

funded by the  
**European Commission**



### CONTENT

- 2 Editorial
- 3 Industrial User Club
- 4 Inside
- 8 Technology Breakthroughs
- 10 Tutorial
- 13 Entrepreneurship in Photonics
- 14 Events

Dear reader,

in your hands you hold the fourth Newsletter of the European Network of Excellence for Biophotonics PHOTONICS4LIFE (P4L). The third issue has been released right before the Photonics Europe in Brussels, where Biophotonics was the leading theme and Photonics4Life was active in manifold ways (see articles on pages 9 and 14).

Our most important news is however that we were assigned a very important task by the European Commission, which is to initiate a discussion on the scope of a possible ERA-NET PLUS on Biophotonics. An ERA-NET Plus is a research initiative which is co-funded by the European Commission and participating countries. The total funding available could be up to 30 million €. As a first step towards the ERA-NET PLUS action, Photonics4Life, together with Photonics21, will organize a Biophotonics concertation meeting. The purpose of this event is to bring together on-going EU projects on biophotonics and other interested stakeholders in order to present their achievements and also to create a shared vision concerning the needs for European biophotonics and the scope of actions which should be covered by an ERA-NET Plus on Biophotonics. There will also be a presentation on the upcoming photonics calls which will be of interest to those considering new Biophotonics proposals.

The concertation meeting will take place in Brussels at the 5th November, so mark this date in your calendar, if you would like to become part of this action. If you contact us in time, we would be delighted to provide you more information on this.

Best wishes, Juergen Popp



## P4L-Projects – 2<sup>nd</sup> Call

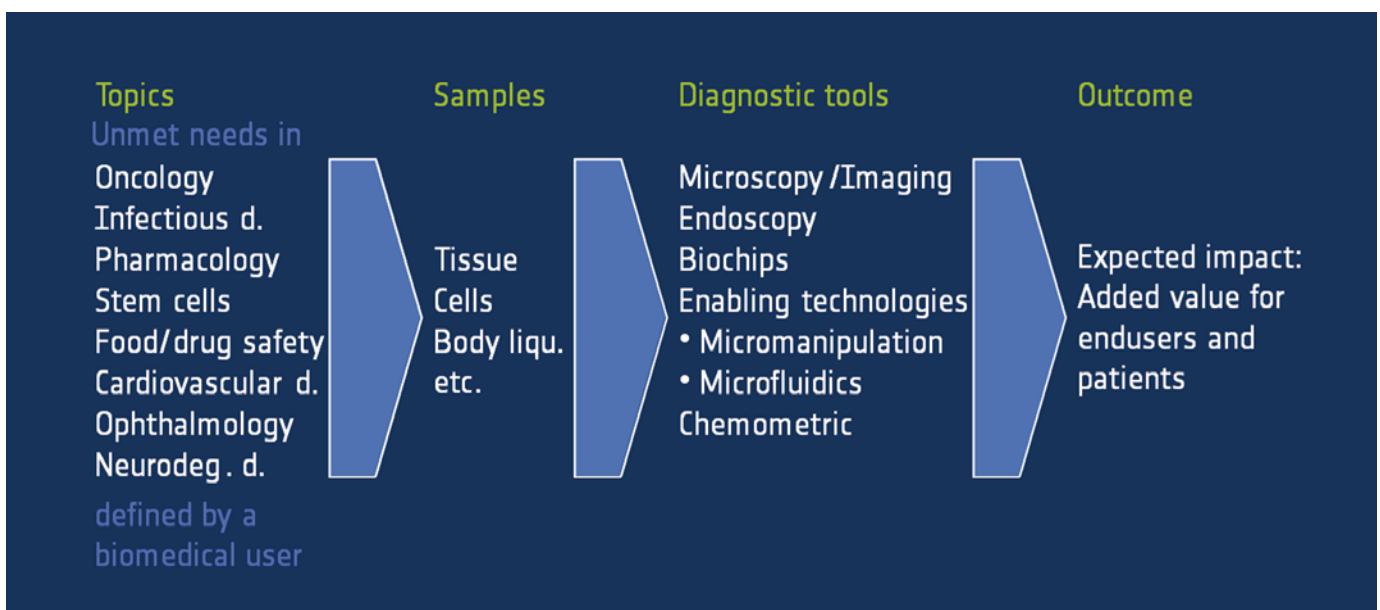
“P4L-Projects” are research projects within Photonics4Life that facilitate not only the cross-fertilization between the different partners but also between Photonics4Life and industry. They enable the partners to focus on their core expertise by coupling complementary capabilities. For the second call both the associated partners of P4L (see backside of the newsletter) and also companies were encouraged to participate.

P4L gives special preference to interdisciplinary projects to promote the breaking down of barriers between the different disciplines working in the field of Biophotonics and to generate direct benefit for the biomedical enduser and/or the patient according to the innovation chain (see figure).

The first two project proposals that were granted within the 2<sup>nd</sup> call are *Molecular mechanisms of tumor expansion – a multimodal imaging approach to evaluate human basal cell carcinoma* and *Skin tumor diagnosis by Optical Coherence Tomography*. They both employ different techniques but deal both with skin cancer and involve clinicians and consequently are merged. Project No. 3 *Holographic and AFM imaging of cells grown in hybrid scaffolds* aims towards the replacement of animal experiments which renders the project definitely relevant, especially as clinicians and a new Associated Partner (FORTH-IESL) are directly involved. *Cell growth stimulation by spatial and temporal photonic control of polymersomes* focuses on the controlled growth of neuron cells which is seen as a very relevant medical

challenge. This project also involves clinicians and an Associated Partner of P4L. Project No. 5 *Feasibility study for label free in-vitro toxicological hazard assessment* again addresses the problem that animal experiments will soon have to stop in the European Union. An unmet need is therefore clearly addressed and as a Associated Partner JRC IHCP is involved. The project *Quantification of the collagen organization in connective tissue by Second Harmonic Generation (SHG) imaging* aims at monitoring corneal diseases. The unmet need is already obvious from its title and as clinical partner the Ophthalmic Dept., Prato Hospital in Florence is participating. The project *Quantitative analysis of therapeutic nanoparticle induced hyperthermia* is dealing with gold nanoparticles. The speciality of this project is to explore if it is possible to destroy cancer cells selectively by an employment of optical tweezers. Project No. 8 deals with the assessment of food adulteration by fiber optic diffuse light absorption spectroscopy (*Fiber-optic diffuse-light absorption spectroscopy for food applications*). The last two projects are the first industrial projects in P4L – the first is called “*Generalized vibrational spectroscopy on a chip*”. The second industrial project aims to support the surgeon by optical guidance during cochlear implants surgery (*Fiber Optic Sensors as Guidance Tools for Intra-Cochlear Electrode Insertion: a Feasibility Study*).

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



# Industrial User Club

Besides structuring and integrating Europe's Biophotonics R&D activities, P4L wants to link the expertise of its members with SMEs and large companies, in order to stimulate Biophotonics innovation. Therefore, P4L's Industrial User Club (IUC) was established, as the short link between industrial companies and the academic partners in P4L. So far, 14 European companies became a member of the IUC. In chronological order, these companies are 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), Cochlear Technology Centre (Belgium), LLTech (France), Hamamatsu Photonics UK (UK) and JenLab (Germany).

In addition to the original advantages, which can be consulted on the following link (<http://industry.photonics4life.eu/Industry/Memberships/Benefits>), these companies can take part in a P4L Industrial Project. Cochlear is the first company to benefit from this opportunity: The industrial P4L project entitled "Fiber Optic Sensors as Guidance Tools for Intra-Cochlear Electrode Insertion: a Feasibility Study" is a collaboration in which 3 P4L partners (VUB, USTAN, IPHT), one associated partner (IMTEK) and Cochlear have

joined forces. The project, which started at August 1<sup>st</sup>, aims to determine the technological and economical feasibility of integrating a fiber optic sensor (either a shape sensor or an imaging probe) in the electrode array of a Cochlear implant to facilitate its insertion.

In the context of the IUC, we are also looking forward to welcome Visolas, a future spin-off from P4L partner KIT that develops a tunable visible organic laser for biophotonic applications. At the same time, this is also the first supported business project by the P4L consortium. In order to prepare this start-up, a representative from KIT participated in our Intensive Training "Entrepreneurship in Photonics" (see page 13).

If you would like to join the P4L IUC, please consult the following link <http://industry.photonics4life.eu/Industry/Memberships/How-to-join>, or contact the P4L IUC officer Tom Guldemont at [tguldemo@b-phot.org](mailto:tguldemo@b-phot.org).

