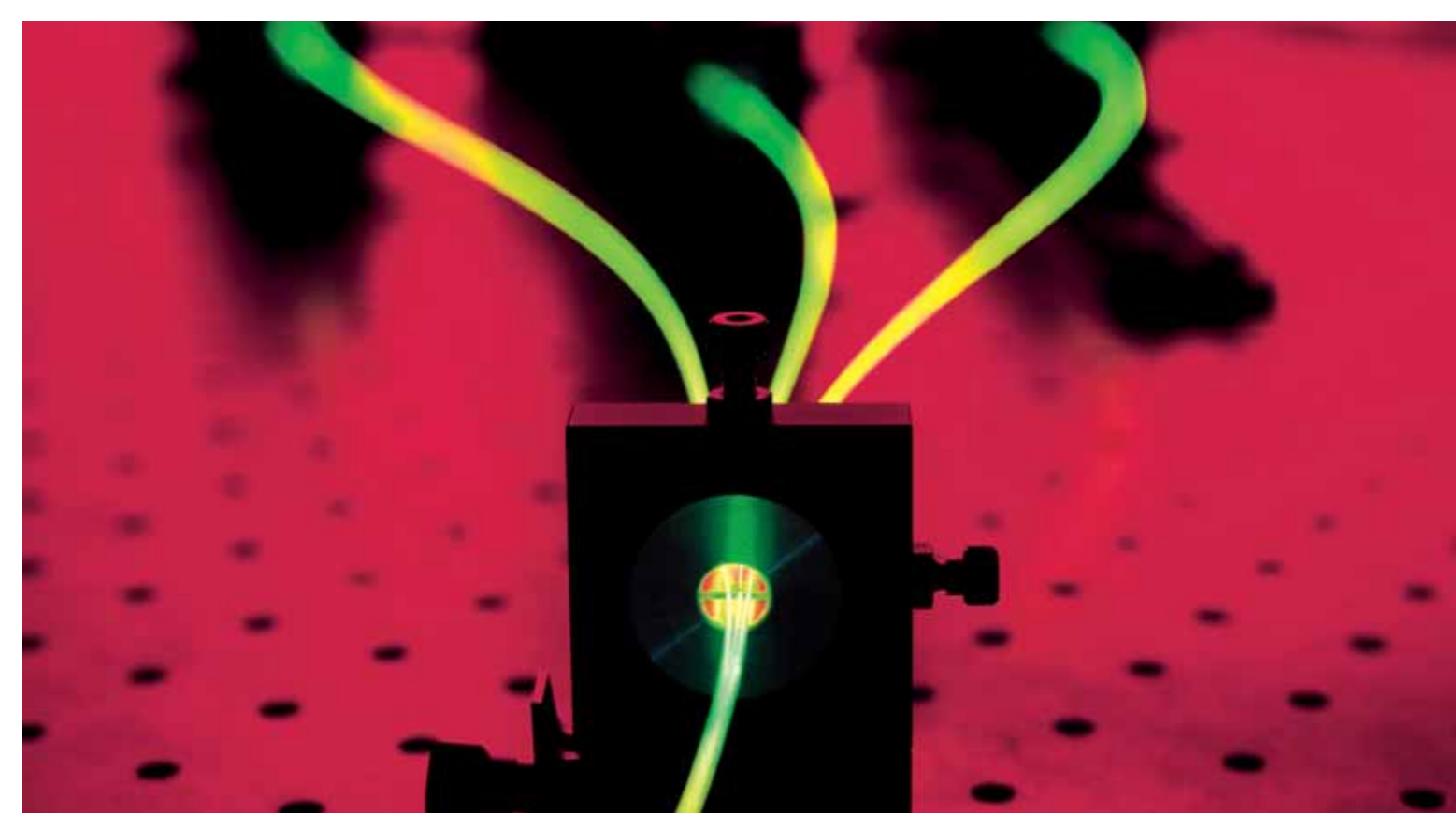
The DLR **Institute of Technical Physics** in Stuttgart conducts security and defence research in selected fields of optics and photonics, particularly the investigation and development of new laser sources, active optical systems and laser sensor technology. Projects and ventures are usually conducted in cooperation with international partners from research and industry. Research activities focus on the areas of high and medium power laser sources, active imaging and tracking, laser vulnerability and protection, optical countermeasures, and active laser sensor technology.

