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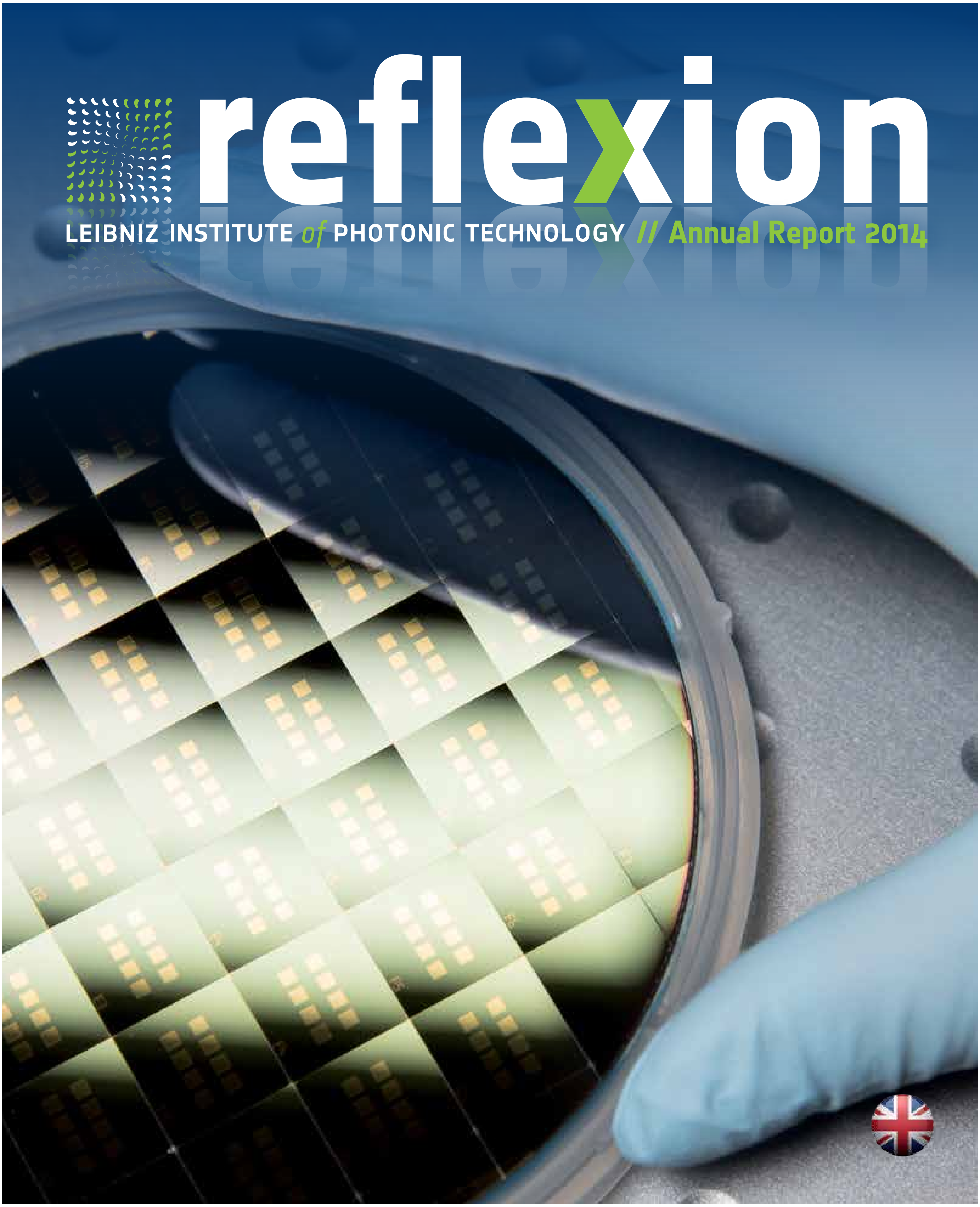
LEIBNIZ INSTITUTE *of* PHOTONIC TECHNOLOGY // Annual Report 2014



Available on the App Store

The Annual Report as App for the iPad

LEIBNIZ INSTITUTE *of* PHOTONIC TECHNOLOGY

ipht jena

Member of the Leibniz Association

Research, Development and selected events at the IPHT were supported by:

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Prof. Dr. Jürgen Popp // Scientific Director

Frank Sondermann // Administrative Director

Dear readers,

» this annual report appears in a new look: In addition to the printed edition, which presents selected highlights from the past year in the form of a magazine, this entire report – including detailed contributions on current research and additional video material – will appear for the first time as an iOS app for the iPad (further formats will follow). As usual, all content can, of course, be downloaded as a PDF from our website www.ipht-jena.de. Using these different distribution channels, our goal is to reach a wider audience, regardless of the preferred reading habits of each individual. We have also for the first time published two separate versions – one in German and one in English.

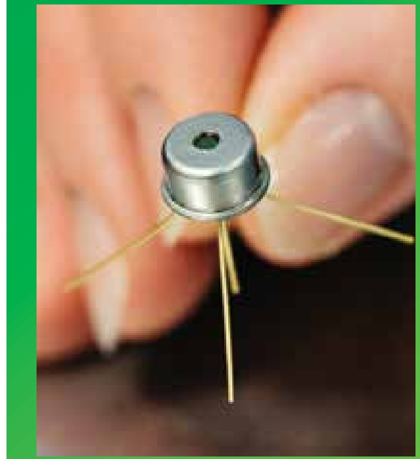
Just as in the past, this report provides you with an overview of the current research and strategic developments taking place at IPHT. The successes reported on here would not have been possible without the continual support of the Free State of Thuringia and the federal government. We would like to take this opportunity to extend our appreciation. Many thanks as well to all of our partners with whom we have collaborated closely and on a strong basis of trust on research projects and in workgroups and networks.

Since its founding, IPHT has been in a continuous state of flux, always developing and sharpening its profile. In all of these years, IPHT has been able to count on a few crucial constants: the willingness and capability of the scientific council, the board of trustees, and its members to act in an advisory capacity, as well as the awesome dedication of its employees to continue on this path together. Very special thanks go out to all of these persons and committees.

Prof. Dr. Jürgen Popp
Scientific Director

Frank Sondermann
Administrative Director

Content

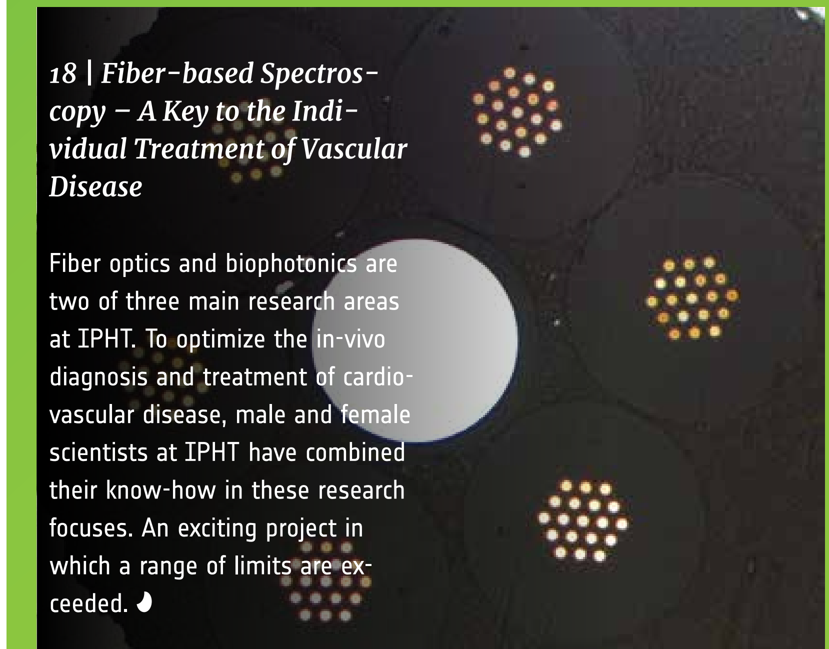


22 | IPHT in Outer Space

IPHT's thermoelectric sensor is one of many components on the Philae lander, which was sent into outer space as part of the ESA's Rosetta mission in 2004. In 2014 he landed on the Chury comet. There, he is supposed to perform noncontact temperature measurements of the comet's surface – within a tenth of a Kelvin.

08 | Optical Medical Technology – Jürgen Popp in a discussion with Michael Bauer

Prof. Dr. Jürgen Popp, scientific director of IPHT, and Prof. Dr. Michael Bauer, assistant director of anesthesiology and intensive care at the University Hospital of Jena, have been working together for many years in the field of biophotonics with a focus on optical medical technology. They met at the University Hospital of Jena to take stock of the present and discuss the future of biophotonics.



18 | Fiber-based Spectroscopy – A Key to the Individual Treatment of Vascular Disease

Fiber optics and biophotonics are two of three main research areas at IPHT. To optimize the in-vivo diagnosis and treatment of cardiovascular disease, male and female scientists at IPHT have combined their know-how in these research focuses. An exciting project in which a range of limits are exceeded.

Spot our Annual Report as App!

» The IPHT app for the iPad is directly available at the App Store. In addition to the content of the printed version the user friendly app contains current scientific contributions from the research areas of Biophotonic, Fiber Optics and Photonic Detection. The textual content is made up by multimedial features and a detailed appendix including the entire publication list of the IPHT. Moreover the integrated news feed informs about the latest reports and press releases. The app running on other devices will be launched soon.

This symbol refers to additional information (for example scientific contributions on the subject or videos) in the app.

Installation Manual:

1. *Open the App Store on your iPad.*
2. *Enter „IPHT“ to the search box and pick the IPHT app out of the hit list.*
3. *Click „load“ to activate the automatic installation process.*

Annual Review

IPHT has been a member of the Leibniz Association for more than a year now and has taken its place among the ranks of the Association. Since joining, IPHT has enjoyed better visibility within the national and international research community. »

» IPHT profits from the excellent reputation of the Leibniz association as well as from the large Leibniz network: existing scientific collaboration with other Leibniz institutes has been intensified and new collaborative projects are currently being set up or are in the planning stages. The Leibniz research alliance coordinated by IPHT, "Medical Engineering: Diagnostics, Monitoring, and Therapy" officially started in 2014. The first main task of the group was to set concrete goals and provide a clear vision for the next five years. IPHT is participating in the project, mainly focusing on the research performed by the workgroups "Point-of-Care Diagnostics" and "Multimodal Imaging". These activities are compatible with IPHT's strategic goal to establish itself as a central figure within the research community in the field of optical medical technology. Together with its partners, IPHT intends to cover the entire value chain from fundamental research to industrial transfer.

At the European level, IPHT is coordinating two COST actions. The goals of these actions are to combine national research projects, to effectively utilize the existing European-wide source of knowledge, technical equipment, and financial resources, and to build lasting networks. Within four years, specific subject-related networks will be created for research and applications experts. The COST action "PerspectH2O" combines competencies from approximately 100 European research institutes to examine the light-induced splitting of water and create targeted structures to imitate this principle in the laboratory. The goal is to create a never-ending energy source. In Raman4Clinics, research scientists from twenty-two European countries are working on the advancement of research in the field of Raman-based technologies for use in the clinical diagnosis of diseases such as, for example, cancer, arteriosclerosis, dementia, and sepsis.

The 24th International Conference on Raman Spectroscopy (ICORS2014) hosted by IPHT in cooperation with the Friedrich Schiller University of Jena and the Abbe Center of Photonics in Jena was one of the highlights of 2014. The fact that it was possible to organize the international conference in Germany for the first time in twenty years is evidence of IPHT's leading role in this research field. With more than 925 participants from 47 countries, the conference was the largest symposium in the 48-year history of ICORS.

Active in the organization of events, IPHT is currently assisting in organization of the International Congress on Biophotonics 2015 (ICOB2015) in Florence, as well as in several activities as part of the International Year of Light. The opening event of the Year of Light, which was organized by IPHT in cooperation with the Fraunhofer Institute for Applied Optics and Precision Engineering and the city-operated company JenaKultur, delighted 2,700 visitors at the Jena Sparkassen-Arena.

The excellent research infrastructure and optimal working conditions at IPHT form the basis for the increasing attractiveness of the institute among visiting scientists, domestic and from abroad. This past year, 24 scientists came to the institute to research. For example, as part of the highly-competitive EU application process, two Marie-Curie stipends were awarded to research scientists for their stay at IPHT. The Marie-Curie measures established by the European Commission serve to promote a joint European research area and to improve the mobility of research scientists.

