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Table of Contents

The OASIS project.................................................................................................................. 4
Introduction - Biophotonics in the Netherlands................................................................. 5
Overview of companies involved in the OASIS project.................................................... 7
Description of Dutch companies involved in the OASIS project....................................... 8
Further resources about Photonics in the Netherlands..................................................... 13

Topsector High Tech Systems & Materials (HTSM) and Photonics as KET
Netherlands Enterprise Agency
Dutch Photonics Roadmap

Overview of life science infrastructures, universities and research Institutes.................... 15
Description of Life Science Infrastructures and Institutes involved in the Oasis-project........ 16
Other Universities, Facilities and Research Institutes....................................................... 21
PhotonicsNL association as national platform for photonics............................................. 23
The OASIS project

OASIS - Open the Access to Life Science Infrastructures for SMEs
The OASIS project aims to improve the links between life science facilities, research projects and product development. The previous large investments in biophotonics are made more accessible to SMEs to allow a competitive advantage in new products development and validation. Large scale research facilities and technology platforms are usually sets of laboratory equipment that are mainly available to academia and to a certain extent to industry. It can be very large-scale equipment, unique to a country or a continent as well as technological halls shared by a wide scientific and technological community, which develops competencies in a specific area. In the field of the life sciences, the management of open access for researchers and world-class research programmes between these facilities is under consolidation through existing programmes like Instruct, EuroBioimaging, Biophotonics Plus and the network of excellence Photonics4Life. Large companies have established strong collaborations with these facilities. However, there is still room for improving the economic outputs and the involvement of SMEs in order to create more value and jobs from early scientific results. By February 2015, the OASIS consortium has inventoried and analysed about 120 companies, unmet needs from 14 hospitals and 14 agrifood companies and more than 70 Life Science facilities. Nine workshops are organised at each partners’ premise during the life time of the project to promote exchanges and spread the information and results from the project.

Website: http://www.fp7-oasis.eu
Coordination and Support Action (CSA) project from FP7-ICT-2013-11 objective 3.2 Photonics.
Grant agreement no: 619230

9 Photonics clusters involved in the project:
- Optitec, Marseille, France
- CNR-Optoscana, Florence, Italy
- PhotonicsSweden, Kista, Sweden
- OptecBB, Berlin, Germany
- Politecnico di Milano, Italy
- SECPhO, Barcelona, Spain
- PhotonicsNL, The Netherlands
- Photonics Bretagne, Lannion, France
- Swansea University, UK

Duration: 30 months (Dec. 2013 to May 2016)
Coordination: Cecilia Pinto, Optitec
Remarkable contributions throughout history
The Netherlands has a rich history in photonics. This long rich tradition started in 1690 with Christian Huygens and his Traite de La Lumiere. Huygens was one of the greatest Dutch physicists, a telescope (device) builder and also the founder of the theory of the propagation of light. The first optical device builder was Antonie van Leeuwenhoek, who constructed the first microscopes. The Dutch physicist Frits Zernike received the Nobel Prize for theory of the propagation of light and its application in the phase-contrast microscope. In recent years world class electron microscopes, wafer steppers and space instruments have been developed and built in the Netherlands.

Topsector Policy in The Netherlands
The Dutch government has defined nine topsectors. Through our top sectors, we are stepping up our efforts in areas that show major growth potential and in which we are already achieving solid results. The most important topsectors where Biophotonics plays an enabling role are High Tech Systems & Materials, Health & Life Sciences, Horticulture and Agro & Food.

Biophotonics in Life Sciences & Health, Horticulture and Agro & Food
Today, the Netherlands remains a major player in the global Life Sciences and Health industry, with a strong technological position in Biophotonics in the complete value chain. The Dutch sector owes this position to collaboration, cooperation and coalition building between businesses, research institutes and universities, supported by government, linking research to product and business creation.

The Netherlands counts 10 universities with a medical center where Biophotonics play an important role in the research programs for Life Sciences & Health. The research at these universities is more application driven in developing new instruments for medical diagnosis and therapy. Just some examples of “State of the Art” research areas that already have led to new innovative products are hyper spectral cameras for early and non-invasive diagnostics, forensic research at the crime scene and fiber optic sensors for non-invasive blood analyses.

Besides these universities we have the Delft University of Technology (TUD), the Eindhoven University of Technology (TU/e) and Twente University (UT). The research at these universities is more technology driven in finding and manufacturing new photonic components in a broad sense. A ‘State of the Art’ example is the development of advanced Photonic IC’s (PIC’s) for sensing (UT region) and ICT applications (TU/e region). Imagine, a complete spectrometer on a chip!

Besides the universities there are several other research institutes where Biophotonics is an important research topic and especially on the nanoscale (e.g. Physics of Biomolecular systems and Nanophotonics). The most important institutes will be described in this brochure.

In the topsector Horticulture and Agro & Food the Wageningen University & Research Center (WUR) takes a unique position. WUR is a world-renowned center that combines fundamental and applied research with innovative education in the areas of food, agrotechnology, production systems, nature and the environment.