[www.dlr.de/TP/](http://www.dlr.de/TP/)

#### Forschungszentrum Karlsruhe (FZK)



Optics and Photonics are among FZK's areas of expertise. For example, microoptical devices are produced with LIGA-technology (LIGA is an acronym standing for the main steps of the process, i.e., deep X-ray lithography, electroforming, and plastic molding) which was developed at FZK, using the synchrotron radiation source ANKA. Micro-spectrometers are successful in industrial applications. Recently, planary refractive X-ray lenses have been developed and



manufactured. Other technologies, including reaction moulding, hot embossing or injection moulding, enable the low cost production of microoptical components. The synchrotron radiation source ANKA has made available measurement techniques and applications of the most important imaging technologies at FZK. A new chair for Biophotonics was established recently.

[www.fzk.de](http://www.fzk.de)

#### Karlsruhe Institute of Technology (KIT)



FZK and Universität Karlsruhe (TH) have founded the Karlsruhe Institute of Technology (KIT). This cooperation between a university and a non-university research institution will help overcome the "pillar" structure of the German science system. The partners jointly define main activities and organisational structures, and combine their resources. KIT is designed to enhance research-oriented structures at the university and promote the transition from disciplinary to project-oriented research. For further details please refer to page 7 of this publication.

[www.kit.edu](http://www.kit.edu)

### FRAUNHOFER-GESELLSCHAFT



#### Fraunhofer Institute



#### for Applied Solid State Physics (IAF)

The Fraunhofer Institute for Applied Solid State Physics (IAF) in Freiburg is a leading research centre for III-V compound semiconductors and their application to micro-, nano-, and optoelectronic devices and modules. These are key components for a variety of applications, including innovative safety and security systems. Violet and ultraviolet LEDs are the basis of novel integrated sensors for the detection of ozone as well as for solid-state lighting. Mid-infrared semiconductors lasers covering the 2 – 12  $\mu\text{m}$  range find various applications in the rapidly advancing area of spectroscopic sensing and imaging systems, for the stand-off detection of explosives. High-power diode lasers emitting around 2  $\mu\text{m}$  are used for medical therapy and materials processing. Advanced infrared detector arrays with simultaneous, pixel registered dual-band and dual-colour detection of infrared radiation are also part of our high-tech portfolio.

[www.iaf.fraunhofer.de](http://www.iaf.fraunhofer.de)



### Fraunhofer Institute

#### for Physical Measurement Techniques (IPM)

The Fraunhofer Institute for Physical Measurement Techniques (IPM) in Freiburg develops and builds optical sensor and imaging systems. These mostly laser-based systems combine optical, mechanical, electronic and software components to create perfect solutions of robust design that are individually tailored to suit the conditions at the deployment site. Fraunhofer IPM develops customised systems that enable service providers to supply sophisticated, high-tech services. The Institute creates functional models and prototypes for modules as well as turn-key systems. Upon request, development packages can include the transfer of such models and prototypes to mass production. Optical spectroscopy is one of the Institute's core competencies, in particular ultraviolet-visible, near-infrared, mid-infrared and terahertz spectroscopy. Other core competencies based on laser technology are laser imaging and high-speed distance measurement as well as holography. Bioanalytics, railroad measurement systems and space technology are the main areas of application for the optical systems developed by Fraunhofer IPM. Fraunhofer IPM is one of the leading research institutes in the field of thermoelectrics in Europe.

[www.ipm.fraunhofer.de](http://www.ipm.fraunhofer.de)



### Fraunhofer Institute

#### of Solar Energy Systems (ISE)

Photovoltaic solar energy generation, building technology and solar thermal power stations are some of the main areas of focus at Fraunhofer Institute of Solar Energy Systems (ISE) in Freiburg. Because optical technologies play a major role in solar energy research, ISE features a separate "Optical components and systems" business area which comprises several solar technology market segments. These include windows and facades as well as solar thermal collectors and



solar thermal power stations. Even non-solar sectors such as light and display technologies benefit from the know-how of the Freiburg researchers. The spectrum of technology fields ranges from nano structures for optically functional surfaces to diffractive optics and large-area coatings for the mirrors on solar thermal power stations. Founded in 1981, and with a workforce currently numbering 650, Fraunhofer ISE is Europe's largest solar research institute.

