KSOP
Karlsruhe School of Optics & Photonics

KIT
Karlsruhe Institute of Technology

International M.Sc. and Ph.D. Program in Optics & Photonics

Interdisciplinary Qualification in Cutting-Edge Research at the International Graduate School of the Karlsruhe Institute of Technology

Relevance of Optics & Photonics for the Future

Executive Board Message

Since the year 2000, more than 10 Nobel Prizes directly linked to Optics & Photonics have been awarded. This includes not only basic research but also application oriented breakthroughs that facilitated the transformation of our society.

Energy-efficient light sources, optical communication and digital camera systems are impressive examples. At the same time, the discipline is mobilizing innovation-driven branches of our economy, such as industrial automation and production, digitalization of the society, autonomous mobility as well as medical technologies and personal health monitoring. The future progress and growth in this field rely on dedicated researchers and graduates trained in an interdisciplinary environment.

In 2006, the **Karlsruhe School of Optics & Photonics** was founded as one of the first Graduate Schools within the scope of the German "Excellence Initiative" at the Karlsruhe Institute of Technology (KIT). The Excellence Initiative was introduced to focus attention on internationally leading German universities. The excellence status of KSOP was renewed by international experts in 2012.

In 2021, KSOP became sustainably funded through the KIT by the Federal Ministry of Research and Education (BMBF) and the State of Baden-Württemberg.

Prof. Dr. Ulrich Lemmer
Coordinator Karlsruhe School of Optics & Photonics

KSOP brings together the best talents in engineering and natural sciences.

Comprising a **Master's** and a **Ph.D. Program** in Optics & Photonics, the educational concept is designed to qualify its graduates for accelerated careers at world leading academic institutions and in high-technology industries.

The Master's program provides international students the opportunity to deepen their knowledge in optics and photonics while exploring the possibility of a future working either in industry or academia.

KSOP actively promotes the thesis work of its doctoral researchers by dedicated supervision, mentoring, networking as well as scientific and technical training. Moreover, KSOP augments the professional skills of its graduates by tailored personal and management training.

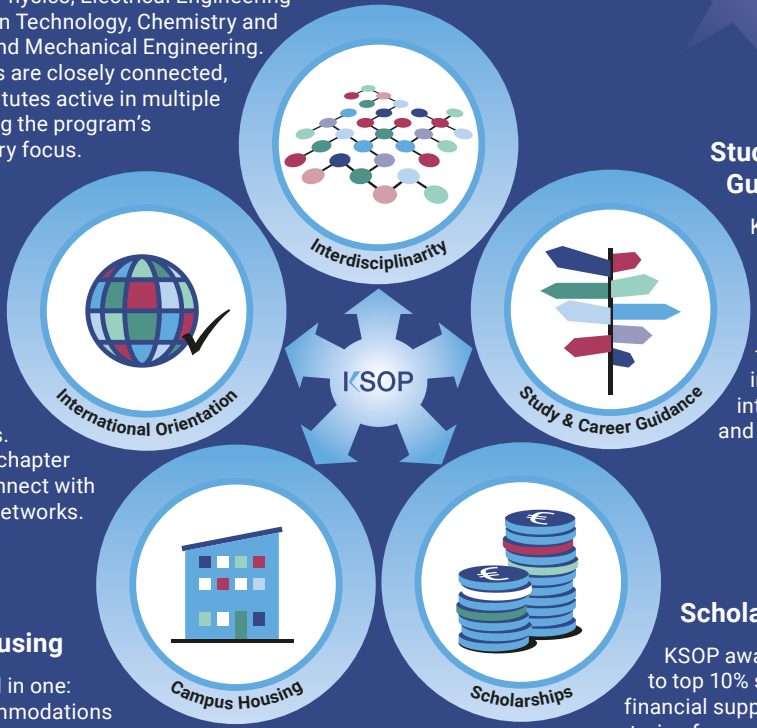
Currently, KSOP encompasses professors from 17 institutes and four different KIT Departments, i.e. Physics, Electrical Engineering and Information Technology, Chemistry and Biosciences, as well as Mechanical Engineering. Over 900 students, doctoral researchers and alumni have positioned KSOP as a premium education, research, and innovation hub.

Join us as a student, a doctoral researcher or as an academic or industrial partner. We are looking forward to a rewarding collaboration.

5 Reasons for KSOP

Interdisciplinarity

KSOP's interdisciplinary structure supports its Master and Ph.D. programs, uniting professors from 17 institutes across four faculties: Physics, Electrical Engineering and Information Technology, Chemistry and Biosciences, and Mechanical Engineering. Research areas are closely connected, with many institutes active in multiple fields, reflecting the program's multidisciplinary focus.



International Orientation

KSOP offers a diverse and international environment, with over 1000 Master's, Ph.D. students, and alumni from more than 70 countries. Through the OSKar student chapter at KIT, students can also connect with the global Optica and SPIE networks.

Study & Career Guidance

KSOP offers personalized study support and career services, including workshops on applying to German industry, interview training, intercultural skills, and teambuilding.

Campus Housing

KSOP offers all in one: Campus accommodations and academics as well as leisure facilities (i.e., a music room) can all be found under one roof.

Scholarships

KSOP awards scholarships to top 10% students, including financial support and personal mentoring from experts at partner companies like ZEISS, Bosch, and Polytec.

KSOP

RESEARCH AREA I
Photonic Materials & Devices

RESEARCH AREA II
Quantum Optics & Spectroscopy

RESEARCH AREA III
Biomedical Photonics

RESEARCH AREA IV
Optical Systems

RESEARCH AREA V
Solar Energy

M.Sc.

M.Sc. Program (2 years)

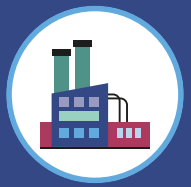
Europhotonics Master Program

Ph.D. Program (3 years)

MBA FUNDAMENTALS

MBA Fundamentals Program

Career in:

RESEARCH  /  INDUSTRY

Karlsruhe

Weather

One of the warmest & sunniest places in Germany!

Mobility

Comfortable & fast to reach by train

approx. travel durations:

International Airport	
Frankfurt	1 hour
Basel	1.5 hours
Paris	2.5 hours
Munich	3 hours
Zurich	3.5 hours
Amsterdam	5.5 hours
Berlin	5.5 hours
London	6 hours
Prague	7 hours

Bicycle-friendly city

High frequency tram network for a car-free city center

City's population: 300,000
Students at the KIT: 23,000

In the Heart of Europe – A Great Place to Live and Study

- **Karlsruhe offers something for everybody`s taste** with its academic centers of excellence in music, art, design, media and technology. In the heart of Europe, it offers easy access to mountains, lakes, rivers, forests, castles, skiing and other outdoor sports. The **Rhine**, one of Europe's most important rivers, runs through it, and beyond lies the beautiful **French Alsace region** that you can reach by train in only 20 minutes.
- **Frankfurt Airport** as Europe's 4th largest airport is only one hour away by train.
- The **technology region** Karlsruhe is one of the leading commercial and innovation regions in Europe.
- Karlsruhe is also called "the **city of justice**", since the German Federal Constitutional Court and Federal Court of Justice are seated there.
- Its **unique fan-shaped** city architecture was a role model for Washington DC in the USA.
- It is situated right next to the world-renowned **Schwarzwald** (Black Forest).
- Castle **Neuschwanstein**, Germany's famous "fairy-tale Castle", is only 370 kilometers away.
- Karlsruhe is a **UNESCO** City of Media Arts.
- **Museums & Galleries:** The world-famous Center for Art & Media Karlsruhe, called "ZKM" is located there.
- **Music Festivals:** "DAS FEST" in July each year, for example, is one of Germany's largest open-air festivals.
- **Sports:** Karlsruhe has more than 240 sport clubs that offer 90 different kinds of sports. A wide variety of sport clubs are also based within the KIT for students.
- **Trade Fair Center:** Innovative events & international trade fairs

Students therefore enjoy a high quality of living in a technology region within a leisure paradise, surrounded by nature.