The Netherlands has more than over 120 photonic companies. About 30 companies are directly related to Biophotonics. In this Oasis-brochure 16 companies will be described.
### Overview of companies involved in the OASIS project

<table>
<thead>
<tr>
<th>Company name</th>
<th>Website</th>
<th>Data 2013</th>
<th>Main Activity/Product</th>
<th>Oasis*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adviesbureau JFH Snel</td>
<td><a href="http://www.jfhnsnel.nl">www.jfhnsnel.nl</a></td>
<td>0.06</td>
<td>Monitoring of photosynthesis</td>
<td>Yes</td>
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<tr>
<td>Avantes</td>
<td><a href="http://www.avantes.com">www.avantes.com</a></td>
<td>10</td>
<td>Spectrometers</td>
<td>Yes</td>
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<tr>
<td>Cosine</td>
<td><a href="http://www.cosine.nl">www.cosine.nl</a></td>
<td>2</td>
<td>Optical Instruments</td>
<td>A'dam</td>
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<td>Demcon</td>
<td><a href="http://www.demcon.nl">www.demcon.nl</a></td>
<td>12</td>
<td>System Integrator &amp; Medical Products</td>
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<tr>
<td>Diagnoptics</td>
<td><a href="http://www.diagnoptics.com">www.diagnoptics.com</a></td>
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<td>Innovative diagnostic technology and products</td>
<td>Yes</td>
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<tr>
<td>Focal</td>
<td><a href="http://www.focal.nl">www.focal.nl</a></td>
<td>1,5</td>
<td>Optical OEM-systems for industry</td>
<td>A'dam</td>
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<td>FTS Forensic Technical Solutions</td>
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<td>0,5</td>
<td>Forensic research with spectral cameras</td>
<td>A'dam</td>
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<td>Hittech Multin</td>
<td><a href="http://www.hittech.nl">www.hittech.nl</a></td>
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<td>System integrator and FBG-production</td>
<td>A'dam</td>
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<tr>
<td>Lambert</td>
<td><a href="http://www.lambertinstruments.com">www.lambertinstruments.com</a></td>
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<td>Fluorescence life time imaging</td>
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<tr>
<td>LioniX</td>
<td><a href="http://www.lionixbv.nl">www.lionixbv.nl</a></td>
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<td>Micro-fluidic sensing and integrated optics</td>
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<tr>
<td>MetaSenze</td>
<td>Start-up</td>
<td>0,3</td>
<td>Innovative diagnostic technology</td>
<td>A'dam</td>
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<td>PR Sys Design</td>
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<td>Machine learning solutions and training with PerClass software</td>
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<td>Quest Innovations</td>
<td><a href="http://www.quest-innovations.com">www.quest-innovations.com</a></td>
<td>unknown</td>
<td>Hyper/multi spectral cameras</td>
<td>Yes</td>
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<tr>
<td>RiverD</td>
<td><a href="http://www.riverd.com">www.riverd.com</a></td>
<td>&gt;1,2</td>
<td>Diagnostics with Raman spectroscopy</td>
<td>Yes</td>
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<td>Technobis TFT-FOS</td>
<td><a href="http://www.technobis.com">www.technobis.com</a></td>
<td>&gt;3</td>
<td>Fiber Bragg grating sensors and PIC's</td>
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<tr>
<td>XIOPhotonics</td>
<td><a href="http://www.xiophotonics.com">www.xiophotonics.com</a></td>
<td>&lt;1</td>
<td>Integrated lasersources</td>
<td>Yes</td>
</tr>
</tbody>
</table>

* From the start of the Oasis-project 14 Dutch companies were involved in the project. During a successful Oasis-workshop in Amsterdam 2 more companies, Cosine in Leiden and a new startup company MetaSenze in Enschede, join the Oasis-project.

** The precise turnover of the companies is in most cases unknown and is just an estimation based on the number of FTE’s.
Description of Dutch companies involved in the Oasis-project

Adviesbureau JFH Snel is a consultancy for the Dutch Horticultural sector. It is involved in the development of online sensors for monitoring photosynthesis in greenhouse crops. Its expertise comprises plant biology, biophysics, sensor technology and greenhouse horticulture.

Our main activities are:
- Development of photonic sensors for plant photosynthesis in greenhouses.
- Develop model based decision support systems for greenhouse growers.
- Support growers in using the combined sensor and decision support system.

These activities are carried out in collaboration with Dutch and German partner SME's.

Avantes is the leading innovator in the development and application of fiber optic spectroscopy instruments and systems with over two decades of experience developing customer-defined spectrometer configurations. With a long history of consulting with clients across diverse industries and applications, Avantes is an experienced partner, equipped to guide customers who want a solution tailored to their application and research needs.

By building best in class spectrometers and providing second-to-none customer service, Avantes offers customers the peace of mind that the Avantes solutions they purchase will meet and exceed their expectations.

Avantes instruments and accessories are also deployed into many OEM applications in many industries in markets throughout the world. With over 20 years of experience in fiber optic spectroscopy and thousands of instruments in the field, Avantes is eager to help our customers to find the perfect solutions for their spectroscopy challenges.