EU-Commissioner Johannes Hahn (in the middle) along with the Thuringian Ministers Uwe Höhn and Christoph Matschie at the IPHT.

Kick-off International Year of Lights

Detailed information about the organizational structure, current key figures and staff statistics could be found on pages 40 to 50.

+ Appendix including the list of publications

Gala Dinner during the XXIV. International Conference on Raman Spectroscopy at the historic marketplace Jena: 1.000 guests made a time travel to the Middle Ages and experienced an unforgettable evening with knights, jugglers and minnesongs.

Lucky winner: The team supervised by the IPHT got the first place in the federal youth competition „Jugend forscht".

During the iENA inventor fair IPHT scientists were awarded with the bronze medal for their patent of solar cells on tissues.

Optical Medical Technology – Jürgen Popp in a discussion with Michael Bauer

Prof. Dr. Jürgen Popp, scientific director of IPHT, and Prof. Dr. Michael Bauer, assistant director of anesthesiology and intensive care at the University Hospital of Jena, have been working together for many years in the field of biophotonics with a focus on optical medical technology. They met at the University Hospital of Jena to take stock of the present and discuss the future of biophotonics. »

» *Prof. Bauer, Prof. Popp, optically-based medical technology will play a more significant role in the years to come. Why?*

Michael Bauer: The occurrence of both age-related and widespread diseases, such as cardiovascular disease, dementia, respiratory diseases, and diabetes, continues to rise. These diseases are highly complex, and their course is often influenced by many factors that differ in range depending on the individual patient. In addition, the treatment of serious infectious diseases, such as sepsis, is often time sensitive. The standard diagnostic methods used to date provide reliable results; however, we doctors require more exact diagnostic methods to more quickly and precisely treat diseases.

Jürgen Popp: Biophotonic technologies have been continuously developed over the course of the past ten years. They have the potential to add value to the diagnosis and treatment of the aforementioned medical diseases.

Biophotonics can record and monitor cell conditions gently and in a non-contact way; with the help of light, we can obtain biochemical and molecular information from bodily fluids and tissue quickly and marker free.

We are now able to go one step further. In close collaboration with doctors, we seek to develop state-of-the-art microscopic and spectroscopic methods and prepare them for clinical use.

Prof. Popp, are you able to achieve this at IPHT?

Jürgen Popp: At IPHT we have the know-how and an excellent technological basis in the fields of fiber technology, photonic detection, system technology, and micro/nanotechnology. We can use this technical as well as personnel strength to promote biophotonics and, in particular, optical medical technology, as well as to research solutions to medical problems. For example, we discovered an optical solution for the exact identification of plaque in the arteries. In arteriosclerosis, plaque deposits made of fat and cells collect on the inner arterial walls. If "arterial buildup" continues, this can lead to a heart attack or stroke. With the help of Raman spectroscopy, we receive information on the chemical composition of the deposits. This is important for doctors to know in order to initiate individual treatment. Not all plaque is life threatening and needs to be treated by setting stents. In many cases, drug treatment is sufficient. Cancer is another example. We are researching and developing standard techniques for identifying and characterizing cancer tissue with the help of light. With these standardized techniques, doctors will be in a position to distinguish between healthy tissue and the onset of abnormal changes and even recognize the edge of the tumor during operation or during endoscopic examination.

Sepsis is another good example. We are currently working with the group of Prof. Bauer (CSCC) at the Jena University Hospital and research partners throughout Europe on a suitable biophotonic solution. The goal of our research and development work is a miniature laboratory which can be used to obtain the required information for appropriate treatment quickly from just a few drops of blood.

Also the development of improved imaging methods and technologies to better understand cell processes and the genesis of diseases at the molecular level provides solutions to medical problems.

Prof. Bauer, Prof. Popp, why have you been working for so many years so close together in the field of optical medical technology?

Michael Bauer: For many reasons: First, it is important for scientists to know how doctors work. At the same time, doctors should be aware of the technological possibilities. Existing needs and challenges have to be identified and weighed together. Second, by collaborating together, laboratory prototypes can be tested in an application-oriented manner and ultimately validated for everyday clinical use. This is important because it allows appropriate adjustments.

Jürgen Popp: Feedback from clinical end users can be integrated directly into the further development of a technology. The close interaction guarantees self-sustaining research – especially concerning the support of young male and female researchers and the training of technical experts. Optical medical technology not only requires collaboration with partners in the medical field, but an interdisciplinary research approach as well. Thus, the Leibniz research alliance "Medical Engineering: Diagnostics, Monitoring, and Therapy" was initiated this past year. As part of the Leibniz Association, we can take advantage of expertise from any number of different fields. The range of research covered in "Optical Medical Technology" is comprehensive – from fundamental research to the development of laboratory equipment, spanning the entire innovation chain. As part of this network, IPHT concentrates primarily on the research and development of fast point-of-care tests and the development of new imaging methods.

Michael Bauer: In addition, there is a long tradition of successful collaboration between the IPHT and the University Hospital in Jena (e.g., in sepsis research within the CSCC or as part of the InfectoGnostics research campus). More than thirty partners are developing solutions for the fast and inexpensive on-site analysis of acute infections, such as tuberculosis, or food pathogen diagnostics.

Prof. Popp, what role will optical medical technology play at IPHT in the future?

Jürgen Popp: As part of our motto "Photonics for Life" at IPHT, we are researching customized optical solutions to problems specific to the areas of life and environmental sciences, and medicine. The focus of our research and development revolves around the three main research focuses: biophotonics, fiber optics, and photonic detection. Optical medical technology is a part of biophotonics and deepens our existing research profile. This sharpening of our profile within biophotonics is an important, positive, and lasting development, especially in terms of increasing competitiveness. The fact that the Thuringian state government, the federal government, and the EU have all identified optics and photonics as central topics with a future fortified our decision to establish optical medical technology as a strategic research focus at IPHT.

Infection Diagnostics

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Sepsis begins with a localized infection caused by bacteria. Normally, the body is able to restrict the disease to its origin; however, in some cases, the pathogens and their toxins spread through the bloodstream to the entire body. The organism responds with an infection that spreads to all the organs in a short amount of time which can cause a serious multiple organ failure. The symptoms of sepsis are not always clear. Fever, increased pulse, and rapid breathing can also be signs of other serious diseases. Doctors, therefore, rely heavily on their experience when making a diagnosis so far. »

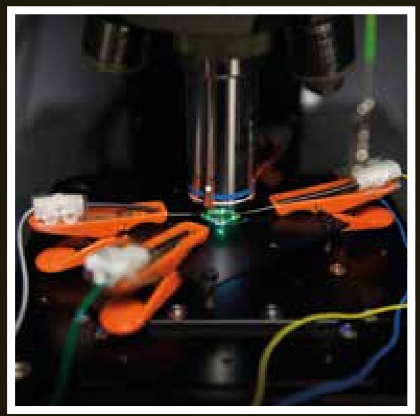
» Reliable information on the triggering pathogen and its resistance potential is provided via a biochemical analysis, such as a blood culture, after at least 24 hours. Every hour that passes without the administration of effective antibiotics worsens the patient's chances of survival. Thus, if sepsis is suspected, a broad-spectrum antibiotic is given. To effectively treat the patient, it is important to quickly and reliably diagnose sepsis.

As part of the EU project HemoSpec, research scientists from six European countries are working on the development of a miniature laboratory to meet these medical needs.

Dr. Ute Neugebauer, a research scientist at IPHT and the Center for Sepsis Control and Care (CSCC) is participating in this project. Using light, she is researching one of three key technologies that this unit is designed to combine. With the help of Raman spectroscopy, Neugebauer is seeking molecular and biochemical information on white blood cells (i.e., leukocytes). They fight foreign organisms, such as bacteria and viruses, in the body. If the body has an infection, more leukocytes are present in the blood. If the leukocytes detect a pathogen, they are activated and begin to render these intruders harmless, for example, through phagocytosis (devouring) or the production and release of certain molecules, such as antibodies or chemical messengers. Thus, activated leukocytes differ from deactivated leukocytes. "We want to recognize this difference with the help of Raman spectroscopy. Our goal is to find out if we can determine whether the patient is suffering from sepsis based on the activation state of the leukocytes," said Dr. Neugebauer. Her colleagues at IPHT are working

Urin samples from patients

Sample preparations



Dielectrophoresis Raman setup

on other elements of the miniature laboratory: holographic microscopy to count the cells and a microfluidic chip to separate and distribute the blood on the platform. These elements are supplemented by the research performed by the European project partners, who are working on reading biomarkers in the blood with the help of fluorescence-based methods, the development of miniaturized modules for the Raman and fluorescence analysis, and the development of software that controls everything.

By combining these technologies in a single unit, it should be possible to obtain reliable information from just a few drops of blood within a few hours. The miniature laboratory should be handy and user friendly so that it can be operated by both doctors and nurses. Therefore, the scientists are working closely with doctors to ensure that it meets clinical requirements. The first clinical studies are currently being run with eighty patients at Jena University Hospital.

Using Raman spectroscopy, it is not only possible to obtain molecular and biochemical information on white blood cells but on disease pathogens as well – directly in bodily fluids and without the need for a time-consuming cultivation step. The spectrum of a pathogen is very individual, much like a person's fingerprint. Thus, compiling a "database of culprits" with the spectra of relevant pathogens is time consuming. Male and female scientists from IPHT and the Institute of Physical Chemistry (IPC) at the Friedrich Schiller University of Jena have been working on this database for a few years now. It is the basis for the fast and positive determination of pathogens and thus the basis for targeted treatment.

The fundamental technology was researched by IPHT in collaboration with IPC. The Berlin-based company rap.ID developed this technology further for commercial use. With the help of a spectroscopic measurement method and in combination with a statistical analysis method, the Bio Particle Explorer identifies whether or not, and if so, with which and with how many germs patients' blood and urine samples or air and water samples are contaminated. By comparing these samples with the database, similar to a criminal database, the isolated pathogens can be detected within a matter of a few hours. Presently, IPHT is working with rap.ID to improve the quality and reproducibility of characterization and to optimize the manageability of the Bio Particle Explorer.

In addition to the identification of pathogens, the subject of resistances to antibiotics is an important area of research at IPHT. The young researchers' group headed by Ute Neugebauer focuses on urinary tract infection pathogens. In medical microbiology, the identification of pathogens and their sensitivity to antibiotics using standard methods takes at least twenty-four hours. In this time, calculated treatment with antibiotics is often begun to counter the infection as quickly as possible. However, at a time of increasing resistances, this form of treatment is bound to fail.