Karlsruhe Institute Of Technology (KIT) – Campus & Infrastructure

Study With the Best

The Karlsruhe Institute of Technology (KIT) is one of the leading technical universities in Germany and Europe. Outstanding rankings and evaluations vouch for the standard of research and education at KIT.

This is without a doubt the most beneficial result of the 2006 merger of the Karlsruhe Research Center and the former University of Karlsruhe, which dates back to 1825. Currently, KIT is one of the largest research and teaching institutions in the world. The student satisfaction in Karlsruhe is among the top in Germany due to a **systematic, balanced curriculum and excellent teaching staff**.

Karlsruhe Institute of Technology

QS 2022 Employability Ranking

#1 #10 #46

Germany | Europe | Worldwide

KIT Rankings

KIT Infrastructure

KIT offers a very comprehensive university infrastructure. Young scientists get a fascinating framework for their explorations at projects, experiments and plants in major research institutions. Furthermore, there is a 24/7 library, diverse culture, music, and sport offerings. KIT has numerous **student organizations** where students can put the theory from their lectures into practice. There is, for instance, a group working on autonomous model cars (KITcar) or a team for innovative field robots (KaMaRo Engineering e.V.).

Optic Students Karlsruhe (OSKar)

OSKar is part of a worldwide network of student chapters of the **OPTICA** (formerly OSA) and of **SPIE** and comprises a group of enthusiastic students coming from different academic and cultural backgrounds, united by the common interest in sharing Optics & Photonics knowledge. The combination of Engineering, Physics, and Optics students in the team gives rise to diverse and complementary ideas that are materialized in different projects and events.

"When I started my Master's degree in KSOP, I found the opportunity in OSKar to achieve one common vision: To meet passionate students who want to spread knowledge about Optics & Photonics. OSKar has focused on participating in outreach activities of KIT and KSOP and provides a great opportunity to integrate in the local community. Additionally, activities like company excursions, invited lectures, "Stammtisch", and many more provide academic, industrial, and networking spaces to further advance our careers. My key takeaway from OSKar is the network it has built: OSKar alumni give an unparalleled advantage at the beginning of our professional careers. From all this, I highly recommend joining the group and sharing the love of optics with everyone."

Orlando Torres Perales, Former President of the Student Chapter Optic Students Karlsruhe

Light Up Your Future! KSOP Master's Program

KSOP M.Sc. Program

Interdisciplinary Approach

The KSOP M.Sc. Program aims at educating excellent students in Optics & Photonics worldwide. The interdisciplinary research structure of the international graduate school forms the basis for this outstanding 2-year Master's program. Completely taught in English, the program is developed for 40 students each year who apply with a completed Bachelor's degree in natural or engineering sciences.

KSOP unites **17 institutes of the KIT**. The KIT is the Research University in the Helmholtz Association of National Research Centers in Germany. The research and educational concept of KSOP has been established to optimally reflect the **multidisciplinary research** among natural scientists and engineers. KSOP research activities cover the most important topics in Optics & Photonics and excel, particularly in the **five research areas.** They are strongly interlinked and most institutes feature research projects in more than one of the areas.

KSOP's educational concept is supported by **Premium industry partners**. These partners provide students with internships, excursions, individualized workshops, career events, and even master thesis scholarships.

What's Unique

Industry Network: The studies include an elaborated industry internship program with partners from the Optics & Photonics industry. Furthermore, company visits and career events are offered regularly to all students. This cooperation is of high value not only for students but also for industry partners, as it provides a gateway for future employment opportunities.

Industry Lecture by ZEISS: Students have the chance to attend lectures by innovation specialists from industry and create new business ideas.

Smart Factory@Industry: At KSOP, students can take part in industry training projects by key players in the German industry. This program is exclusive and allows a few students each year to participate.

Scholarships: For outstanding students who are among the best 10% students of their class, scholarships are offered.

International Student Community: Students from all over the world convey an international studying atmosphere to the Master's program. KSOP students also have the opportunity to join the worldwide OPTICA (formarly OSA) and SPIE network through the OSKar student chapter at KIT.

Key Data & Benefits

2-year International Master´s Program | Prerequisites: B.Sc. Degree in Optics & Photonics, Natural or Engineering Sciences

Specializations | Photonic Materials & Devices, Quantum Optics & Spectroscopy, Biomedical Photonics, Optical Systems, Solar Energy

Benefits | Industry Internships, Networking, Intensive Lab Training, Language Courses & Business Etiquette Training

KSOP Scholarship Program | Scholarships Available for Outstanding Applicants

Program Language **English |** Start **October**

KSOP MASTER'S PROGRAM

Structure of the M.Sc. Program

Key Facts

Duration	2 years
Degree	Master of Science (M.Sc.)
Workload	120 ECTS including an 8-week internship
Specializations	5 Research Areas
Teaching Language	English
Start	Yearly in October

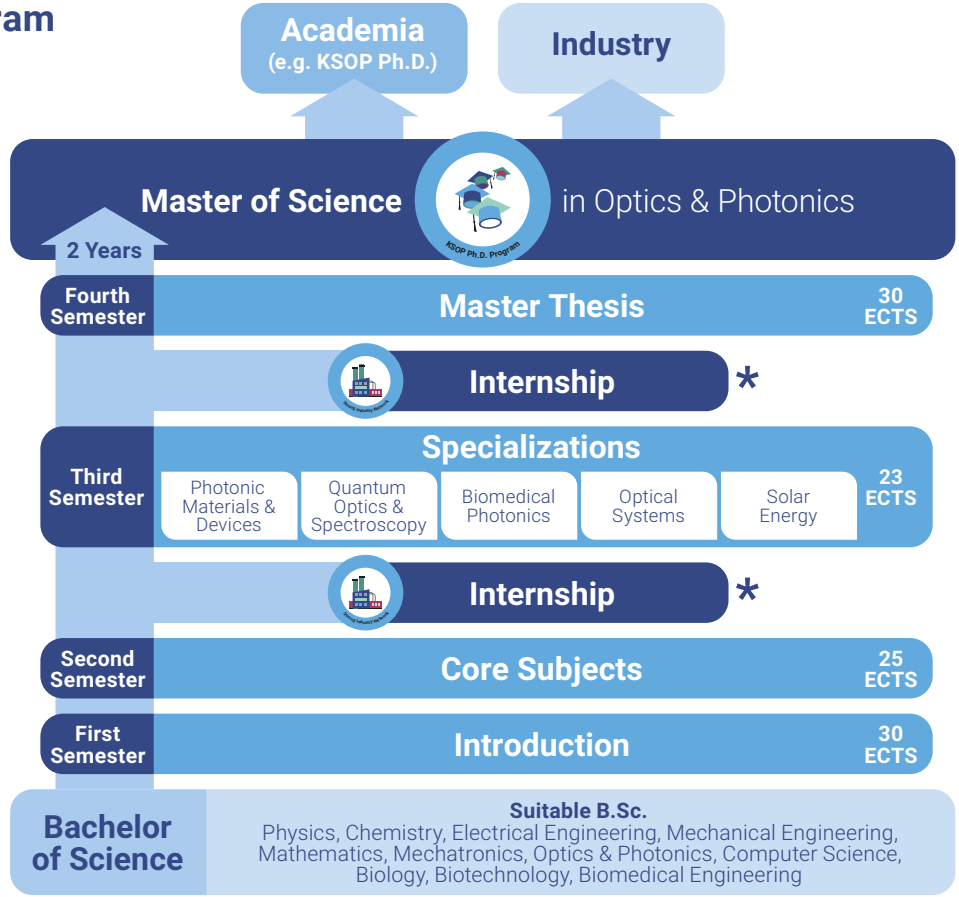
After completing the **fundamental introductory courses** and core subjects in the first two semesters, each student chooses a **research specialization**. An optional eight-week internship will take place either between the second and third semester or between the third and fourth semester. It is credited with 12 ECTS.

