ABN·AMRO

Photonics lights up Dutch manufacturing industry

PhotonicsNL Netherlands

November 2017

Contents

Photonics is all around us

Not many of us are familiar with the term 'photonics'. Still, most of us use it on a daily basis. The best-known example is the fibre optic cable, which uses light as a way of transmitting data to provide faster broadband. A bare essential these days, since the explosive growth in the amount of data and the Internet of Things could cause the internet as we know it to clog up in just a few years' time[1]. Photonics is set to play an increasingly prominent role across the global industry. It has been identified by some, including the European Commission and the Dutch Centre of Expertise HTSM (High Tech Systems & Materials), as a key technology 21st century. But what is photonics exactly? What can we do with it and what position does the Netherlands have on the international stage? This report sheds light on this interesting field.

Photonics: the technology of light

The Netherlands has a rich tradition in optics and photonics. It all began in 1690 when Christiaan Huygens, one of the country's greatest mathematicians and physicians, built the first telescope to see the rings of Saturn. He also proposed the wave theory of light, describing it in his famous *Traité de la Lumière*. The first optical instrument maker was Antoni van Leeuwenhoek, also a Dutchman, who built microscopes. To this day, the Netherlands continues this tradition. Dutch engineers are helping build the Extremely Large Telescope (ELT), a telescope with a 39-metre diameter mirror designed to discover exoplanets. But the country is also a major player at the other end of the scale – right down to nanometre level. Cells and molecules are changed to make them emit light themselves (fluorescence microscopy), and we develop and produce photonic ICs. These are just a few examples of how – fast forwarding a couple of centuries – the Netherlands is still up there with the world's best.

Photonics is the technology of generating, transmitting and detecting light waves or light particles, also known as 'photons'. The name 'photonics' is derived from the elementary particle 'photon' in the same way as 'electronics' is named after the 'electron'.

Over the past fifty years, photonics has evolved into an innovative technology, driven by the invention and development of the laser as a light source, new production techniques and new optic materials and components, such as industrial lenses. It is difficult to keep count of the sheer number of products and end products that are being launched onto the global markets. What is remarkable is their novel character: the products are sustainable, energy-efficient, small and increasingly less expensive to buy. Technological developments and rapidly growing demand drive affordability.

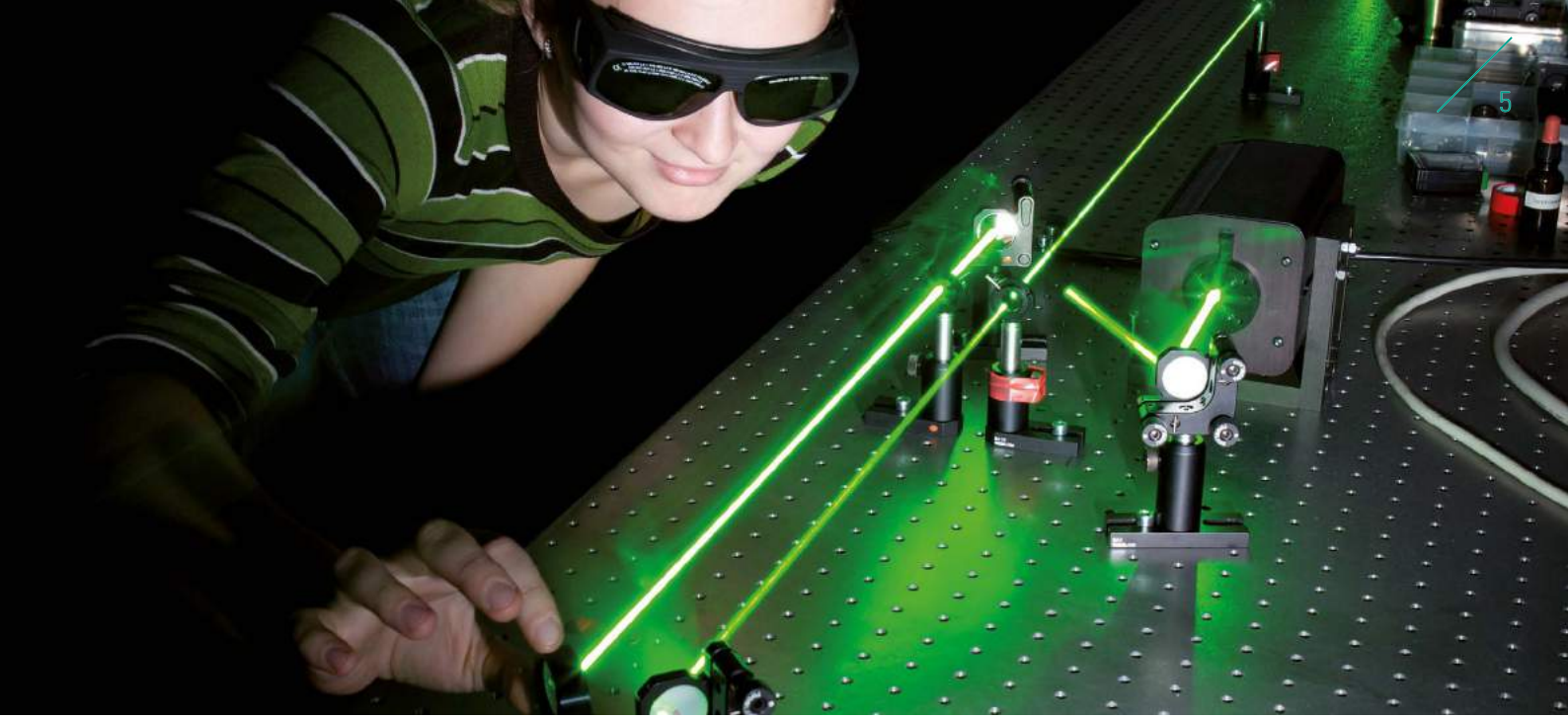
Apart from fibre optics communication, photonics has also paved the way for products such as:

- smartphones
- energy-efficient, Hi-Res LED displays (computers and TVs)
- LED lighting
- Blu-ray
- solar cells in all shapes and sizes.

Most of these products are mass-produced in Asia, at the lowest possible cost. However, there are also less well-known photonic products that are not primarily intended for consumers. Photonics has become a vital element of international high-tech manufacturing, especially in the medical, defence and agri-food sectors. It is these niche markets that provide opportunities for European and Dutch businesses. This is where they can bring to bear their technological know-how and capabilities to provide customised products that resolve some of the challenges customers face. This report identifies three areas where photonics is applied and that are of interest to Europe (and the Netherlands): **Biophotonics, Imaging & Sensors and Integrated Photonics**. Although the technology for these end markets is often still in the research, certification or development phase, we have already seen some products that are ready to go to market.

What does this report cover?

This report zooms in on these three photonics segments (Chapter 1) and offers statistics on the global and EU photonics markets. It also covers the key players and current trends (Chapter 2), looking more closely at the Dutch market and a market survey of Dutch photonics companies conducted by PhotonicsNL (Chapter 3). The report provides a list of Dutch photonics manufacturers and concludes with a note on the Dutch and global markets. We also give a number of recommendations that we believe are important for a small country such as the Netherlands to make the most of the social and economic opportunities offered by this technology.



Promising photonic technologies

Biophotonics: source of healthcare innovation

If you take biology and throw photonics into mix, what you get is Biophotonics: a branch of industry that develops and uses optic technology to measure, analyse, and visualise biological materials without causing damage to them. Think tissue, cells, or even DNA. Microscopy is probably the best-known example of Biophotonics, growing at a faster pace than other photonics sectors, driven by its strong link with the international medical technology market.

The Netherlands is a global leader in Biophotonics, already boasting many innovative spin-off companies that build optic instruments and devices for hospitals, GPs, and patients alike. Examples include blood analysis devices to check blood levels without the need for finger-pricking. There is, in fact, a thoroughly Dutch device that gauges the risk of heart and vascular disease or diabetes without patients having to prick their finger. Developed by Diagnoptics, a company based in the northern city of Groningen, the Age Reader – as it is known – is produced in the Netherlands. These types of applications help alleviate the physical strain on patients and could also substantially reduce healthcare costs.

The development of new and affordable optical sensors has also been instrumental in the success of Biophotonics. Prices of state-of-the-art components, such as lasers, LEDs, optic detectors and 'ordinary' lenses, have fallen significantly over the last few years. Not just because of evolving technological capabilities, but also precisely because they are used en masse in everyday devices, such as smartphones. A comparison with electronics springs to mind – the first discrete transistor brought on to the market in the 1950s cost just under a "tenner". These days, a couple of billion of transistors are squeezed into one square centimetre, but the principle is still the same. Electronics actually kick-started the development of optical components.

Imaging & Sensors: looking at things differently

Imaging & Sensors is a field that develops optical systems to detect and visualise changes in the properties of materials. Surely the most impressive example of this is the camera built into a smartphone, with a tiny LED light next to it that can produce an enormous flash of light. It will not be long before we can use our smartphones as optical spectrometers, for example to photograph a discolouring of the skin that might point to a carcinoma.

What is a spectrometer?

A spectrometer is actually an old optic instrument (Isaac Newton's prism) that splits and measures the different colours (wavelengths) of light. You can use a spectrometer, for example, to determine the chemical composition of fluids across a much wider wavelength spectrum than our own eyes are sensitive enough to see. If you hook up your spectrometer to a special camera, you can very precisely tell the colour composition of objects from the image generated. This technology is called Spectral Imaging. In the past, these were large and expensive tools, suitable only for use in laboratories. As technological developments progress, they are becoming cheaper and much smaller.

Which brings us neatly back to Biophotonics, where professional spectral cameras are used on an increasingly wide scale, not just in healthcare but in all kinds of other sectors as well. Spectral cameras are used, for example, in agriculture and horticulture to monitor the quality of fruit and sort out healthy seeds, by astronomers to unveil the chemical composition of exoplanets, and in forensics to analyse bodily fluids found at a crime scene.