[www.ise.fraunhofer.de](http://www.ise.fraunhofer.de)

### LEIBNIZ GEMEINSCHAFT



### Kiepenheuer Institute of Solar Physics (KIS)



For several years, projects aimed at optimising solar image and spectral data have been conducted at the Kiepenheuer Institute of Solar Physics (KIS) in Freiburg. The methods implemented subsequent and real time optimisation, using adaptive and multi-conjugative adaptive optics. While adaptive optics are routinely used for almost all scientific observations at the vacuum tower telescope on Tenerife, multi-conjugative adaptive optics are still at the experiment stage, although they are due to be implemented in the new GREGOR sun telescope. Optical technologies will also form an essential element of a large-scale European solar telescope, the feasibility of which is to be examined shortly. KIS cooperates with institutes in Europe and the USA that are engaged on similar projects, and that conduct large-scale scientific projects (such as SUNRISE, a solar telescope that is to fly to the Antarctic) where optical technologies are used.

[www.kis.uni-freiburg.de](http://www.kis.uni-freiburg.de)



### FORSCHUNGSGESELLSCHAFT FÜR STRAHLWERKZEUGE MBH (FGSW)



The name FGSW (Research Association for Beam Tools) is synonymous with extensive laser expertise ranging from application-related research, the development of innovative laser technology to technology transfer and products suitable for industry. FGSW possesses diverse competencies based on many years of experience in laser technology, and conducts various research and development projects. Special competencies are predominantly focused on laser development, process development, process control as well as the development and implementation of system-related components suitable for industry.

[www.fgsw.de](http://www.fgsw.de)

### The FGSW Centre for Diagnostics of Laser Based Production Processes

In 2005, a Centre for Diagnostics of Laser Based Production Processes was opened at FGSW. This centre, the only one of its kind in the world, offers ultra-modern diagnostics and measuring equipment for process diagnostics and beam diagnostics, for micro as well as for macro material processing.

Upon its completion, the centre will incorporate the following equipment and measuring systems: Beam Analyzers like the Spiricon M<sup>2</sup>-200 and the Primes HP-MSM, High Speed Spectrometer, High Speed Video Camera with Laser Illumination, the world's fastest High Speed Infrared Camera, the world's fastest High Speed Microfocus X-Ray Video System, the world's fastest ICCD Camera for Short-Time Diagnostics, High Speed Handling System, Confocal Image Profiler, Nanosecond Laser System, and Picosecond Laser System.



## Contract research institutes

### INSTITUT FÜR MIKROELEKTRONIK STUTTGART (IMS CHIPS)



IMS CHIPS manufactures diffractive optics on the basis of customer designs, using quartz substrates. The etching depth range is between a few nanometers and 1 micrometer and the advanced equipment and processes allow very tight depth and uniformity tolerances. IMS CHIPS is involved in industry-oriented research in silicon technology, application-specific integrated circuits, photo lithography and image sensors as well as vocational education. The Institute has alliances with small- and medium-scale companies and co-operates with top international semiconductor corporations and suppliers. IMS CHIPS is a partner in national and international research projects.

[www.ims-chips.de](http://www.ims-chips.de)

means of photothermal methods, e.g. determination of quality and thickness of coatings and characteristics of hardening.