DEMCON develops and realizes medical devices for diagnosis, therapy, care and self-care. Applications are found in fields including surgery, therapy and diagnostics. Examples include an operating system for eye surgery, a hand scanner for rheumatoid arthritis or a ventilator. Clients may be medical technology start-ups, established SMEs or major OEMs. In the development of medical devices, DEMCON follows a structured design approach for the three successive phases of proof of principle, prototype and pre-production. With this approach the potential design risks are identified and eliminated at an early stage. DEMCON provides for production in-house and sets up the entire supply chain for this. The link with production supports the optimisation of the cost price and produceability in the design phase. At discretion of the client, the transfer from design to production by a third party can be supervised. In all cases DEMCON successfully makes medical devices into serial products.
Cosine develops and builds measurement systems for its customers. These find use in scientific, industrial, medical, environmental, energy, agri/food, security, semiconductor and space applications, with customers ranging from small high-tech companies to the European Space Agency, IBM and EADS. The cosine team consists of 20 highly educated people who develop transparently in close collaboration with the customer. With its broad experience in different technological areas they provide innovative, out-of-the-box measurement solutions. Technologies span the field of applied physics, with extensive experience in spectroscopy, lasers, radiation and 3D imaging systems.

Diagnoptics Technologies www.diagnoptics.com is a young medical technology company with worldwide operations from Groningen, The Netherlands. Diagnoptics Technologies researches, manufactures and markets the AGE Reader technology, an innovative diagnostic technology that can be used to noninvasively assess the concentration of AGEs (Advanced Glycation End-products) in a subject's skin tissue. The AGE Reader SU enables clinical researchers to easily assess AGE concentration and infer the risk of cardiovascular disease. Recently, Diagnoptics introduced the AGE Reader mu, a compact solution for general practitioners and diabetologists. Diagnoptics Technologies sells its products through a network of international partners. The office in Groningen is primarily involved with research and development, monitoring of production, sales and servicing.

Focal Vision and Optics designs and delivers optical measurement systems to be used in many industrial applications. These systems could be OEM-modules that will be further integrated into complex devices or could be single systems to be used for quality precision inspections on products or samples made of e.g. sheet metal or cast steed, flat or shaped glass, plastic and rubber, agro-organic material, fabrics or living tissue or cells. The optical measurement systems shall in all cases provide reliable and reproducible 100% optical inspection results. Often our designed systems replace sample based and/or human eye inspection and shall contribute to process optimization and cost reduction for Focal's customers. In-line optical measurements and inspections in industrial production environments are carried for two purposes: 1) detection of defects or anomalies on the inspected item is required, 2) metrology: accurate shape measurement in 2D or 3D on the object up to μ domain. The specialists at Focal develop high end hardware and software for both type of inspections and combinations of both. Focal has the combination of optical system engineering expertise and advanced machine vision programming and artificial intelligent system design. Depending upon the nature of the inspection the most appropriate illumination strategy will be defined as a first step in system design. Design choices for either coaxial illumination, back light, dark field, strobed high intensity illumination, type of light sources (LED, halogen, plasma etc.) and filtering and polarization will be evaluated and fixed. Some applications require wavelength specific illumination in e.g. UV, visual light, the near of far infrared. Focal has an optical laboratory with measurement equipment and a various lab set-ups allowing the engineers to perform sample and sensitivity tests. The next stage of the design optical inspection system is the definition of the algorithms that should fit with the images and the required type of measurement. A generically developed platform for user interaction, PLC-communication and logging & monitoring will in most cases be used in the final delivery of the optical measurement system. Focal's approach of using modular building blocks for obvious generic functions and application specific robust algorithm development for the specific items, ensures short development and roll-out cycles.
RiverD creates and brings to market innovative solutions for unmet diagnostic needs based on Raman spectroscopic analysis of cell and tissues. The company is a spin-out of the Erasmus Medical Center in Rotterdam, the Netherlands. The RiverD team comprises Raman experts and engineers who have worked at the forefront of developments in Raman spectroscopic characterization of cells and tissues for over 20 years. Our current product portfolio consists of instruments for in vivo skin analysis and for bacterial typing, fully optimized microscope objectives for Raman spectroscopy, and the High Performance Raman Module (for OEM-customers). We are always on the lookout for new applications and actively engage in development projects with academic partners and partners from industry. We would welcome the opportunity to discuss your idea!

Hittech Multin B.V. is part of the Hittech Group, which is a group of centrally controlled independent companies operating as a system supplier, extended workplace and partner of OEM companies. With a total staff of around 500 people and just over €100M annual turnover, the Hittech Group and its companies form a solid unity and strengthen each other with different competences. The total staff of Hittech Multin B.V. located in Delft, The Netherlands is around 80 people and reached €24M turnover in 2014. The focus is on development, (value-) engineering and assembly. Uniting these disciplines results in synergy between thinking and acting, between inventing and building, between creativity and practice, and between high-technology and affordability. The markets, in which Hittech Multin BV, is mainly active are: Micro-electronics and semiconductors, Laboratory and scientific analysis equipment, Medical devices, Measuring and analysis instruments and Packaging. The mission of Hittech Multin B.V. is to give OEM companies the opportunity to concentrate on their most important core competences by taking over development and/or production (assembly) and/or supply chain management in a permanent partnership in lifecycle management.