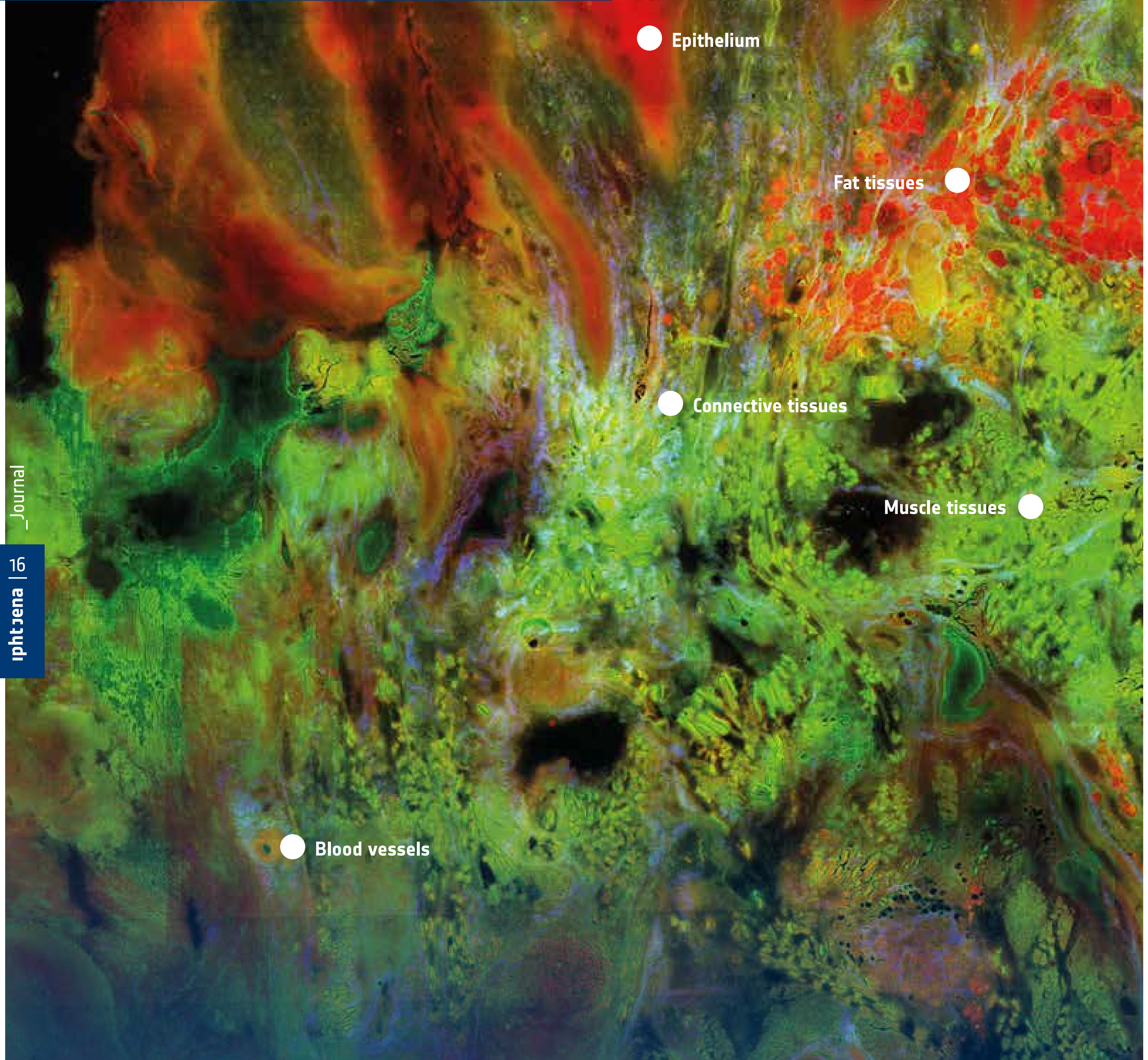
With a combined dielectrophoresis Raman setup, the young researchers' group developed an innovative method that makes it possible to detect pathogens much more quickly (in significantly less than twenty-four hours) and directly from patient material. The scientists capture the pathogens on a chip using electric fields (dielectrophoresis) in microstructured regions to subsequently identify the collected pathogens using Raman spectroscopy within a little more than half an hour.

In a second step, the pathogens that were incubated with antibiotics are applied to the chip. The interaction between the two is then monitored. From the Raman spectra obtained using this method, it is possible to draw conclusions about existing resistances. Unlike the preparation of an antibiogram, this method provides information on possible resistances to antibiotics within just 3.5 hours. This was verified with Vancomycin-resistant enterococci. Patient-specific treatment with antibiotics can be started much sooner.

\+ *Corporate film HemoSpec*

Raman spectroscopy is a non-contact, optical analysis method for material characterization. This method is based on the Raman effect, which is named after the Indian physicist and Nobel Prize winner Sir C.V. Raman. The Raman spectrum gained from the sample (solid, liquid, or gas) under examination is as unique as a fingerprint. Raman spectroscopy is used in very different fields, including medicine, art, archaeology, geology, and forensics.

Raman4clinics



» Since the fall of 2014, IPHT has been coordinating the European COST Action “Raman4clinics – Raman-based applications for clinical diagnostics.” COST Actions focus on bundling national research projects into concentrated actions on different topics and thus effectively using the European-wide existing capacity of knowledge, technical equipment, and financial resources and building long-lasting international networks.

“Raman4clinics” provides a framework for the tasks covered by the participating national research groups from 21 European countries. Within conferences, summer school programs, workshops, and exchange programs for the male and female research scientists, raman-based applications will be further developed for clinical diagnostics within the next four years. IPHT will mainly contribute to the research and development of infection diagnostics and histopathology. Further topics of research are fiber optic endoscopy, cytopathology for cancel cell monitoring, and therapeutic monitoring of antibiotics in body fluids.

Tissue of throat area

Medicars – A Compact Microscope Used in Medical Diagnostics

» Differentiating between healthy and malignant tissue (e.g., in cancer) is an integral part of medical diagnostics. To distinguish between cancer and altered, benign tissue, a sample of the tissue is removed during operation, stained, and evaluated under the microscope.

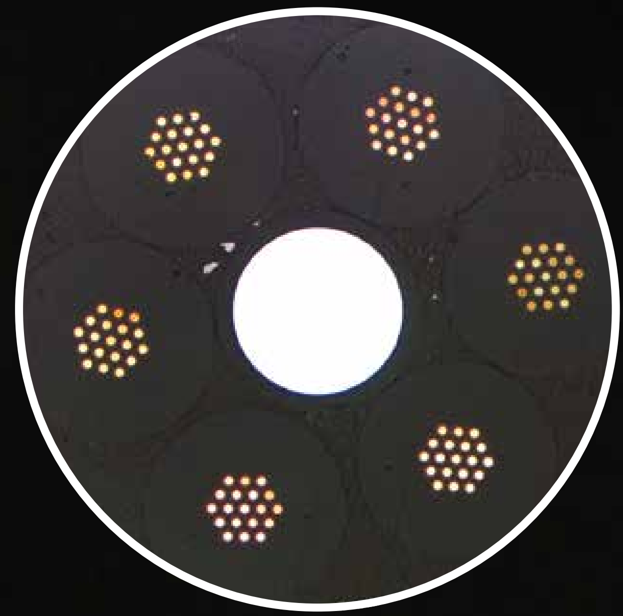
As part of a project funded by the Federal Ministry of Education and Research (BMBF), research scientists at IPHT designed a compact microscope together with partners from the Technical University of Dresden, the University of Heidelberg, the University of Stuttgart, the University of Konstanz, and the Institute of Applied Physics in Jena. With this microscope, doctors can produce high-resolution multimodal images of tissue samples without staining the samples. This allows diseased tissue to be precisely localized and removed in a targeted manner. Unlike with staining, the multimodal images can be produced within a matter of minutes.

The technological basis of the Medicars microscope is an imaging method known as coherent anti-Stokes Raman spectroscopy (CARS), which utilizes the lipid content of epithelial tissue, connective tissue, and fatty tissue, for example, to distinguish between the different types of tissue. In addition to this method, two other contrast mechanisms are used (i.e., two-photon fluorescence (TPF) microscopy and second harmonic generation (SHG)). All three contrast methods combined provide doctors with chemical, structural, and functional information about the tissue.

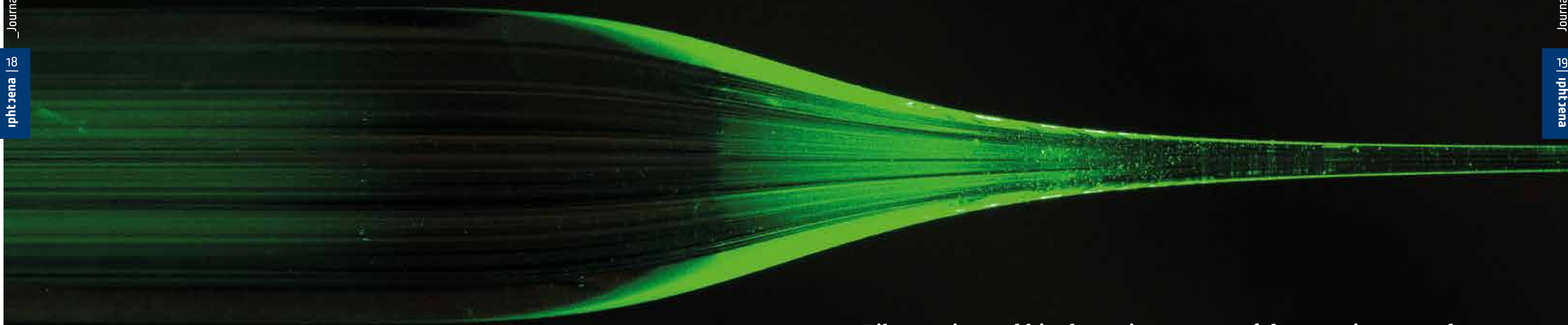
To gain clinically relevant information during an operation, the Medicars microscope was developed in such a way that its total footprint, including its controls and laser, is suitable for the operating room and that the unit can be operated by non-expert personnel trained in its use. The goal is to improve patient care, especially during surgical treatment. Medicars has been explored and developed within the research focuses biophotonics and fiber optics. The new photonic process has been researched and developed within the research focuses biophotonics and photonics detection.

Medicars has been tested application orientated in cooperation with Prof. Dr. Orlando Guntinas-Lichius at the Department of Otolaryngology in Jena.

Fiber-based Spectroscopy – A Key to the Individual Treatment of Vascular Disease



Cross section of a Raman probe developed at IPHT



Fiber optics and biophotonics are two of three main research areas at IPHT. To optimize the in vivo *diagnosis and treatment of cardiovascular disease, male and female scientists at IPHT have combined their know-how in these research focuses. An exciting project in which many challenges have been tackled.* »

» Light is a special tool. When coupled into optical fibers, it can transmit data and information such as, for example, measurement signals. From scattering light by molecules, one can obtain molecular and biochemical information fast and contract free. "The idea was to combine both of these features to optimize the existing gap in the diagnosis and treatment of arteriosclerosis," says Prof. Dr. Jürgen Popp, scientific director at IPHT. Within the European Network of Excellence for Biophotonics Photonics4life, which is coordinated by IPHT, the contact to the cardiologist Professor Dr. Bernhard Brehm was established. Together with him the idea was born to quickly and precisely determine the chemical composition of plaque.

The medical need for such a study is great because arteriosclerosis and its consequences – stroke and heart attack – are among the most common causes of death in western industrial nations. In this chronically progressive disease, the arterial walls build up deposits, called plaque. If and how the deposits must be treated depends on their biochemical composition. Better knowledge of the composition of the plaque would help make a more accurate risk assessment. Dangerous, so-called vulnerable, plaques could be more precisely diagnosed. Individualized medical treatment would then follow.

One established method of diagnosis of plaque is heart catheter examination, in which the form and structure of the coronary arteries can be made visible with the help of x-ray procedures using contrast agents; however, with this method, the molecular and biochemical composition of the plaque cannot be identified. Therefore, the diagnosis and individualized treatment is more difficult.

With a probe from the company EM Vision consisting of several light-guiding optical fibers, a spectroscopic analysis was performed in a model experiment in cooperation with Jena University Hospital. "We were able to show that the use of light during heart catheter examination provides precise information on the molecular composition of plaque," says Dr. Christian Matthäus, researcher at IPHT.

The fiber-spectroscopic probe is not yet suited for human application because the probe head is inflexible at a length of 5-6 cm due to the integrated filters. The risk of damaging the delicate coronary arteries during examination is too high. To meet the medical need for more flexible fibers, Matthäus and his colleague Dr. Sebastian Dochow, also working at IPHT, requested help.

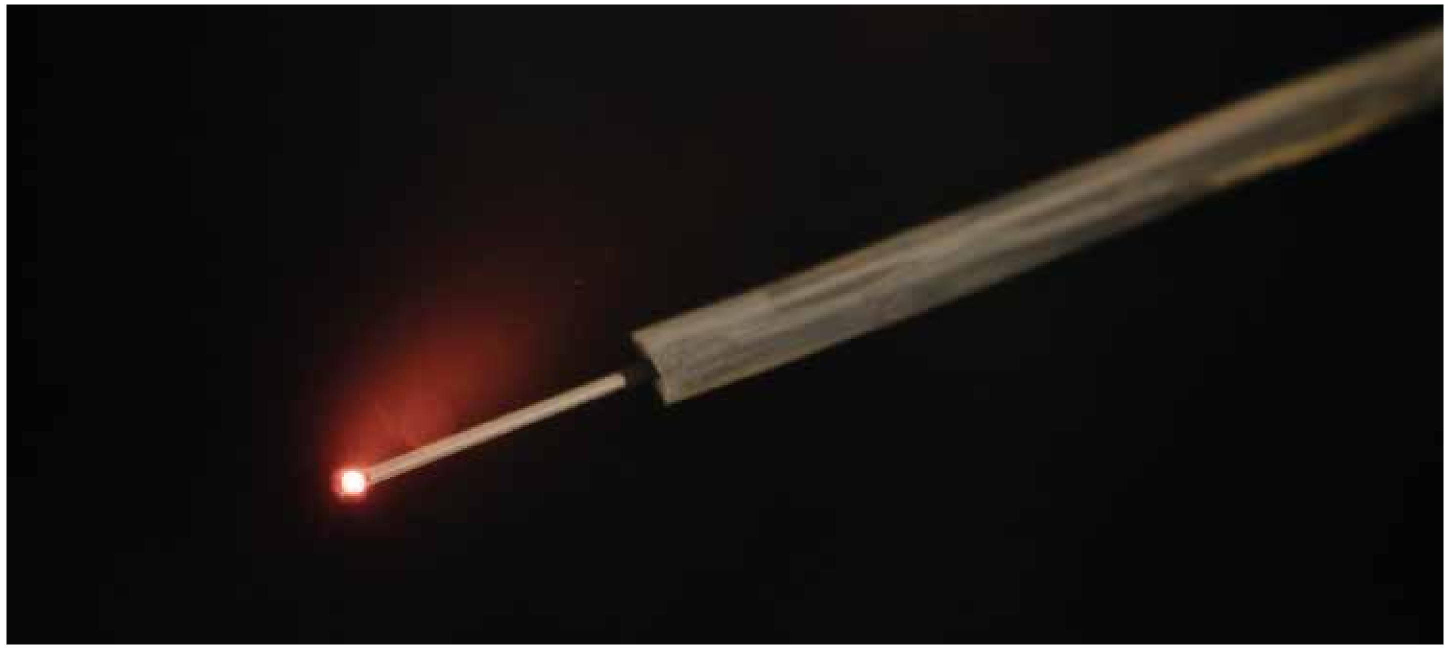
"The filters in the sensor head separate the excitation light required for Raman-spectroscopic examination from the noise generated in the fiber. We, therefore, needed a solution that replaces the filters in the probe," said Dr. Martin Becker, a fiber technician at IPHT. In the framework of the joint BMBF-funded project Fiber Health Probe, Fiber Bragg gratings (periodic structures) were inscribed in the fiber core. The gratings match the wavelength of the coupled light to their defined structure. At congruence, light is reflected back at a certain wavelength; thus, only the required light is guided through the core.

