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**Dear reader,**

in your hands you hold the third Newsletter of the European Network of Excellence for Biophotonics PHOTONICS4LIFE (P4L). The time between the second and this issue was a very busy one. The second issue has been released during the LASER World of Photonic in Munich, where P4L was highly active. On a special Biophotonics area we were present with a booth and held the industrial workshop "Visions for better health care". With more than 250 visitors we consider the event a big success and want to thank all contributors. Many of us were also highly engaged contributing to the ECBO, the European Conferences on Biomedical Optics. Overall we think the fair as well as the conferences were highly enjoyable and successful, despite the difficult economical times we have to pass through.

Our most important internal news are that we have passed successfully the first regular review meeting and that we paved the way for an enlargement of Photonics4Life. Accordingly, we accepted six new Associate Partners, which add valuable knowledge and technical possibilities to our network. Our newsletter will introduce these new members in detail. In this issue you can learn more about the Fondazione Don Carlo Gnocchi. The new partners already contributed to our scientific meeting that we held from November 16th to 18th in Barcelona and which was especially dedicated to Women in Photonics (see page 13).

The next large Biophotonics event will take place in the framework of Photonics Europe from April 12th to 16th in Brussels. Again, Photonics4Life will contribute in manifold ways. We would be happy to meet you there!

Best wishes, Jürgen Popp



# Photonics4Life

As Biophotonics is a very broad topic with various subdisciplines, it is obvious that it hardly can be represented in its whole broadness by a strongly limited number of research institutes. Having 13 core partners, Photonics4Life has already exceeded the upper limit for a Network of Excellence of 12 partners. Nevertheless Photonics4Life decided to create the possibility of a so-called Associate Partnership to broaden the already available and to gain new expertise. The Associate Partner will be able to actively participate in the research and networking activities of Photonics4Life.

One prominent example for the networking activities is the Summerschool of Biophotonics held last year in June in Ven, Sweden, where one of our new Associate Partners, namely the Department of Photonics Engineering of Technical University of Denmark, was heavily involved. Concerning research, the new partners will be already involved in the second call for P4L-projects, which are small projects within the P4L consortium that facilitate the cross-fertilization between different partners. The requirements for the associated partnership are as follows:

- The key research domains of the organisation need to match the scope of the activities of Photonics4Life
- There should be a strong motivation to join P4L (to become an associated partner, the organisations must really be committed)
- The know-how and expertise should be of added value for or complementary to the already existing know-how and expertise of the consortium ("fill in gaps")
- The organisation should match the scale of the other P4L partners
- The organisation should not already be part of a local cluster of one of the partners

A local cluster generally includes all local research institutes or institutes of a university a core partner cooperated already with at the start of the Photonics4Life. The original idea was again that 13 partners are not enough to represent Biophotonics as a whole. The core partners mainly represent the technology and methods developer, while the users like biologists and especially physicians were missing. However, each core partner has his own local partners with which he cooperates, among which might be also some technology and method developers. However the vast majority of the local cluster partners are users. Having this in mind the actual size of Photonics4Life is much bigger than the number of 13 core partners suggests.

It is one aim for this year to make the cooperation between the core partners and their local cluster partners more transparent to allow and initiate a direct cooperation between local cluster partners and different core partners or even between two local cluster partners from different core partners.

We believe that the inclusion of associate partners and the stronger involvement of local cluster partner will give Photonics4Life a much bigger dimension than it already has and that these actions are important steps towards a self-supporting structure.

» [www.photonics4life.eu](http://www.photonics4life.eu)

## Associated Partners

Technical University of Denmark	Prof. Peter Andersen, <a href="mailto:peta@fotonik.dtu.dk">peta@fotonik.dtu.dk</a>
Fondazione Don Gnocchi	Dr. Furio Gramatica, <a href="mailto:fgramatica@dongnocchi.it">fgramatica@dongnocchi.it</a>
Institute of Electronic Structure & Laser FORTH	Dr. Maria Farsari, <a href="mailto:mfarsari@iesl.forth.gr">mfarsari@iesl.forth.gr</a>
Technical University of Wroclaw	Prof. Henryk Kasprzak, <a href="mailto:henryk.kasprzak@pwr.wroc.pl">henryk.kasprzak@pwr.wroc.pl</a>
Centre Suisse d'Electronique et de Microtechnique	Prof. Peter Seitz, <a href="mailto:peter.seitz@csem.ch">peter.seitz@csem.ch</a>
University of Freiburg	Dr. Andreas Seifert, <a href="mailto:andreas.seifert@imtek.uni-freiburg.de">andreas.seifert@imtek.uni-freiburg.de</a>
Research Centre Ispra	Dr. Maurice Whelan, <a href="mailto:maurice.whelan@jrc.ec.europa.eu">maurice.whelan@jrc.ec.europa.eu</a> Dr. Peter Macko, <a href="mailto:peter.macko@jrc.ec.europa.eu">peter.macko@jrc.ec.europa.eu</a>

## Industrial User Club

One and a half year after the kick-off of Photonics4Life, 10 European companies have joined the P4L Industrial User Club (IUC). At the end of 2009, these are the P4L IUC members, in chronological order:

- Monocrom (Spain)
- Inject Enterprise (Russia)
- Elliot Scientific (UK)
- Advalight (Denmark)
- Avasha (Switzerland)
- LLC SPE „Nanostructured Glass Technology“ (Russia)
- Modulight (Finland)
- Luminostix (The Netherlands)
- Cosingo (Spain)
- Analytik Jena (Germany)

All of these companies are level 1 member, which means that they get access to the P4L knowledge management centre (KMC) without any membership fee. In this KMC, first class information is available on the huge amount of capabilities present in P4L to support development, fabrication, commercialization and clinical use of biophotonics developments. It allows finding the unknown expert, the missing instrumentation or the right potential to fill the gap in the development as well as in the fabrication process line. The only request for a company is to sign up as a member and to provide info on its expertise and activity leading to at least 1 entry in the P4L database.

Companies that are interested in an IUC membership, can visit the P4L IUC website <http://industry.photonics4life.eu>, where they can download the IUC agreement.

### Contact

Tom Guldemont  
Vrije Universiteit Brussel (VUB)  
[tom.guldemont@tona.vub.ac.be](mailto:tom.guldemont@tona.vub.ac.be)

## Entrepreneurship in Photonics

As part of WP 7, VUB organized the intensive training “Entrepreneurship in Photonics”, which took place in Brussels from January 25th to February 5th 2010.