Lambert Instruments specializes in advanced imaging solutions. All of Lambert Instruments’ products offer extreme light sensitivity so they can record clear images in low-light situations. Applications include high-speed imaging and fluorescence lifetime imaging. Lambert Instruments high-speed imaging products can record high-speed video in low-light situations. This enables applications like single-photon imaging, voltage-sensitive dye research and in-vivo fluorescence imaging. Optional ultra-short exposure times in the order of nanoseconds remove motion blur in recordings of fast-moving subjects. The high-speed imaging product line includes complete cameras and image-intensifying attachments for high-speed cameras.

The Lambert Instruments FLIM Attachment records fluorescence lifetime images in a matter of seconds and instantly presents the resulting fluorescence lifetime as a colorized overlay on the original image. It is compatible with widefield epifluorescence microscopes and is available with a number of modulated LED and laser lightsources. In addition to standard product lines, Lambert Instruments also offers custom solutions based on your requirements. Experienced engineers analyse your application and propose the most effective solution. This way, you will be assured of a well-defined product that meets your needs.
Description of Dutch companies involved in the Oasis-project

LioniX is a leading co-developer, manufacturer and provider of products and components based on cutting-edge micro/nano technology for its original equipment manufacturer (OEM) customers. The main focus markets include Life Sciences, Telecom, Datacom, Industrial Process Control and Space. LioniX provides design to manufacturing and ‘horizontal integration’ by partnering with foundries, suppliers of complementary technologies and R&D institutes. The company specializes in applications of integrated optics, microfluidics and optofluidics including surface functionalization. LioniX offers small volume manufacturing, second sourcing as well as transfer to medium and high volume manufacturing.

For easy access to their proprietary waveguide technology (TriPleX™) LioniX launches regular Multi Project Wafer (MPW) runs in which users can design their new application. New applications required more often Photonic Integrated Circuits (PIC) from different platforms (hybrid integration) and the combination with InP is a very logic one. During Photonics West the complete value chain of the MPW technology will be shown and LioniX also shows a combination of their technology with InP functionality.

LioniX (and XiO Photonics) participated in the Oasis-project and they have now merged into LioniX International. LioniX International BV has been established in April 2016, funded by Panthera Group BV and YMK Photonics Co Ltd. LioniX International BV has acquired LioniX BV (www.lionixbv.com), Satrax BV (www.satrax.nl), XiO Photonics BV (www.xiophotonics.com) and OctroliX BV. For more information please visit: www.lionix-international.com

XiO Photonics B.V designs and manufactures customized Photonic IC modules for manipulating visible and NIR laser light in Life Science applications like confocal microscopy, DNA-sequencing, bio-sensing and imaging. Started in 2009 XiO Photonics has used its vertically integrated capabilities to deliver a complete photonic solution to OEMs and system integrators in volume production. XiO Photonics expertise covers the total range from optical chip design, fiber-chip coupling, chip-chip coupling, PCB and electronic design and manufacturing and photonic component package design and manufacturing.

Quest-Innovations develops and manufactures high quality multi- and hyperspectral cameras and dedicated software for advanced imaging applications. The main markets that Quest focuses on are: defense & security, science & life science, medical industry, agriculture and industry, UAV optimized solutions. Quest manages the market with 2 different divisions, Quest Medical Imaging for the medical industry and Quest Innovations for all other markets. Quest is both ISO 13485 and ISO 9001 certified. For both markets Quest supplies OEM modules and complete end user applications. The machine vision cameras help to improve customer businesses in numerous ways, whether by improving quality and accuracy of products, lowering production line inspection costs, increasing production yields or creating more effective surgical tools for cancer surgery. Quest-Innovations are able to deliver standard and/or customized solutions for any application where (multi-spectral) camera vision technology is an integrated part of a process, product or service.
Description of Dutch companies involved in the Oasis-project

**FTS**

FTS is involved in the development of hyper- and multispectral imaging systems which are suitable for use at the crime scene, forensic laboratory or hospital. In the development we perform research concerning the biological, chemical and spectroscopic aspects of biological changes that can be encountered in the forensic and medico-legal field. Specifically for validation of forensic techniques, in close collaboration with the Netherlands Forensic Institute, we perform measurements on the crime scene, analyze the obtained data and write forensic reports. Our expertise on biophysics was largely obtained in the field of biomedical physics and adopted for forensic applications. Currently we mainly focus on the determination of the age of biological traces on the crime scene and the age of wounds on crime victims, both unique worldwide. Our main expertise is the decomposition of the spectra into the contributing scattering and absorbing components in the medium under investigation based on solutions of the radiative transport equation. Furthermore, optical engineering and performing clinical and forensic internal and external validation according to quality standards is also our expertise.