This solution only works with single-mode fibers (i.e., fibers with a small core). The light collected with such fibers is too weak to record a Raman spectrum. The multi-mode fibers that are common in this field have a core with a large diameter; however, the coupled light cannot be filtered in a targeted manner in the core.

"What we need are customized fibers that can be used to collect a large amount of light and to filter light in a targeted manner," says Dr. Dochow. To manufacture these fibers, his colleagues from the fiber optics group have at their disposal technological equipment that is, on the international level, essentially unique – from materials to all steps of the fiber manufacturing process to characterization. Together with Sebastian Dochow und Christian Matthäus, they are currently researching the applicability of multi-core fibers. In these fibers, the light is guided together through several cores and bundled at the end.

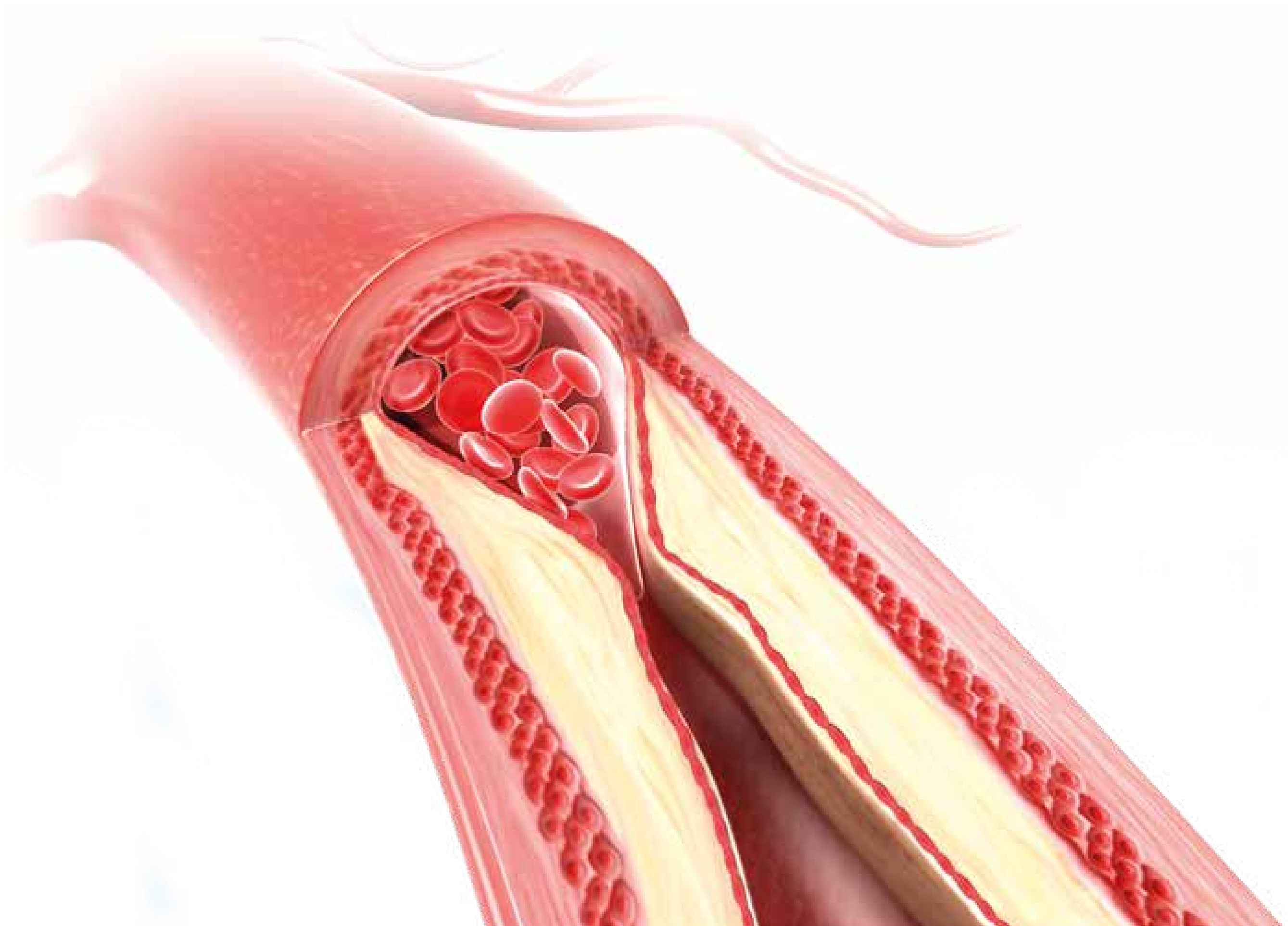
Although fiber optimization has not yet been completed, the research scientists at IPHT are already thinking ahead to the next step. Optical coherence tomography (OCT) is an imaging method for cardiovascular examination. Similar to Raman, OCT works with scattered light that interacts with the arterial walls. "For doctors, it would be ideal to obtain not only chemical information with a single device but information on the shape and size of the plaque as well," said Dr. Dochow.

OCT and Raman work with different excitation waves. The multi-core fibers should, therefore, be developed in such a way that they can be integrated in optical coherence tomography in the future.

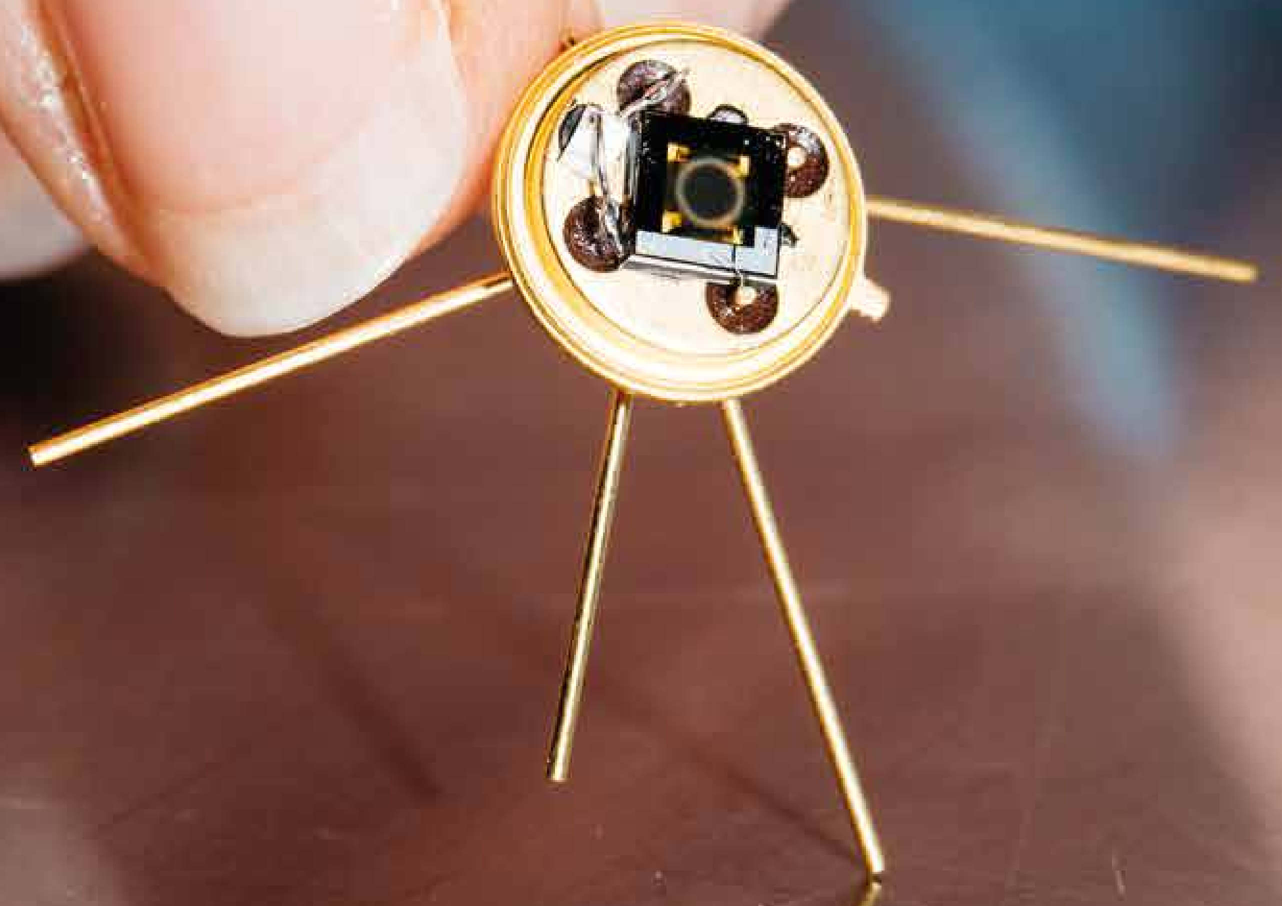


Raman probe

The fiber optic Raman probe is suited not only for cardiovascular applications but is, generally speaking, applicable to each endoscopically accessible disease. The research scientists at IPHT are researching, in collaboration with their colleagues from Jena University Hospital, the molecular analysis of colon cancer and brain tumors. With the Institute of Physical Chemistry (IPC) at the University of Jena, IPHT is also investigating which optical fibers are suited for which tissue and how to analyze the signals obtained. Other possible application fields include non-medical uses, such as the analysis of explosives, drugs, medicine, and liquids.