During their studies, Master students come into direct contact with KSOP research groups. Graduates of the Master's program can apply for the **KSOP Ph.D. Program** to deepen their knowledge in Optics & Photonics.

Rolling admission process

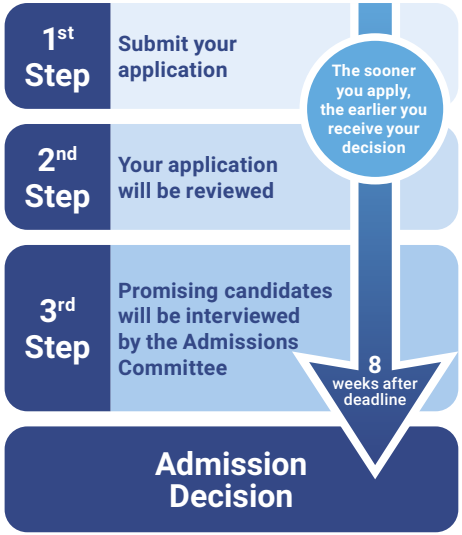
Applications can be submitted from **December to September each year**.

This increases the chance to be admitted earlier, allowing ample time to secure a visa, accommodation, finances, and more!



* An eight-week internship will take place either between the second and third semester or between the third and fourth semester. This internship is optional and is credited with 12 ECTS.

Steps to Apply



Voices of KSOP Alumni

Maximillian Büttner
is now working at TRUMPF as Executive Assistant to Head of R&D

"For me, KSOP was all about opportunities.The opportunity to study at one of the most renowned universities in Germany in a modern environment, with international fellow students and a close practical focus and close exchange with industry partners. With its wide range of specialization options, the Master's programme offers the right courses for everyone. Above all, the interdisciplinary background of the fellow students enriches the program immensely."

Pubali Chaudhury
is currently pursuing her PhD in Physics

"KSOP was more than just a master's program for me — it was a gateway to discovery. It provided me with the opportunity to delve into the very foundations of physics while engaging with cutting-edge research at the forefront of photonics. The dynamic international collaborations and the inspiring guidance of esteemed professors broadened my perspective not only on science but also on the power of knowledge exchange. I am truly grateful for this transformative journey."

More Alumni Voices

Inter-disciplinarity | Study with the Best | Strong Industry Network | International Orientation | Scholar-ships | Study & Career Guidance | Campus Housing | Perfect Location | Ph.D. Program | Research | Publications | Patents | Awards | Hall of Fame

Looking for a Bright Future? KSOP Ph.D. Program

KSOP Ph.D. Program

Research+ Concept for Success

The Karlsruhe School of Optics & Photonics offers a **3-year Ph.D. program** in one of the research areas: Photonic Materials & Devices, Quantum Optics & Spectroscopy, Biomedical Photonics, Optical Systems, and Solar Energy.

KSOP provides Ph.D. candidates with an optimal research environment at the Karlsruhe Institute of Technology (KIT) to carry out first rank Ph.D. projects in the multidisciplinary field of Optics & Photonics. Integrated into the Graduate School, doctoral researchers pursue their projects autonomously. To support their endeavor, a **Thesis Advisory Committee (TAC)** and a **Co-Supervisor** accompany the research work of the doctoral researcher. All Ph.D. positions are financed.

Since successful careers in industry and academia often require leadership and interdisciplinary knowledge, emphasis is laid on management skills, which are taught as **management modules** within KSOP, in addition to the **technical and scientific modules**.

In addition to that, KSOP fosters an active **network** amongst both its active members and alumni. A scientific exchange with international peers and leading scientists is facilitated through events and international conferences.

Spezializations

RA I | Photonic Materials & Devices | Research in new materials-, synthesis-, and deposition technologies fosters new designs of photonic materials and devices, e.g., luminescent nanoparticles, organic films, or photoresists.

RA II | Quantum Optics & Spectroscopy | Spectroscopy plays a crucial role in uncovering and characterizing novel quantum and non-linear phenomena molecular photophysics or atmospheric chemistry.

RA III | Biomedical Photonics | Biomedical photonic technologies are crucial for noninvasive clinical monitoring, molecular diagnostics, or imaging of physiological parameters in living cells, humans, and whole organisms.

RA IV | Optical Systems | Sensing and machine perception systems, laserbased manufacturing, and production monitoring are examples where optical materials and devices are integrated into real-world applications.

RA V: Solar Energy | The conversion of solar radiation into electrical energy might one day cover the major part of the electricity supply. Light management by means of tailored plasmonic or dielectric structures can reduce costs of the future solar electricity.

Key Data & Benefits

3-year International Doctorate Program | Prerequisites: M.Sc. Degree in Optics & Photonics, Natural or Engineering Sciences

Research Areas | Photonic Materials & Devices, Quantum Optics & Spectroscopy, Biomedical Photonics, Optical Systems, Solar Energy

Benefits | English working language, Supervision & Mentoring Concept, National and International Networking, Modular Training (Management, Technical, and Scientific)

KSOP Scholarship Program | Scholarships Available for Outstanding Applicants

Program Language **English |** Start **Individual |** Location **Karlsruhe, Germany**

Why KSOP?

Benefits of the Ph.D. Program

ADDITIONAL BENEFITS

ADVANCING COMPETENCIES

- Technical Modules
- Scientific Modules
- Management Modules
- **MBA Fundamentals Program** (OPTIONAL)

SUPERVISION & MENTORING

- Mentor
- Thesis Advisory Committee
- Ph.D. Thesis Supervisor
- Faculties

NETWORKING

- Ph.D. Seminars
- KSOP Get-Together
- Ph.D. Welcome Days

***Suitable M.Sc.: Physics,** Chemistry, Electrical Engineering, Mechanical Engineering, Mathematics, Mechatronics, Optics & Photonics, Computer Science, Biology, Biotechnology, Biomedical Engineering

Voices of KSOP Ph.D. Alumni

"I joined KIT in 2013 to build up my research group dedicated to light management solutions in optoelectronics. In parallel, I had the chance to be a KSOP mentor for 7 years. It gave me the opportunity to exchange and launch successful cooperation with many KSOP members who were at different career stages and were working in different areas of Optics & Photonics.

This environment was an asset for me and my students as it enabled to develop a core technical expertise and simultaneously, to cultivate a culture of curiosity for other scientific and business-related topics. The capacity to deep dive into certain technologies and applications while being able to rapidly comprehend and analyze new domains is a key aspect of my mission at ZEISS, and an advantage for any position in research.

The network of academic and industrial experts that I have created within KSOP is an invaluable resource, which I continue to use in order to foster innovative ideas."

Dr. Isabel Allegro,
KSOP Alumna

"I chose the KSOP PhD Program due to its opportunities beyond research and science: The additional trainings and workshops vastly extended my skill set, like the MBA Fundamentals Module that is also highly regarded in industry. The mentoring program gave me invaluable personal and professional guidance to help me during the challenges of the PhD.

Additionally, during all technical and social events, I could connect with brilliant people, some of them even helped me later during my job search. Overall, this program gave me incredible opportunities in career development, skill-building, and networking with talented, supportive people."

Dr. Aiman Roslizar,
KSOP Alumnus

"I truly enjoyed my time with KSOP while doing my PhD. I appreciated the wide range of additional activities that helped me grow beond my core research training. The modules were well-designed, and I could choose those most relevant to my interests – including ones focused on motivation and essential skills. The PhD seminars were insightful, offering valuable peer exchange and opportunities to practice presenting my work.