Another use of Imaging & Sensors involves new types of sensors that can measure a range of physical quantities. Some optic sensors are highly sensitive to mechanical bending and used increasingly frequently, for example, to measure the weight of a passing train or the mechanical deformation of aeroplane wings or helicopter blades. In the medical sector, sensors are sometimes used in surgical equipment. All these sensors would not exist if it were not for the availability of affordable optic chips, which convert the data measured into usable information. That's where we enter the world of Integrated Photonics.

Integrated Photonics: the optic chip of the future

Biophotonics and Imaging & Sensors have combined to produce a relatively new field of technology: Integrated Photonics. This field develops and makes micro-chips that process light signals. Because they are small and use little energy, they can be built into a variety of devices. Needless to say, prospects for Integrated Photonics are very promising indeed. These chips are produced much in the same way as electronic chips (ICs), the difference being that light is the data storage medium. Photonic Integrated Chips (PICs) are already being used in the telecom sector, for example to transmit data across multiple colours (wave lengths) at the same time using optic fibre cables. But they can also be put to use as cheap but accurate chips in sensors to process data measurements, such as pressure, temperature or movement, or the chemical concentration of substances in fluids ("lab-on-a-chip").

Fully embedded in the Dutch value chain

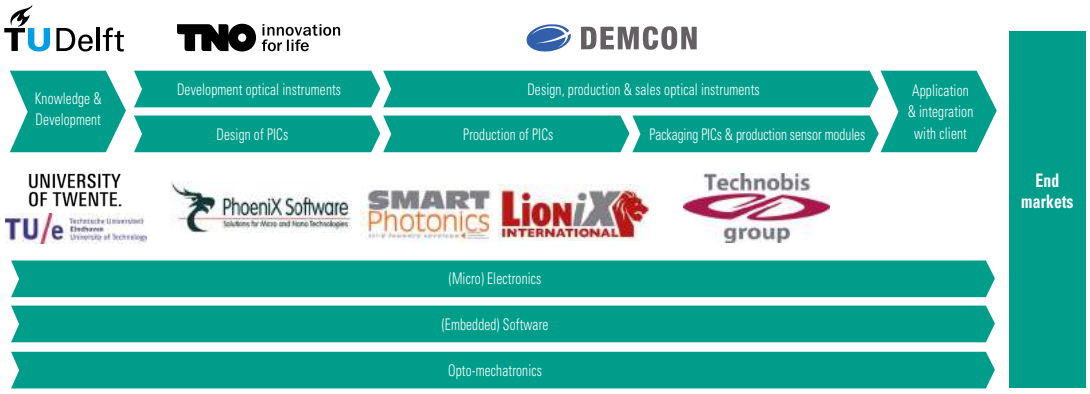
The Netherlands has a leading position in Integrated Photonics, founded on years of scientific research conducted by the universities of technology in Eindhoven and Twente, in collaboration with innovative SMEs and multinationals such as Philips and ASML. This has generated a range of spin-off companies and led to a concentration of businesses shooting up around these universities, all involved in some way or other in integrated photonics. The Photon Delta initiative is an example in point.

What is unique about the Netherlands is that it is home to the entire value chain, from sensor design and engineering to the production of PICs (the "foundry") through to their application in end-products (e.g. Smart Photonics in Eindhoven and LioniX in Enschede).

The figure below shows the Dutch value chain and examples of spin-offs. A full list of all Dutch photonics manufacturers can be found in the table in the middle of this report.

Figure 1

Photonics' value chain in The Netherlands



As photonics technology is developing rapidly, the next few years will be "make or break". If the Dutch universities and industry want to remain on top of their game, they will need to know what their strengths and weaknesses are, what the competition looks like, and what the opportunities and threats are. A market survey of key Dutch players will then come in handy.