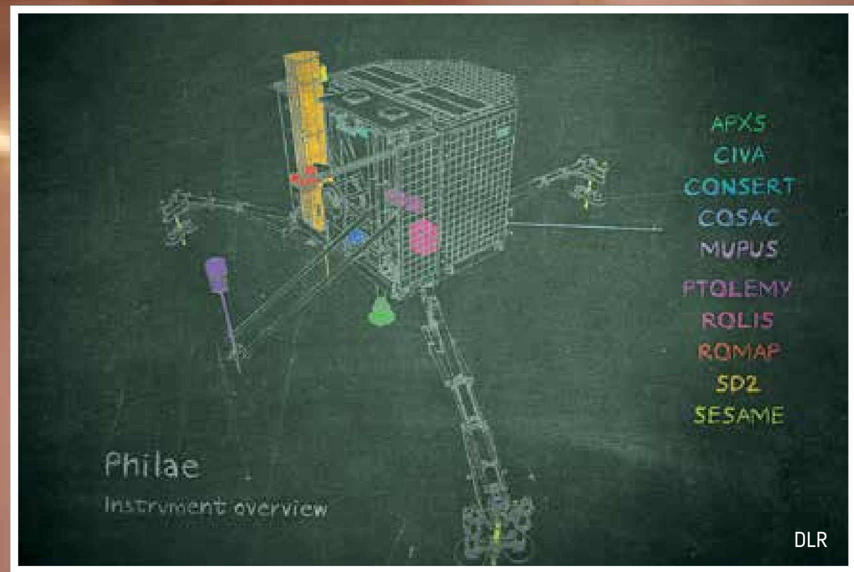


IPHT in Outer Space

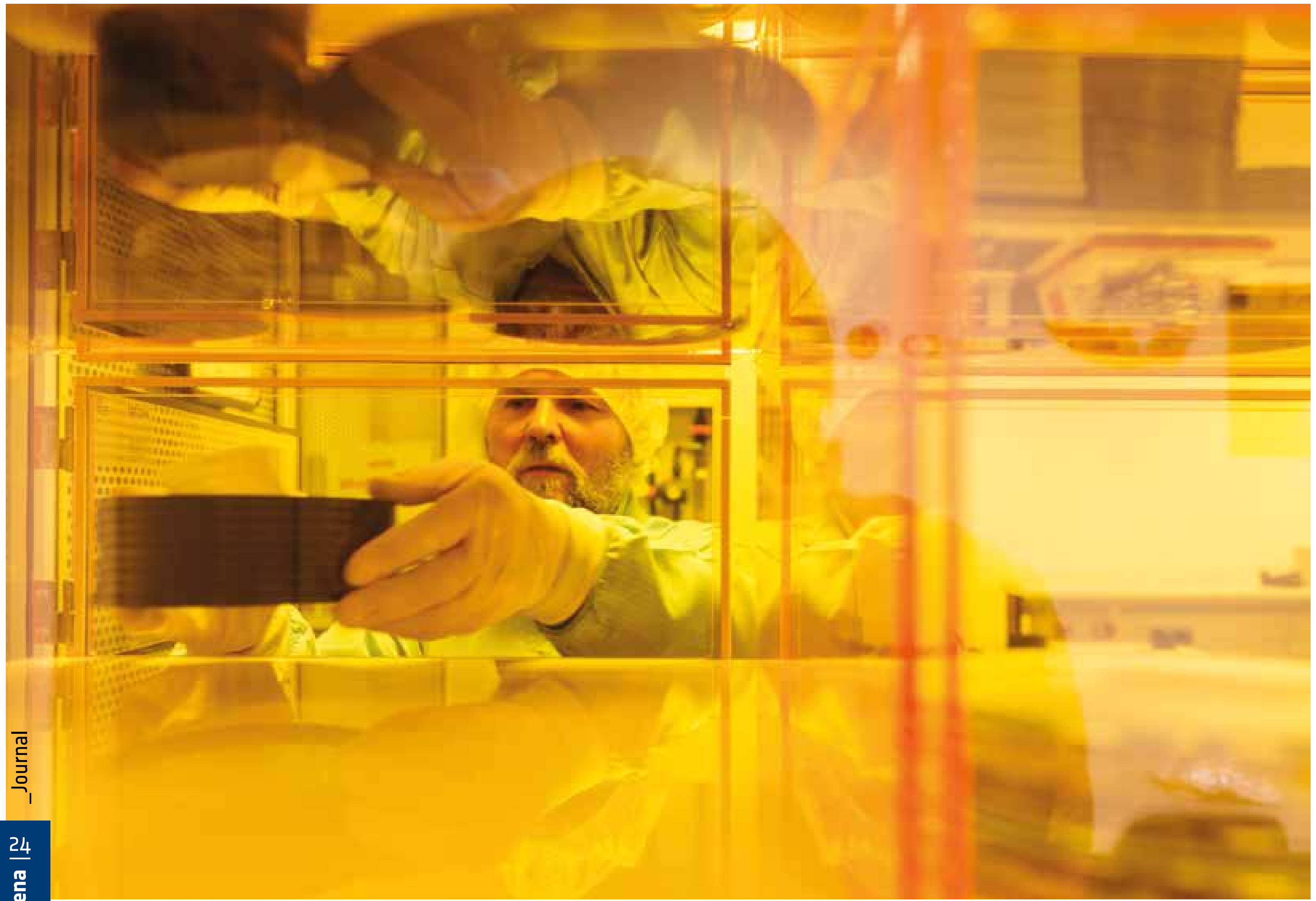


A sensor head approximately 10 millimeters in diameter that rests on five legs and contains a 3.6 mm x 3.6 mm large chip. It is hard to believe that such a small component can be used to perform non-contact temperature measurements (e.g., the surface temperature of the Chury comet) accurately to within a tenth of a Kelvin. IPHT's thermoelectric sensor is one of many components on the Philae lander, which was sent into outer space as part of the ESA's Rosetta mission in 2004 and landed on the Chury comet in 2014. »

Philae touchdown



Philae all instruments



Dr. Ernst Kessler

» The research scientists at IPHT's predecessor institute were not aware that the infrared sensors they developed would one day be sent to outer space on a European Space Agency (ESA) launcher. "Originally, these sensors were developed for non-contact temperature measurements and for use in infrared spectrometers produced by the company Carl Zeiss Jena," said Dr. Ernst Kessler, a research scientist who has been working at IPHT for more than 30 years. "However, as early as the mid-1970s, contributing work in the form of highly-sensitive radiation detectors was performed for Soviet missions to Venus."

Thus, it was not a coincidence that the German Aerospace Center (DLR) requested IPHT specifically to develop a sensor for non-contact temperature measurements on the surface of the 67P/Churyumov-Gerasimenko comet as part of the Rosetta mission that was set to launch in March of 2004. A regular contact thermometer would not be able to make accurate measurements because the surface of the comet is covered in dust. The challenge for the IPHT research team was not only to develop a robust sensor with high detectivity but to adapt it to withstand the harsh conditions in space. The housing, which was designed at IPHT specifically for the sensor, has a small hole through which the air escapes upon passage from the earth's atmosphere into outer space. In the vacuum created, the sensor achieves its highest thermal sensitivity.

Almost 15 years later, IPHT gained the attention of Astrium Crisa – a Spanish subsidiary of EADS – when they were in need of a sensor for the Curiosity rover as part of the NASA Mars mission Mars Science Laboratory. "When our Spanish colleagues told us they performed a global search for a sensor developer like us, we were, of course, proud," said Dr. Kessler.

Thermoelectric sensors convert thermal radiation to electrical voltage signals. From these measurement signals, the temperature of the radiation source can be determined. A regular contact thermometer would not be able to provide reliable measurements on the comet because the surface is covered in dust.

[1] The Threat of Orbital Debris and Protecting NASA Space Assets from Satellite Collisions (2009)

Even today, IPHT is in the unique position to develop and manufacture thermoelectric sensors with the highest detectivity worldwide. In addition, sensors at IPHT can be customized and developed – even in quantities of one.

Currently, Ernst Kessler and his colleagues are working on a new and exciting space project. This time it does not deal at all with temperature measurement but rather with orbital debris and space junk, for example the remains of abandoned satellites or the debris from satellite collisions and explosions. According to information from NASA, almost 500,000 particles that are larger than one centimeter in diameter are in orbit around the earth. The detection and measurement of these particles is important to prevent collisions with space stations and satellites. Objects that are larger than five centimeters are located by following their orbital flight path from earth; however, very little is known about smaller particles. A thermal detector chip developed by IPHT in collaboration with the company etamax space GmbH will provide information on particles that are 5-20 micrometers in size.

IPHT won the bid for another NASA project and will submit thermoelectric sensors for the first round of feasibility studies. If IPHT's sensors make the final cut, then they will presumably be used in the flight to Jupiter's Europa moon in 2022.

Due to these numerous projects, Ernst Kessler's group has received an international reputation. Also, Dr. Kessler is a co-investigator for NASA and thus a member of an international team of experts.

Nevertheless, the question continues to be raised as to whether the sensors developed 20 years ago remain contemporary. Dr. Kessler affirms this view: "This type of detector was developed for space conditions that still exist today and applications that are still used today and thus do not require optimization. I know that is tough to believe in a time when higher, faster, farther is the defining goal. But, we simply got it right the first time."

Although these sensors, which have been researched and developed within the research focus photonics detection, are tailored for applications in outer space, they are still suited for other application fields. For example, they are used to monitor the composition of anesthesia gases or to determine the age of airplane oil. Another possible field of application is the exploration of deposits of natural resources in the earth.

+ current air and ground temperatures on Mars
+ background information on DLR space missions

Further space missions in which IPHT is currently participating

ESA's BepiColombo Mission

Goal: Measure the mineralogical composition and temperature of Mercury's surface.
Start: expected in 2016

Jaxa Mission Hayabusa

Goal: Collect information on the surface temperature and the surface mineralogy of the asteroid.
Start: The probe has been in space since the beginning of December 2014; it is expected to land the middle of 2018.

NASA/ESA's InSight Mission to Mars

Goal: Collect information on the surface temperature and surface mineralogy of the planet.
Start: March 2016

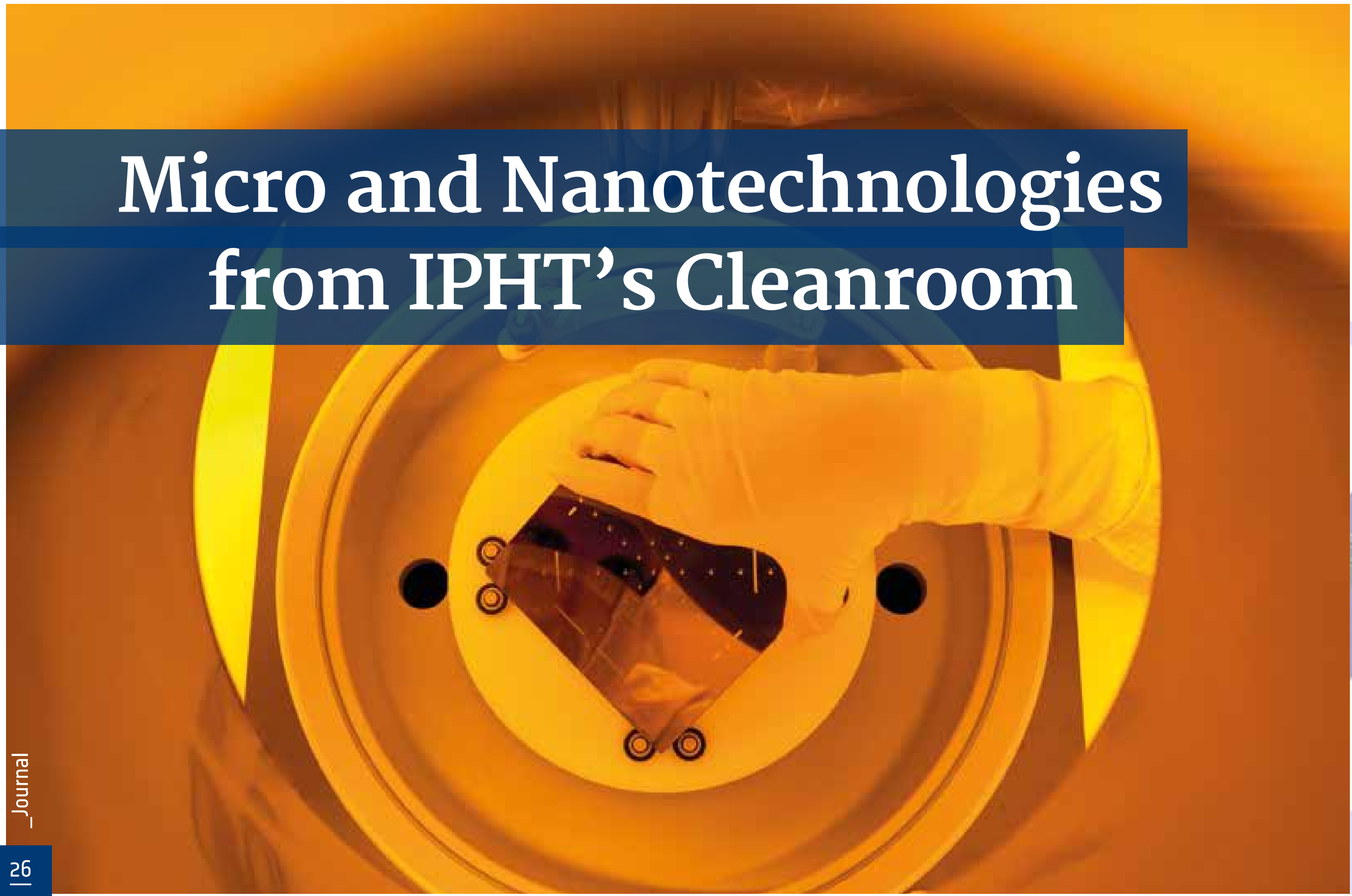
ESA-Exomars

Goal: To establish mineralogical composition and identify organic pigments
Start: approximately 2018

NASA-Mars2020

Goal: To acquiring information about Martian geology, atmosphere, environmental conditions, and potential bio-signatures
Start: 2020

Micro and Nanotechnologies from IPHT’s Cleanroom



Photolithography at IPHT’s cleanroom

» The successful implementation of IPHT’s research objectives requires the development and maintenance of a comprehensive pool of intertwining micro and nanotechnologies. Based on targeted fundamental research, these technologies form the basis for the technical implementation of photonic sensor concepts, for example, and their systemic integration into ultrasensitive measurement systems. For this purpose, IPHT has a state-of-the-art cleanroom on its premises that is well equipped with the technological infrastructure necessary to produce nanostructures and 3-D functional elements. The cleanroom makes it possible to synergistically combine top-down techniques (micro and nanolithography) with bottom-up techniques (nanoparticles, nanowires, molecular techniques) at IPHT.