Through the various events, I developed both professionally and personally, built meaningful networks, and gained fresh perspectives. In the end, I felt that KSOP not only supported my academic journey at KIT, but also played a key role in my personal development."

More Ph.D. Alumni Voices

KSOP Qualification Program EURO-PHOTONICS

Europhotonics

Photonics in Europe

Next to its own Master's program, KSOP is also a member of the European Erasmus Mundus Master's Program **EUROPHOTONICS.** The EUROPHOTONICS Master's offers excellent teaching at top-level universities and individual study mobility throughout Europe. An **extensive two-year master-level teaching program** focused on advanced and applied research topics that will constitute the near and extended future scientific goals in the field of Photonics Engineering, Nanophotonics, Biophotonics, and their interdisciplinary applications.

Partner Institutions

Germany	Karlsruhe Institute of Technology (KIT)
France	Aix Marseille Université (AMU)
	Ecole Centrale de Marseille
Spain	Universitat Politecnica de Catalunya (UPC)
	Institute of Photonic Sciences (ICFO)
	Universitat de Barcelona (UB)
	Universitat Autonoma de Barcelona (UAB)
Finland	Tampere University of Technology
Lithuania	Vilnius University

Program & Mobility Structure

Semester 1	Fundamentals (AMU)	Depending on the personal mobility structure, graduates will receive a Master of Science degree awarded with 120 credits by at least 2 universities. The language of instruction is English.
Semester 2	Core Subjects & Industry Internship (KIT or AMU)	
Semester 3	Specialization (participating university)	
Semester 4	M.Sc. Thesis (participating university)	

Dr. Radwanul Hasan Siddique
KSOP Alumnus, Team Leader
Samsung Semiconductor (USA)

"I thank Europhotonics/KSOP for accepting me in their organization, allowing me to train under their state-of-the-art facilities and most importantly shaping my personal and professional identity beyond my limitations.

Its unique and interdisciplinary scientific and management programs educated me in physics, chemistry, mathematics, biology, and business of optics and provided an exposure to world-class research, to top-notch institutions and industries.

Above all, it made me who I am – confident, broad-minded, and passionate, which facilitates the working process in every aspect of my life and career. I wish the whole team all the best to keep encouraging the bright young minds and enlightening us with next-generation innovation and technologies!"

Key Data

- 2-year M.Sc. in Europhotonics
- 3 M.Sc. Degrees
- 3 Different European Countries
- Scholarships Available
- Support in Accommodation, Relocation & Administration

KSOP Research Areas

Key Technology Research

Optics & Photonics are key technologies of the 21st century. They form, e.g., the basis for today's optical communications, environmental sensing, biomedical diagnostics in the life sciences, energy efficient lighting and solar energy harvesting.

Future progress and growth rely on dedicated research and graduates trained in an interdisciplinary environment. Consequently, the KSOP research areas were set up to cover many important aspects of Optics & Photonics.

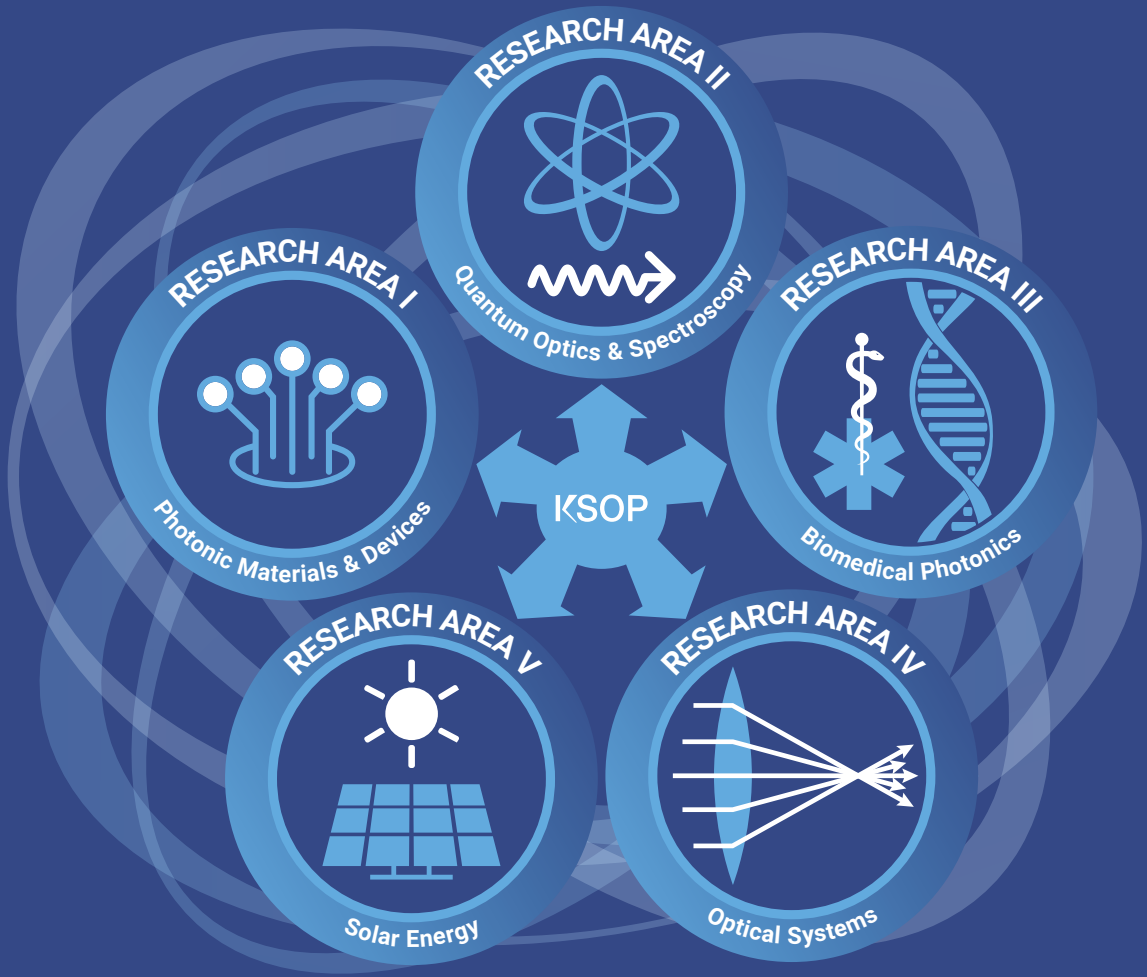
The research and educational concept of KSOP has been established to optimally reflect the spirit of multidisciplinary research among scientists and engineers. Therefore, all research areas are strongly interlinked and most institutes feature research projects in more than one of the research areas.