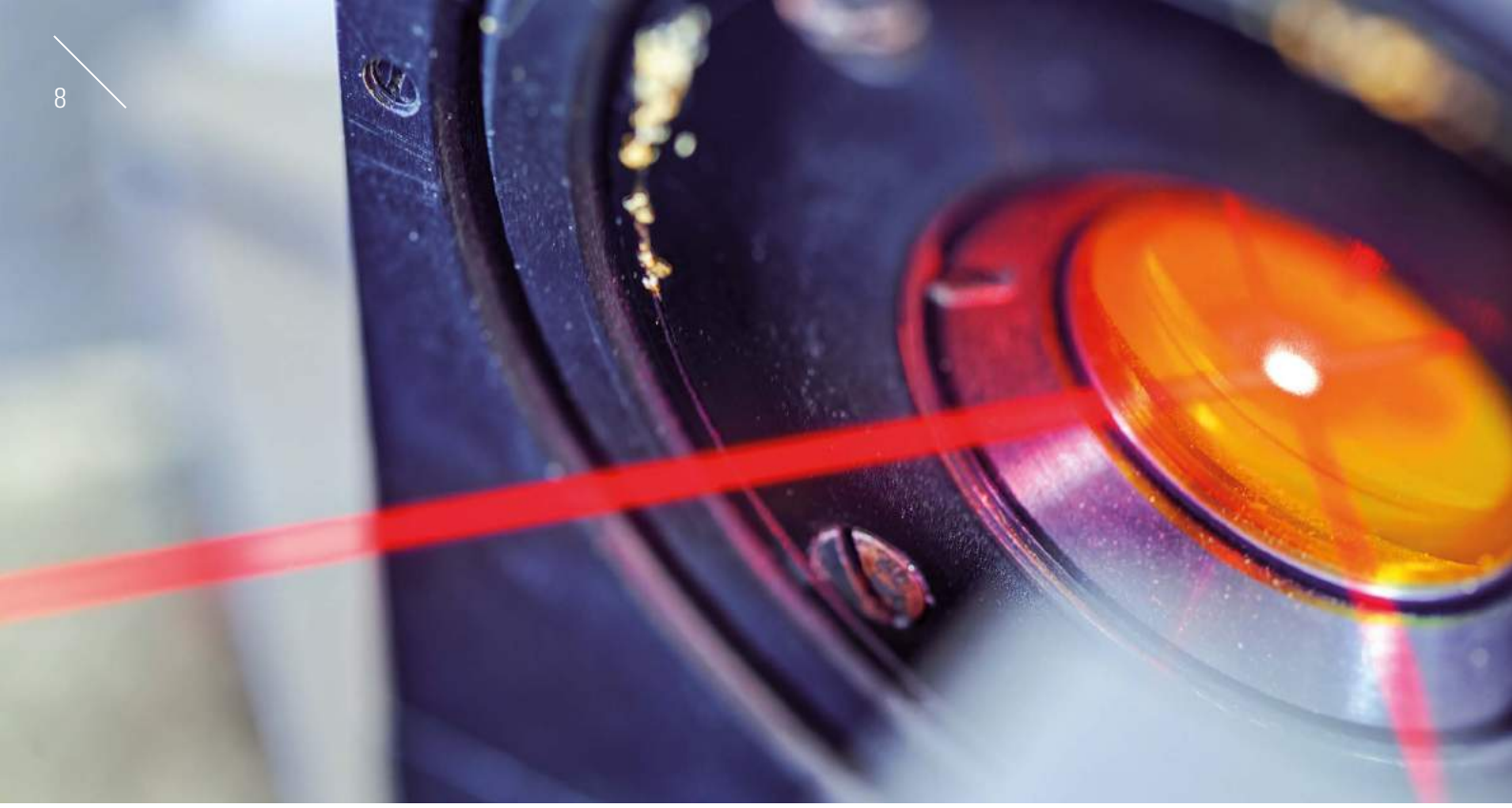
Dutch photonics manufacturing in close-up

In May 2017, working with ABN AMRO Bank, the sector association PhotonicsNL surveyed the Dutch photonics market and its growth potential. The survey specifically covered Biophotonics, Imaging & Sensors, and Integrated Photonics, analysing the current size of these markets and their strengths and weaknesses. We also identified the opportunities and obstacles for companies wishing to operate or expand in the Netherlands. This effectively set the parameters for securing the Netherlands' leading position.

A total of around 160 businesses, universities and knowledge centres are involved directly or indirectly in photonics in the Netherlands. Between them, they capture the entire product/value chain, from research to the production of devices and delivery of services to end-users. We confined our study to photonics manufacturing. Around 70 businesses across the chain operate within this segment (for a list of all Dutch companies, see the table in the middle of this report). We contacted all of them and received 34 responses. It is the first ever survey of the Dutch photonics market.

Definition of photonics manufacturing

In our market survey, we used the following definition:
"The photonics manufacturing industry makes innovative and sustainable (end-)products or devices that necessarily incorporate photonics and optics, using the fundamental properties of light (photon): propagation, wavelength, energy, polarisation, and material interaction."



Asia and US dominate global photonics market

Mass-produced consumer electronics often contain components that have been made using photonics technology. Examples are cameras, displays, the LED flashlight on a smartphone, the laser in a CD player, or the collectors in solar panels. The global market for products that thank their existence to photonics is huge. In 2014, the international society for optics and photonics SPIE estimated its value at around 1,450 billion dollars (2014) and the number of jobs at 3.5 million[4].

Figure 2 shows that the bulk of global revenue is generated by consumer electronics. Together with lighting and displays, it is approaching the 1,000 billion dollar mark. Defence and security are another key market for satellites and body scanners, and is expected to grow substantially as geopolitical tensions increase.

Finally, the solar panel market (PV cells) accounts for a big chunk of global revenue as demand for solar power as a renewable energy source has grown worldwide over the last few years, driven in part by falling prices.

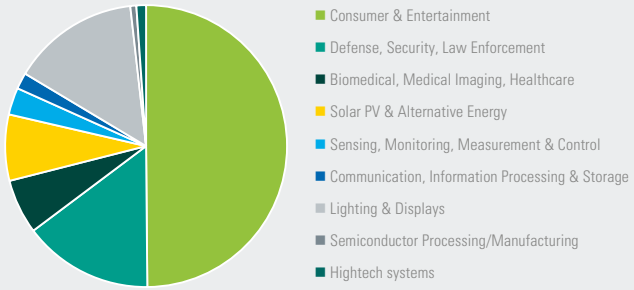
Japanese-US tête-à-tête

SPIE's sum shown in Figure 2 is not entirely correct. Although photonics has become unmissable in the markets referred to above, the products involved contain much more than just photonic components. SPIE estimates the actual size of the international photonics market at around 182 billion dollars (2014), see Figure 3. This estimate represents the actual revenue from photonics manufacturing, such as the production of LEDs, lenses, lasers, optical sensors, and optic cables.