## Contact

Tom Guldemont  
Vrije Universiteit Brussel (VUB)  
[tguldemo@b-phot.org](mailto:tguldemo@b-phot.org)  
<http://industry.photonics4life.eu>



**analytikjena**

**avasha**

advanced optical and  
photonic engineering



Hear now. And always Cochlear™

**COSINGO**  
Imagine Optic Spain S.L.

**Elliot Scientific**  
for research and industry



**HAMAMATSU**  
PHOTON IS OUR BUSINESS

**inject**

**JenLab**

**LLTECH**  
LIGHT FOR LIFE TECHNOLOGIES

**Luminostix**

**modulight**  
on your wavelength

**monocrom**  
LASER DIODE DEVICES

# The Institute of Photonic Sciences (ICFO)

ICFO-The Institute of Photonic Sciences was created in 2002 by the government of Catalonia and the Technical University of Catalonia. ICFO is a center of research excellence devoted to the sciences and technologies of light. The Institute carries out frontier research and trains the next generation of scientists and technologists. ICFO actively collaborates with many leading research centers, universities, hospitals, and a range of private companies based locally and all over the world.

ICFO currently hosts 19 research groups working in more than 50 different laboratories. Available to them are a Nanophotonics Fabrication Lab, a Super-resolution Light Microscopy & Nanoscopy Lab, an

nanophotonic devices, remote sensors, optoelectronics, integrated optics, ultra-fast optics, biophotonics, and biomedical optics. Projects are run as part of both medium- and long-term programs. ICFO performs cutting-edge research both in fundamental and applied fields. The Institute carries out world-class science and regularly publishes high-impact results in prestigious international journals. As for applied research, ICFO has registered a significant number of patents and actively promotes the creation of spin-offs by its researchers.

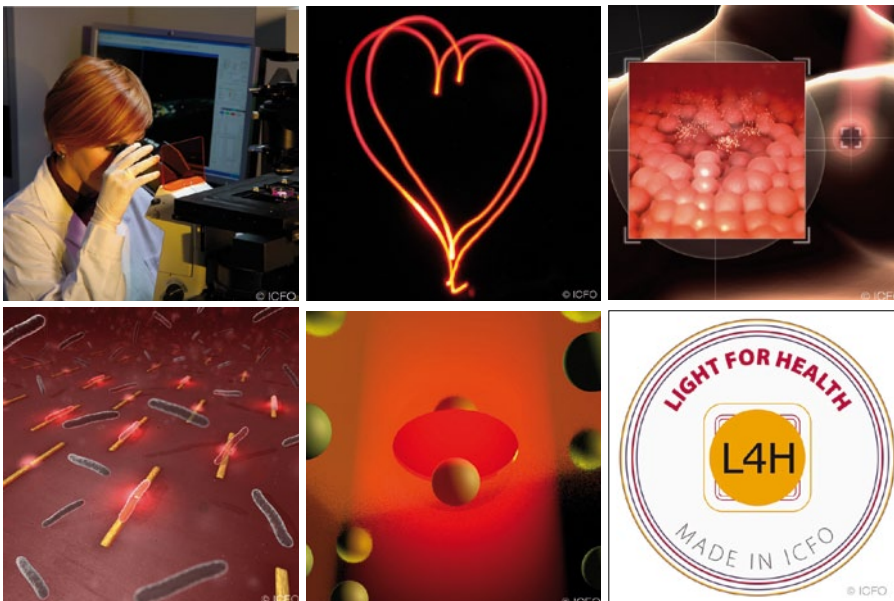
Currently, ICFO counts about 200 researchers, a number that is continuously growing. By 2014, when ICFO completes

therapies. Examples include photodynamic cancer therapies, pulse oximetry, laser surgery, near infrared spectroscopy, optical coherence tomography, advanced microscopy, and laser treatments in dermatology.

ICFO conducts research and development at the cutting-edge of biophotonics and nanophotonics, with a special focus on imaging modalities and techniques that aim at continuously breaking the limits of resolution (both spatial and temporal). Ongoing programs include a variety of advanced multiphoton and fluorescence techniques, single-molecule approaches, pioneering near-field nanoimaging, plasmonics and nanoantenna approaches, Raman imaging, photothermal imaging, and diffuse optical imaging, among others. ICFO also hosts several programs in nanosurgery, neuro-intensive care monitoring, plasmonic oncology, and dermatology.

## Light for Health Program

ICFO recently created the **Light for Health Program** and sets its sights on bringing forward developed photonic techniques to the outside world especially in the life sciences and agro food area. ICFO collaborates with hospitals, health-care centers, biomedical research centers, universities, medical institutes and companies, acting as the local BioPhotonics Hub. The program focuses on establishing links and joint projects with local and international biomedical industries, organizing workshops, schools and conferences, as well as spin-off generation, dissemination and outreach activities.



Advanced Engineering Lab and a range of other support facilities. All research groups and facilities are located in a dedicated 10.000 m<sup>2</sup>-building situated in the Mediterranean Technology Park in the metropolitan area of Barcelona.

Research at ICFO encompasses four broad thematic areas: nonlinear photonics, quantum photonics, nanophotonics, and biophotonics. Our researchers work in a great variety of fields, including quantum information technologies,

its ongoing expansion phase, the Institute is to count more than 300 researchers working in 25 different research groups.

## Biophotonics at ICFO

In part with support from Fundació Cellex Barcelona, ICFO has been involved in a range of activities aiming to harness the power of photonics for improving human health. Photonics plays an increasing role in a variety of medical techniques and practices, including non-invasive diagnosis, advanced imaging, and non invasive

## Contact

Niek van Hulst  
 ICFO – The Institute of Photonic Sciences  
[niek.vanhulst@icfo.es](mailto:niek.vanhulst@icfo.es)  
[www.icfo.es](http://www.icfo.es)

# Vrije Universiteit Brussel (VUB)

The Vrije Universiteit Brussel (VUB) is a middle-sized but complete university located in Brussels, Belgium. It was formed in 1970 as the Flemish offshoot of the French-speaking Université Libre de Bruxelles. The biophotonics research within the Faculty of Engineering at VUB focuses on micro-photonics and medical imaging.

## Micro-photonics

In the field of micro-photonics, the Brussels Photonics Team (B-PHOT) of the Department of Applied Physics and Photonics works on the development of low-cost plastic microminiaturized systems for biochemical analysis. These photonic labs-on-chips aim at measuring the absorption and fluorescence of molecules in micro-fluidic channels. For the development of these systems B-PHOT can rely on its expertise in micro-photonics, including its micro-optical design platform, its Deep Proton Writing prototyping technology, and its large-scale micro-optical measurement centre in clean room conditions. Photonic labs-on-chips open opportunities for point-of-care diagnosis, environmental monitoring, food and drinking water quality testing and industrial analysis such as the monitoring of degradation of lubricant oils in industrial machinery.

Another topic at B-PHOT is the use of Micro-Structured optical Fibers (MSFs) featuring Bragg gratings for biomedical sensing applications. A first application is the monitoring of multi-axial stress build-up in dental resin cements due to a

polymerization shrinkage of the material system. MSF sensors are also integrated in flexible and stretchable polymer sheets to create skin-like structures which are sensitive to various degrees of touch, pressure and deformation. These artificial photonic skins open opportunities for respiration and cardiac activity monitoring as well as for the detection of pressure points under bed-ridden patients. Finally the use of MSFs for imaging and shape sensing in minimally invasive medical procedures is investigated.

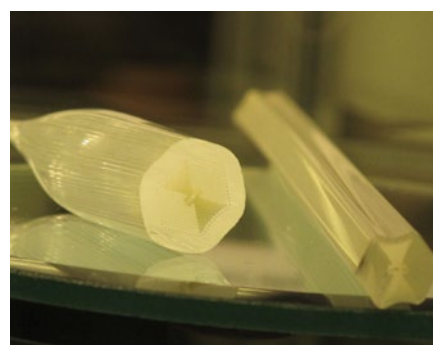
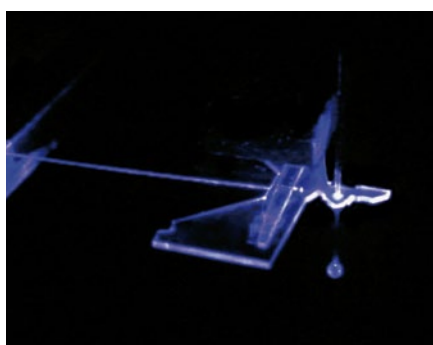
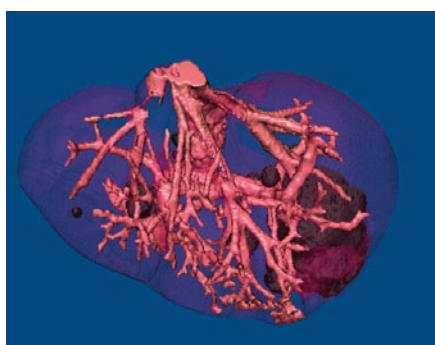
## Medical imaging

The Image Processing & Machine Vision (IRIS) group of the Department of Electronics and Informatics focuses on several topics in the field of medical imaging. A first topic is the development of automated image processing schemes for the extraction of biomedical parameters to quantitatively assess the presence or evolution of a disease and for "Content Based Search" which deals with searching and correlating data spread over heterogeneous databases. IRIS has a significant expertise in compression of data resorting from various imaging modalities. Another core competence of IRIS is the behavioral analysis and recognition of activities of elderly and the correlation of these data with various health parameters such as biochemical analytes to determine the health state of the patient. Finally IRIS also works on the characterization of the anatomy of the brain surface, fusion and compression of medical imaging data.