The training consisted of 3 modules:

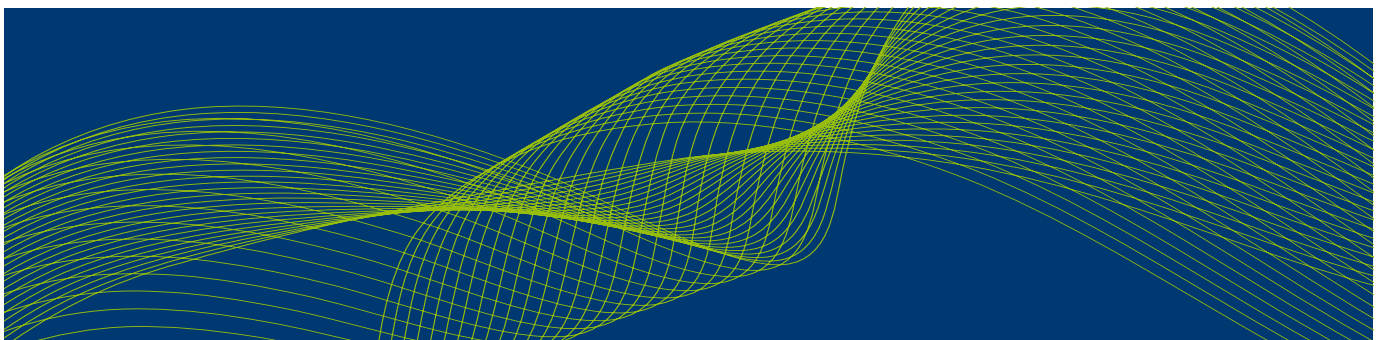
- Introduction to Business Economics
- Business Aspects of Photonics
- Business Plan

In total, 15 entrepreneurial researchers from all over Europe participated in this event. 13 persons attended the first and the second module, while 7 subscribed for the third module. Amongst the participants were 8 P4L researchers, benefiting from a € 400 reimbursement. A more detailed retrospect report about this training will follow in the next P4L

newsletter. For more information, please visit [www.photonics4life.eu/P4L/Events/Intensive-training-on-Entrepreneurship-in-Photonics](http://www.photonics4life.eu/P4L/Events/Intensive-training-on-Entrepreneurship-in-Photonics).

### Contact

Tom Guldemont  
Vrije Universiteit Brussel (VUB)  
[tom.guldemont@tona.vub.ac.be](mailto:tom.guldemont@tona.vub.ac.be)



# Institute of Photonic Technology (IPHT)

The Institute of Photonic Technology (IPHT) is a non-profit, non-university research facility located in Jena, Germany. The institute currently employs nearly 300 employees. It was founded in 1992 and is listed as a corporate society.

To address important future markets with great potential for growth, such as biomedical diagnostics or thin-film photo-

voltaics IPHT focuses on six different, but interconnected, fields of research.

The interdisciplinary and institution-wide, comprehensive scientific approach promotes synergetic effects within the institute and allows to transfer own concepts into novel components and instruments in cooperation with many industrial and academic partners.

various technological areas. This combination facilitates development according to the corporate motto "from ideas to instruments" to the full system solution.

## Photonic Systems

Photonic systems offer an extremely wide field of application due to the variety of applicable spectral ranges available. The technological research and work performed at IPHT targets the development of sensors and their integration into systems that detect photons in a wide frequency spectrum or use them to measure dependent physical variables. The combination of state-of-the-art micro and nanotechnology with comprehensive competency in system integration is one of IPHT's unique capabilities.

## Fiber Technologies

The aim of IPHT's technological research and work is the development of novel fiber structures with active cores for fiber light sources, fibers with nonlinear properties, photosensitive fibers and micro-structured fibers with dimensions down to the nanometer range. With innovative material technologies and precise micro and nanostructures, fibers create new possibilities for the intelligent manipulation of light propagation characteristics.

## Micro/Nanotechnology

Micro and nanotechnologies make up the technological innovations center of IPHT. With state-of-the-art lithographic techniques and methods of self organization complex functional micro and nanostructures are developed and produced for use in detectors, plasmonic structures, and photonic systems. The combination of thin-film technology, nanolithography, and microsystems technology is one of IPHT's unique features.

## Biophotonics

The two central pillars of Biophotonics research at IPHT are the following: biomolecular analytics and biomedical imaging as well as the development of new micro-spectroscopic approaches. With this focus the Institute has positioned itself into the crucial role of an interdisciplinary research gateway and mediator between physics and engineering on the one hand and life sciences and medicine on the other hand.

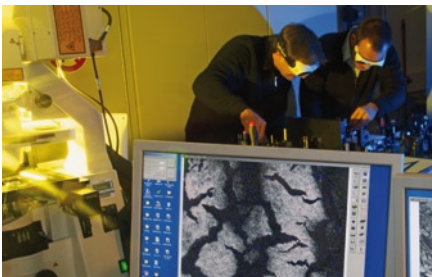
## Fiber Optics

Fiber optics research at IPHT is supported by the Institute's unique ability to develop special optical fibers in a unique and complete production chain – from material development via preform technology and the in-house production of fibers down to modeling, characterization and application competences. IPHT possesses special expertise in the application of active fibers for fiber lasers and fiber light sources, in the generation of fiber Bragg gratings, in fiber tapers and in spectrally encoded fiber sensor systems.

## Thin-Film Photovoltaics

At IPHT two research departments focus their activities on material production and characterization, material integration in new solar cell concepts, and photon management. The scientists in Jena possess unparalleled know how in the area of large-surface laser crystallization and vapor-liquid-solid growth of silicon nano wires, which is the basis for the development of new concepts in photovoltaics.

Research in these fields is strongly supported by IPHT's outstanding expertise in



## Contact

Jürgen Popp  
Institute of Photonic Technology (IPHT)  
[juergen.popp@ipht-jena.de](mailto:juergen.popp@ipht-jena.de)  
[www.ipht-jena.de](http://www.ipht-jena.de)

# Karlsruhe Institute of Technology (KIT)

Karlsruhe Institute of Technology exists as legal entity since October 1st, 2009. It is the merger of Forschungszentrum Karlsruhe GmbH and Universität Karlsruhe (TH), identified as one of the first three German top universities in the frame of the German Excellence Initiative in 2006. KIT is funded jointly by the Federal Republic of Germany and the State of Baden-Württemberg with about 8000 employees and an annual budget of about 700 million Euros. At the present about 18500 students are enrolled in KIT. KIT bundles the missions of both precursory institutions: A university of the state of Baden-Württemberg with teaching and research tasks and a large-scale research institution of the Helmholtz Association conducting program-oriented provided research on behalf of the Federal Republic of Germany. Within these missions, KIT is operating along the three strategic fields of action of research, teaching, and innovation.

## Biomedical Research

Biomedical research at KIT focuses on the identification of genetic and non-genetic (environment, living conditions, etc.) causes of complex diseases. Work concentrates on the development of cancer, the formation of cancer metastases, and the control of embryogenesis. The research on the features of cancer and embryonic cells are not only of theoretical interest but may be of crucial importance to the development of therapeutic strategies. For this aim DNA chip technology is developed and applied as well as automated determination

of gene profiles in cells and investigation of protein interactions. Developing new biophotonic systems based on nano and micro structures will contribute positively to a decrease in health care costs.

## Nano- and Microscale Research and Technology

Research in nano- and microscale technology at KIT aims at developing application-tailored solutions at the interface of microsystem engineering and nanotechnology. This work gives major impulses to technical innovations in a variety of industrial sectors. It plays a key role in implementing new physical, chemical or biological effects and functionalities as well as novel materials. The interdisciplinary approach is based on a pool of technologies comprising mechanical, optical, magnetic, fluidic, electrical, materials science, and information technology competences. Thus, it combines very different disciplines in both fundamental science and application oriented developments for a multiplicity of industrial and socially relevant application fields.

In the field of microtechnology KIT's research is focused on non silicon materials processing and application oriented development in micro fluidics, micro process engineering, and photonics.