[www.uni-ulm.de/ilm](http://www.uni-ulm.de/ilm)

### ZENTRUM FÜR SONNENENERGIE- UND WASSERSTOFF-FORSCHUNG (ZSW)



ZSW (Solar Energy and Hydrogen Research Centre) is dedicated to photovoltaic material research and the development of thin layer technologies. The optimisation of semiconductors for absorbing solar radiation and the design of new solar module construction types represent further challenges alongside innovative production processes for thin layer photovoltaic modules. The areas of photovoltaic, fuel cells and hydrogen technology as well as biogenous fuels are researched at Stuttgart and Ulm. ZSW develops new materials, processes and procedures for optoelectronic applications. Research is focused on thin Cu(In,Ga)Se<sub>2</sub>-layer (CIS) as well as photovoltaic concentrator and tracking systems. In cooperation with Universität Karlsruhe (TH), ZSW develops materials for organic solar cells. ZSW progressed CIS thin layer technology to readiness for series production and supported the commissioning of the world's first production line for CIS photovoltaic modules through a leading company in the solar industry.

[www.zsw-bw.de](http://www.zsw-bw.de)

### INSTITUTE OF LASER TECHNOLOGIES IN MEDICINE AND METROLOGY (ILM)



ILM at Universität Ulm cooperates with university research and supports technology transfer to medium-sized companies. ILM's mission is to tap new application fields for optics and lasers in diagnostic and therapeutic medicine by means of pure and applied research, application and device development in cooperation with regional industry as well as patient trials. The focuses are: (i) fundamental investigation on photon diffusion in tissue and laser-tissue interaction, (ii) application of a variety of optical diagnostic processes, e.g. based on fluorescence methods reaching from basic research (e.g. by laser scanning microscopy) to practical applications as exemplified for caries diagnostics and (iii) development of novel therapeutic systems. The Laser Therapy Centre performs clinical surveys mainly on dermatological and dental uses of lasers. Main focus of laser applications in metrology is the non-destructive testing of materials by

## Optical technologies competence network

### PHOTONICS BW COMPETENCE NETWORK



The optical technologies Photonics BW e.V. competence network was founded in 2000 by nine prominent research institutions and industrial enterprises with the aim of "Strengthening strengths" in Baden-Württemberg. Photonics BW e.V. is a non-profit competence network funded by the Federal Ministry of Education and Research, and today comprises over 50 industrial enterprises, small and medium-sized companies, start-ups, research and educational institutions

as well as banks and consultancies. The aim of Photonics BW e.V. is the promotion of optical technologies in research, development and application, education and further training, as well as PR in Baden-Württemberg. Photonics BW e.V. represents an important contribution to increasing competitiveness and securing investment incentives in the optical technologies sector.

[www.photonicsbw.de](http://www.photonicsbw.de)





## Technology transfer centres

### STEINBEIS FOUNDATION FOR ECONOMIC PROMOTION



STEINBEIS

The Steinbeis Network, over 700 specialist centres worldwide spanning all technology and management sectors, has been building bridges between sciences and academia on the one hand and trade and business on the other since 1983. The services portfolio comprises consulting, research and development, evaluation and expert reports as well as training and employee development. Steinbeis is financially independent and cooperates with experts at universities, universities of applied sciences, universities of cooperative education and research institutes.

[www.stw.de](http://www.stw.de)

#### Steinbeis Transfer Centre for Optical Chemo/Biosensors, Tübingen

Research at the Steinbeis transfer centre at the University of Tübingen focuses on optical chemo and biosensors using reflectometry, interferometry and fluorescence applied to trace analysing of environmental pollutants in water, in clinical diagnostics, fermentation control and the search for active ingredients. The centre has long experience in the modification and configuration of optical components, with immunoassays, data capture and data evaluation comprising chemometric methods.

[www.bioregio-stern.de/steinbeis-transferzentrum\\_optische\\_chemo-\\_und\\_biosensoren](http://www.bioregio-stern.de/steinbeis-transferzentrum_optische_chemo-_und_biosensoren)

#### Steinbeis Transfer Centre for Biomedical Optics and Function Testing, biomed, Tübingen



Steinbeis transfer centre biomed at the Department of Ophthalmology, Universität Tübingen, combines competence from research and industry, specialising in pre-clinical and clinical studies, consulting of industry partners and device development in the area of biomedical

cal optics and function testing of the visual and central nervous system. STZ biomed is a certified member of the network EVI.CT.SE (European Vision Institute. Clinical Trials. Sites of Excellence) as a centre of excellence for Clinical Trials.