In 2012-2014, that revenue increased by 15%. Strikingly, the US and Japan together account for nearly three quarters of the market. However, a study conducted by the European sector association Photonics21 (2015) reveals that China has seen the biggest growth in the past 10 years, mainly at the expense of Japan.

Figure 2

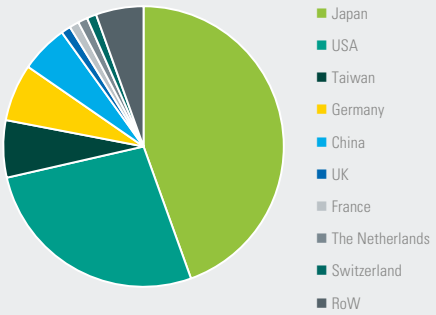
Breakdown of photonics revenue globally, by end market, 2014



Source: SPIE, 2014

Figure 3

Breakdown of photonics revenue, by country, 2014



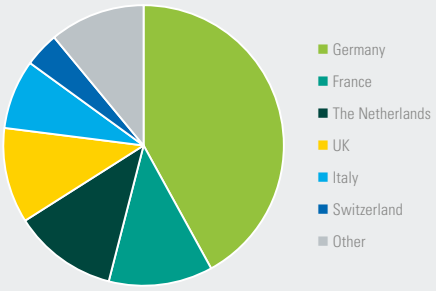
Source: SPIE, 2014

Europe's position

Both SPIE (2014) and Photonics21 (2015) estimate Europe's share of the global market at around 16%, down slightly on 2011 (18%) due mainly to China expanding its market share. European key players are Germany, France and the Netherlands (Photonics21, 2015), see Figure 4. Between 2005 and 2015, Europe's photonics industry grew by around 5% a year, despite the contraction of its solar industry. Photonics21 expects a similar growth rate of 5% to 5.5% for the years ahead.

Figure 4

Breakdown of photonics revenue in Europe, by country, 2015



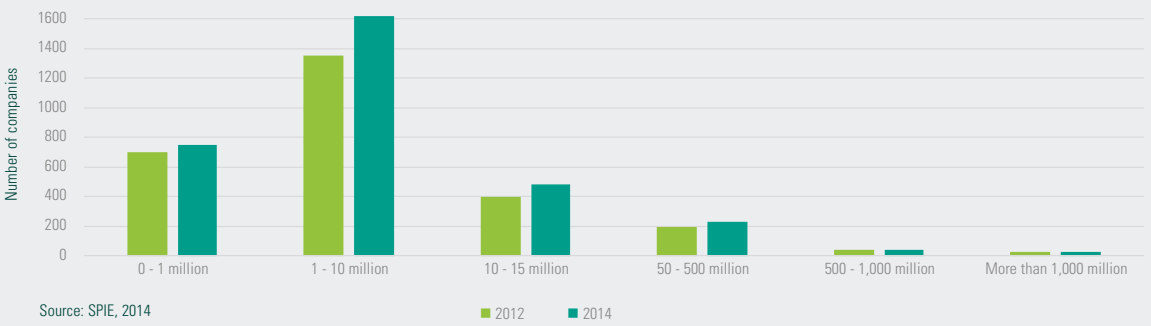
Source: Photonics21, Optech Consulting, 2015

A market made up of small players

Interestingly, SPIE also found that 75% of companies had a global revenue of less than 10 million dollars but still reported the strongest growth figures between 2012 and 2014 (see Figure 5). At the same time, SPIE found that 70% of revenue from photonics was generated by the top 2.5% international companies. These findings make clear that the market is strongly fragmented and only a handful of businesses have succeeded in making their mark. It is unclear precisely why that is. As far as the Netherlands is concerned, we have been able to pinpoint a few clear reasons, including a shortage of funds and highly skilled staff. We'll explain this in more detail in the next section.

Figure 5

Global Photonics Components Suppliers, grouped by revenue (in US$), 2014



Source: SPIE, 2014

The Netherlands and photonics: a country great or small?

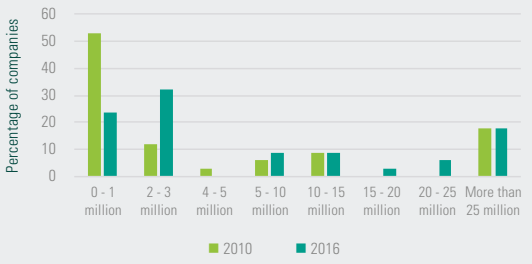
As stated, a total of around 160 Dutch businesses, universities and knowledge centres are directly or indirectly involved in photonics – be it R&D, the manufacture of (end-)products, or the delivery of services. Other than that, there is little data available on the Dutch photonics industry. No inventory of key players, no analysis of opportunities and threats. And no revenue figures. The most recent estimate is the one published by SPIE (2014), which put the total revenue at an odd 2 billion dollars (1.8 billion euros), see Figure 3. SPIE's and Photonics21's estimates factor in only part of the revenue reported by the multinationals ASML, Philips (Lighting, Healthcare), Lumileds, and Canon-Océ.