## Optics and Photonics

In photonics, micro optics and related process development about 150 people are working in both, basic research as

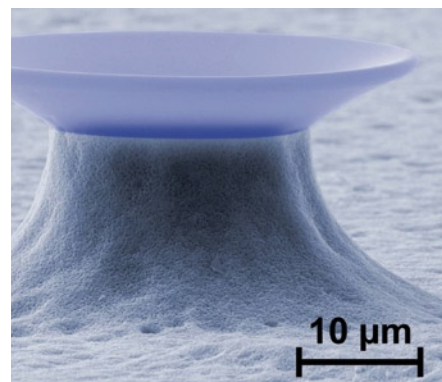
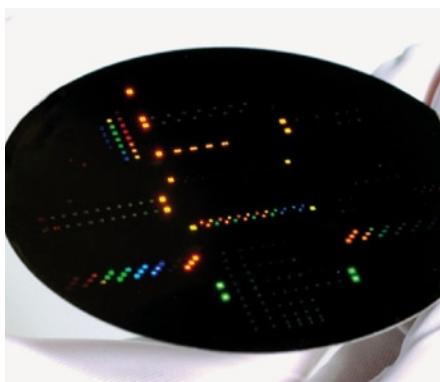
well as covering the entire development chain from materials tailoring, simulation, prototyping, mastering, characterization, packaging, reliability issues and small series fabrication.

One research focus is on polymer micro optics. With its unique infrastructure KIT offers a wide variety of technological available lithography systems on one site in order to do research on all different kinds of active and passive optical elements and systems: a high-end e-beam writer, several beamlines for X-ray-lithography at the local synchrotron light source, two- and three-dimensional laser lithography, and conventional mask based UV-lithography, to name a few. Apart from the development and optimization of high aspect ratio fabrication techniques (e.g. LIGA technique) micro optical systems are developed with a view on mid term industrial applications in the sensor field. Therefore there is a strong activity on micro replication techniques in order to allow for transfer to industrial mass fabrication.

Some 80 PhD students of KIT are members of the interdisciplinary graduate Karlsruhe School of Optics and Photonics.

## Contact

Timo Mappes  
Karlsruhe Institute of Technology (KIT)  
[timo.mappes@kit.edu](mailto:timo.mappes@kit.edu)  
[www.kit.edu](http://www.kit.edu), [www.ksop.de](http://www.ksop.de)



## Associated Partner – Fondazione Don Carlo Gnocchi

Fondazione Don Gnocchi, headquartered in Milano (Italy), is a non-profit organisation involved in the fields of health, rehabilitation, training and international cooperation. It holds 28 centres in 9 Italian regions, with more than 3500 beds and about 5500 operators employed. In 5 centres the Don Gnocchi Foundation performs an activity of scientific research and, in two of them, it has been recognized by the Ministry of Health as "IRCCS" (research hospital of national interest) in the field of rehabilitation. The main research lines are: advanced technology for biomedical applications, molecular medicine, neuroscience, neurological, cardiac and pulmonary rehabilitation, disability. Each year, in all these fields, more than one hundred of peer reviewed papers are published on international journals, and about 150 research projects are planned, declared to Italian Ministry of Health (the government institution monitoring the activity of research hospitals) and executed, leading to translational results applicable at patient's bed.

Within Don Gnocchi Foundation, the Biomedical Technology Department ("Polo Tecnologico") exists from more than 25 years, a quite peculiar characteristics among hospitals – bringing in know how on biosensors and diagnostic tools, devices for rehabilitation and assistive technologies for disabled people and acting as "cultural integrator" between medical and high-tech points of view on the same focus: the patient. Polo Tecnologico has been actively involved in European projects, since the first framework programmes.

Since 3 years, within this department, a Biophysics and Nanomedicine Lab (LABION) is present, strictly collaborating with the Molecular Medicine and Biotechnology Lab in the same centre. More than 20 researchers are employed in these two labs, with different and collaborating skills (biology, nanotechnology, immunology, neurology, engineering, physics), and

a good technical equipment is available, especially in the field of biotechnology. The nanotech equipment is available in collaborating institutions devoted to micro- and nanotechnology. In particular, FDG's Biophysics and Nanomedicine Lab is involved in European Technology Platform in Nanomedicine and collaborates with some major national and international facilities like Milan Polytechnical School and Milan University, Elettra Synchrotron Radiation lab (Trieste), Bionem Lab (Catanzaro), CEA (Grenoble), Tyndall Institute (Cork), etc.

Thanks to the presence of LABION, a special interest was developed in the last two years in nanomedicine and, in particular, in the field of potential applications of photonics in biology and medicine. In fact, a daily comparison and fruitful discussions with clinical chemistry and molecular biology experts, convinced the members of LABION to involve clinicians in deepening the topic, starting from clinical specialties

present in the Foundation. After a quite enthusiastic response we decided to prepare a preliminary questionnaire in which medical doctors were asked to highlight their point of view on biophotonics potential exploitation in medicine. Some first valuable results were obtained and have been presented, as new associated member of Photonics4Life, at Barcelona P4L meeting. Now we would like to extend this project to other and more numerous clinical specialties and to pharma/diagnostics companies marketing people among Don Gnocchi Foundation's network, also involving other P4L members. As a result, we hope to obtain a better profile of end users' expectations in a real exploitation perspective.

### Contact

Furio Gramatica  
Fondazione Don Gnocchi (FDG)  
[fgramatica@dongnocchi.it](mailto:fgramatica@dongnocchi.it)  
[www.dongnocchi.it](http://www.dongnocchi.it)



### WHAT IS AN ASSOCIATED PARTNER?

Academic/research institutes from countries participating in FP7 that work in the field of Biophotonics can become Associated Partners of Photonics4Life. An important requirement is that their scientific expertise extends the existing portfolio of Photonics4Life.

Apart from the internal project management the Associated Partners can participate in all of the existing activities of Photonics4Life like research projects and meetings and have access to the database.

At the end of the year 2009 Photonics4Life had a total of six Associated Partners.

## Local Cluster Partner – University of Florence, LENS

### Description

LENS was established in 1991 with the goal of offering to the European scientific community an institution where new and advanced laser techniques and instrumentation are developed and applied in different fields of science and technology. LENS is a truly interdisciplinary research laboratory, the unifying character being that of employing the laser light for investigating matter under different aspects: from atomic physics to photochemistry, biochemistry and biophysics, from material science to photonics, from art restoration and preservation to solid and liquid state physics. Different state-of-the-art experimental techniques are applied and made available to the users: different set-ups for ultrafast spectroscopy; ultracold atom facilities; ultra-high pressure set-up; molecular beam machines; SNOM facility; biophysics and biophotonics laboratory. Nowadays the Laboratory consists of about 25 scientific permanent staff members and 8 administrative and technical collaborators; about 35 post doctoral fellows and PhD students complete the LENS team.

### Main tasks

Three main tasks are at the basis of the LENS activity: a) develop and maintain a high level research activity in the field of laser investigation of matter; b) provide to the to the European scientific community an institution where new and advanced laser techniques and instrumentation are developed and applied in different fields of science and technology; c) train young European researchers at the PhD and post Doctoral level.

### Biophotonics research

The aim of this research unit is the study of the biophysical properties of biomolecules (proteins and DNA) and cells interacting with the environment during a biological process. The use of manipulation tools (such as optical or magnetic twee-

ers) provides information not accessible with conventional methods. This allows original investigations on fundamental biochemical and cell biological processes, such as regulation of gene expression, transcription, muscle contraction, protein synthesis, virus infection, cell interaction,

this purpose, we are applying non linear microscopy, like two photons, lifetime imaging, second harmonic generation, to study morpho-functional aspect in tissue imaging. Particular attention is devoted to imaging of neural tissue, skin, cornea, and internal organs like bladder. LENS has

### WHAT IS AN LOCAL CLUSTER PARTNER?

Academic/research institutes located close to a core member, typically in the same city or in the surrounding, which already have a cooperation with one of the core members established or plan to do so, can become a Local Cluster Partner of P4L. Like the Associated Partners of Photonics4Life the Local Cluster Partners can also come from all adjacent research fields of Biophotonics like biology or medicine etc. In addition the Local Cluster Partners can participate in all the existing activities of Photonics4Life like research projects and meetings and have access to the database.