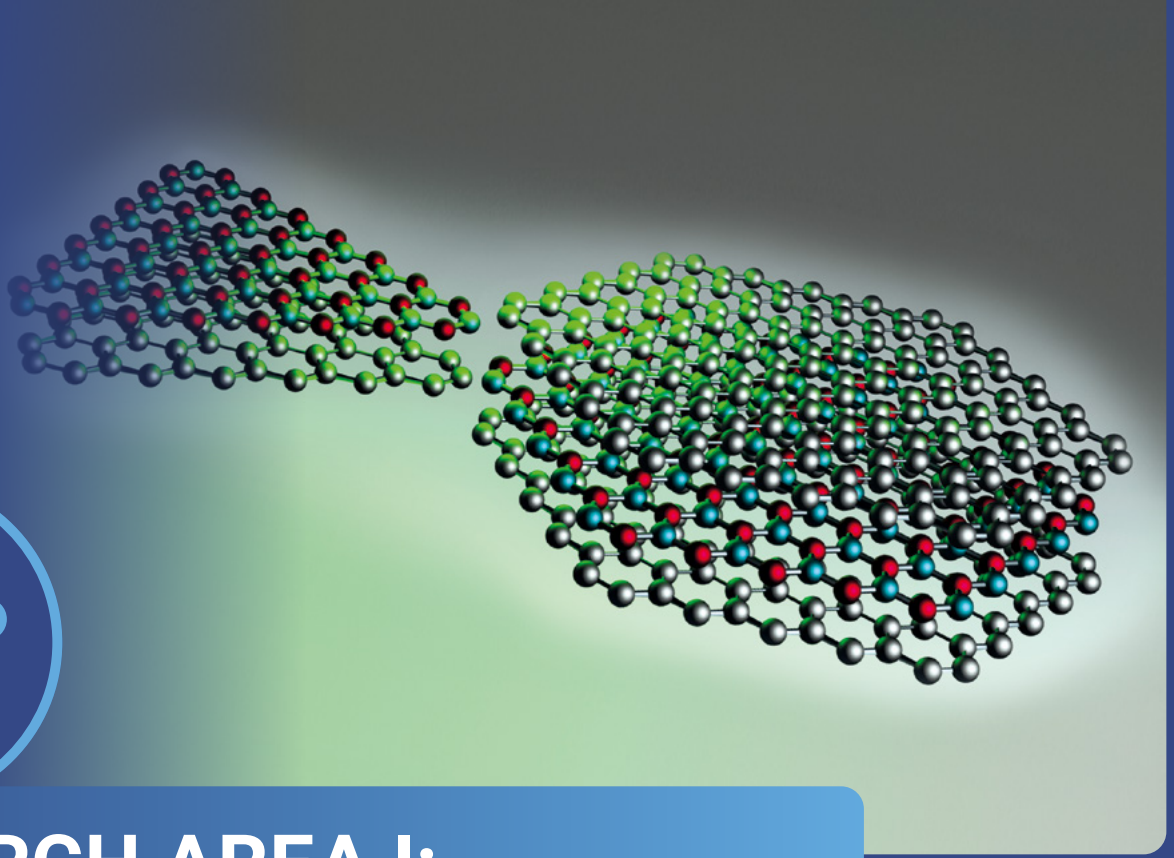
The research areas I - IV were already established in 2006. Meanwhile, sustainable energy supply has become an even more urgent global challenge. Thus, research area V Solar Energy was set up in the next funding period in 2011.

In what follows, the most significant advances in these five research areas, recent KSOP research highlights, and future KSOP measures concerning the research strategy are summarized.

Dr.-Ing. Judith Elsner
Managing Director Karlsruhe School of Optics & Photonics

INTERDISCIPLINARY RESEARCH





RESEARCH AREA I:
Photonic Materials & Devices

RESEARCH AREA I: Photonic Materials & Devices

Optics & Photonics are all about generating, controlling, and harvesting light – which is simply not possible without linear/nonlinear optical materials.

Thus, we explore new materials-, synthesis-, and deposition technologies for, e.g., luminescent nanoparticles and NLO materials, organic films, or photoresists. In addition, novel concepts like optical imaging, plasmonics, photonic crystals, photonic metamaterials, and transformation optics have emerged throughout the last decade, providing completely new conceptual opportunities regarding the design of optical sensors, imaging probes, photonic materials and devices. Furthermore, two-dimensional and three-dimensional lithography and chemical synthesis approaches have improved considerably, such that photonic structures previously believed to be inaccessible have come into reach.

Such research cannot be pursued experimentally only but is always complemented by theory and numerics that can be used to explore photonic materials and design them on-demand. This concerns linear, nonlinear, and quantum aspects. Tools to solve forward and inverse problems, and technologies from the general field of computational material design, also inspired by artificial intelligence, are of current interest. Quantum-chemical tools to study the optical properties of molecular materials and consider them in the design of macroscopic photonic devices are of interest too.

We contribute to all of these developments. Our research is, for example, driven by the quest forever faster and smaller devices for telecommunications, by biomedical material requirements, or by the need for more efficient and/or less expensive solar-energy conversion. By developing key technologies like three-dimensional direct laser writing (DLW), Research Area I also provides the basis for parts of Research Area III 'Biomedical Photonics'.

Future Aims & Goals

Future aims in this research area are designing and realizing novel materials and material functionalities and ever smaller and/or faster devices. To achieve this goal experimentally, serious lithography challenges have to be tackled, especially regarding three-dimensional structures. Furthermore, the theory has to progress towards quantitative modelling of complex photonic nanostructures with predictive power and for the inverse design. We aim to understand from a symmetry perspective photonic materials to conclude on emerging properties that they offer.

A grand challenge throughout our research concerns the translation of these insights into specific applications with societal impact.

Prof. Dr. Martin Wegener

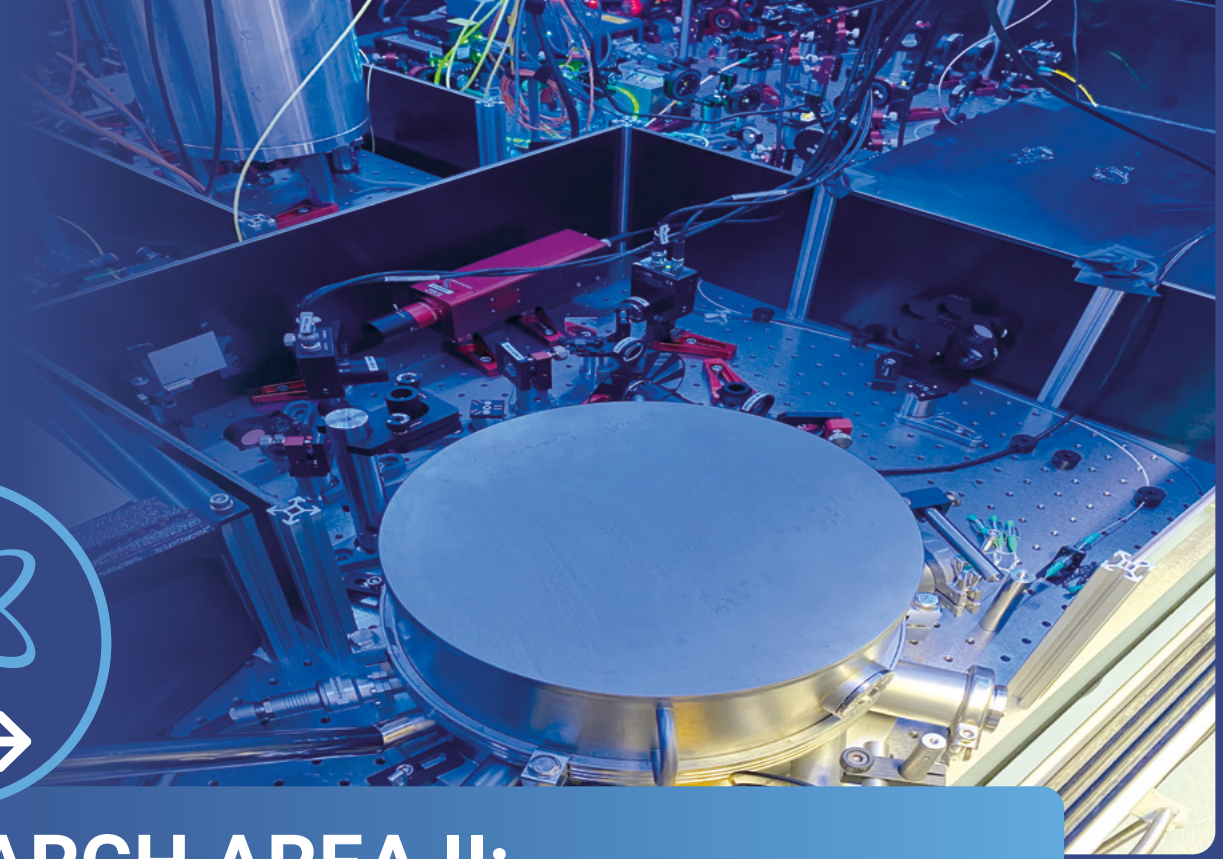
Scientific Speaker of RA I,
Institute of Applied Physics, KIT

RESEARCH HIGHLIGHTS

Metamaterials

Telecommunication Devices

Luminescent Nanoparticles



RESEARCH AREA II:
Quantum Optics & Spectroscopy

RESEARCH AREA II: Quantum Optics & Spectroscopy

Quantum optics is a dynamic research field concerned with the properties of individual quanta of light, called photons, and their interactions with atomic-scale systems.