IRIS has a close collaboration with the In vivo Cellular and Molecular Imaging Center (ICMIC), which is an interdisciplinary centre that studies the development and validation of innovative in-vivo imaging technologies. To this end ICMIC has centralized multiple small animal imaging modalities including a pin-hole gated-SPECT camera, a micro-CT scanner, an echocardiography and a bioluminescence instrument together with a unit for probe development and a vivarium for the housing of animals. One of the current research topics is the combination of non-invasive optical imaging technologies such as bioluminescence imaging and fluorescence imaging with autoradiography techniques. The additional registration of photons in the visible spectrum that are generated through an enzymatic reaction in genetically modified cells will open new applications in the field of molecular imaging.

## Contact

Hugo Thienpont  
Vrije Universiteit Brussel (VUB)  
[hthienpo@vub.ac.be](mailto:hthienpo@vub.ac.be)  
[www.b-phot.org](http://www.b-phot.org)  
[www.etro.vub.ac.be](http://www.etro.vub.ac.be)  
[web.mac.com/appletlc/ICMI\\_Brussel](http://web.mac.com/appletlc/ICMI_Brussel)

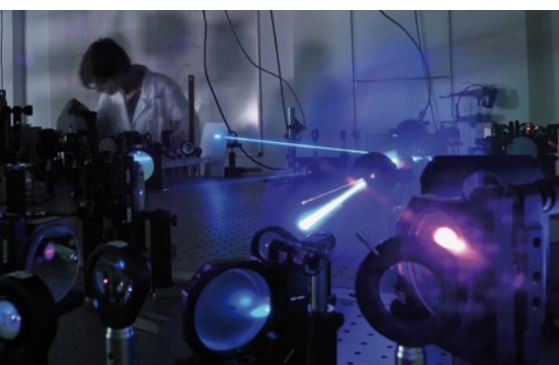


## Associated Partner – Institute of Electronic Structure and Laser (IESL)

The Institute of Electronic Structure and Laser (IESL) was established in 1983 as part of the Foundation for Research and Technology – Hellas (FORTH), also established in 1983. FORTH is one of the largest research centres in Greece with well – organized facilities and highly qualified personnel. It consists of seven Research Institutes located throughout Greece: Heraklion, Rethymnon, Patras and Ioannina.

The research of IESL focuses on fundamental and applied issues related to materials science and technology and laser interactions with matter. The research activities are centred on two major areas:

- Interactions and Photonic Division
- Materials and Devices Division



IESL is part of the LaserLab Europe, and houses the Ultraviolet Laser Facility (ULF-FORTH), a multi-disciplinary scientific laboratory dedicated to laser-based science, supporting high quality basic and technological research. There is a strong interplay in research activities within the above fields with emphasis on crossing the borders between physics, chemistry and biology. Training and education through research and the exploitation of technologically mature applications are equally important priorities.

In the field of Biophotonics, there are three main activities: In-vivo Optical Imaging, Non-linear Microscopy, and Tissue Engineering.

The **In-vivo Optical Imaging** activities concern the design, development and application of tomographic technologies for in-vivo imaging in living systems and tissue samples. There is particular interest in the non-invasive visualization of specific molecular targets and pathways by exploiting the fluorescence signal emitted by fluorescent probes attached to cells or molecules. An important aspect of the research concerns the analysis of images obtained by the system and representing three-dimensional maps of fluorescent concentration in whole animals. This technique, which is called *Fluorescence Molecular Tomography (FMT)* can measure and characterize specific molecular processes, and thus answers can be given in particular biological questions concerning disease development, cell function, gene expression and drug delivery. Similar approaches are also being implemented by the group towards microscopy imaging by using *Optical Projection Tomography (OPT)* to image in-vivo at the sub mm range. In addition, theoretical research concerning the development of novel theoretical tools for the accurate modeling of light propagation in tissue-like media is one of the key developments of the group.

**Non-linear Microscopy** techniques represent the forefront of research in cell biology. These modalities comprise a powerful tool for elucidating structural and anatomical changes of biological samples and for probing functions and developmental processes in vivo at the microscopic level. The investigation of in vivo cellular and sub-cellular activities, by means of these non linear imaging techniques, can provide novel information related to fundamental biological problems, leading to the development of innovative methodologies for the early diagnosis and treatment of several diseases. Research interests at IESL-FORTH concerns the in vivo elucidation of molecular mechanisms and biological processes at the sub-cellular level

using non linear (TPEF-SHG-THG) imaging microscopy measurements. Femtosecond laser pulses are utilized for excitation.

In **Tissue Engineering**, research is focused on the implementation of laser based micro- and nano-processing methodologies for the engineering of 3-dimensional (3D) biomaterials or materials relevant to tissue engineering applications. The principal objective is to investigate the potential use of the fabricated structures as scaffolds for tissue regeneration. The techniques deployed include two-photon polymerization (2PP), ultrafast laser micro/nano structuring (ULMNS) and Laser Induced Forward Transfer (LIFT). Combinations of the 3D scaffolds obtained with well-defined biodegradable nanostructures in a “scaffold on scaffold” format are additionally investigated. The influence of the topographical features of the fabricated scaffolds on cell behaviour, related to viability, proliferation, motility, adhesion, morphology, cytoskeletal arrangement and gene expression, is examined. Furthermore in each case, control over the topography and surface chemistry of the prepared structures is demonstrated which allows further study of cell response and its dependence on the surface energy of the scaffold. The aforementioned studies on the bioactivity of the fabricated scaffolds were performed by culturing various types of cell lines as well as primary neurons and stem cells. The ultimate goal of the research team is to examine potential medical and/or clinical applications of optimized artificial tissue scaffolds.

### Contact

Maria Farsari  
Institute of Electronic Structure and  
Laser (IESL) – FORTH  
[mfarsari@iesl.forth.gr](mailto:mfarsari@iesl.forth.gr)  
[www.iesl.forth.gr](http://www.iesl.forth.gr)

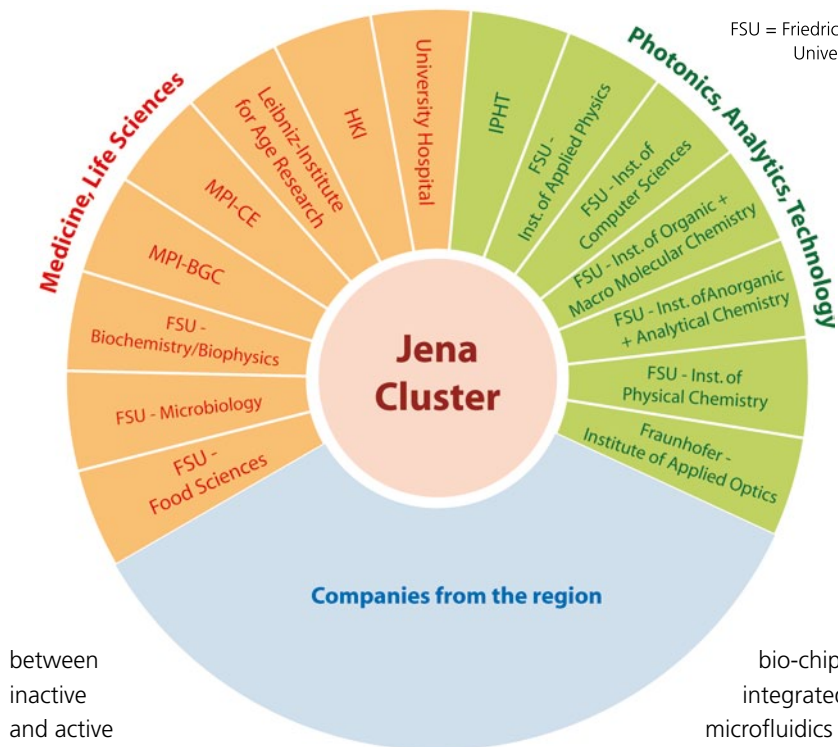
# Local Cluster Jena

The IPHT and its partners are mainly active in three core areas of Biophotonics:

- Health care research
- Life Science research
- Development of advanced Biophotonic tools

Most of the collaborations base upon the renowned expertise of the IPHT in optical spectroscopy such as linear and non-linear Raman spectroscopy. The unique ability to provide information on molecular structures of a sample without the use of dyes makes this technique a versatile tool in manifold applications.