The biophotonics group directed by Prof. Francesco S. Pavone

etc. The use of magneto-optical tweezers also allows a novel approach to the characterization of the physical properties of biopolymers. Our scientific research is focused both on single bio-molecules and more complex systems (i.e. cells, vesicles, viruses, etc). We are also developing and utilizing microscopy techniques useful when high resolution and/or high sensitivity detection have to be achieved. On

also a R&D lab within the clinics devoted to clinical applications.

### Contact

Francesco S. Pavone  
University of Florence, LENS  
[francesco.pavone@unifi.it](mailto:francesco.pavone@unifi.it)  
[www.lens.unifi.it/bio](http://www.lens.unifi.it/bio)

# Superresolution Near-Field Optical Microscopy Reveals a Novel Mechanism for Protein Organization in the Immune System

Researchers from the BioNanoPhotonics group at the Institute of Bioengineering of Catalonia (IBEC) have succeeded to observe preformed nanoscale platforms on cells of the immune system and discovered that in the process of cell adhesion, specific receptors called integrins are organized around GPI-anchored proteins. These proteins activate the integrin and assist throughout the whole process of immune cell adhesion and migration. The results were obtained using a superresolution optical technique called near-field

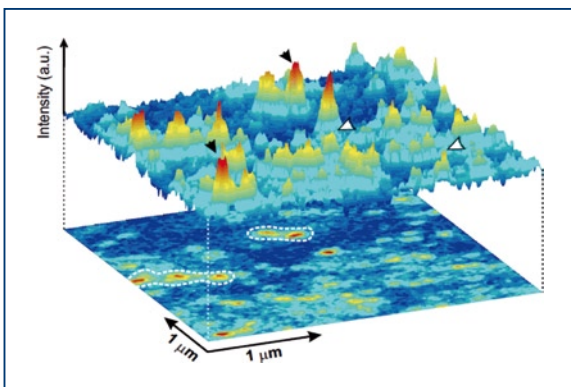
scanning optical microscopy (NSOM), which makes it possible to work at the nanoscale level. The IBEC team adapted the technique to work with biological samples, cells, and biological processes in their natural state. The results have been published in Proceedings of the National Academy of Sciences, USA (PNAS).

The mechanisms controlling protein organization and cell-cell interaction in the immune system have implications for a large number of autoimmune diseases

and allergies, as well as for the rapid transmission of the human immunodeficiency virus, all phenom-

ena that may be caused by defective cell adhesion. Discoveries made in this area – including those of the IBEC group – will broaden the possibilities for the development of new treatments for these diseases.

These findings and the technology now available also open up the possibility of exploring other areas of cell biology with nanoscale imaging since the organization of proteins in the cell membrane is a general mechanism in the rapid response of a cell to its environment. Specifically, further research could shed light on the processes involved in the adhesion of other integrins, which also involves interaction with lipid raft platforms.



**Nanolandscape organization of the cell membrane imaged with NSOM. Proteins on the cell are concentrated in well-defined regions of the membrane (black arrows) constituting pre-assembled nanoplatforms for nascent cell adhesion.**

## Contact

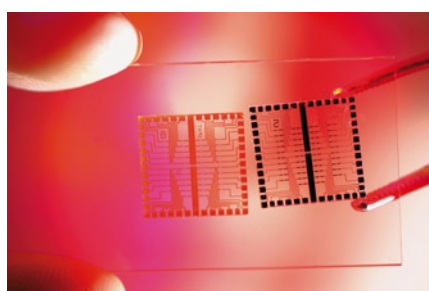
Maria F. Garcia-Parajo  
BioNanoPhotonics Group  
Institute for Bioengineering of  
Catalonia (IBEC)  
mgarcia@pcb.ub.es

# Fast and Reliable Detection: The Electro-Photonic Biochip

Biochips allow miniaturized and parallelized detection of biomolecules. Their application shows great promise in fields like genetics, pathology, forensic, or food safety. Scientists from the IPHT have now developed a detection scheme, which enables fast and specific testing directly on site, rather than transporting the sample to a laboratory.

Instead of an expensive fluorescent technology the biochip from the group of Dr. Robert Möller realizes the readout by either a measurement of the electrical conductivity, the optical transmission or via a

surface enhanced Raman scattering signal. The chip consists of electrode gaps in which captured biomolecules are immobilized. Enzymatic reactions by complementary molecules that bind to their specific partners generate silver nanoparticles.



Depending on the molecules these nanoparticles can now be detected with one of the three different methods.

To create a fully automated analysis system a micro fluidic device has been integrated. Such a system is perfectly suited for the application on site, for instance to detect animal or plant epidemics by analysing saliva or plant sap.

## Contact

Jürgen Popp  
Institute of Photonic Technology (IPHT)  
juergen.popp@ipht-jena.de



## Optical Trapping of Nanoscale Objects by Self-Induced Back-Action

Optical tweezers have been very successful for trapping and manipulating micrometer sized objects, such as cells and bacteria.

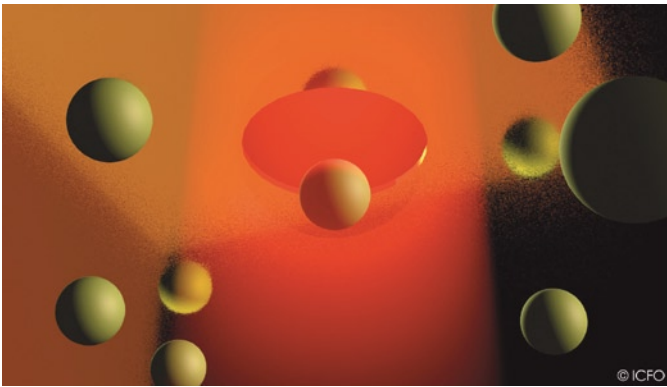
Lately, the Plasmon nano-optics group from ICFO (Spain), in collaboration with colleagues from the University of Victoria (Canada), has achieved low laser intensity optical trapping of nanometer-size particles, through a novel configuration in which the particle itself plays an active role in the trapping mechanism, resulting

in the enhancement of the trap strength (Juan et al., *Nature Physics*, October 2009).

While the magnitude of trapping optical forces decreases very fast with the object size, the increasing thermal motion further contributes in making it escape from the trap. These issues can be solved by using stronger laser intensity, but this runs the risk of damaging the trapped object, especially when dealing with biological

specimens. Juan and co-workers instead directed their laser onto a tiny aperture in a gold film whose dimension was chosen to make

the aperture transmission at the trapping wavelength very sensitive to the position of a nearby particle. This way, if the particle moves away from the aperture, it changes the rate of photons traveling through, thus inducing a force back towards the trap. Because of this effect, which the researchers call 'self-induced back-action (SIBA)', a nanoparticle can be optically trapped while experiencing a very low local laser intensity. The researchers were able to trap polystyrene beads as small as 50 nm in diameter with about 20 times weaker local intensity within the trap compared to conventional optical tweezers. The work therefore paves the way to safely trapping and manipulating nanoscale bio-objects such as viruses.