**Technobis**

Technobis is a group of companies providing development and supply of high-tech instruments and modules for companies worldwide. Technobis targets small, medium and large sized companies, universities and other knowledge institutes, mostly in Europe but with the desire to go worldwide. Technobis seeks opportunities for contract research, supply to larger (OEM) companies, system and application development through international development programs, challenged by fundamental limits. Such contracts are served in many cases by assistance of strategic alliances mostly in high-tech industry, aerospace, automotive and medical markets. Technobis Fibre Technologies provides fibre optic sensing solutions based on integrated photonics. The offered technology is extremely precise, reliable and fast, and fit for extreme conditions. Technobis takes a lead position in miniaturization, accuracy and precision. Improvements with regard to conventional technology regard smaller size, reduced weight and power, solid state, improved mechanical and thermal stability, improved reliability, reduced costs, functionality aggregation and standardization of processes and specifications. Typical applications provided are thermal mapping, vibration monitoring, force sensing, shape reconstruction, pressure/temperature sensing, haptic feedback, deflection sensing, load monitoring, damage and impact detection, heat flux sensing, displacement sensing, etc. Many markets are supported, but with a strong focus on high-tech industry, medical applications and aerospace.

**PR Sys Design**

PR Sys Design has a strong track record in solving practical machine learning problems for industry in applications such as medical diagnostics, sorting natural products and defect detection. Its software tool “perClass” is used by companies such as Bosch, Zeiss or Leica and research institutions such as WUR (Wageningen un.i.), TU Delft, CTR Austria or CRA-W.

PR Sys Design has organized 12 editions of one-week training courses “Machine Learning for R&D specialists” with participants from 15 countries.

Our main activities are:

- Contracting services developing machine learning solutions for industry
- Selling perClass software package
- Offering training courses
Further resources about Photonics in the Netherlands

Topsector High Tech Systems & Materials (HTSM) and Photonics as KET
The Netherlands’ centuries-old tradition of creativity, pragmatism, entrepreneurship, openness and collaboration forms a perfect fit for the HTSM-sector. These qualities make the Netherlands the perfect place to find solutions to the challenges society is facing today in the areas of health & life sciences, security, energy, mobility and climate; solutions that are primarily generated through cross-overs in technology and collaboration. Rapid innovation and collaboration across the value chain is imperative in this highly competitive and highly complex sector and a well-functioning network (‘ecosystem’) of specialised companies and institutions is crucial to achieving this. These ‘ecosystems’ or centres-of-excellence are located around the country and especially in the regions around our universities in Delft, Twente and Eindhoven. See for more information about the HTSM-topsector: www.hollandhightech.nl/international

Netherlands Enterprise Agency
Netherlands Enterprise Agency (RVO) encourages entrepreneurs in sustainable, agrarian, innovative and international business. It helps with grants, finding business partners, know-how and compliance with laws and regulations. The aim is to improve opportunities for entrepreneurs and strengthen their position. The RVO works at the instigation of ministries and the European Union. RVO is part of the Ministry of Economic Affairs. RVO focuses on providing services to entrepreneurs. It aims to make it easier to do business using smart organization and digital communication. RVO works in The Netherlands and abroad with governments, knowledge centers, international organizations and countless other partners. See for more information: http://english.rvo.nl/
From 2006 until 2015 the IOP-project took place in collaboration with PhotonicsNL. This project aimed to stimulate the collaboration between research institutes and innovative companies in the development of photonic devices especially for Life Science & Health applications. At the end of the project an impressive brochure was published with a description of all the participating companies in the project and the final results, and Integrated Photonics as the Key Enabling Technology. You can download this unique brochure on our website: www.photonicsnl.org
Now the project has finished PhotonicsNL will continue all kind of activities which were initiated during the project (e.g. conferences, workshops and educational projects on all levels).

Dutch Photonics Roadmap 2015
To strengthen the overall competitive position of the Netherlands, photonics will play a pivoting role in the HTSM topsector aiming for the manufacturing of broadly applicable products and services for primarily industrial applications.
The Netherlands has an excellent position to bring photonics into numerous markets. We have a high scientific level in important photonic segments (Dutch universities and NWO initiatives) and a highly qualified high-tech industry with specific nano-electronics and mechatronics expertise. Dutch internationals like ASML, Philips and OCE/Canon are big players in the photonics area but the Netherlands has also more than over 120 SME’s which are already embracing photonics for innovation.
A smart photonics ecosystem is active in the Netherlands addressing the full value chain.
You can download the most recent version of the roadmap on our website: www.photonicsnl.org.
Map of Life Science facilities
The table underneath gives an overview of the most important life science facilities, Dutch universities and institutes. On the left page you can find their location. The Netherlands counts for seven universities with an academic medical research center including an academic hospital and three universities with more focus on technology development in Photonics and Optics (TUDelft, TU/e and UT). All these universities and research institutes will be described later.

<table>
<thead>
<tr>
<th>Institute</th>
<th>Achronyme</th>
<th>MC</th>
<th>Oasis</th>
<th>Website</th>
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<tr>
<td>TNO Delft</td>
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<td>Academic Medical Center University of Amsterdam</td>
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The Van ‘t Hoff program is a collaborative research and innovation program, initiated by TNO, in the field of biomedical optics. This Shared Innovation Program aims to improve medical diagnosis and therapy through development of innovative medical devices based on photonics and biomedical technologies. Specifically, we develop biophotonics-based technologies to enable less invasive surgical procedures, better screening and monitoring of diseases in asymptomatic stages and better and/or personalized treatment for patients, leading to reduced healthcare costs and improved outcomes.