[www.stz-biomed.de](http://www.stz-biomed.de)

#### Steinbeis Transfer Centre for Laser Processing and Diagnosis, Heidelberg

This Steinbeis centre is dedicated to laser-supported spectroscopic diagnosis of systems with a very small absorption effect, such as proof of trace substances in gases or molecule monolayers on surfaces and their chemical conversions. In addition, optical and mechanical properties of amorphous, nano-crystalline and crystalline materials are determined using laser processes.

[www.stw.de/transfer/su-profile.html](http://www.stw.de/transfer/su-profile.html)

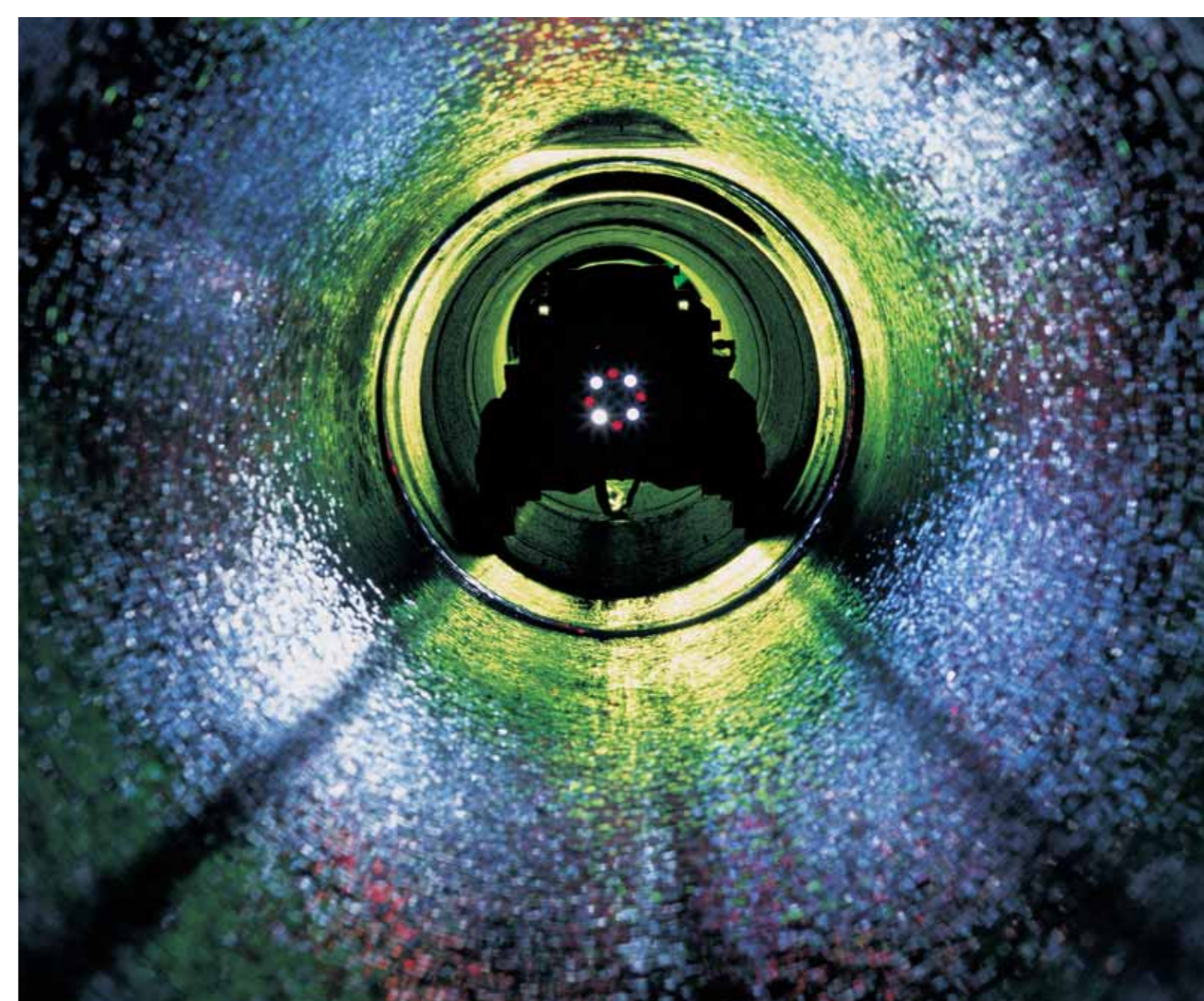
#### Steinbeis Transfer Centre for Laser Processing and Innovative Production, Pforzheim