**"SIBA" optical trapping of a nanoparticles near a nanohole in a metallic film.**

### Contact

Romain Quidant  
Plasmon Nano Optics Group  
ICFO – The Institute of Photonic Sciences  
[romain.quidant@icfo.es](mailto:romain.quidant@icfo.es)

## The Terahertz Video Cam: Discreet and Fast Security Scans

After terroristic acts like the attempt from Detroit around Christmas, people desire for security rises. On the other hand people find precautionary measures like security scans bothersome or even a violation of privacy. Scientists from the Institute of Photonic Technology (IPHT) have developed a promising security camera capable of detecting hidden weapons, which at the same time respects people's privacy and works in a passive modus: The camera utilizes THz waves emitted by human bodies to uncover hidden objects like hand guns or explosives. As it does not depict any contrast of the human

body, intimate details remain unseen.

To achieve this task the IPHT group around Torsten May visualizes electromagnetic waves with frequencies below 1 THz.



These are detected with superconducting bolometers. To decrease thermal noise the receiver has to operate at very low temperatures (0.3 K). The IPHT THz camera is able to provide images at a repetition rate almost in video range. This year further improvements will be made to allow the recording of persons passing by the camera without a blurring of the image.

### Contact

Jürgen Popp  
Institute of Photonic Technology (IPHT)  
[juergen.popp@ipht-jena.de](mailto:juergen.popp@ipht-jena.de)

# A Brief Tutorial on Biomedical Diffuse Optics

Turgut Durduran, Ph.D., [turgut.durduran@icfo.es](mailto:turgut.durduran@icfo.es)  
 Medical Optics Group (ICFO-MEDOPT)  
 ICFO – The Institute of Photonic Sciences, Barcelona, Spain  
[www.icfo.es](http://www.icfo.es)

A report in 1929 [1] employed light to “see” tumors buried in deep tissues and basic ideas from those measurements still survive today in biomedical diffuse optics (NIRS, DOS, or DOT). A key contribution to the field was made by Jobsis in the late 1970s [2] who observed a spectral window in the near-infrared (NIR, ~650–950 nm) wherein photons could travel deep in tissue, as a result of the relatively reduced absorption of water and hemoglobin (see Figure 1)<sup>1</sup>.

While the idea of using light to probe tissue morphology or function is an obvious one, it turns out that beyond a relatively superficial (<1mm) level, it is non-trivial. Therefore, these “traditional” techniques remain qualitative (at best) or are fraught with systematic

errors (at worst). In a nutshell, for most tissues of interest, the light propagation is effected by scattering and absorption. Three length scales are important: (1) A rather short “scattering length” (~1 – 100 $\mu$ m) which corresponds to the typical distance traveled by photons before they scatter. (2) A longer “random walk step” which corresponds to the typical distance traveled by photons before their directions randomize (~1mm). A wavelength ( $\lambda$ ) dependent reduced scattering coefficient ( $\mu'_s(\lambda)$ ) denotes the reciprocal of the photon transport mean free path. (3) A wavelength dependent absorption length which corresponds to the typical distance traveled by a photon before it is absorbed. In the near-infrared range, this absorption length is much longer (~200 mm) than

scattering and its reciprocal is denoted by the absorption coefficient ( $\mu_a(\lambda)$ ).

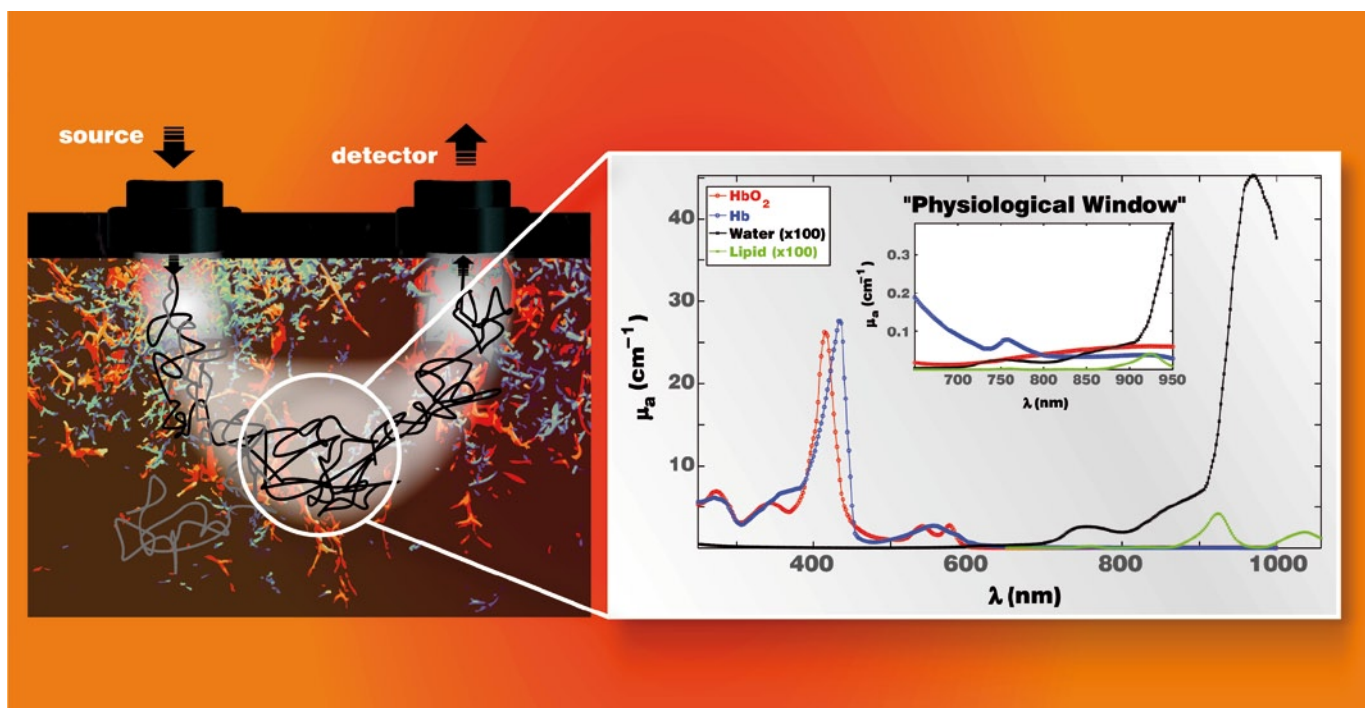
Based on this understanding, the most critical advance that allowed the development of biomedical diffuse optics was the acceptance that light transport over long distances is well approximated as a diffusive process [4]. This has provided the necessary physical model to quantitatively separate tissue scattering from tissue absorption, and to accurately incorporate the influence of boundaries and heterogeneities. It has effectively paved the way for quantitative measurements.

Table 1 summarizes the salient features of diffuse optical monitors. Most commonly reported quantities are oxy- and deoxy-hemoglobin, water and lipid

<sup>1</sup> As a historical side-note, the spectra of oxy-hemoglobin in the infra-red was reported in the first article of the first volume of Physical Review Series I [3]. Special thanks to I J Bigio who has pointed this out.