The cleanroom extends across two floors and a surface area of approximately 1,500 square meters. Thanks to the excellent cleanroom conditions and climate control, micro and nanoscale functional structures can be reliably produced on wafer formats of up to 6 inches. In addition, IPHT operates its own mask generation line. Direct access to the state-of-the-art electron beam coating facility at the neighboring Fraunhofer Institute of Applied Optics and Fine Mechanics (IOF) is of strategic importance to IPHT. The quality management of important basic technologies has been certified according to ISO since 2002.

+ Cleanroom video
+ Scientific contribution “E-beam with Character Projection: A Powerful Tool for Wafer-scale Nanolithography”

Coating II: A three-chamber sputter cluster with up to twelve targets and high-vacuum vapor deposition equipment are used to produce complex layer systems and plasmonic precious-metal films.

ALD / Dry Etching: For the fabrication of extremely thin, low-defect, surface-conform dielectric layers, atomic layer deposition (ALD) is available.

Dry Etching: With ion beams or plasmas, structures are transferred to metallic and dielectric layers.

Coating I: Metallic thin films are applied to the wafer's surface in a vacuum using vapor deposition and sputtering techniques.

2nd Level

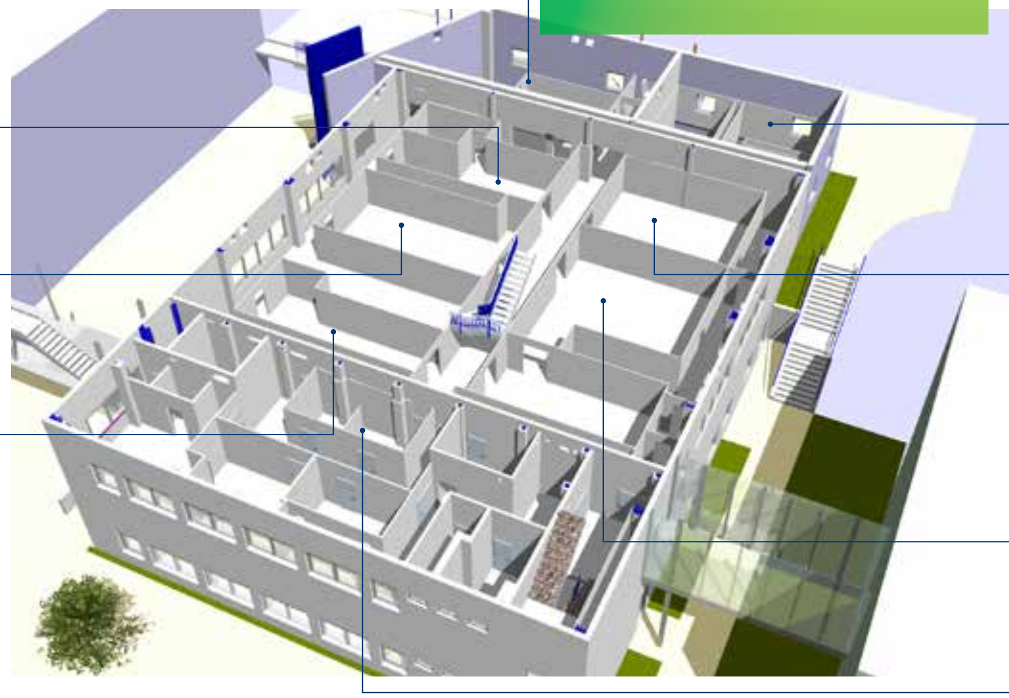
Coating III: Production of metal layer systems for IR sensor technology.

LPCVD: Dielectric thin films and membrane layer systems for MEMS applications are produced via chemical vapor deposition (CVD) processes.

AVT Laboratory: For system applications, the individual chips of a wafer are bonded to special carriers and integrated into housings in a laboratory for assembly and connection technology.

Wet Chemistry I + II: MEMS technologies with structured membranes in a cantilever design for IR and THz sensors are based on our wet chemical silicon etching processes.

1st Level



Nanoanalytics: Process and quality control of nanostructures using a scanning electron microscope and atomic force microscopy (AFM).

Electron and Laser Beam Lithography: In this method, the resist layer is illuminated using a laser or electron beam. This allows the production of even finer structures in the range of 0.8 µm (laser beam) and 0.03 µm (electron beam).

Photolithography: A defined structure (i. e., a resist mask) is produced on a photoresist-coated wafer – the basic platform for microtechnical components – using UV light. The mask's smallest patterns are approximately two micrometers in size.

Airlock: Employees use special clothing to prevent human-related contamination of the cleanroom.

Shaping the Future of Energy with Light

Fossil fuels are finite, and yet, approximately 86 percent of the energy being used still originates from oil, gas, or coal. In light of increasing commodity prices and considering the shortage in supply, this is still too high. To avert the impending energy crisis, inexpensive and renewable sources of energy must be developed and used. »

» Hydrogen is considered the energy source of the future. Because hydrogen is a component of water, it is available in large quantities. When it is burned, it produces water again.

One approach to gaining hydrogen is photocatalytic water splitting. With the help of light, water is split into its components hydrogen and oxygen. This process imitates the biochemical process that plants practice on a large scale – photosynthesis, thus the conversion of light to chemical energy.

In 1972, this process was discovered by the Japanese chemists Akira Fujishima and Kenichi Honda. Since that time, scientists have been looking for a way to use photocatalytic water splitting for industrial applications. They have been only moderately successful because these methods are not yet efficient enough.

This is the starting point of the work of Prof. Dr. Benjamin Dietzek, a researcher at IPHT.

Within the research focus photonics detection, he and his male and female colleagues are trying to understand the details of the steps that take place at the molecular level in novel molecular photocatalysts. For this purpose, a light-absorbing center (here, a dye) is linked to a reaction center. The reaction center can be a coordinated metal ion, a metallic nanoparticle, or a semiconductor surface. Hydrogen is created at the interface between the reaction center and the surrounding aqueous solution.

"We are particularly interested in the transfer of electrons to the reaction center. This step occurs within a millionth of a millionth of a second," says Dietzek. With the help of time-resolved spectroscopy, he can image the transfer: Light pulses that last approximately 30 femtoseconds (i.e., 30 billionths of a millionth of a second) form the basis of an ultra-fast camera. With this camera, the movement of individual atoms and, thus, the timescale of the transfer of electrons can be recorded.

With resonance Raman spectroscopy, Dietzek can research which subunit of the molecule absorbs light or which unit in which spectral range participates in the absorption of light. This can affect the efficiency of the catalysts because the larger the absorbed part of the sun spectrum, the more efficient the generation of hydrogen.

By changing individual parameters (e.g., the structure of the dye, the nature of the reaction center, or the connection between the two), Benjamin Dietzek can find out which effect these changes have on the transfer of electrons.

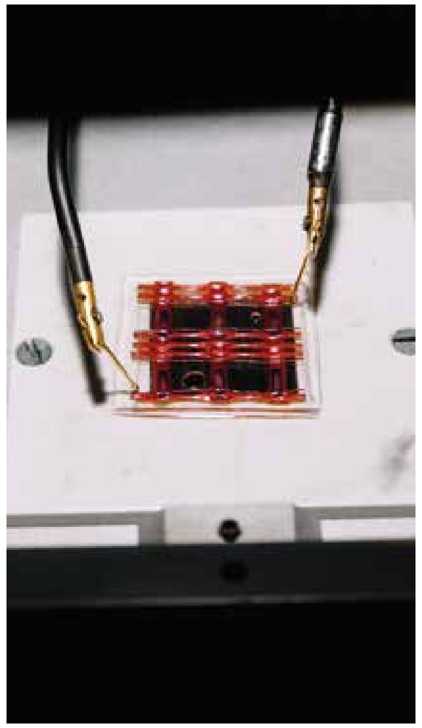
"We are not only interested in the molecular processes in photocatalytic water splitting but in the functional interfaces as well. For this reason, we study processes in which a molecular interaction occurs at solid boundary layers," says Dietzek. One current research object is dye-sensitized solar cells. In this type of solar cell, light is absorbed by a thin dye-film located on a semiconductor, which together form a photoactive electrode. The electrons that are set free leave the dye via the semiconductor and reach a solar cell contact. These solar cells have always had a low degree of efficiency. Here, it is also necessary to understand the basic transfer steps of the electrons between the dye and the semiconductor material in order to know how to optimize the process.

Solar Fabric for a Self-sufficient Energy Supply

The topic of Dr. Jonathan Plentz' research at IPHT is also solar cells. Together with his male and female colleagues, he has researched the material basis and manufacturing technology of solar cells on an optical fiber fabric. "The solar fabric developed by us is extremely light and flexible. When integrated into clothing, curtains, or tents, it could serve as a self-sufficient energy supply for small electrical devices that now represent a large portion of the entire energy consumption," said Dr. Plentz.

To manufacture the solar fabric, the research scientists at IPHT prepared thin-film silicon solar cells in several layers on Vitrulan's optical fiber fabric with metal contact wires woven into it and processed them into mini modules. These modules are protected by a highly-transparent silicon layer. This solar fabric has the special feature that the applied solar cells can be connected and assembled at a later point depending on power and voltage requirements. This makes inexpensive production at the industrial level possible. "The fabric could be produced in panels like cloth and pieces cut out arbitrarily afterwards," said Plentz. A piece of solar fabric that is 8 cm x 14 cm in size is sufficient, for example, to power a smartphone. In a next step, Dr. Plentz and his colleagues would like to increase the reproducibility of the solar cells on the fabric to achieve this goal.

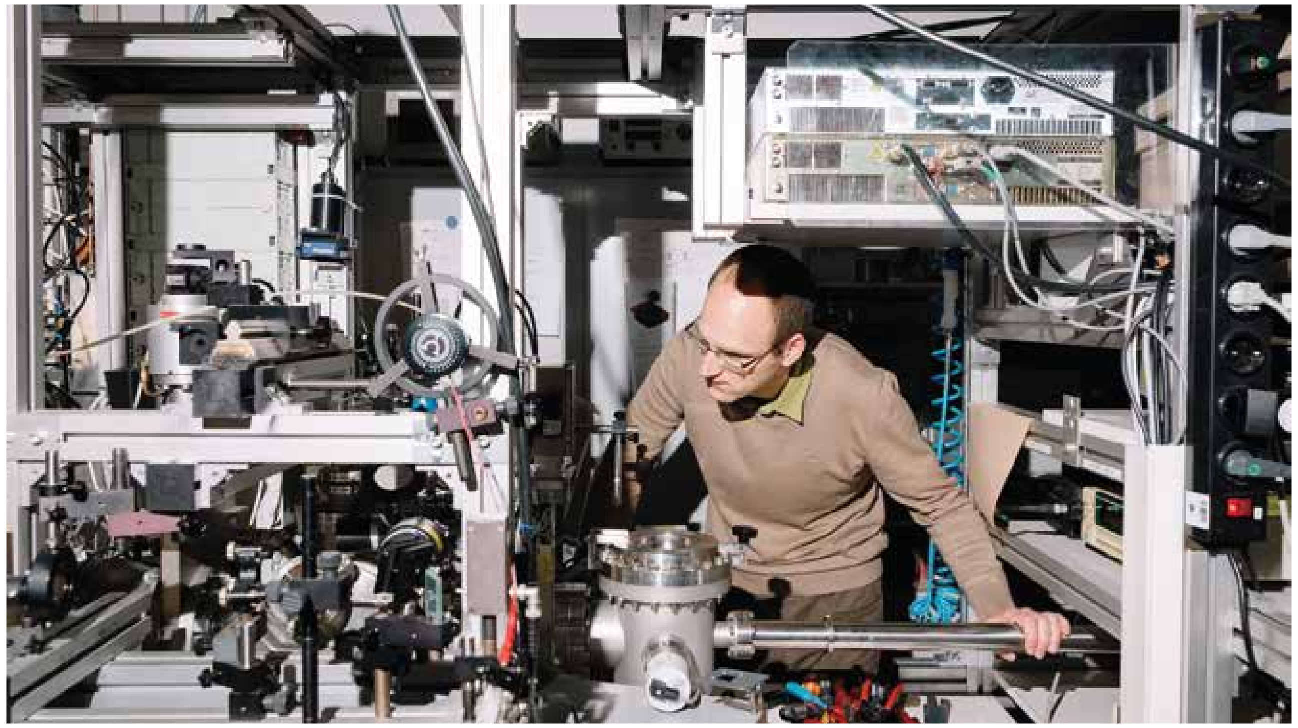
+ Scientific contribution "Solar Cells on Textiles"