Together with various departments from the University Hospital Jena the IPHT works on new methods and applications for improving the well-being of patients. In oncology, the focus is on developing methods to improve detection of cancer, because the success of therapy generally depends crucially on the early initiation of therapy. Conventional Raman Spectroscopy can tell healthy from cancerous tissue, but the disadvantage is the low sensitivity. Therefore Coherent Anti-Stokes Raman Spectroscopy (CARS) is used, where a second laser is used to increase the signal. There is an especially strong cooperation in Jena in the field of detecting brain and intestinal tumours. The partners also develop techniques that allow a more accurate determination of tumour boundaries in-vivo and thus make an almost complete, but still gentle removal of the tumour possible. With the Clinic for Anesthesiology and Intensive Care the IPHT is developing methods for rapid and accurate determination of Sepsis pathogens and their resistances (preferably within 1 h) by using the molecular fingerprint obtained by spectroscopy. Furthermore the partners also work on ways to quickly and accurately determine the host response with Biophotonic techniques. In other projects with the departments of cardiology and neurology, tasks are to distinguish



FSU = Friedrich Schiller University Jena

between inactive and active arterial plaques and to visualize neuronal activity. Together with the Jena Biochip Initiative (JBCI), the Centre for Molecular Biomedicine and the Max Planck Institute for Chemical Ecology (MPI-CE) the IPHT is well involved in developing chip-based analytical and diagnostic procedures, e.g. for the detection of pathogens in air, food and liquids.

With the research findings from the various projects from the cluster the IPHT and its partners together with companies from the region like Carl Zeiss AG or Analytik Jena strive to develop better Biophotonic tools in the area of advanced microscopic and spectroscopic devices. In addition, the IPHT focuses together with the institute of applied physics (FSU) and the Fraunhofer institute of applied optics on the development of novel laser sources with desired spectral properties, including those with a tunable frequency range (e.g. fibre lasers). Another focus area of the IPHT together with the institute of physical chemistry (FSU) and the centre for Molecular Biomedicine (FSU) are

bio-chips with integrated microfluidics and spectroscopic abilities.

The aim of these technologies in addition to the realization of robust, portable and low-cost analytic systems is the development of new features that are out of reach with today's technologies and that minimize the detection limits. Critical success factors for new detection systems are sensitivity, specificity and robustness of the evidence, but also the cost per information, the time from sampling to result, and the ability to capture multiple parameters in parallel.

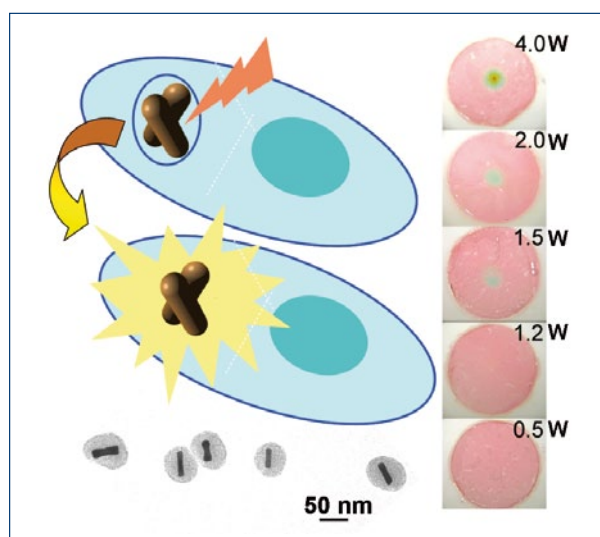
Solutions in Biophotonics can arise only through close cooperation as a lack of interdisciplinarity has been proven to be the major stumbling block in practice. The IPHT in Jena has successfully overcome this lack through manifold collaborations with other local players.

## Contact

Juergen 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)

# Nanoparticles to Fight Cancer: Laser Activatable Gold Nanorods and Nanoshells

The Project “NIR-laser-activated gold nanoparticles: perspectives in minimally invasive diagnosis and therapy” was a cooperation between CNR, SSU, IMPERIAL, MESA+ and ULUND to investigate the potential of near infrared (NIR) sensitive nanoparticles for cancer treatment. These nanoparticles are designed for systemic



**Scheme of cell treatment with gold nanorods. Insets: TEM of gold nanorods with a silica jacket and photographs of gold nanorods-chitosan films upon NIR irradiation**

injection into the body, spontaneous accumulation into the tumor, and efficient generation of radiative and non radiative effects of diagnostic and therapeutic relevance upon excitation with NIR light. The optical properties of these nanoparticles originate from plasmon oscillations, which is an interface effect. Aqueous suspensions of gold nanorods and nanoshells were self-assembled by overgrowth of gold seeds, uniformly adsorbed onto silica beads or incompletely coated with a cetrimonium surfactant, to obtain shells (~100 nm diameter × 15 nm thickness) or rods (~60 nm length × 15 nm diameter). Thereafter these nanoparticles were coated with a variety of functional jackets, such as biopolymers, minerals, organic dyes and biological macromolecules to enable active delivery to the tumor.

We demonstrated the potential of gold nanorods and nanoshells as novel contrast agents for two photon luminescence and fluorescence lifetime imaging. In contrast to their macroscopic counterpart, gold nanorods and nanoshells exhibit decent luminescence on excitation with blue and violet light, with ultrafast decay

(~50 fs)<sup>[i]</sup>. This, in association with their extreme two photon absorbance at NIR frequencies, results into two photon luminescence action cross sections as high as ~108 GM<sup>[ii]</sup>. We proved stable two photon luminescence imaging down to below 5 µg ml<sup>-1</sup> gold nanorods in polyvinyl alcohol (1 mW, 800 nm), with lifetime below the ps regime, which is another timescale from body components, i.e. ~1 ns. These results may be exploited for cancer diagnosis and imaging.

We undertook the combination of gold nanoshells with an organic sensitizer such as Indocyanine Green (ICG) (at a rate of ~10 µg ml<sup>-1</sup> ICG per 40 µg ml<sup>-1</sup> metallic gold), as a prototype of drug delivery and multifunctional carrier. Since the plasmon oscillations of gold nanoshells overlap the optical absorbance of ICG, this architecture enables simultaneous photothermal conversion and ROS generation on excitation with NIR light, which was tested to treat different models of bacteria. While at present no synergistic effect was observed due to net quenching of ROS generation, bleaching of ICG may benefit from substantial retardation<sup>[iii]</sup>.

Gold nanorods and nanoshells may tend to flocculate in biological fluids, which

may be incompatible with intravenous injection. PEGylation of these nanoparticles proved effective to prevent flocculation, while enabling their bio-conjugation. However even under ideal conditions, the colloidal stability of nanoparticles may be impaired by biological pathways such as endocytosis, which induces hybridization of plasmon oscillations and loss of optical properties. Silanization proved ideal to gain steric hindrance and prevent detrimental interference of the plasmon oscillations, which was verified in innovative models of aggregation. Another issue on gold nanorods and nanoshells is their stability on NIR laser irradiation under conditions useful for cancer imaging and therapy. Nanoparticles were dispersed into bio-mimetic polyvinyl alcohol and chitosan, and then irradiated under different regimes of biomedical interest. Statistical modifications were assessed by spectromicroscopy in an attempt to correlate optical and geometrical parameters. At present, we are drawing thresholds for photothermal damage (typically above 10 W cm<sup>-2</sup> and 200°C), which is paramount in view of hyperthermic applications.

- [i] M.B. Mohamed, V. Volkov, S. Link, M.A. El-Sayed, *Chem. Phys. Lett.* 317, 517 (2000).
- [ii] P. Zijlstra, J.W.M. Chon, M. Gu, *Nature* 459, 410 (2009).
- [iii] C.D. Geddes, H. Cao, J.R. Lakowicz, *Spectrochimica Acta Part A* 59, 2611 (2003).

## Contact

Fulvio Ratto and Roberto Pini  
Istituto di Fisica Applicata  
“Nello Carrara”, Consiglio Nazionale  
delle Ricerche (IFAC-CNR)  
[r.pini@ifac.cnr.it](mailto:r.pini@ifac.cnr.it)

## Optofluidic Dye Laser in a Foil

Optofluidics covers liquid-based optical and photonics elements or components. Optofluidic lasers are miniaturized liquid dye lasers emitting visible light. They may be used as light sources for integrated optics or integrated photonic sensor systems. For bringing optofluidic lasers to markets fabrication technologies suitable for mass production must be used. In addition, a reduction of material costs is desired. Thermal nanoimprint and thermal bonding of all polymer devices is a promising approach to fulfill both requirements.