Features	Accessible quantities
Functional physiology	Microvasc oxy-hemoglobin concentration (HbO <sub>2</sub> or HbO <sub>2</sub> )
Non-invasive	Microvasc deoxy-hemoglobin concentration (Hb or $\Delta$ Hb)
Fast (ms to sec)	Microvasc total hemoglobin concentration (THC or $\Delta$ THC)
Safe (no ionizing radiation)	Microvasc cerebral blood volume (CBV or $\Delta$ CBV)
Portable Instrumentation	Microvasc blood oxygen saturation (StO <sub>2</sub> )
Suitable for multi-modality use	Oxygen extraction fraction (OEF)
Relatively inexpensive	Microscopic lipid concentration
Deep tissue (1–5 cms)	Microscopic water concentration
Deep: Low resolution (0.5–1cm)	Microscopic scattering ( $\mu'_s$ )
Surface (100 $\mu$ m–1000 $\mu$ m)	Blood flow (BF or rBF)
Surface: High resolution ( $\mu$ m)	Cerebral metabolic rate of O <sub>2</sub> extraction (CMRO <sub>2</sub> or rCMRO <sub>2</sub> ) Oxidized cytochrome c-oxidase Contrast agent concentration

**Table 1: Salient features of diffuse optical monitors. “Microvasc” denotes “Microvascular”, prefix “r” implies “relative change” and prefix  $\Delta$  implies “differential change”.**



**Figure 1:** Photons undergo “random walk” in tissues with multiple scattering and absorption (“loss”). Two paths, (gray) ending up in absorption and (black) reaching the detector are shown. The “cloudlike” section illustrates the so-called “banana-pattern” which shows the most probable paths of photons that reach the detector. It can be calculated by the “three-point” Green’s function solution of the photon diffusion equation. The absorption ( $\mu_a$ ) spectra of main tissue chromophores in the microvasculature over a large wavelength range is shown on the left. The inset shows the so-called “physiological window” in the near-infrared where tissue absorption is low.

concentrations. This information is often combined to derive information about other physiological parameters such as blood volume and blood oxygen saturation. The scattering coefficient is also of interest and provides information about cell membranes, organelles, nuclei and surrounding fluids. Furthermore, the same approach could be used to measure the often time-dependent concentrations of exogenous contrast agents such as indocyanine green (ICG) which improve the contrast and/or specificity. To learn more about these and other applications, readers can consult recent reviews [5,6].

There are a multitude of approaches to diffuse optical instrumentation and in general two categories of instruments are utilized: (1) portable monitors that are used to acquire continuous data at few measurement points, and, (2) imaging devices that utilize many (tens to thousands) of source and detector positions. There are also many types of probes that were utilized demonstrating the versatility of the technology. Figure 2 shows il-

lustrations of three most common source types and various probe geometries.

In order to carry out imaging, complex image reconstruction algorithms are utilized to obtain two or three-dimensional tomographic images which are qualitatively similar to those obtained with X-ray computed tomography. Image reconstruction in diffuse optics, however, is a much more difficult process due to lossy, multiple scattering which often implies an ill-posed, under-determined system of simultaneous equations that need to be iteratively solved. In this case, many of the simplifying assumptions used in spectroscopy are relaxed and a more realistic model of position dependent optical properties are utilized. Tomography is critical in certain applications such as the identification of localized heterogeneities such as tumors in tissue and it often improves the quantification of the measurements [6].

In the clinics, diffuse optical methods were utilized for a variety of applications

[5, 6]. Here I highlight two common applications:

1) For optical mammography and oncology in general, diffuse optical probes have potential to enhance sensitivity and specificity of breast cancer detection/diagnosis by providing physiological information directly related to tumor vascularity and oxygenation. They offer great deal of promise for therapy monitoring since the destruction of vasculature and other similar mechanisms are at root of many cancer treatments. Furthermore, they offer promise for individualized therapy design since major therapies such as chemotherapy and photodynamic therapy rely on local oxygen to function which could be monitored by diffuse optical tools.

2) For neurology/neuroscience, they provide unique information about the microvasculature. Other modalities are either limited to the macrovasculature or are limited to few time-points since they require patient transport and expensive instrumentation. Diffuse optical

probes, on the other hand, can be utilized at the bed-side providing continuous, on-invasive and safe measurements of important physiological parameters such as the activation flow coupling and dynamic cerebral autoregulation.

Other applications include exercise medicine, peripheral vascular disease, cardiac surgery monitoring and oncology in general. They have also found numerous applications in pre-clinical studies on animal models. The biomedical diffuse optics field has also been branching into many other related and exciting areas of

applications ranging from optical coherence tomography to photoacoustic tomography. It is beyond scope of this tutorial to cover all but interested readers will find more information about these subjects in references.

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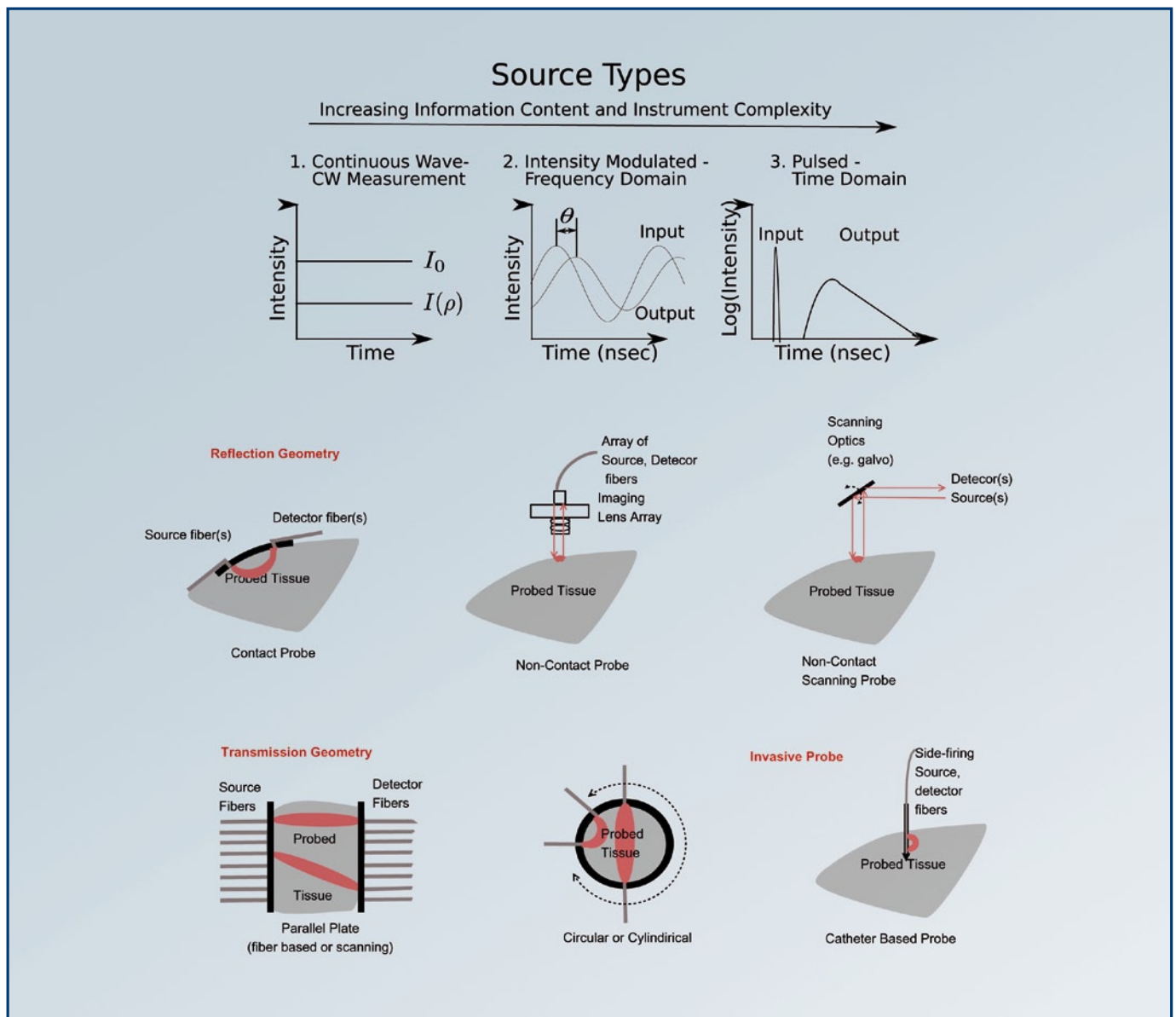