It comprises the fundamental understanding of the basic processes encountered in spectroscopy, the working principle of lasers, as well as applications of quantum light for quantum technologies such as secure communication, or for interconnecting future quantum computers into quantum networks.

RA II covers experimental and theoretical research on fundamental quantum optics phenomena and their applications, as well as the development and application of advanced spectroscopic methods.

One focus is the investigation of materials that can serve as quantum light sources and optically addressable quantum bits. To control light-matter interactions, engineered photonic devices are developed, ranging from optical microcavities to nanoplasmonic antennas and integrated optical circuits. Expanding a detailed theoretical understanding of novel materials and photonic devices is key to these developments.

On the other hand, advanced spectroscopic methods which can probe sample composition and properties play a crucial role in helping to uncover and characterize novel quantum and nonlinear phenomena in many fields, ranging from molecular photophysics to atmospheric chemistry. At KSOP, methods are developed and applied, including ultrafast spectroscopy, remote sensing, and highly spatially resolved imaging. Such advanced techniques are essential for expanding research horizons, e.g., in materials science and nanotechnology.

Future Aims & Goals

Grand goals of this RA are to push the development of quantum communication over large distances, and to realize optically addressable quantum bit registers for quantum computing and quantum information storage, which could serve as building blocks of a future quantum internet.

Further, RA II will be devoted to develop spectroscopic tools for molecular sensing with significantly enhanced spatial- and temporal resolution. Well-defined applications for such high-resolution nanochronoscopic tools also require parallel improvements in sample quality. Here ion- and neutral particle traps offer interesting perspectives, e.g., for controlled gas adsorption, molecular orientation, and ultralow temperatures enable access to noise-free environments.

Prof. Dr. David Hunger

Scientific Speaker of RA II,
Institute of Physical Chemistry, KIT

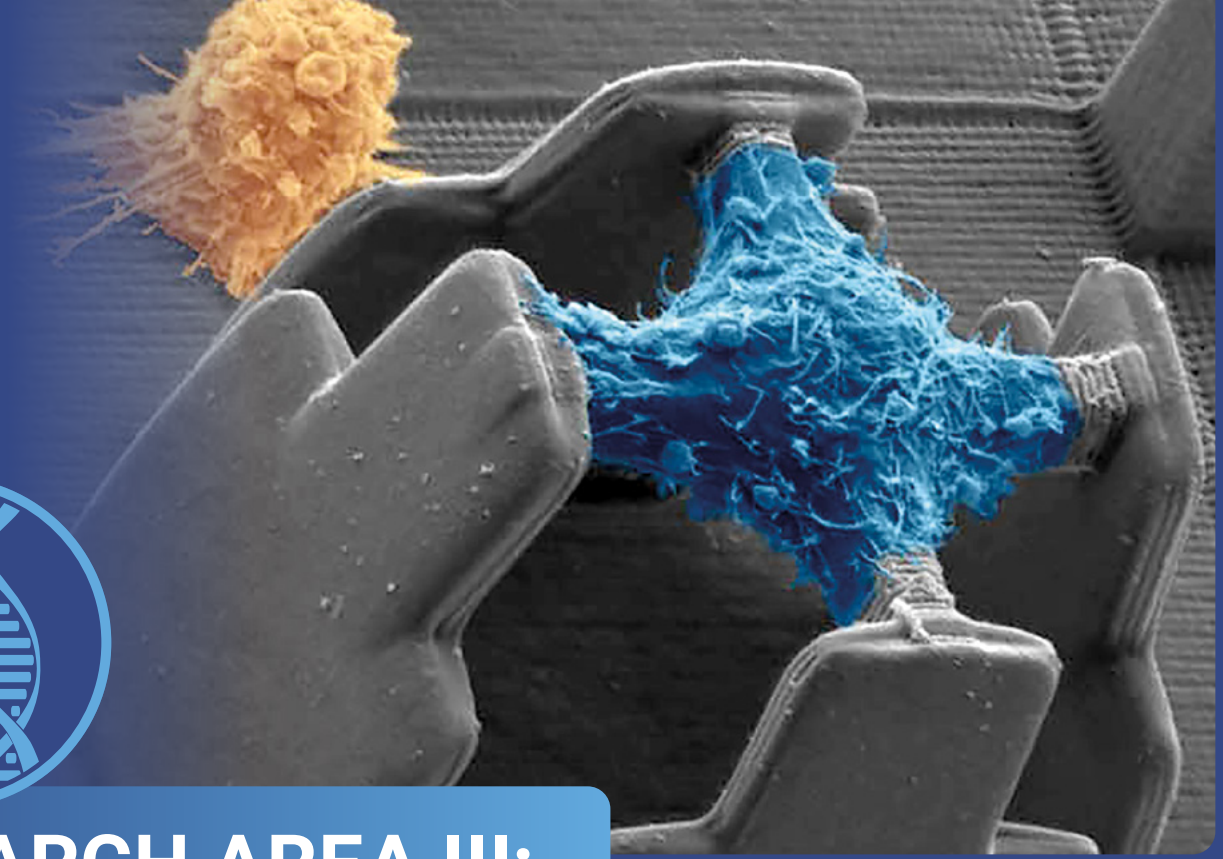
RESEARCH HIGHLIGHTS

Optically Addressable Quantum Bits

Cavity Enhancement of Light-Matter Interactions

Ultrafast Spectroscopy

Remote Sensing



RESEARCH AREA III: Biomedical Photonics

RESEARCH AREA III: Biomedical Photonics

Advances in Optics & Photonics have always driven progress in many areas of biology and medicine.

For example, biomedical photonic technologies are crucial for non-invasive clinical monitoring, molecular diagnostics, or imaging of physiological parameters in living cells, humans, and whole organisms. In addition, new optics-based tools have been engineered to manipulate biological systems by, e.g., laser-tweezers or light-switchable dyes and proteins for optogenetics. Regarding microscopy, several fluorescence-based microscopic techniques have been further developed and applied to image biological samples with sub-diffraction resolution. These techniques include pointillism approaches, like photoactivation localization microscopy (PALM), stochastic optical reconstruction microscopy (STORM), and structured illumination microscopy (SIM).

Research activities within KSOP span from advanced microscopy to the development of optics-based personal health monitoring. Super-resolution microscopic techniques are further developed into live-cell imaging modes. In addition, intelligent high-content screening microscopes for biological samples, e.g., zebra fish, are engineered.

Furthermore, several optical methods for the detection and quantification of biomolecules are developed. These include ultra-sensitive micro-disk resonators, and other bio-functionalized nanophotonic structures for parallel detection in lab-on-a-chip applications (see Research Area IV). Moreover, non-invasive monitoring of essential human blood parameters such as pressure and glucose levels has been developed. Finally, direct laser writing (see Research Area I) is applied to fabricate three-dimensional 'designer petri-dishes' to study cell behavior and stem-cell differentiation.

Future Aims & Goals

With these novel multifunctional substrates, the effects of spatial ligand distributions and mechanical scaffold stiffness on cell behavior and stem-cell differentiation can now be systematically studied in three-dimensional environments. Further work in Research Area III aims at developing light microscopy super-resolution methods into live-cell imaging modes to study biomolecular interactions in living systems at the highest achievable spatial and temporal resolutions. The basic research activities on biomolecular sensing techniques chall be targeting the ultimate goal of label-free single-molecule detection.