In the course of a cooperation project of the KIT young investigator group headed by Dr.-Ing. Timo Mappes with the group of Prof. Anders Kristensen from the Technical University of Denmark, KIT's Ph. D. student Christoph Vannahme has now succeeded for the first time in producing a laser embedded in a foil of 350  $\mu\text{m}$  in thickness only, which reaches a much higher power than conventional lasers.

In a parallel process that is easy to transfer to industrial fabrication, laser production on the chip starts by providing a TOPAS® (Cyclic Olefin Copolymer (COC)) foil with a combination of nano- and microstructures. This is accomplished by embossing grating structures with a pe-

riod of 185–190 nm via thermal nanoimprint using a stamp. After covering this structure with another foil of the same material by thermal bonding, a microchannel of 1.6  $\mu\text{m}$  in height and 0.5 mm in width with nanostructures bottom is obtained. When passing a liquid dye through this channel and optically pumping it, laser light is generated as a result of the Bragg-reflection in the grating structure at the bottom of the channel. The period of this grating determines the wavelength of the emitted laser light. Using two different periods, different laser wavelengths can be obtained with the same liquid (e. g. 566 nm and 581 nm). The channel design allows for high pulse energies of more than 1 micro-joule and small bandwidths of the laser light. As the liquid is pumped through the microchannel, the dye molecules are exchanged constantly and very long service lives are reached. The results were published in *Optics Express* 18 (9): 9280–9285. This is yet another step towards versatile polymer based lab-on-a-chip systems with multicolor lasers on chip.

### Contact

Timo Mappes  
Karlsruhe Institute of Technology (KIT)  
[timo.mappes@kit.edu](mailto:timo.mappes@kit.edu)



## P4L members score highest at international innovation competition

This year's SPIE Photonics Europe Conference in Brussel on 12–16 April 2010, was very well attended by 2,150 researchers. Here the Photonics Innovation Village served as showcase of creative technology demonstrations developed by universities and research centres. Among the 21 demonstrations on display from 12 countries, three P4L members received critical acclaim from a jury in an associated competition - proving the high innovation potential of the P4L network. The first place was given to Thomas Woggon from Karlsruhe Institute of Technology (KIT) for VISOLAS, a tunable visible organic laser for spectroscopy. Woggon was a participant of P4L's intensive training entrepreneurship (compare report on page 13).

The first runner-up in the competition was Lawrence Bogaert of Vrije Universiteit Brussel (VUB) with ISIS<sup>3D</sup>, an Image Steering Integrated Screen for 3D imaging. Maria Farsari, ISEL-FORTH, won the second runner-up prize with photosensitive materials for two-photon polymerization.

Nature Photonics reported in details about the success of these three P4L members:

<http://dx.doi.org/10.1038/nphoton.2010.145>

# Fast and Efficient Detection of Pathogens Using Raman Spectroscopy and Chip-Based Methods

Robert Möller, Petra Rösch and Jürgen Popp

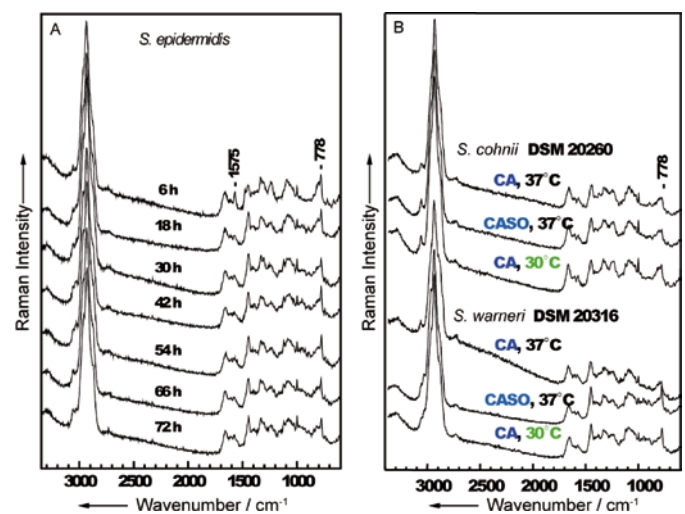
The detection and identification of microorganisms is not only of high relevance for a variety of medical applications, rather it has become an important analytical task in many fields like food production, environmental applications, biotechnology and many more. By identifying microorganisms, disease causing agents or microbial contaminations in food or environmental samples can be confirmed. With the ever growing knowledge about the importance of microorganisms in our everyday life the demand for fast detection methods grows continuously. However, the microbiological standard methods of cultivating microorganisms on selective media are time consuming. Often cultivation results are achieved after 3–14 days, which is not sufficient for many analytical tasks, where a fast (within hours) identification would be necessary. Because of those shortcomings of the established methods, immunological methods, e.g. ELISA, and biochemical methods, e.g. PCR have been adapted for the identification of pathogens. With these methods a faster identification, usually within 1 or 2 days can be achieved within a specialized laboratory.

Because of the high demands on the selectivity, specificity and speed of the analysis optical methods can play a major role in detection of pathogens. A further advantage of optical methods is that measurements are normally non-destructive and non-contacting<sup>1</sup>. Especially vibrational spectroscopic methods e.g. Raman spectroscopy have a tremendous upside, as specific spectra can be used for the identification. Besides the identification of substances Raman spectroscopy is especially interesting for the analysis of biological samples, because many solvents and particular water show only a very weak Raman signal. By combining a

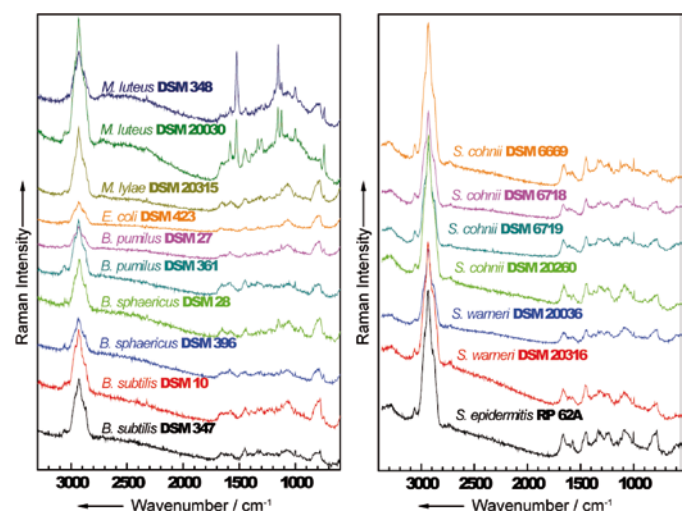
Raman setup with a microscope a device with a high spatial resolution is created. Such a micro Raman setup allows a spatial resolution in the sub  $\mu\text{m}$  range, which is small enough to collect Raman spectra from a single bacterium.

Using a micro Raman setup extensive chemical information can be collected, which can be used for the characterization and identification of pathogens on molecular level. The collected spectra are sum spectra over the entire components of the bacteria cell. Because of differences in the composition each strain of microorganisms possesses a specific molecular and therefore spectral fingerprint, which can be used for the characterization and identification of single microorganisms via Raman spectroscopy<sup>2–4</sup>. Furthermore differences in the composition, due to the growing phase and condition, can be displayed in Raman data.

As the changes in the molecular composition are often subtle multivariate statistical data analysis tools are used for the characterization. Such analysis



**Fig 1: Characterization of growing phase and condition by Raman spectroscopy, (A) with an ongoing cultivation of *S. epidermidis* changes in the Raman spectra can be detected, which can be used for the identification of the growing phase. (B) The cultivation of *S. cohnii* and *S. warneri* in different media (CA-Corynebacterium agar; CASO-Trypticase soy yeast extract) and by different temperatures can also be identified by Raman spectroscopy<sup>2</sup>.**

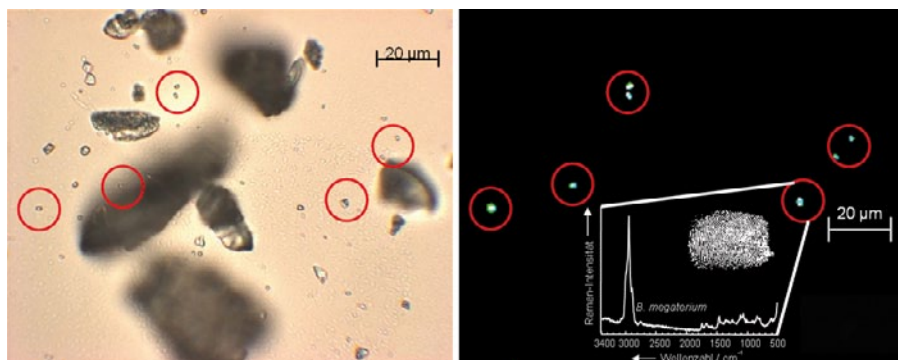


**Fig 2: Identification of bacteria using Raman spectroscopy, because of differences in the composition each strain of microorganisms possesses a specific molecular and therefore spectral fingerprint, which can be used for the characterization and identification of single microorganisms via Raman spectroscopy<sup>2–4</sup>.**

algorithms are fundamental for the classification of the measured spectra to a certain species or strain of pathogens. To realize such a classification a databank with reference spectra is necessary. Based on those reference spectra together with the appropriate chemometrics (statistical analysis tools) a classification of unknown pathogens can be achieved<sup>5, 6</sup>. The use of this method for the identification and classification of pathogens is highly specific and achieves recognition rates of 90 % and higher on strain level.