First ever market survey of Dutch industry

In order to obtain more accurate market data, PhotonicsNL conducted a market survey of 34 Dutch photonics manufacturers. Operating across the entire value chain, the respondents were all given the same questions and answer options. The results paint a portrait of Dutch photonics manufacturing and the expectations of Dutch entrepreneurs.

Figure 6

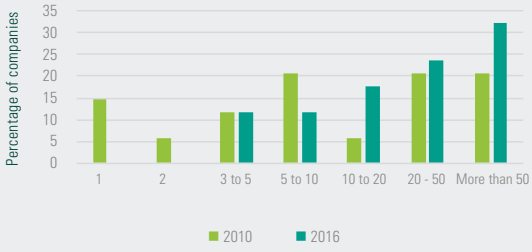
Breakdown of Dutch photonics companies, by revenue category (in Euro), 2010-2016



Source: PhotonicsNL, 2017

Figure 7

Breakdown of Dutch photonics companies, by number of employees, 2010-2016



Source: PhotonicsNL, 2017

SMEs are important to Dutch photonics

What's striking about photonics manufacturing in the Netherlands is the high level of involvement of SMEs. There are relatively many small businesses, with 65% of manufacturers reporting a maximum revenue of 10 million euros and 40% employing no more than 20 people. See Figures 6 and 7. On the other end of the scale, there is a small group of multinationals, including ASML and Philips. These findings mirror the global market survey carried out by SPIE.

Revenue and jobs on the rise

Another remarkable feature of the photonics manufacturing industry is the growth in employee numbers. Between 2010 and 2016, employment rose by an average of 37% (see Figure 7). In the same period, respondents saw their revenue go up by an average of 31% (Figure 6), Imaging & Sensors accounting for the bulk of this growth. Nearly half of respondents operate in this field (Figure 8). Given these revenue figures, we were also interested in how profits evolved between 2010 and 2016. In 2010, only half of respondents made a profit; by 2016, this had increased to well over 85% (see Figure 9).

Businesses are positive about the future

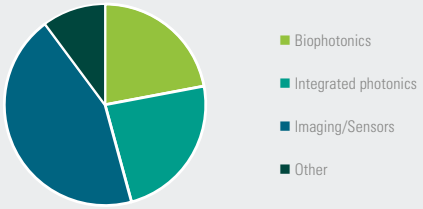
Nearly all respondents expected to remain profitable or to turn a profit in the next few years (see Figure 11). They were also optimistic about the future, with almost 60% of respondents expecting to achieve annual revenue growth of more than 10%. A third went so far as to say that they expected to grow by more than 20% (see Figure 10). The number of jobs is also set to grow, with more than 85% of respondents quoting growth rates of 5% to 20% or more. This is shown in Figure 12.

Integrated Photonics grows fastest

Respondents expected Integrated Photonics to see the biggest growth. This is in line with the rapid development of this field globally and in the Netherlands. The PhotonDelta platform set up in Eindhoven in 2016 is a good example. Although originally a spin-off of the Eindhoven University of Technology, it has since expanded to include a variety of manufacturers of PICs for ICT applications.

Figure 8

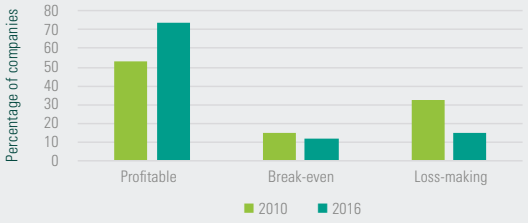
Breakdown of Dutch photonics companies, by application



Source: PhotonicsNL, 2017

Figure 9

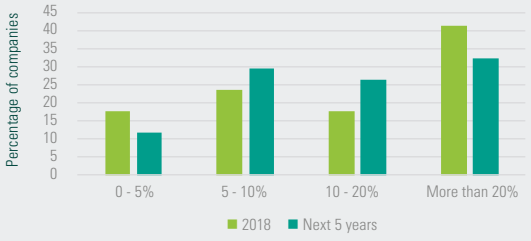
Breakdown of Dutch photonics companies, by profitability, 2010-2016



Sorce: PhotonicsNL, 2017

Figure 10

Breakdown of Dutch photonics companies, by expected annual revenue growth



Source: PhotonicsNL, 2017

Figure 11

Breakdown of Dutch photonics companies, by expected annual profit growth

Source: PhotonicsNL, 2017

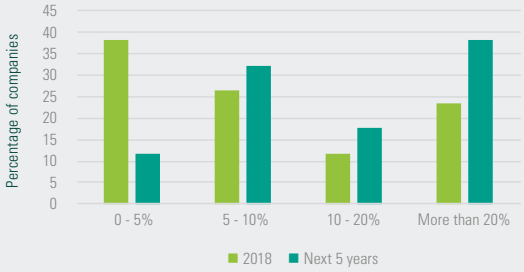
In addition to ICT uses, Integrated Photonics is also increasingly becoming a key technology for innovative sensors and instruments. The University of Twente has picked up on this as well. Working with companies such as LioniX International and Phoenix Software, its institute for nanotechnology MESA+, in particular, is conducting many research projects in this field. Twente University and businesses there have actually joined the PhotonDelta platform to help strengthen and accelerate the development of Photonics Integration.