Figure 2: Most common types of sources and various types of probe geometries that are utilized in diffuse optics. Shaded red volumes illustrate, roughly, the probed volumes for a given sourcedetector pair.

# Women in Photonics – Careers with Obstacles

Nowadays women seem to be successful in many respects. They are overtaking men on the educational path, climbing the academic career ladder. As an example. 56 percent of university graduates in Germany are female, and 41 percent of doctorates are awarded to women. But there it stops: only about 15% are professors. This situation of women in academia and research can be found overall in Europe. It can be described as horizontal, vertical and contractual segregation: women are concentrated in certain domains, encounter problems climbing up the hierarchical ladder, and have poorer working conditions. Although the overall situation is progressing, the rate of growing will take until 2070 before any kind of parity is achieved [1]. Can we afford to wait? Four decades of research on the topic has shown that the under representation of women is an international problem with multiple causes. Most of these causes are “invisible”: only in the outcome we notice that women have fewer opportunities, but during their career, most women cannot point them out. This has led to the notion of “micro inequalities [2] that accumulate to form obstacles – in many cases even only the lack of advantages [3] – for women in science. It is not only the accumulation of small disadvantages that limits the possibilities for women in science. The ground-breaking study of Wenerås and Wold demonstrated that even when equally qualified women have lower success rate in selection and promotion procedures [4].

Among actual investigations in the fields that are connected to photonics, Elke Van Den Brandt from Vrije Universiteit Brussels [5] has realized a large survey that included more than 1.300 responses from male and female researchers in micro-optics from both public and private organizations and from different countries. ELke Van Den Brandt addressed 9 themes that give significant information on the status of women in optics: the current position,

career history, daily work activities, satisfaction, future ambitions, work values, work-family balance and perceived discrimination). The results are obvious and striking at the same time: Micro-optics is confronted with horizontal, vertical and contractual segregation. This cannot be explained by differences in career history or the ambition to move on. According to this study, women in optics follow similar career paths and are significantly more ambitious than their male counterparts. Obstacles in women’s careers are the lack of job security and promotion opportunities. Women also perceive significantly more discrimination than men and have less confidence in the fairness of selection and promotion procedures. Although not perceived as an obstacle, household responsibilities influence women’s careers.

In sum, these perceived obstacles lead to a low job satisfaction. Women are considerably less satisfied with their situation than men, and it is also correlated to the intent to turnover and the ambition to look for a job with a different employer. These correlations are stronger for women than for men: being dissatisfied is for women a greater obstacle than for men. If Europe wants to create a competitive knowledge society, it will have to face this challenge and start activities to include all available human capital. It is therefore also the task and aim of European networks of excellence as Photonics 4 Life (P4L) to improve the situation of female researchers in the field. Biophotonics is a vital field at the interface between biology, medicine and photonics. In view of the strong segregation of women in photonics, analyzing the situation of women in photonics therefore gives a first insight into the question, why only a limited number of women is active and successful up to the top as a scientist. Understanding the role of micro-obstacles, and the rise of dissatisfaction due to the lack of advantages, is essential in attracting and retaining female talent. P4L aims at identifying these reasons



Images from:  
Humboldt-Kosmos  
94/2009 and  
Fa. Intention, Bonn

particularly for the field of biophotonics, and subsequently implement measures to face the most important weaknesses in equal treatment. There is a vital interest in implementing these measures according to the surveys above: because women will only be attracted to a certain field if the obstacles are reduced and overall satisfaction is growing, including more women into scientific research will also improve the quality of science. And that is what all scientists in the field are eagerly are looking for – not waiting until 2070.

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## Contact

Cornelia Denz  
Westfälische Wilhelms-Universität Münster  
[denz@uni-muenster.de](mailto:denz@uni-muenster.de)

## Photonics4Life's first Biophotonics Summerschool – A Report

The 4th International Graduate Summer School on the beautiful island of Ven, Sweden, was also the first summerschool coorganized by Photonics4Life. It was held between the 6th and 13th of June 2009. Four hundred years ago Tycho Brahe built his famous observatory on this island. In that time the best scientists from all over Europe came to Ven in order to discuss recent inventions Tycho Brahe made. In 2009 Photonics4Life and its partners Stefan Andersson-Engels and Peter Andersen brought some of the best and well known scientists of the emerging field of Biophotonics to the island to discuss recent results in this field with 75 PhD students and young Postdocs. Photonics4Life supported three of the speakers and 21 of the attendees via the Photonics4Life Training Program.

The first lecture was given by Sune Svanberg who summarized the use of lasers in medicine. The next lecturer, Steven Jacques, introduced the field of Tissue optics where Monte Carlo simulations are used to model the diffusion of photons in highly scattering media. On that topic Steven Jacques also held interesting workshops. Katarina Svanberg gave an overview of Photodynamic Therapy. On the next day the students could listen to Hubert van de Bergh who explained how an idea can be turned into a final product used in the clinic. Roy Taylor explained the physical basics of supercontinuum light sources that open a wide range of biomedical applications.

On the first 3 days all participants of the Summerschool could present their recent results in evening poster sessions. All students and lecturers participated actively and used the opportunity to

have fruitful discussions. The next four lectures introduced optical techniques ranging from super resolution up to the centimetre scale. First Stefan Hell explained how it is possible to trace single proteins with STED microscopy. The next talk was held by Kishan Dholakia and his talk focused on light matter interaction. These effects are widely used in order to manipulate cells and nanoparticles with optical tweezers. The next lecture was given by Joseph Izatt. This was an overview of Optical Coherent Tomography which can be used to image the retina. The last lecturer of this block, Eva Sevcik- Muraca, presented the so called NIR-Fluorescence Tomography in order to screen the patient for lymphatic flow. Bruce Tromberg introduced another screening approach. He used structured light in order to extract optical properties from the tissue for differentiating cancerous tissue from healthy one. Finally, Darryl Bornhop gave a talk on backscattering interferometry for biomedical sensors. The Biophotonics Summerschool 2009 ended with a fantastic gala dinner where the girls were dressed with a flower ring following a Swedish tradition. The dinner started with the thanks to lecturers and the awarding of the poster prize. Sebastian Berning won with his poster about STED microscopy. After a traditional Swedish meal the evening ended with Cuban music and dance. On the departure day when all participants left the island of Ven, the students of the school said Goodbye to new friends. While staying on the island a lot of new ideas were born and collaborations were planned.