As single cells of pathogens are identified using this method, time and labour consuming steps of cultivation are not necessary anymore and an analysis can be performed directly with a given sample. However, a sample usually consists of a complex matrix containing all kinds of abiotic and biotic particles. And normally only a very small number of those particles are of interest for an analysis via Raman spectroscopy. So in order to achieve a fast identification of pathogens in a complex sample an identification method for the particles of interest would be helpful. This can be realized via a simple fluorescent staining. This staining allows differentiating between abiotic and biotic as well as live and dead pathogens. This differentiation speeds up the investigation of the sample as now only a small portion of the particles needs to be investigated via Raman as only the live and/or dead pathogens are of interest.

However, fluorescent signals are usually 5 to 6 orders of magnitude stronger than Raman signals and a combination of Raman and fluorescence is only possible if one uses fluorescent dyes with specific properties. The chosen fluorescent dyes are not excited by the used laser for the Raman analysis. For the staining of live bacteria SYTO 9 was used, which is only enriched in living bacterial cells. In a first step all living pathogens are identified using this fluorescent labelling. In a second step the selected particles can be analysed using the above described procedure, using a Raman laser for the analysis that does not excite the selected dye<sup>7, 8</sup>. With such a simple staining



**Fig 3: Identification of bacteria combining fluorescence and Raman spectroscopy. In a complex sample (left) the particles of interest are defined by a fluorescence staining and are identified by their specific Raman spectra (right).**

method it is possible to identify living and dead biotic particles in a complex sample, allowing the fast and specific identification of pathogens without any extensive sample preparation steps, as they are usually necessary for other methods of identification.

The fast and specific identification of pathogens has been successfully demonstrated on a variety of different samples in gases, fluids and solids and also eukaryotic cells have been investigated<sup>9</sup>. With industrial partner this technology will be further developed, to realize a highly automated system for the specific identification of pathogens via Raman spectroscopy.

Besides the fast and specific identification of pathogens another trend in the development of analytical tools is the development of technologies for onsite or point-of-care detection. One of the most discussed solutions for these problems is the use of biochips or microarrays. Such a biochip consists of a solid substrate (glass, silicone, etc.) on which capture molecules are bound in an order fashion. By incubating such a chip with a sample the molecules in the sample bind to their complementary capture molecules on the chip<sup>10, 11</sup>. To analyse this biomolecular recognition event many different methods have been described. The most dominant method today is fluorescent labelling. Through the incorporation of a fluorescent dye into the complex of capture and target molecule the binding becomes detectable. Because all the capture mol-

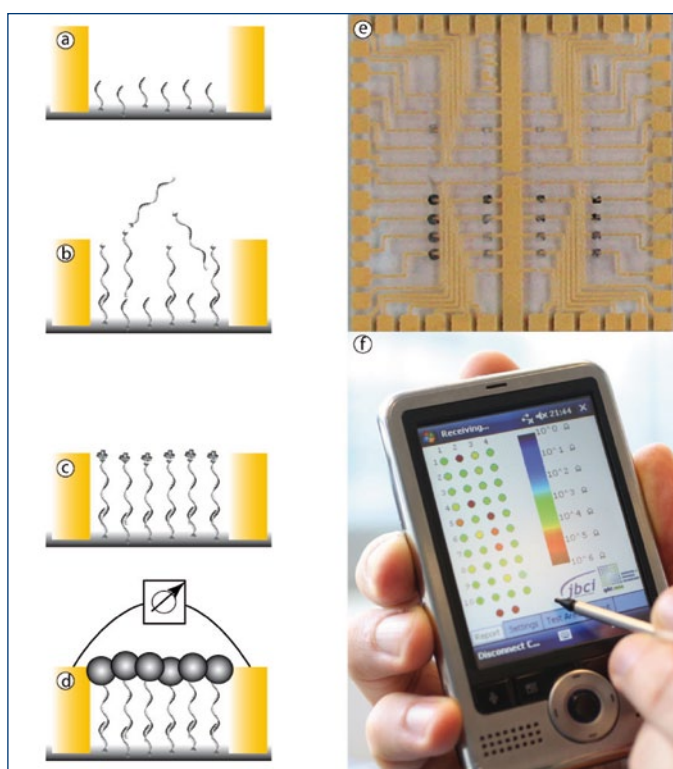
ecules on a chip are known and immobilized in an ordered fashion the fluorescent readout of a biochip allows the identification of biomolecules (pathogens) based on the pattern of fluorescent spots on the chip<sup>12</sup>.

If the identified biomolecules are characteristic for a selected pathogen chip-based methods can also be used for the identification of pathogens. By using short synthetic DNA fragments as capture molecules microorganisms can not only be identified based on specific DNA sequences, but specific molecular information can be collected e.g. resistances against antibiotics and other drugs. In addition to the parallel testing of many different molecules (pathogens) in one sample with one chip-based analysis, because many different capture molecules that can be immobilized on a single chip, there are other advantages that make biochip interesting for the onsite detection of pathogens. Because of their production methods biochips are small, usually only a couple of cm<sup>2</sup>, and can be produced in large quantities. Furthermore, the analysis can be automated and miniaturized make portable detection systems possible.

Even so biochips have this potential for a realization of onsite detection systems using this technology, there are only a few examples of competitive systems in the market today. Rather the use of biochips for the analysis of many analytical tasks is still lab based with bulky and expensive equipment. For an onsite detection system not only the detection of the relevant

biomolecules has to be automated and miniaturized, but rather the entire process including sample possessing, sample handling, and data processing<sup>13</sup>. Furthermore, a portable diagnostic device needs a robust and reliable detection method. The realization of small, robust and cost efficient detection device for a fluorescent

structures. In each gap a specific capture molecule is bound. After the incubation with the sample and the binding of the target molecules to its complementary capture molecules, metal nanoparticles or an enzyme are bound to the immobilized target molecules and silver is deposited on the particles or through the enzyme.



**Fig 4: Chip-based electrical detection of DNA.** For the chip-based detection capture molecules are bound within a electrode gap (a), the complementary target molecules bind (b) and the complex of capture and target molecules is labelled with an enzyme (or nanoparticle) (c), finally silver is deposited around the enzyme and the electrode gap is bridge with metal. This metal deposition can be measured on a chip with electrode structures (e). The readout can be done with small hand held devices enabling a portable and robust detection technology (f).

based analysis is possible but quite challenging. So there has been an intensive search for alternative labelling and detection methods for biochips. One possible method is the use of metallic nanoparticles as labels for biochips<sup>14, 15</sup>. Metallic nanoparticles can be coupled to biomolecules with numerous methods and offer a variety of different optical, gravimetric and electrical detection methods<sup>16</sup>. Especially the electrical detection seems interesting for portable detection systems as it requires only simple technical setup. For an electrical readout the biochip has to be modified with electrode gap

tasks. Raman and chip-based detection of pathogens are not competing technologies rather they will complement each other. The chip-based detection has the potential for the realization of portable detection device for an onsite detection of specific pathogens. While Raman will allow the fast identification of pathogens in complex samples with minimum sample preparation required. The two described technologies each have their advantages that make them especially suitable for different applications.

This creates a continuous layer of metal that bridges the electrode gap and the binding of the target molecules can be detected via a simple DC conductivity measurement<sup>17–19</sup>. The deposited silver can also be detected optically as the formed silver spots are grey or black<sup>20</sup>.