Dutch market: international and specialist focus

In the Netherlands, three end-user markets stand out from the crowd: Imaging & Sensors, Monitoring, Measurement & Control, and Biophotonics. Relative to the global end-markets identified by SPIE (see Figure 2 in section 2), Netherlands is more or less an outlier. Major end-user markets selling mass-produced items are present in the Netherlands only to a limited extent, whereas "high-complexity, low-volume" markets like Sensing, Monitoring, Measurement & Control, and Biomedical, Healthcare & Medical Technology are very important (see Figure 13). This finding is in line with the market situation that we described earlier on. The Dutch industry also has a strong international focus. The majority of respondents indicated they had more customers abroad than in this country.

Figure 12

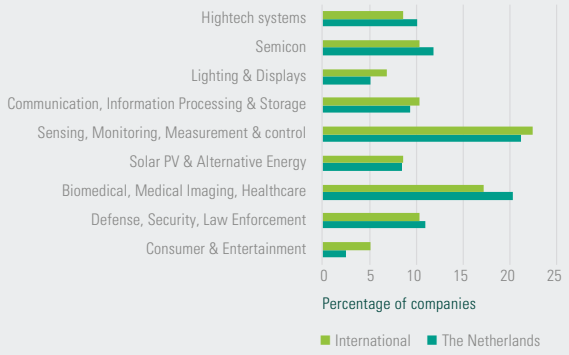
Breakdown of Dutch photonics companies, by expected annual growth in number of employees



Source: PhotonicsNL, 2017

Figure 13

Breakdown of end markets in which Dutch photonics companies operate



Source: PhotonicsNL, 2017

Dutch photonics has seen relatively strong growth in recent years. Despite the limited size of the industry and the companies operating in it, respondents were positive about the prospects for growth and further development of their operations. This was dependent, however, on a number of conditions.

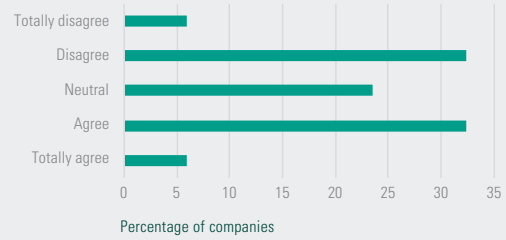
Requirements for future growth

Highly skilled staff

The shortage of highly skilled staff is a major concern for Dutch businesses. In a technically complex and innovative market such as photonics, this is all the more relevant as employers are specifically looking for people with a university background in optics, electronics and photonics (see Figures 14 and 15). In the rest of Europe, demand for skilled staff is also high and so is the potential for job growth[2]. Finding staff for assembly, installation or maintenance positions is much easier.

Figure 14

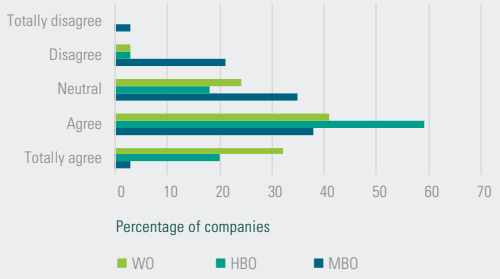
Argument:
"The Netherlands has sufficient photonics expertise"



Source: PhotonicsNL, 2017

Figure 15

Argument: "Photonics companies are looking for staff with formal education in and knowledge of photonics"

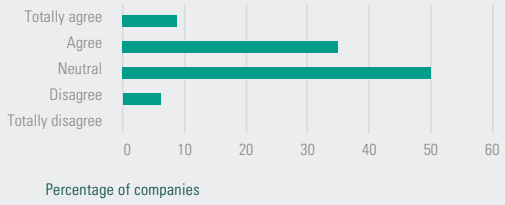


Collaboration is vital to success

More than half of respondents indicated they considered it vital to work more with others (see Figure 16). One of the reasons cited is that this would allow them to scale up their operations at all levels more quickly and stay ahead of the foreign competition. Partnerships between businesses (mainly large industries at present) and universities was necessary to be able to recruit sufficient technical staff going forward. Joining forces with universities would also provide an incentive to developing new technologies and production methods.

Figure 16

Argument: "Photonics companies in the Netherlands should collaborate more to accelerate the innovation drive"

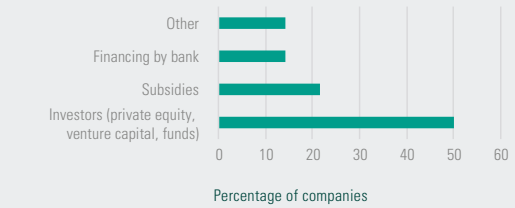


Source: PhotonicsNL, 2017

One such successful partnership is the Dutch Optics Centre (DOC) based in Delft, a joint initiative of TNO and Delft University of Technology. This knowledge platform focuses on developing new optical and photonic instruments in close collaboration with photonics businesses and manufacturing. The platform benefits greatly from the wealth of expertise and facilities available from TNO and Delft University. The projects undertaken by DOC are based on actual questions from the end-user market. This "technology pull" effectively ensures a full chain approach involving knowledge centres, businesses and end-users of new optical instruments and devices.