Key features of the Van ‘t Hoff program are partnerships with health foundations, leading academic hospitals, industrial companies, research institutes and international standards issuing bodies. Our Health Foundation partners ensure access to reliable information about what’s really needed and provide considerable leverage to get solutions reimbursed. Truly disruptive innovations by definition are not included in existing safety standards (ruling market admission). We take part in (re)shaping the world-wide IEC/ISO standards, so that disruptive innovations can reach the market much quicker.

The Van ‘t Hoff program thus forms an eco-system which enables acceleration of medical and technological innovations and their implementation in health care. TNO is a respected and active member of IEC/ISO, Photonics 21 and the European Photonics Industry Consortium (EPIC).
The Life Science Trace gas Facility develops state-of-the-art laser spectroscopic and mass spectrometric methods for the detection of trace gases, relevant for biological and medical sciences. The latest laser and optical fiber technology is exploited in combination with matching detection methods to retrieve and computer-analyze trace gas concentration data within seconds. The laser-based analytical instruments operate in the 1.5-10 μm wavelength range with maximum coverage of the molecular fingerprint region and superior wavelength agility. The latter enables rapid and accurate examination of complex gas mixtures. Recently, several research projects started developing mid- and near-infrared Frequency Combs for fast Fourier Transform Spectrometry for chemical analysis. The Facility offers European scientists from biomedical fields the opportunity to perform state-of-the-art trace gas research on their biological samples. In close cooperation with biological and medical research groups this has led to new insights in biological and medical sciences. There is a close cooperation with Academic Hospitals exploring the potential of exhaled breath gases for the monitoring of the physiological conditions of human subjects. This has led to laser based detectors for detection of NO in relation to asthma, HCN in relation to bacterial infection of the lungs and acetone in relation to diabetes.

Erasmus University Medical Center Rotterdam is one of the 10 best medical institutes in Europe and is one of the 30 best research institutes worldwide. Erasmus MC is committed to a healthy population and excellent care through research and education. Erasmus MC has achieved its current position by making choices in the broad field of medical research, and the dissemination of these choices through investment in people and facilities. This gives researchers the freedom to develop new lines of research, to facilitate cooperation and researchers are encouraged to look beyond national borders. This has made Erasmus MC increasingly attractive to top scientists and talented young researchers. Erasmus MC excels in different areas of research, the study of basic and clinical domains, as well as public health and prevention. Research of the Erasmus MC is at the heart of society, resulting in innovation, quality and increased efficiency in patient care. The general research aim of the Erasmus MC is to translate the discoveries to bedside applications.

An excellent example in Biophotonics is the collaboration between the company RiverD (see page 10) and Erasmus MC in developing new medical diagnostic instruments based on Raman spectrometry. Erasmus MC incubator offers potential entrepreneurs office space, lab space, access to a network of professionals, advice, coaching, and training at a unique location in Rotterdam.
The Biomedical photonics group is part of the Biomedical Engineering & Physics (BME&P) of the academic medical center, University of Amsterdam. The BME&P department is situated in the hospital, which enables collaborations with various clinical disciplines (e.g. urology, cardiology, pulmonology). We also form a natural center of gravity for the physicists and engineers at the AMC. As an expertise center on biomedical physics and engineering, and we regularly provide support for physicians and clinical researchers.

The research of the Biomedical photonics group focuses on the Physics of the interaction of light with tissue to gather quantitative functional information of tissue. We use the generated knowledge on biomedical optics for the development, introduction and clinical evaluation of (newly developed) optical imaging and analysis techniques.

The department hosts an interdisciplinary team of physicists, biologists, chemists, medical researchers and technicians. This research is embedded in a range of Dutch and international scientific organizations and networks, e.g. the “Institute Quantivision”, a center of research excellence on priority medical devices, the Virtual Physiological Human program “EUHeart”, and the Marie Curie Research Training Network “SmArter”. These research projects have resulted in over 30 PhD graduations since 2012, from which approximately 50% of the projects was directly related to SME’s.

The mission of Institute QuantiVision is to develop medical imaging devices, software and protocols to enhance the efficiency, efficacy and economy of healthcare in the Netherlands, with focus on cardiovascular diseases, oncology and neurology. In particular, starting from clinical questions, Institute QuantiVision will develop high quality medical devices and protocols for quantitative analysis and integration of images at microscopic and macroscopic scale in order to improve diagnosis and therapy. Healthcare improvement will be achieved by increasing diagnostic sensitivity, improving disease monitoring, improving localization of therapy, and improving evaluation of response to therapy.

To complete our mission, we aim to:

- enable better, faster, and more affordable diagnosis and monitoring of patients.
- improve therapeutic imaging support and enable image-guided optical biopsies that are more reliable, time-efficient, less invasive than standard tissue biopsies.
- develop sophisticated data reduction and feature extraction methods, so that healthcare professionals can make optimal use of all available data without suffering from data overflow.
- disseminate developed knowledge by education and devices and protocols in collaboration with industry, both nationally and internationally.
Medical technological equipment is essential in medicine and academic health care within the VU University medical center. The department of Physics and Medical Technology (FMT) facilitates innovation and use of this equipment VUmc wide with a focus on management, assurance of quality, safety and effectiveness. The **development section** develops and manufactures new medical instruments and devices. In the field of medical technology the **medical technology section** of FMT performs maintenance, support and management of all medical equipment in the VUmc. She is also responsible for the quality and safety of medical devices. FMT aims within the **physics section** at the application and development of physical methods in medicine. In addition, the physics section provides education in the field of medical physics and medical technology for medical students and various university and other studies.