Characterization of a miniaturized solar panel

Solar fabric

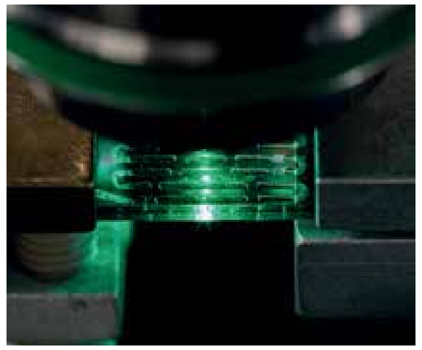
"We are making our contribution to the goal of replacing fossil fuels with hydrogen as the primary energy source of the future." //
Benjamin Dietzek



Jonathan Plentz scrutinising the coating process

Scientific Contributions in the App

Biophotonics



In the biophotonics research focus, IPHT implements innovative photonic methods and tools – based on applied fundamental research – in molecular spectroscopy and hyperspectral imaging as well as in fiber, chip, and nanoparticle based analytics. The application fields range from fundamental research in the life sciences to food and environmental safety to clinical diagnostics.
In the app, you will find the following contributions on this research topic:

» ***Ex vivo* and *in vivo* Diagnostics with the Help of Multimodal Imaging**
Bocklitz // Dochow // Chernavskaia // Bekele Legesse // Heuke // Schmitt // Popp

» **Identification of Hepatic Stellate Cells in Liver Tissue using Raman Spectroscopy**
Galler // Bauer // Popp // Neugebauer

» **Raman Spectroscopy for the Diagnosis of Liver Cancer**
Tolstik // Matthäus // Marquardt // Stallmach // Popp

» **Tracing Lipids inside Macrophages – Understanding the Development of Atherosclerotic Plaques**
Stiebing // Matthäus // Lorkowski // Popp

» **Functionalized SERS Labels for Tumor Cell Detection**
Krafft // Freitag // Popp

» **Structural and Chemical Studies of Teeth using Raman and FTIR Spectroscopy**
Krafft // Anwar-Alebrahim // Popp

» **Towards Online Drug Monitoring: Fast and High-throughput LOC-SERS Detection of Methotrexate and Levofloxacin**
Hidi // Mühlig // Jahn // Henkel // Weber // Cialla-May // Popp

» **A Novel Calibration Concept for Reproducible Quantitative LOC-SERS Measurements**
Kämmer // Olschewski // Bocklitz // Rösch // Weber // Cialla-May // Popp

» **Localized Surface Plasmon Resonance-based Sensors for DNA Detection**
Jatschka // Csaki // Stranik // Fritzsche

» **Manipulation of scattered light from single nanoparticle by subwavelength interference layers**
Wirth // Garwe // Bergmann // Stranik // Csaki // Fritzsche

» **Transport of Nanoparticles in Biological Tissue for Toxicity Investigations**
Müller // Stranik // Gläser // Fritzsche

» **On-site Detection of Plant Pathogens by Employing a Powerful On-chip Hybridization Strategy**
Schwenkbier // Pollok // Cialla-May // Weber // Popp

» **Single-Virus Detection using a Combination of Atomic Force Microscopy and Image Analysis Methods**
Bocklitz // Kämmer // Stöckel // Trautmann // Cialla-May // Weber // Deckert-Gaudig // Zell // Deckert // Popp

» **Identification of Meat-associated Pathogens via Raman Spectroscopy**
Meisel // Stöckel // Rösch // Popp

» **Nanoscale Catalysis**
Deckert // Singh // Deckert-Gaudig // Zhang

» **Cavity-enhanced Raman Spectroscopic Analysis of $^{13}CO_2$ Labeling Experiments in Environmental Research**
Frosch // Jochum // Popp

Fiber Optics

In the fiber optics research focus, IPHT performs fundamental research on the propagation properties and efficient and flexible control of fiber-guided light; it also researches fiber modules and systems for a wide range of applications.
In the app, you will find the following contributions on this research topic:

» **Novel Hollow-core Fibers for Light Guidance in the UV**
Hartung // Kobelke // Schwuchow // Wondraczek // Bierlich // Popp // Schmidt // Frosch

» **Microstructured Fibers for Complex Sensory Applications**
Kobelke // Bierlich // Wondraczek // Ludwig // Unger // Schuster

» **Optical Properties of Ultrapure Water in the Ultraviolet Spectral Range**
Kröckel // Schmidt

» **Fiber-based Microresonators for Use in Biochemical Sensors**
Wieduwilt // Schmidt

» **Yb-Doped Lanthanum/Yttrium-Aluminosilicate Glass for Laser Applications**
Litzkendorf // Grimm // Schuster // Pochert // Ludwig // Schwuchow // Dellith // Bartelt

» **Length-distributed Measurement of Temperature Effects in Yb-doped Fibers During Pumping**
Leich // Fiebrandt // Schwuchow // Jetschke // Unger // Jäger // Rothhardt // Bartelt

» **Large-Core REPUSIL Amplifier Fibers for Use in Scaling the Pulse Power in Rods**
Jäger // He // Leich // Grimm // Kobelke // Zhu // Bartelt

» **Tapered Fundamental-Mode Fiber Laser with Wavelength Stabilization at 976 nm and 10 W of Output Power**
Leich // Jäger // Grimm // Eschrich // Jetschke // Becker // Hartung // Bartelt

» **Plasmonic Bandgaps in Metal-filled Photonic Crystal Fibers**
Spittel // Bartelt // Schmidt

» **Production of Chirped Fiber Bragg Gratings in the Visible Spectral Range as Components for Laser Systems**
Becker // Elsmann // Latka // Rothhardt // Bartelt

» **Detecting Phosphates in Water using Online Fluorescence Detection and a Flow-Injection Analysis**
Kröckel // Schmidt

Photonic Detection

The photonic detection research focus deals with the research and implementation of systems for the highly sensitive temporally, spatially, and spectrally resolved detection of light.
In the app, you will find the following contributions on this research topic:

» **Thermopile Chip Based Calorimeter for the Study of Aggregated Biological Samples in Segmented Flow**
Kessler // Hänschke // May

» **Silicon/PEDOT:PSS Hybrid Thin-Film Solar Cells**
Andrä // Junghanns // Plentz

» **Solar Cells on Textiles**
Plentz // Gawlik // Brückner // Andrä

» **Self-Calibrating Lensless Holographic Microscopy with Long Working Distance**
Riesenberg // Kanka // Grjasnow // Wuttig

» **AlN-Dünnschichtmembranen für neue Sensorsysteme**
Goerke // Ziegler

» **Spatially Resolved Single Photon Detection with a Quantum Sensor Array**
Ilichev // Oelsen

» **From 2D to 3D: new processing methods for airborne acquired magnetic field data.**
Stolz // Chwala // Schiffler // Queitsch // Meyer

» **Investigation of Intrinsic Relaxation Processes to Optimize Optically Pumped Magnetometers**
Scholtes // Woetzel // IJsselsteijn // Schultze // Meyer

» **Large Construction Site in 793: Fossa Carolina at the Focus of Geophysics**
Linzen // Schneider // DunkeL // Schiffler // Stolz // Hübner // Meyer

» **Spectroscopic Measurements of Particle-Laden Flames**
Müller // Paa // Wagner // Burkert

» **Not all silica glasses are alike – Accelerated absorption degradation for DUV laser applications**
Mühlig // Bublitz

» **Measurement of the Nonlinear Refractive Index of Selected SAL Glasses**
Karras // Litzkendorf // Grimm // Schuster // Paa // Stafast

» **E-beam with Character Projection: A Powerful Tool for Wafer-scale Nanolithography**
Hübner // Zeitner

Equal Opportunity at IPHT

The advancement of female scientists – not just in management positions – and the establishment of measures to balance work life and family life are high-priority tasks at IPHT. »

» As part of its equal opportunity efforts, the Leibniz Association is pursuing the goal of providing career advancement opportunities to men and women based on their qualifications and individual career aspirations. In this context and in particular, the percentage of women in management positions must be swiftly and continuously increased. IPHT appreciates the commitment of the Leibniz Association and is an advocate of achieving these objectives within a reasonable period of time. IPHT has already taken a number of measures to reduce the deficits in these areas.

The challenge to increasing the female presence in management is linked to the fact that the percentage of female students majoring in physics – and thus the number of female graduates altogether – is much lower than that of male colleagues. Female students are much more prevalent in the humanities. Thus, the search for suitable female candidates is not always easy.

For IPHT, this means that the goal of increasing the percentage of women in management positions can only be achieved if female research scientists are targeted and encouraged to pursue management roles during their graduate and postgraduate studies. There are many long-term prospects available for young, qualified female scientists at IPHT. There are opportunities available for female scientists to take on the responsibilities and tasks that precede management positions in preparation of such leadership roles and to become more involved in the Institute. This strategic course of action has already yielded positive results: The female leader of several research grous started their successful scientifc research careers at the IPHT, where they acquired the necessary leadership skills.

When refilling vacant department head positions, headhunters will be used in a targeted search for suitable female managers to be won for IPHT.

One important aspect of this effort is the improvement of conditions for balancing work life and family life. The management is committed to using appropriate resources to pave the way for male and female research scientists at IPHT to better meet the specific needs related to familial responsibilities. These resources include flexible working hours and consideration of familial interests when setting up meetings and deadlines.

To optimize and expand these and other measures in the future, an Equal Opportunities workgroup was initiated at IPHT. Under the personal leadership of the scientific director, this workgroup made it its goal to determine the needs and resources involved in implementing and enforcing the standards set by the Leibniz Association.

"Equal opportunity is an integral part of the Leibniz Association. It is firmly embedded in our maxim to attain and retain the most talented, creative, and capable minds in science and research." //

Prof. Dr. Matthias Kleiner, President of the Leibniz Association

Awareness of reconciling family life and work

Interview with Dr. Maria Wächtler

» ***Mrs. Wächtler, you work full-time as a research scientist at IPHT. How do you manage to balance work and family life so well?***

I have a 10-year-old and a 6-year-old child; during the day, they both go to school where they are supervised until well into the afternoon. The hours before and after school have to be very well organized. Who is going to pick up the children from school? What happens if somebody falls ill? Who is going to do the shopping for dinner? My husband feels just as responsible for the care of our children as I do, but we both have the ambition to further our careers. Luckily, our parents are able to help us out when need be. In addition, I am able to count on IPHT as an employer who is very considerate of my family situation.

What measures offered by IPHT do you take advantage of to help balance work and family life?

I definitely take advantage of the opportunity afforded me to set flexible working hours. I have the freedom to come in later or leave earlier than usual and finish up any outstanding work at home. Of course, that is not possible when I have laboratory measurements to make, but it is certainly acceptable when I am working on a paper for publication.

How do your colleagues react?

Very positively. Many of my male and female colleagues, including many department heads, also have children and know how flexible one often has to be. At IPHT, awareness of the balance between work and family life is very high.