Prof. Dr. Martin Bastmeyer

Scientific Speaker of RA III,
Zoological Institute, KIT

RESEARCH HIGHLIGHTS

Super-resolution Microscopy

Optical Biosensing

Tailored three-dimensional Scaffolds for Cell Culture

RESEARCH AREA IV: Optical Systems

RESEARCH AREA IV: Optical Systems

In real-world applications, optical materials, devices and spectroscopic approaches are integrated into optical systems.

Examples are sensing and machine perception systems, laser based manufacturing, optical metrology for production monitoring, and optical communications. Research and development have led to tremendous performance improvements and have enabled new fields of applications. Thus, the market for optical systems has grown considerably throughout the last five years.

KSOP research in this area addresses a wide variety of optical systems with a broad spectrum of applications. For example, driver assistance systems have significantly reduced accidents of automobiles. The development of three-dimensional visual perception systems for autonomous vehicles is one of our long-term goals. Similar approaches form the basis for cognitive machines and robots. Furthermore, our research addresses the ever increasing demand for more energy efficient, ultra-high bandwidth optical communication systems. This requires novel architectures and data-transmission schemes that take advantage of newly emerged linear and non-linear photonic devices (see Research Area I). In addition, novel optical sensor systems for visual inspection as well as optical lab-on-a-chip systems for biomedical purposes are investigated within KSOP.

Future Aims & Goals

Future research in the field shall investigate Bayesian techniques for robust three-dimensional optical scene perception and scene understanding for mobile machines. We aim at fully autonomous navigation of robots and vehicles. The long-term impact of such technological advances can hardly be overestimated. Accident-free automobiles and fully automated multimodal logistics are two innovations enabled through optical scene perception. Furthermore, we will increase the energy efficiency and band-width of optical communication systems by the integration of novel photonic signal processing concepts that combine the advantages of energy-efficient passive photonic circuits with FPGA-based digital techniques. The third field offering unprecedented innovations is addressed by lab-on-a-chip optical systems. The integration of optical and fluidic functions on one chip and an increased sensitivity by applying both fluorescent and label-free biomedical detection with efficient read-out schemes will be in the focus of future research in this field.

Prof. Dr.-Ing. Christoph Stiller

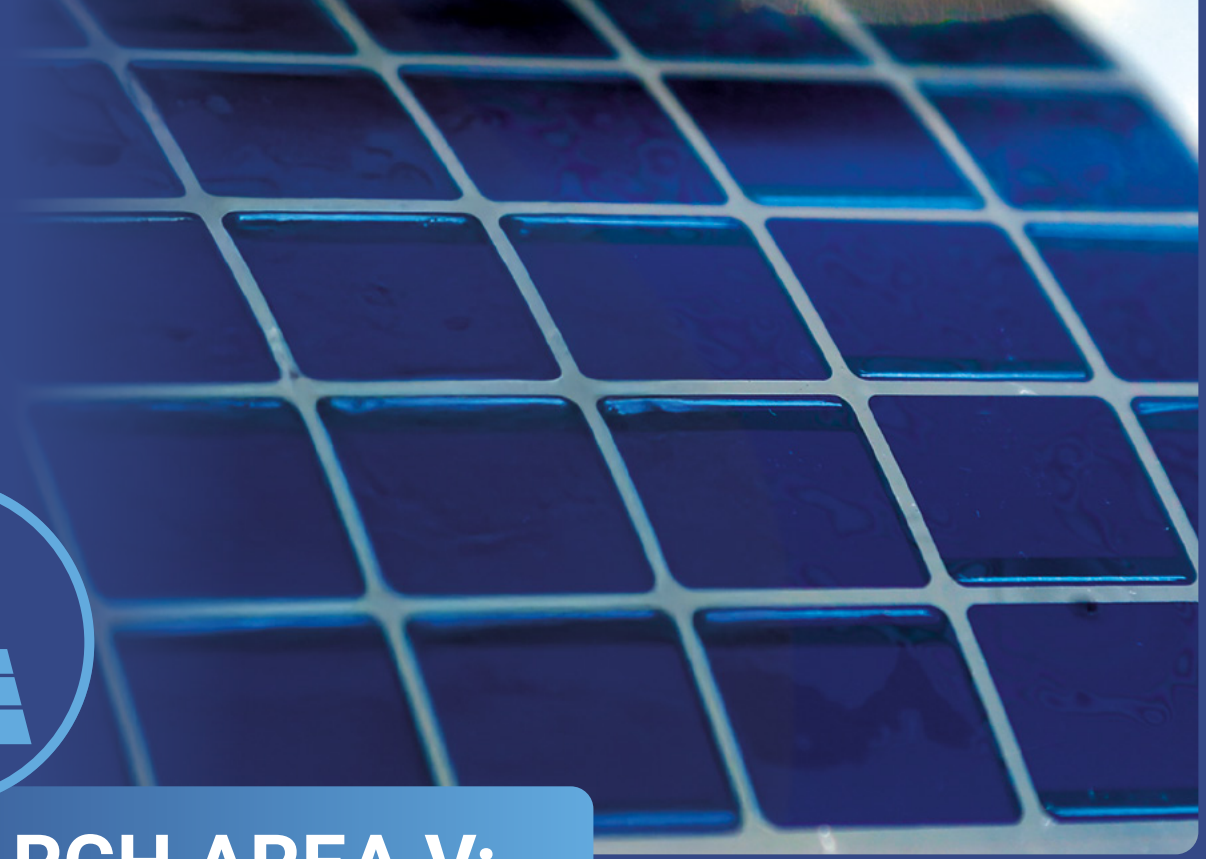
Scientific Speaker of RA IV, Institute of Measurement & Control Systems, KIT

RESEARCH HIGHLIGHTS

Autonomous Vehicles

High Bit-rate Optical Communications

Lab-on-a-chip Systems



RESEARCH AREA V: Solar Energy

RESEARCH AREA V: Solar Energy

The direct conversion of solar radiation into electrical energy is expected to cover a major fraction of the electricity supply in the upcoming decades.

Over the past decade, solar panel installations have grown at an impressive pace, reaching a cumulative global peak capacity of around 1.6 TW by the end of 2023. Nevertheless, further breakthroughs in efficiency, as well as in affordable materials and scalable production processes, remain crucial.

Optics & Photonics research can contribute in various ways to the goal of affordable future solar electricity: Light management by means of tailored plasmonic or dielectric structures can reduce the costs since it allows for a thickness reduction of the solar cells. Another central aspect is the research on novel materials with improved photovoltaic properties.

Cost reduction can not only be achieved by improved efficiencies but also by reduced deposition costs. Thus the study of novel semiconductors that can be deposited by cost effective methods is another important aspect of solar cell research.

Future Aims & Goals

We have extended our facilities for the fabrication and the characterization of novel photovoltaic materials and cells and have implemented several new laboratories over the last years. We are ramping up activities in the field of perovskites semiconductors and are covering all aspects from novel materials (including lead-free compounds) over device architectures towards module fabrication and building integration. RA V has furthermore started significant activities on tandem solar cells combining perovskite semiconductors with silicon and CIGS solar cells.

The development of low-cost, high efficiency all printed foils for light and spectrum management is an additional important goal of our research.

Prof. Dr. Uli Lemmer

Scientific Speaker of RA V,
Light Technology Institute, KIT

RESEARCH HIGHLIGHTS

Perovskite solar cells

Solution processable solar cells

Tandem solar cells

Light management and spectral conversion

Advanced spectroscopy

Strong Partner for Industry

Benefits for our Partners

- **Influence the choice of scholarship holders:** Through the sponsorships, KSOP finances the studies and further education for numerous scholarship holders. With a partnership, you can influence the selection of suitable candidates and thus control the education of potential young talents for your company.
- **Get a personal impression:** Get to know students at networking events and start recruiting early during their studies.
- **Present your company to potential future employees:** Strengthen your employer branding through excursions and career days at your company.
- **Educate young talents according to your needs early on and tie them to your company:** Gain future employees through internships and master's theses.
- **Employer branding through professional marketing by KSOP:** Benefit from KSOP's communication channels and place your company with future experts.