This Steinbeis centre specialises in all areas of laser material processing, laser hard-surfacing and laser coating, in particular extremely hard layers on shaping, punching and machining tools. Other areas of expertise include hard metals of the most diverse compositions, laser soldering especially of high grade steel sheet, laser annealing, in particular power train components and laser welding of macro to micro parts.

[www.stw.de/transfer/su-profile.html](http://www.stw.de/transfer/su-profile.html)

#### Steinbeis Transfer Centre for Optics and Photonics, Aalen

This Steinbeis centre offers both measuring and test techniques for light, ultraviolet and infrared technology and processing of free-form surfaces in the aspherical optics centre. Measuring of the optical



properties of materials, infra-red thermography, the measuring of lamps, lasers, LEDs and receivers of all kinds in the ultraviolet, light and infrared wavelength range is available, as well as the calculation, simulation and construction of optical and electronic components.

This centre is also a service provider in laser protection and danger analysis, offering expert reports, consultancy and training in the fields of optics, photonics, vision and radiation protection.

[www.awfe.de](http://www.awfe.de)

#### Steinbeis Transfer Centre for Optoelectronics and Sensor Technology, Karlsruhe



This Steinbeis centre covers customised product developments, problem analysis, processing of solution proposals and the testing of laboratory samples. The portfolio also includes the development

of prototype systems, their further development to readiness for series production and market launch support.

[www.stw.de/transfer/su-profile.html](http://www.stw.de/transfer/su-profile.html)

#### Steinbeis Transfer Centre Lighting Technology, Weingarten

The Steinbeis transfer centre Lighting Technology (STZL) offers services for the development of optical illumination systems by simulation and optimization with nonsequential ray tracing. Light sources can be modelled or measured by near field photo goniometry delivering ray data sets for optic design software.

The STZL FIFA-software enables modelling and optimization of the spectral properties of light sources, e.g. LEDs.

[www.stzl.de](http://www.stzl.de)



## Join us on the web!

### [www.baden-wuerttemberg.de](http://www.baden-wuerttemberg.de)

The official site of the State Government supplies general information and current news as well as topics drawn from the political, economical, research und educational, tourism and social spheres.

### [www.bw-invest.de](http://www.bw-invest.de)

This site contains an overview on the State of Baden-Württemberg as a business location as well as a company database.

### [www.study-guide-bw.de](http://www.study-guide-bw.de)

The StudyGuide contains a wealth of information on educational opportunities, research, life and work in Baden-Württemberg.

## Contact us!

### [info@bw-wfk.de](mailto:info@bw-wfk.de)

For further information on our services, visit [www.bw-wfk.de](http://www.bw-wfk.de)

### Baden-Württemberg International



Agency for International Economic  
and Scientific Cooperation

Haus der Wirtschaft  
Willi-Bleicher-Str. 19  
70174 Stuttgart  
Germany

Phone: +49(0)711.22787-0  
Fax: +49(0)711.22787-66

E-Mail: [info@bw-i.de](mailto:info@bw-i.de)  
Internet: [www.bw-i.de](http://www.bw-i.de)

### Published by:

Baden-Württemberg International, Stuttgart, first edition, April 2008

### Technical and scientific advice:

Photonics BW e.V.  
Competence Network for Optical Technologies  
[www.photonicsbw.de](http://www.photonicsbw.de)

### Graphic Concept and Design:

[www.jungkommunikation.de](http://www.jungkommunikation.de)

### Photographs:

[www.berndmueller-fotografie.de](http://www.berndmueller-fotografie.de)  
Cover picture shows the waver, whose active (luminiferous) coat consists of the new semiconducting material gallium-nitrite (GaN). The "pick-up sticks" provide electric current to test the LED-chips on the waver.



# Baden-Württemberg

The German Southwest.