By combining this robust electrical readout principle with a miniaturized PCR and a sample preparation a modular system has been created for the onsite detection of plant pathogens and diseases of live stock. This platform can be easily adapted to other

## References

- 1 R. Petry, M. Schmitt and J. Popp, *Chemphyschem*, 2003, 4 (1), 14–30
- 2 M. Harz, P. Rösch, K. D. Peschke, O. Ronneberger, H. Burkhardt and J. Popp, *Analyst*, 2005, 130 (11), 1543–1550
- 3 M. Harz, P. Rösch and J. Popp, *Cytometry A*, 2009, 75 (2), 104–113
- 4 P. Rösch, M. Schmitt, W. Kiefer and J. Popp, *Journal of Molecular Structure*, 2003, 661 363–369
- 5 P. Rösch, M. Harz, K. D. Peschke, O. Ronneberger, H. Burkhardt, A. Schule, G. Schmauz, M. Lankers, S. Hofer, H. Thiele, H. W. Motzkus and J. Popp, *Analytical Chemistry*, 2006, 78 (7), 2163–2170
- 6 P. Rösch, M. Harz, M. Schmitt, K. D. Peschke, O. Ronneberger, H. Burkhardt, H. W. Motzkus, M. Lankers, S. Hofer, H. Thiele and J. Popp, *Applied and Environmental Microbiology*, 2005, 71 (3), 1626–1637
- 7 M. Krause, B. Radt, P. Rösch and J. Popp, *Journal of Raman Spectroscopy*, 2007, 38 (4), 369–372
- 8 M. Krause, P. Rösch, B. Radt and J. Popp, *Analytical Chemistry*, 2008, 80 (22), 8568–8575
- 9 P. Rösch, M. Harz, K. D. Peschke, O. Ronneberger, H. Burkhardt and J. Popp, *Biopolymers*, 2006, 82 (4), 312–316
- 10 M. Schena, R. A. Heller, T. P. Theriault, K. Konrad, E. Lachenmeier and R. W. Davis, *Trends Biotechnol*, 1998, 16 (7), 301–306
- 11 G. Ramsay, *Nat Biotechnol*, 1998, 16 (1), 40–44
- 12 V. G. Cheung, M. Morley, F. Aguilar, A. Massimi, R. Kucherlapati and G. Childs, *Nat Genet*, 1999, 21 (1 Suppl), 15–19
- 13 H. Schulze, G. Giraud, J. Crain and T. T. Bachmann, *Journal of Biophotonics*, 2009, 2 (4), 199–211
- 14 A. Csaki, R. Möller and W. Fritzsche, *Expert Rev Mol Diagn*, 2002, 2 (2), 187–193
- 15 J. Yguerabide and E. E. Yguerabide, *Anal Biochem*, 1998, 262 (2), 157–176
- 16 N. L. Rosi and C. A. Mirkin, *Chem Rev*, 2005, 105 (4), 1547–1562
- 17 W. Fritzsche, R. Möller, M. Urban, H. Stürmer and U. Klenz, *transkript LABORWELT*, 2002, II 4–8
- 18 R. Möller, R. D. Powell, J. F. Hainfeld and W. Fritzsche, *Nano Letters*, 2005, 5 (7), 1475–1482
- 19 S. J. Park, T. A. Taton and C. A. Mirkin, *Science*, 2002, 295 (5559), 1503–1506
- 20 G. J. Zhang, R. Moller, R. Kretschmer, A. Csaki and W. Fritzsche, *Journal of Fluorescence*, 2004, 14 (4), 369–375

# Entrepreneurship in Photonics

As part of P4L Work Package 7, VUB organized an intensive training entitled "Entrepreneurship in Photonics". The modular training was held in Brussels and took place from January 25<sup>th</sup> until February 5<sup>th</sup> 2010.

Courses were lectured by VUB-professors, as well as by photonics entrepreneurs and professionals, representing companies such as Philips Healthcare, Barco, Trinean, FOS&S, Optrima, and P4L IUC member Cochlear. A visit to the optical sorting company BEST was also part of the programme.

## The training was structured in 3 modules:

**Module 1** (3 days) provided an **introduction to business economics** and high tech entrepreneurship. A wide range of disciplines were covered, such as finance, marketing, human resources, intellectual property rights, strategy and management.

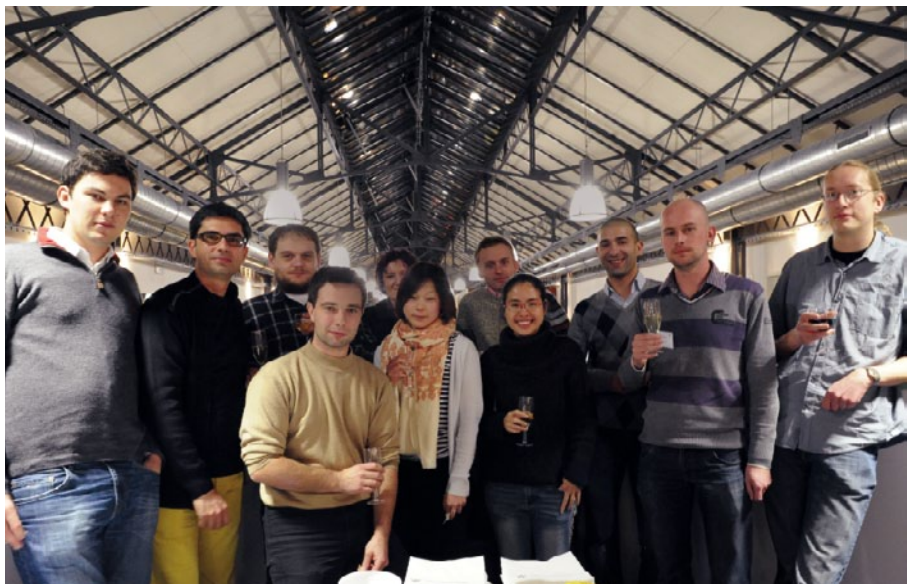
**Module 2**, called "**Business aspects of Photonics**" (5 days), provided an overview of the photonics markets and the typical business aspects associated with these markets. Several sectors, where photonics plays an enabling role, were addressed, such as displays, lighting, solar energy, lasers, industrial automation, and in particular life sciences and health.

**Module 3, "Business plan"** (2 days), provided guidance to (potential) entrepreneurs on how to prepare and negotiate a business plan. In the end, participants could present their business project to a jury of venture capitalists and professionals, which provided feedback on the

projects. Thomas Woggon, from P4L partner KIT, took this chance and used this experience during the Innovation Village at SPIE Photonics Europe 2010, where he was rewarded with the 1st prize for Best Innovation.

As subscribers could choose for a combination of modules, there were 13 persons attending the 1<sup>st</sup> module, 13 persons following the 2<sup>nd</sup> module and 7 persons in the 3<sup>rd</sup> module. The training

After each module, an evaluation via questionnaire was carried out. The feedback in general was very positive: On average, the sessions of all modules combined were rewarded with an excellent score of 8, 9 on 10. As a consequence, a repeating of the training was strongly recommended by the participants. The next edition will take place in January 2011. If you are interested in participating, please send an e-mail to Tom Guldemont at [tguldemo@b-phot.org](mailto:tguldemo@b-phot.org).



was highly international as the in total 15 participants were coming from 7 different countries (Belgium, Germany, The Netherlands, France, Italy, Spain and Poland). 8 participants were registered as a member of P4L and therefore benefited from a partial reimbursement, while 2 attendees were members of NEMO, the EU-funded Network of Excellence on Micro-Optics. Additionally, 2 people from the photonics industry subscribed.

## Contact

Tom Guldemont  
Vrije Universiteit Brussel  
[tguldemo@b-phot.org](mailto:tguldemo@b-phot.org)

# Towards Better Health Care: Targeting Unmet Medical Needs

A fresh impetus for researchers was provided by the conference "Biophotonics – Photonic Solutions for Better Health Care", which took place from April 12 to 16 as part of Photonics Europe in Brussels. For the first time, the oral program featured not only premium-class talks on the latest technologic advances in the field, but also a dedicated medical session entitled "Towards a Better Health Care: Unmet Medical Needs". The European



**Dermatology Professor Daniela Massi speaking about medical demands**

Network of Excellence "photonics4life" together with Laser Lab Europe had invited renowned physicians to unravel challenges in various medical fields, ranging from oncology to infectious diseases, and to state their expectations on user-oriented optical solutions.

"Time matters", was the clear message of Prof. Michael Bauer (Univ. Hospital Jena, Germany) who spoke on diagnostic needs in the field of sepsis. In order to avoid mortal cases, the analysis time for pathogen identification must be reduced from currently about 36 hours to about 30 minutes after onset of sepsis. Not only the pathogen must be reliably identified but also resistances and host responses must be determined. This means that blood-culture based procedures must be supported by photonic point-of-care solutions combined with PCR.

In the field of oncology, all speakers expected further major benefits from novel optical procedures for tumor diagnosis. Their potential for an early recogni-

tion and detailed description of tumors should be exploited further in order to promote less invasive, targeted therapies. Pathologist Prof. Axel Niendorf (Inst. for Diagnostic Histopathology, Germany) recommended that molecular diagnostics should be applied to complement rather than replace morphological assessment. Such multimodal approaches could provide major advances in tumor grading and enable individual therapy recommendations. Prof. Katarina Svanberg (Lund Univ., Sweden) and Prof. Alfonso Crisci (Univ. of Florence, Italy) emphasized the importance of in-vivo fluorescence diagnosis for improved therapies, e.g. by



**Audience following the session**

using it for a fast and reliable intraoperative delineation of tumors. The benefits of non-invasive optical biopsies in dermatology were approved by Prof. Daniela Massi (Univ. of Florence, Italy) and Prof. Hans Peter Berlien (Elisabeth Klinik, Germany). However, the available imaging and manipulation methods, e.g. the use of short laser pulses, and their effects should be studied further to allow their routine use in dermatology.