Qualification for Innovation

The KSOP prepares students and doctoral researchers for the labor market of the German and worldwide Optics & Photonics industry. The close cooperation to industry partners is of high value for industry on the one hand and KSOP students and doctoral researchers on the other hand.

Advantages for Industry

KSOP industry partners have an exclusive access to high potential and international junior staff. The research and teaching environment fosters innovations and empowers the industry partners to ensure their technological competitiveness.

On top of this, the challenge to solve social and technological problems can only be managed by cooperations between research, industry, and politics. Therefore, the initiative Promotion of Junior Researchers in Optics & Photonics was founded by KSOP. Industry partners can choose from a gold, silver, platinum & start-up cooperation partnership with KSOP and profit from its network, e.g. recruit young professionals for practical training, a master's thesis or jobs.

Advantages for Students & Doctoral Researchers

By gaining experience in well-known international companies via internships or master's thesis projects, students get in contact with potential future employers and prepare for their professional careers.

An Interface between industry and its members:

- Internships & master's thesis projects
- Recruiting events & industry workshop
- Networking events between science & industry, i.e. the symposium "Karlsruhe Days of Optics & Photonics" (KDOP), and the KSOP Summer School

Why KSOP Graduates are a strong asset for your company:

- Highly qualified professionals with an interdisciplinary M.Sc. in Optics & Photonics
- Practical, industry-driven education through close partnerships with leading companies
- Well-connected through a global network in cutting-edge research and high-tech industries
- Solid academic foundation in key STEM fields such as Electrical Engineering, Physics, Information Technology, Mechanical Engineering, Mathematics, Chemistry, or Biology

Become a partner and enable the training of international junior staff for the Optics & Photonics industry!

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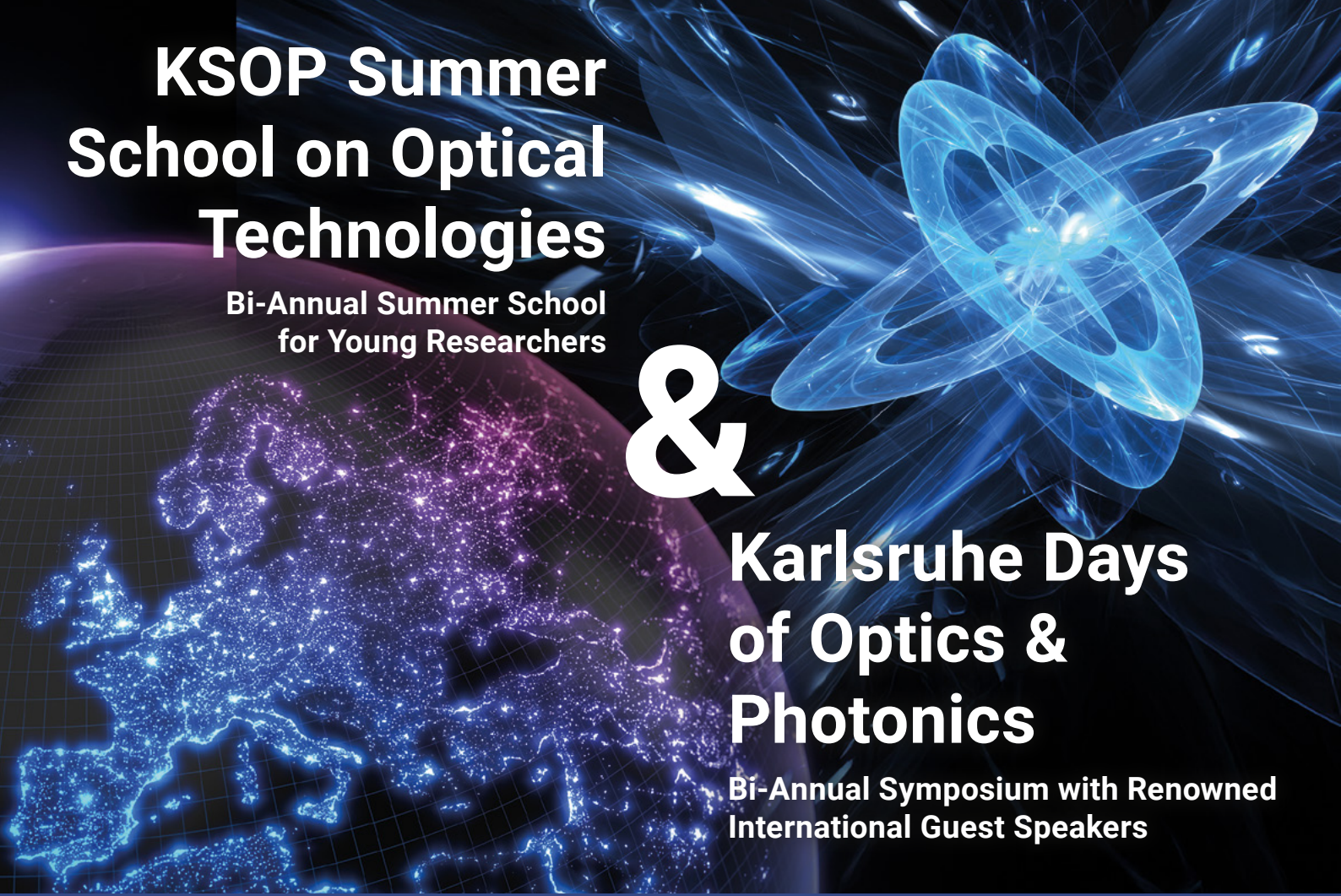
KSOP Summer School on Optical Technologies
Bi-Annual Summer School for Young Researchers
&
Karlsruhe Days of Optics & Photonics
Bi-Annual Symposium with Renowned International Guest Speakers

Scientific Events

At KSOP we do not only feel as a school in Optics & Photonics but also as a forum on scientific exchange in Optics & Photonics topics. KSOP hosts a variety of scientific events that promote knowledge exchange, interdisciplinary collaboration, and international networking in the field of optics and photonics.

One of the highlights is the **Karlsruhe Days of Optics & Photonics (KDOP)**, a flagship conference held every other year, where international researchers, students, and industry experts come together for keynote lectures, scientific talks, and poster sessions, fostering collaboration and the exchange of cutting-edge research.

In alternating years, KSOP also hosts the **KSOP Summer School**, a two-day event exclusively for Ph.D. students. The Summer School offers in-depth lectures on advanced topics in optics and photonics, along with interactive workshops. Beyond academic sessions, participants also enjoy a social program, including a hike through the picturesque region of Bad Herrenalb, providing a unique blend of academic learning and outdoor activities.

KSOP offers regular opportunities for students to engage with the broader academic community, including **Ph.D. Seminars** held four times a year, where doctoral candidates can present their research and receive feedback.

To celebrate academic achievements, KSOP holds an annual **Graduation Ceremony** for M.Sc. students. Following the **General Assembly**, which provides a chance for students, faculty, and staff to connect, a separate **BBQ** event is organized to foster community spirit in a relaxed setting. Additionally, KSOP arranges informal **Get-Together** Events for M.Sc. and Ph.D. students, encouraging networking and exchange among students from different programs.

These events enrich the academic experience at KSOP, providing a well-rounded environment for both **professional and personal growth.**

KSOP Events

The KSOP Success Story:

Over 1000 Master, Doctoral Researchers & Alumni from 70 Different Countries

KSOP

Karlsruhe School of Optics & Photonics

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