The Development Group of FMT is responsible for the design, development and construction of various medical instruments and appliances for the patientcare, education and scientific medical research. The Group has a well-equipped electronic and machine shop.

The physics section deals with the application and development of physical methods, techniques and devices in medicine. The physics section includes the following subdivisions:

- Research [www.vumc.com/branch/pmt/physics/research](http://www.vumc.com/branch/pmt/physics/research)
- Education & Training [www.vumc.com/branch/pmt/physics/education](http://www.vumc.com/branch/pmt/physics/education)

Some examples of medical applications where Photoncis is involved as enabling technology are: optical biochips and biosensors, optical delivery systems, photonics for minimally-invasive and point-of-care diagnosis and surgical lasersystems.

A quite unique application area is spectral imaging techniques to study the interaction of equipment with the patient in view of safety, treatment quality and development of new applications. The Advanced Optical Imaging Lab provides specialized setups for close-up imaging, high contrast imaging, high speed (< microsecond), thermal imaging and multispectral imaging. Depending on the cooperation structure or project the following equipment is accessible for third parties: 3D-printing facilities, CAD/CAM facilities, C&C machining and Laser machining.

Since 2008 FMT participates in Pontes Medical. Within Pontes Medical projects are started to commercialize new developed medical technological products originated from FMT and the VU Medical Center. For more information about Pontes Medical see: [www.pontesmedical.com](http://www.pontesmedical.com)
Wageningen University & Research Centre is the contract research organisation of Wageningen University & Research Centre (WUR). WUR is a world-renowned centre that combines fundamental and applied research with innovative education in the areas of food, agrotechnology, production systems, nature and the environment. The domain of Wageningen UR consists of three related core areas:

- Food and food production,
- Living environment,
- Health, lifestyle and livelihood

It is this changing world that is the real specialisation of Wageningen UR – the domain of good and safe food & food production, food security and a healthy living environment. In essence, Wageningen UR is a research institution that not only develops knowledge but also helps to apply it.

WUR is a world leading expert in greenhouse construction, climate control, energy saving and efficient energy conversion where light transmission, scattering and spectrum are essential factors. Additionally, new sustainable concepts for crop production are developed in Wageningen UR Phenomics Innovation and Demonstration Centre High throughput phenotyping facilities. These facilities are rapidly becoming essential for significant advancements in plant breeding. The necessary integration of image analysis, pattern recognition, plant physiology including crop growth models, quantitative and molecular genetics, automation and robotics poses several scientific challenges.

The expertise of all groups at Wageningen UR comes together in the Phenomics innovation and demonstration centre, which is the organization’s entry point to facilities and tools for large scale field and greenhouse phenotyping. These enabling technologies include 2D and 3D plant reconstruction modules, hyperspectral cameras, X-ray tomography for root analysis, chlorophyll fluorescence setups and other novel sensors plus vision-guided robotics to automate manual labor, as well as recently developed software for modeling growth and yield in 3D, which facilitates predictions of plant performance based on the measured phenotypic features.

At the Wageningen University and Research Centre several research projects are currently exploring the potential of these technologies spanning the full spectrum from long-term academic research to industrial applications.
Other universities, facilities and research centers

AMOLF (FOM) Amsterdam
AMOLF employs about 130 fte research staff and 70 fte support staff. AMOLF’s yearly budget is 14 million euro. The institute is located in Science Park Amsterdam. AMOLF carries out research in two main directions: Physics of Biomolecular systems and Nanophotonics. The Nanophotonics group carries research in the following fields: NanoOptics, Photonic Materials, Surface Photonics, Resonant Nanophotonics, Photonic Forces and Hybrid Solar Cells. In addition, in June 2014 the Advanced Research Centre for Nanolithography was established with a strong emphasis on the physics involved in the generation of high intensities of EUV light, optical elements for EUV light, EUV photo-chemistry. This Centre is strongly connected with the interests of ASML Veldhoven NL.

University of Twente – Mesa+
MESA+ is one of the world’s largest nanotechnology research institutes; and it’s the largest research institute in this field in the Netherlands. A total of 525 researchers work together on cutting-edge research at the highest level.

MESA+ Nanolab
MESA+ has a 1250 m² state-of-the-art NanoLab, which consists of three closely intertwined units: the cleanroom, analysis facilities and the BioNanoLab. Research at the nanometer scale needs a laboratory with extreme specifications, whereas the NanoLab is constructed to meet such high standards. NanoLab NL has the aim to build up, maintain and provide a coherent and accessible high-level, state-of-the-art infra-structure for nanotechnological research and innovation in the Netherlands.