The session attracted big interest so that Photonics4Life coordinator Prof. Juergen Popp judges it as a successful step towards a closer cooperation of users and developers, and plans to present similar formats in upcoming conferences. With activities like this, the P4L network aims to close the gap between users and developers of Biophotonics solutions. According to experts, this gap is the most important bottleneck to further advances in the field.

## Event Calender

(co-)organized by photonics4life  
contribution from photonics4life partners

### August 2010

#### 08–13 August

##### **Boston, Massachusetts, United States**

International Conference on Raman Spectroscopy (ICORS XXII)

#### 27 August – 02 September

##### **Ballyvaughan, Ireland**

Biophotonics and Imaging Graduate Summer School (BIGSS) 2010

### September

#### 06–08 September

##### **Edinburgh, United Kingdom**

Faraday Discussion 149: Analysis for Healthcare Diagnostics and Theranostics

#### 11–16 September

##### **Egmond aan Zee, Netherlands**

International Conference of Advanced Laser Technologies (ALT)

#### 22–30 September

##### **Quebec, Canada**

Biophotonics Week

#### 27–29 September

##### **Brussels, Belgium**

ICT 2010

#### 28 September–01 October

##### **Jena, Germany**

MiCom 2010

### October

#### 05–08 October

##### **Saratov, Russian Federation**

Saratov Fall Meeting

#### 18–20 October

##### **Maynooth (Dublin), Ireland**

BioPIC 2010

#### 26–29 October

##### **Paris, France**

EOS Annual Meeting 2010 – Topical Meeting 1

### November

#### 05 November

Concertation Meeting for an ERANET Plus on Biophotonics

### January 2011

#### 22–27 January

##### **San Francisco, United States**

Photonics West

**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

**Local Cluster Partners**

**IPHT**

Department of Internal Medicine II, FSU Jena\*  
Institute of Pathology, FSU Jena\*  
Department of Anaesthesiology and  
Critical Care Therapy, FSU Jena\*  
Department of Gastroenterology, FSU Jena\*  
Department of Neurosurgery, FSU Jena\*  
Department of Neuropathology, FSU Jena\*  
Leipzig Institute for Age Research – Fritz Lipmann  
Institute, Jena\*  
Max-Planck Institute for Biogeochemistry, Jena\*  
Max-Planck Institute for Chemical Ecology, Jena\*  
Institute of Nutrition, FSU Jena\*  
Institute of Microbiology, FSU Jena\*  
Institute of Biochemistry and Biophysics, FSU Jena\*  
Leipzig Institute for Natural Product Research and  
Infection Biology – Hans-Knöll-Institute\*  
Institute of Physical Chemistry, FSU Jena  
Institute of Condensed Matter Theory and  
Solid State Optics, FSU Jena  
Institute of Optics and Quantum Electronics,  
FSU Jena  
Institute of Applied Optics, FSU Jena  
Fraunhofer Institut für angewandte Optik  
und Feinmechanik  
Institute of Applied Physics, FSU Jena

**UoM**

Center for Biomedical Optics and Photonics  
(CeBOP), Medical Faculty, University of Muenster  
Institute of Applied Physics / University of Muenster  
Clinic for Dermatology, University of Muenster\*  
Institute of Physiological Chemistry,  
University of Muenster  
Gastroenterological Molecular Cell Biology,  
University Hospital Muenster\*  
University Hospital Muenster\*  
Center for Molecular Biology of Inflammation\*  
Leibnitz Institute for Arteriosclerosis Research\*  
SFB 656: Molecular Cardiovascular Imaging\*  
Institute for Zoology and Genetics,  
University of Muenster\*  
Bioanalytik Muenster\*  
Nanobio-Center\*  
Institute for Hygiene, University Clinics (UKM)  
Münster (Euregio-project “EurSafety Health-net”)\*  
Max Planck Institute for Molecular Biomedicine\*  
European Institute of Molecular Imaging (EIMI)  
Center for Nonlinear Science (CeNoS)  
University of Applied Sciences Muenster  
Center for Nanotechnology (CeNTech)  
Competence Center for Nanoanalytics (CCN)  
European Research Service GmbH  
Multilevel Molecular Assemblies: Structure,  
Dynamics and Function (SFB TRR 61)  
Optical Technologies group, Institute for Applied

**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)

Physics (Prof. Dr. C. Fallnich)

**MESA+**

Biophysical Engineering Group\*  
Department of surgical oncology, NKI-AVL  
Amsterdam\*

**CNR-IFAC**

Institute of Neurosurgery, Catholic University, Rome\*  
Istituto dei Sistemi Complessi - ISC CNR, Firenze  
Ophthalmic Dept., Prato Hospital, Firenze\*  
University of Florence – Dermatologic Clinic\*  
University of Florence – Medical Physics unit,  
Dept. of Clinical Physiopathology\*  
University of Florence – LENS

**IOGS**

Laboratoire d’Optique Appliquée, Paris  
Solids Mechanics Laboratory (LMS) –  
Ecole Polytechnique  
Lyon Nanotechnology Institute (INL) –  
Ecole Centrale Lyon

**VUB**

Centre for Heart and Vascular Disease, UZ Brussel  
Pneumology Department, UZ Brussel  
Stomatology & Maxillofacial Surgery Department,  
UZ Brussel  
Academic Department of Otorhinolaryngology,  
Sint-Augustinus hospital, Antwerp

**USTAN**

School of Medicine, University of St Andrews\*  
School of Biology, University of St Andrews\*  
Ninewell Hospital, Dundee, NHS Tayside\*  
Strathclyde Institute of Pharmacy and Biomedical  
Sciences, University of Strathclyde\*  
Division of Medical Sciences, University of Dundee\*  
Division of Pathway Medicine, University of Edinburgh\*  
Chemistry Department, University of Edinburgh\*  
SULSA, Scottish Universities Life Science Alliance

**IMPERIAL**

Department of Histopathology, Division of  
Investigative Science, Imperial College\*  
Institute for Cancer Research, Chester Beatty  
Laboratory, London\*  
Department of Biology\*  
Department of Bioengineering\*  
National Heart and Lung Institute\*  
Institute of Biomedical Engineering\*  
Charing Cross Hospital, London\*  
St Mary’s Hospital, London\*  
Hammersmith Hospital, London\*  
University College London  
London Research Institute of the Cancer

**Arrangement**

Karlsruhe Institute of Technology (KIT)

**Print**

Elser Druck, Mühlacker, Germany

**Next issue**

March 2011

For additional information please visit  
<http://www.photonics4life.eu>

Research Fund\*

Department of Computing, Imperial College  
Department of Chemistry, Imperial College  
Department of Physics, Imperial College

**ICFO**

Bellvitge Institute of Biomedical Research (IDIBELL)\*  
Hospital de la Santa Creu i Sant Pau, Barcelona\*  
Institute for Bioengineering of Catalonia (IBEC),  
Barcelona\*  
Institut d’Investigacions Biomèdiques (IDIBAPS),  
Barcelona\*  
Centre for Genomic Regulation (CRG), Barcelona\*

**VTT**

Institute of Medical Technology, University of Tampere\*  
Department of Biomedical Engineering,  
University of Tampere\*  
Finnish Centre for Alternative Methods,  
Medical School, University of Tampere\*  
Regea Institute for Regenerative Medicine,  
University of Tampere\*  
Optoelectronics Research Centre, University of  
Tampere  
Chemistry Department of the University of Oulu

**KIT**

Institut für Toxikologie und Genetik (ITG), Karlsruhe\*  
Institute for Biological Interfaces 2, Karlsruhe  
Institute of Technology\*  
Institute for Microstructure Technology (IMT),  
Karlsruhe Institute of Technology  
Light Technology Institute (KIT)  
Institute for Nanotechnology (KIT)

**ULUND**

Department of Dermatology\*  
Department of Oncology\*  
Department of Ear-Nose and Throat\*  
Department of Physics

**SSU**

Scientific Institute of Fundamental and Clinical  
Uro nephrology, Saratov State Medical University  
named after V.I. Razumovsky\*  
Saratov Scientific Research Institute of Cardiology\*  
Department of Biology of SSU, Laboratory of  
Experimental Physiology\*  
Department of Biomedical Physics of SSU,  
Laboratory of Biodynamics  
Department of Hospital Surgery, Gastroenterology  
Centre, Saratov State Medical University\*  
International Institute of Nonlinear Dynamics, SSU\*  
Biology Department, Saratov State University\*

\* Biomedical User

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
UK-ER	Department of Medicine 1, University Hospital Erlangen Markus Neurath, markus.neurath@uk-erlangen.de	Germany