The 4th Biophotonics Summerschool brought every participant the insight of being a member of an emerging field of science.

## Photonics Europe Innovation Village

Brussels, Belgium – April 12–16, 2010

SPIE Photonics Europe will take place again in the week from 12 to 16 April 2010 at the Square Conference Centre in Brussels.

During this event, the 4th edition of the Photonics Innovation Village is organized by SPIE's organizing partner, the Vrije Universiteit Brussel. 21 innovative researchers were selected and receive a booth to demonstrate a prototype of their photonics-related product to the Photonics Europe visitors. We are proud to say that the constituting partners of P4L will be well represented. Researchers of Photonics 4 Life will participate in the Innovation Village, demonstrating an electro-photonics biochip. Furthermore, there will also be booths from P4L partners VUB (3 prototypes) and KIT (2), and from P4L associated partner IESL-FORTH (1).

The Brussels SPIE Student Chapter will organize 2 events as part of SPIE Photonics Europe 2010:

**Career event: Stop waffling and kick-start your career  
Tuesday, April 13th: 1 PM–5 PM**

During the Career Event companies have the opportunity to present their business to a young international audience and to meet possible future employees. Students following the interuniversity and Erasmus Mundus "Master in Photonics" programs in Flanders (Universities of Brussels and Ghent) will attend the event in the framework of their curriculum.

Participants will first receive a lecture on how to perform a good job interview. Afterwards the companies have the time to introduce themselves in a short slide show. To conclude, company representatives and young potentials will have the opportunity to further interact in break-out sessions, while enjoying an authentic Belgian waffle.

## Best practices for a successful future in photonics

Wednesday, April 14th: 1 PM–5 PM

The idea of this event is to give undergraduate students, PhD students and young professionals working in photonics the chance to get acquainted with the opportunities and possible threats when doing research in photonics.

The speakers will cover topics as communication within academic and non-academic fields, writing projects, intellectual property rights and of course research.

## Event Calender

(co-)organized by photonics4life  contribution from photonics4life partners

Date	Event	Location	Link
<b>March 2010</b>			
30 March	Dutch Photonic Event	Nieuwegein, Netherlands	<a href="http://www.photonics4life.eu/P4L/Events/Dutch-Photonic-Event">http://www.photonics4life.eu/P4L/Events/Dutch-Photonic-Event</a>
<b>April</b>			
11 – 14 April	Trends in Optical Micromanipulation II	Obergurgel, Austria	<a href="http://www2.i-med.ac.at/medphysik/ToM_II/index.html">http://www2.i-med.ac.at/medphysik/ToM_II/index.html</a>
11 – 14 April	Biomedical Optics (BIOMED)	Miami, USA	<a href="http://www.osa.org/meetings/topicalmeetings/BIOMED">http://www.osa.org/meetings/topicalmeetings/BIOMED</a>
12 – 14 April	SPIE Photonics Europe 2010	Brussels, Belgium	<a href="http://www.spie.org/photoniceurope">http://www.spie.org/photoniceurope</a>
<b>May</b>			
10 – 13 May	Annual Meeting of Photonics4Life	St. Andrews, United Kingdom	<a href="http://www.photonics4life.eu/P4L/Events/Annual-Meeting-of-Photonics4Life">http://www.photonics4life.eu/P4L/Events/Annual-Meeting-of-Photonics4Life</a>
<b>June</b>			
09 – 11 June	International Conference on Laser Applications in Life Sciences 2010	Oulu, Finland	<a href="http://www.ee.oulu.fi/LALS-2010/Summer_school/Summer_school.htm">http://www.ee.oulu.fi/LALS-2010/Summer_school/Summer_school.htm</a>
29 June – 01 July	EOS Conference on Laser Ablation and Nanoparticle Generation in Liquids (ANGEL 2010)	Engelberg, Switzerland	
<b>September</b>			
22 – 30 September	Biophotonics Week	Quebec, Canada	<a href="http://biophotonicsweek.biophotonicsworld.org/">http://biophotonicsweek.biophotonicsworld.org/</a>
<b>November</b>			
01 – 03 November	BioPIC 2010	Maynooth (Dublin), Ireland	<a href="http://www.photonics4life.eu/P4L/Events/BioPIC-2010">http://www.photonics4life.eu/P4L/Events/BioPIC-2010</a>

### Editor

European Network of Excellence for Biophotonics – P4L

### Coordinator

Prof. Dr. Jürgen Popp  
Institute of Photonic Technology (IPHT)  
Albert-Einstein-Straße 9  
07745 Jena, Germany  
juergen.popp@ipht-jena.de

### Network support officer

Dr. Thomas Mayerhöfer  
Institute of Photonic Technology (IPHT)  
Albert-Einstein-Straße 9  
07745 Jena, Germany  
thomas.mayerhoefer@ipht-jena.de

### Editorial staff

Dr. Timo Mappes  
Karlsruhe Institute of Technology (KIT)  
Dr. Georg Obermaier  
Karlsruhe Institute of Technology (KIT)

### Arrangement

Karlsruhe Institute of Technology (KIT)

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P4L Partners

IPHT	Institute of Photonic Technology Juergen Popp, juergen.popp@ipht-jena.de	Germany
UoM	University of Muenster Gert van Bally, Ce.BOP@uni-muenster.de	Germany
MESA+	University of Twente Vinod Subramaniam, v.subramaniam@tnw.utwente.nl	Netherlands
CNR IFAC	Istituto di Fisica Applicata "Nello Carrara" Roberto Pini, R.Pini@ifac.cnr.it	Italy
IOGS	CNRS Institut d'Optique graduate school Michael Canva, michael.canva@institutoptique.fr	France
VUB	Vrije Universiteit Brussel Hugo Thienpont, hthienpo@vub.ac.be	Belgium
USTAN	University of St. Andrews Kishan Dholakia, kd1@st.andrews.ac.uk	United Kingdom
IMPERIAL	Imperial College of Science, Technology & Medicine Mark Neil, mark.neil@imperial.ac.uk	United Kingdom
ICFO	The Institute of Photonic Sciences Niek van Hulst, niek.vanhulst@icfo.es	Spain
VTT	Valtion Teknillinen Tutkimuskeskus Markku Käsäkoski, markku.kansakoski@vtt.fi	Finland
KIT	Karlsruhe Institute of Technology Timo Mappes, timo.mappes@kit.edu	Germany
LLC	Lund Laser Centre Katarina Svanberg, katarina.svanberg@med.lu.se	Sweden
SSU	Saratov State University Valery Tuchin, tuchin@sgu.ru	Russian Federation

P4L Associated Partners

CSEM	Centre Suisse d'Electronique et de Microtechnique Peter Seitz, peter.seitz@csem.ch	Switzerland
FDG	Fondazione Don Carlo Gnocchi Furio Gramatica, fgramatica@dongnocchi.it	Italy
IESL-FORTH	Institute of Electronic Structure & LASER FORTH Maria Farsari, mfarsari@iesl.forth.gr	Greece
IHCP	Research Center Ispra Maurice Whelan, maurice.whelan@jrc.ec.europa.eu	Italy
DTU	Technical University of Denmark Peter Andersen, peta@fotonik.dtu.dk	Denmark
IMTEK	University of Freiburg Andreas Seifert, andreas.seifert@imtek.uni-freiburg.de	Germany
WUT	Wroclaw University of Technology Henryk Kasprzak, henryk.kasprzak@pwr.wroc.pl	Poland