Excellent Young Scientists

Tobias Tieß

2007 – 2010
Bachelor of Science in Physics

2010 – 2013
Atlantis MILMI Dual Degree Master Program with stays at the universities in Orlando, FL (USA), and Jena

Current degree
Master of Science in Photonics and Optics

since 2013
Dissertation on "Tunable Fiber Lasers based on Fiber Bragg Grating Arrays"

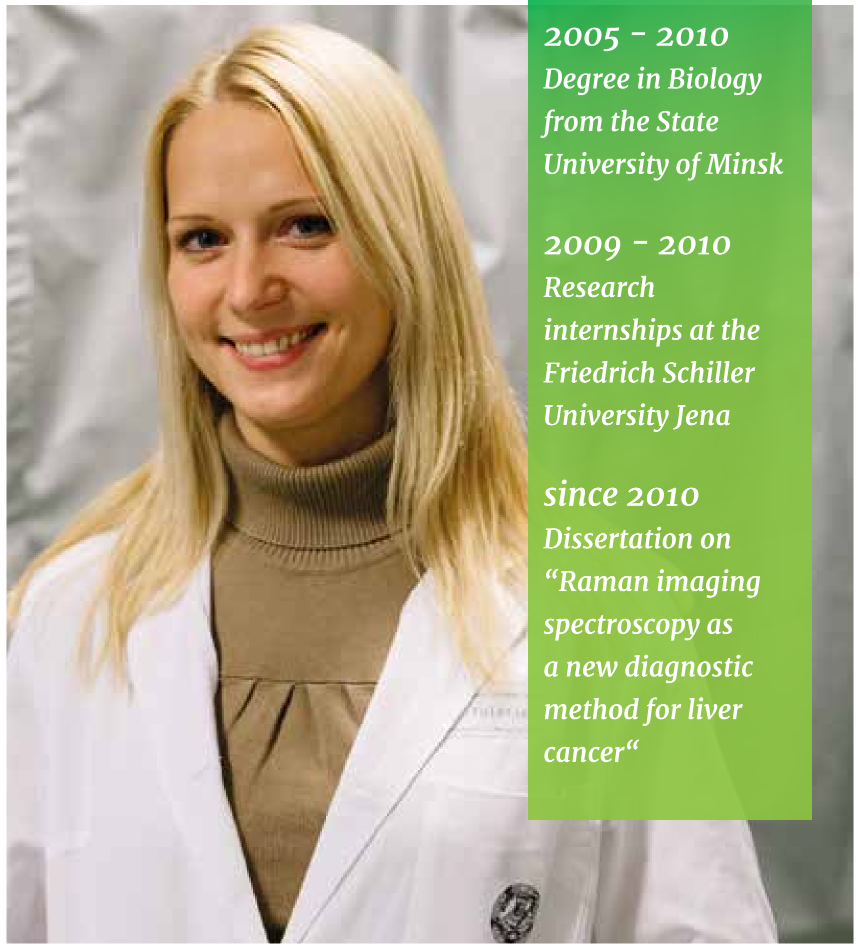
Tobias Tieß // Young Researchers Award from the German Branch of the European Optical Society

Tatjana Tolstik

2005 – 2010
Degree in Biology from the State University of Minsk

2009 – 2010
Research internships at the Friedrich Schiller University Jena

since 2010
Dissertation on "Raman imaging spectroscopy as a new diagnostic method for liver cancer"



Tatjana Tolstik // Hermann Strauß Research Award of the DCCV 2014

» Young male and female scientists at IPHT were recognized with a series of prizes and awards for excellent research performances this past year. This reinforces IPHT in its effort to support and educate young research scientists. Young, skilled personnel secures a future of innovation and growth.

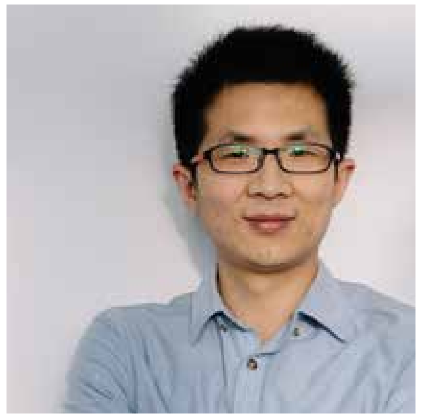
IPHT supports young, talented male and female research scientists at all levels of their career – from undergraduate studies to graduate studies to postdoc research and gaining the qualifications necessary to take on a leadership position. In addition, young male and female researchers can take advantage of funding opportunities offered by the Leibniz Association.

IPHT is interested in awakening the enthusiasm of the very young for science and research. That is why IPHT participates every year at a local research day for schoolchildren in Jena. Together with the Friedrich Schiller University Jena, IPHT organizes a summer school program for science minded boys and girls once a year.

Dr. Sebastian Dochow // Award from the aser Technology Science Society

Wazeem Basheer Karunnapallil // DAAD Award for excellent achievement by a foreign student at a German university

Dr. Maria Wächtler // Albert Weller Award, German Bunsen Society for Physical Chemistry



Zhenglong Zhang // GCCD Young Researchers Award

24th International Conference on Raman Spectroscopy

With more than 925 participants, the XXIV. International Conference on Raman Spectroscopy, which took place in Jena in August of 2014, turned out to be the largest conference since the first ICORS was held forty-eight years ago. This six-day event, organized by IPHT in cooperation with the Friedrich Schiller University Jena and the Abbe Center of Photonics, was hosted again in Germany for the first time in twenty years. »

» Visitors summarized their impressions as follows, acknowledging the more than two years of preparation that went into the conference: "It seems it's the best ICORS ever." "Excellently organized. The sessions were of high quality." Jena is a prominent international hub in the field of Raman spectroscopy and proved to be a valuable host.

"This is a very nice success story for Jena, the IPHT, and the University."
// Prof. Jürgen Popp, Conference Chair

Visitors from forty-seven countries and five continents accepted the invitation to Jena. In addition to participants from Germany, a large number of research scientists from the U.S.A., India, China, and Great Britain were present. Guests traveled from as far as New Zealand. Together, the participants discussed research results, trends, and the application possibilities of Raman spectroscopy. The scientific program included 413 lectures in seventy-nine sessions, two poster exhibitions with 400 posters, and several workshops for students. During the conference, more than fifty industrial exhibitors presented their products and current developments.

In addition to the excellent scientific program, the participants will remember the comprehensive range of accompanying programs, including the welcome party as well as the city tours and sightseeing excursions around Jena. The incontestable highlight of the conference was the gala dinner at the historic marketplace: knights, jesters, artists, dancers, musicians, and historic craftsmen accompanied visitors on a trip to the Middle Ages.

With the first-ever Raman award ceremony in the categories of "Lifetime," "Best Junior Researcher," and "Most Innovative Technological Development," the conference was ended with a celebration after six days. The next ICORS will take place in Fortaleza, Brazil, in 2016.

+ ICORS image film


Participants during keynote lecture


Industry exhibition


Laureates of Raman Awards


Get-together


Medieval Gala Dinner

Regionally Rooted – Internationally Connected

» Regional, national, and international collaboration is extremely important to IPHT's research. On the regional level, IPHT works closely with Jena's universities. Through its participation in the InfectoGnostics research campus, IPHT is also strongly rooted in Thuringia's research landscape. Membership in networks such as "optonet" and "medways" is indicative of IPHT's involvement in the regional photonics branch.

On the national level, IPHT acts as a joint between photonics and the life sciences, for example, as part of the Leibniz Association's research alliance "Medical Engineering: Diagnostics, Monitoring, and Therapy" or in its role as coordinator of the "Biophotonics Research Focus" funded by the Federal Ministry of Education and Research.

IPHT is a founding member and initiator of international networks such as "Biophotonics4Life" and "Photonics4Life."

IPHT collaborates with partners from 49 different countries worldwide.

IPHT at a Glance – Key figures of 2014

12
Projects funded by the EU
5
of them coordinated by IPHT

Participation in
140
conferences

86
Invited talks

87
Media reports
(print, tv, radio)

185
Peer-reviewed publications

334 Female and male employees

891,6 T €
EU contracts / projects

3.413,9 T €
Industry contracts / projects

6.314,0 T €
National projects

10.413,7 T €
Institutional funding

52 %
Project funding

21,3 Mio €
Total budget

13
Patent applications
5
Patent grants

14
Doctorades
5
of them from women

45
Academic teaching employees

IPHT Celebrates the International Year of Light

IPHT is celebrating the "International Year of Light" together with Jena's universities, non-university research institutes, and technology companies. The four main pillars in terms of content include the following: light technology, light research, light and nature as well as light and culture. Within these subject areas, several activities and events are being planned in Jena. The opening event included a science show entitled "LIGHT Phenomena" starring the WDR anchorman Ralph Caspers. »

» The opening ceremony, which took place in the Jena Sparkassen Arena, was organized by IPHT in cooperation with the Fraunhofer Institute for Applied Optics and Precision Engineering, the city-operated company JenaKultur, and Jena Business Development. In addition to the audience of 2,700 at the sold-out concert hall, 600 spectators followed the show at a public screening area in downtown Jena and 500 other viewers followed the show live on the internet. Caspers, who is known from such shows as the "Sendung mit der Maus" (The Show Starring the Mouse) and "Wissen macht Ah!" (Knowledge Makes You Go "Oh!"), answered questions based on exciting experiments performed live on stage. The questions were submitted prior to the show by Thuringian schoolchildren. The two-hour show of experiments also included acts by the French "Laser Man" and the performance group "Feeding the Fish."

IPHT will be participating in several other activities that will be taking place around Jena as part of the Year of Light. Together with the Friedrich Schiller University Jena and research institutes, located at the Beutenberg Campus, the IPHT organizes a sommer school entitled „Biophotonic – Visions for better health care". These STIFT funded training addresses sophomores and juniors of Thuringian high schools which shows a keen interest in science. IPHT will be showcasing itself during the "Highlights of Physics" theme week. At this event alone, which is being organized by the University of Jena together with the German Physical Society, thousands of visitors are expected.

With its involvement in the Year of Light, IPHT will be actively participating in the efforts to spark the interest of younger generations for academic studies and professions in the field of science, technology, and optics. Furthermore, IPHT will be informing both the specialized and general public about the importance of optical and photonic technologies from Jena as solutions to future questions. The activities in Jena will, therefore, focus, in particular, on the long tradition of optics and photonics in Jena.

Further Information:
www.lichtstadt-jena.de

+ TV recording of the opening ceremony

The International Year of Light and Light-based Technologies is a global initiative started by internationally-active scientific organizations and UNESCO. The goal of the Year of Light – as proclaimed by the United Nations – is to raise awareness of the importance of light-based technologies among the general public.

Anchorman Ralph Casper talking to Jürgen Popp.


Laserman


Dr. Dieter Weiss (left) and Minister Wolfgang Tiefensee (right) during an experiment on stage.

Organization Chart

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Research Units

Departments

Spectroscopy/Imaging	Fiber Optics
Prof. Dr. Jürgen Popp	Prof. Dr. Hartmut Bartelt
Quantum Detection	***Nanoscopy***
Prof. Dr. Hans-Georg Meyer	Prof. Dr. Volker Deckert
Nanobiophotonics	***Functional Interfaces***
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Prof. Dr. Jürgen Popp	Leibniz Institute of Photonic Technology, Jena
Frank Sondermann	Leibniz Institute of Photonic Technology, Jena
Prof. Dr. Herbert Stafast	Jena

Budget of the Institute 2014

	in T €
Institutional Funding (Free State of Thuringia)	10.413,7
Project Funding	10.619,5
	21.033,2
Institutional Funding: use	
Staff	6.185,2
Materials	3.004,4
Investments	1.224,1
	10.413,7
Categorization of Project Funding	
Federal ministries	2.306,3
German Research Foundation	566,1
(In addition, IPHT scientists spent DFG funds of 152,6 T € at the University of Jena.)	
Free State of Thuringia	3039,1
(Thereof for restructuring within the framework of EFRE: 338,1 T €)	
European Union	891,6
Contracts of Public Institutions	102,5
Other Fundings	402,5
Subcontracts	629,7
R&D Contracts	2681,7
	10.619,5

Staff of the Institute 2014

	Full-time Equivalents				*People*
	Institutional Funding	*Third Party Funding*	*Others*	*Total*	
Scientists	26,2	52,9	-	79,1	84
Visiting Scientists**	-	-	-	-	26
External financed Scientists*	-	-	-	-	16
External financed Employers*	-	-	-	-	2
External financed Doctoral Candidates*	-	-	-	-	42
Doctoral Candidates	6,5	26,6	-	33,1	56
Technical Staff	35,1	37,5	-	72,6	77
Administration	14,4	-	-	14,4	15
Management	5,7	3	5	13,7	15
Trainees	1	-	-	1	1
Total Staff	**88,9**	**120,0**	**5,0**	**213,9**	**334**

* Employees who are not paid through the payroll of IPHT, but have their main focus on IPHT.

** Visiting scientists who worked more than a month on IPHT in 2014. No use of the key date regulation December 31.

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