High Tech Factory
High Tech Factory is the production facility for businesses engaged in work on microsystems and nanotechnology. It is located on the campus of the University of Twente. The NanoLab is open to the companies established in High Tech Factory. Several of the photonic industries in Twente are located or affiliated with the High Tech Factory.

Kennispark Twente
The Kennispark Twente is an innovation flagship. It is home to over 380 innovative companies it is one of the largest innovation campus in the Netherlands. LioniX, PhoeniX, Xio Photonics, Satrax, Optisense, Focal, BioVolt, Solmates are all located in the Kennispark Twente, just meters from the University of Twente and the MESA+ Nanolab.

Delft University of Technology
Photonics and optics research at DUT is centered at the faculty of Applied Sciences and performs cutting-edge research and education in imaging science to advance the fundamental understanding of physical phenomena leading to new innovative imaging principles and revolutionary imaging instruments. The four research groups focus on the following topics:

* Biomedical technology with instrumentation and image analysis for healthcare application and fundamental life sciences research including optics and microscopy for medical diagnostics.

* Nanofabrication and nanoscopy where charged particles are used for fabricating nanoscale devices: Developing nanoscale electron and optical imaging including optical super resolution and optical design for high resolution imaging.
Other universities, facilities and research centers

Eindhoven University of Technology – Cobra Institute

Research in photonics is carried out in the following two Top Research Groups: COBRA Research Institute and the Intelligent Lighting Institute. The COBRA group is one of the world's top institutes in the field of optical communications and focuses on interdisciplinary research in optical communication, concentrated in three areas: Materials, Devices, and Systems and combine the work of researchers in the fields of physics and electrical engineering.

COBRA employs 20 permanent staff members and more than 100 temporary ones, including PhD students and postdoctoral fellows. It has a well-equipped 800 m2 cleanroom facility (Nanolab@TU/e) for researching, measuring and experimenting with the most important semiconductor material of the optoelectronic field: Indium Phosphide (InP).

The TU/e is among the world's ten best-performing research universities in terms of research cooperation with industry. At COBRA, we commit ourselves to multidisciplinary research to tackle the problems that the industry faces in the long term. Our researchers cross boundaries and actively seek industry collaboration. Start-up and spin-out companies from COBRA are: VLC Photonics, EFFECT Photonics, Smart Photonics, Bright Photonics and PhotonX Networks.

The Photonic Integration Group of COBRA has a worldwide reputation in the field of integrated photonics in InP and focuses its research on:

- The introduction of generic integration technologies i.e. technologies that support integration of a broad range of functionalities from a small set of basic components, similar to CMOS technology in electronics.
- The development of photonic ICs on top of electronic ICs (silicon photonics).
- The development of plasmonic nanolasers; ultra-small and ultrafast lasers that can switch with ultralow power and that allow for Very Large Scale Photonic Integration.

COBRA is involved in a number of national and international research projects and plays a leading role in these fields. The research offers ample opportunities for Master and PhD students to do research on advanced photonic ICs or technology and to get a job in a variety of smaller or larger high-tech companies that use Photonic ICs in their products.

The broker organization JePPIX assists organizations around the globe to get access to advanced fabrication facilities for Photonic Integrated Circuits. JePPIX aims at low-cost development of application specific PICs using generic foundry model, and rapid prototyping via industrial Multi-Project Wafer runs and including manufacturing and packaging partners, photonic CAD software partners, R&D labs and photonic ICs design houses.
In the Netherlands, PhotonicsNL (PNL) is the platform for ‘high tech’ companies, knowledge institutes and education at all levels to exchange and spread knowledge regarding photonics. We are well connected to a widespread photonics network, both national and international.

Our photonics expertise and our network is made available to businesses by consultancy, and the organization of photonics courses, photonics seminars and (international) trade shows, like Photonics West in San Francisco, Laser World of Photonics München and our annual Dutch Photonics Event.

Companies and institutes can join the PNL platform and pay an annual contribution. In return, they have free access or pay a reduced fee to a number of activities, organized by PNL. At this moment PNL has 26 company members and about 90 private members.

PNL for business and education
Thanks to our knowledge of photonics and widespread network we are able to give advice to companies with respect to the development of new products, to apply photonics for production processes with the goal to enhance production processes or introduce new production techniques.

Photonics plays a major role in several areas such as ICT, health care & life science, industrial manufacturing, and environmental health and security.

Products in which photonics play a major role as the ‘Enabling Technology’, revenue up to € 350 billion in the world market. With an annual increase of 10%, the photonics market is one of the fastest growing markets. An increase in knowledge and awareness for this new field of expertise in the Netherlands will lead to new opportunities for industry and new business in this international and innovative market.

Besides consultancy for business, PNL strongly aims at the development of photonics education. Especially at the level of secondary and more higher education, too little opportunities are exploited to prepare people, educated in photonics, for a captivating job.

Cooperation
PNL closely cooperates with Netherlands Enterprise Agency (RVO), Mikrocentrum, MinacNed and Netherlands Council for Trade Promotion (NCH). PNL is also involved in several EU-projects to create awareness of photonics in the Netherlands as a Key Enabling Technology. We are in close contact with Photononics21, member of EPIC and member of the European Optical Society (EOS).
THE NETHERLANDS