Figure 17

Expected sources of external funding for Dutch photonics companies



Source: PhotonicsNL, 2017

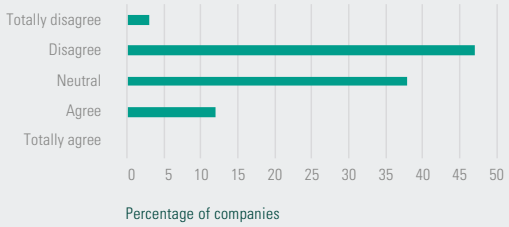
Another example is the development – in collaboration with the Dutch Renal Society – of a handy, portable device to be used for home dialysis. This same device is probably also suitable for use in horticulture and waste water management – that's two for one.

Funding: from subsidy to venture capital?

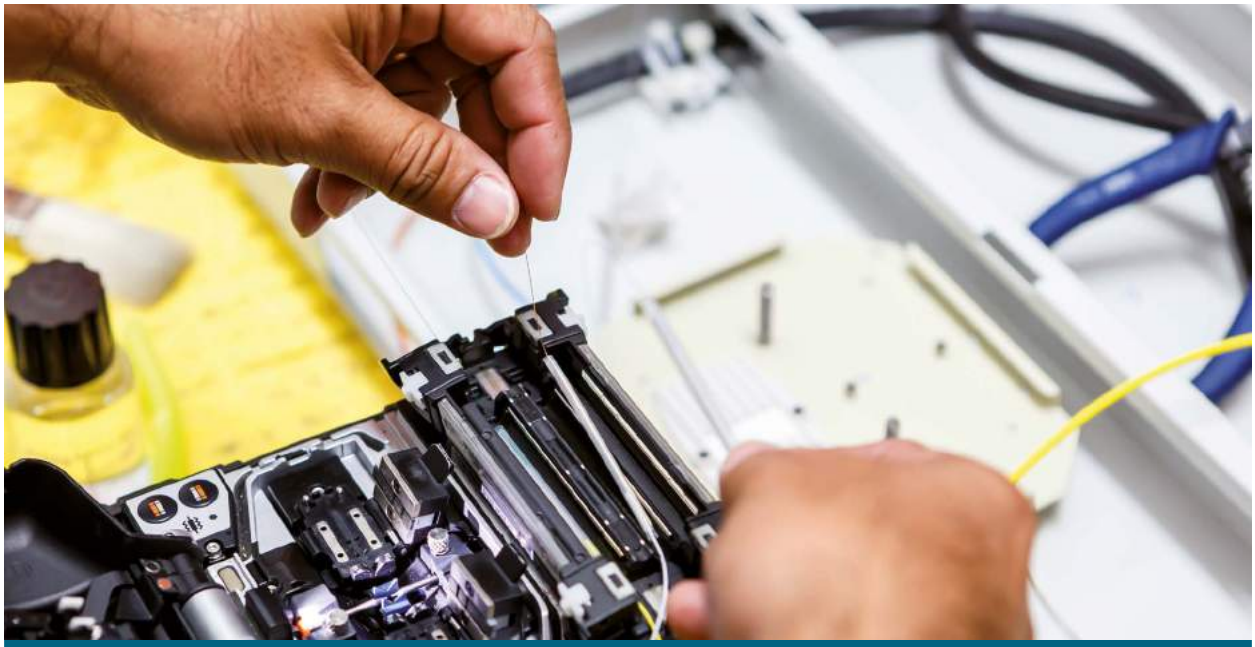
Companies need funds to grow. Our market survey shows that 41% of respondents were looking for external funding mainly from investors (private equity, venture capital or funds) but also government subsidies and bank loans (see Figure 17). Half of respondents indicated that the government was not doing enough to help advance photonics (see Figure 18). To address this situation, Brainport Eindhoven will ask the new government to invest 600 million euros in photonics technology.

Figure 18

Argument: "The Dutch government's investments in photonics are adequate"



Source: PhotonicsNL, 2017



"The new gold"

The European Union has identified photonics as one of five technologies with the greatest economic potential. It has been dubbed "the new gold" in Eindhoven. And they know what they're talking about. In the past few years, Eindhoven University of Technology has invested hundreds of millions of euros in research to develop a faster and less energy-gobbling computer chip. On 25 April, Eindhoven also saw the opening of the Integrated Photonics Institute as part of the PhotonDelta project. The institute's director Ton Backx has called photonics an "awfully interesting field" saying that "chips will need to be a thousand times faster and more energy-efficient in ten years' time than what we have available today. Photonics will make that happen."

Is photonics ready for investors?

Dutch photonics companies are often still dependent on subsidies. We nonetheless believe that a growing number of them are ready for external funding from investors and banks. The key questions are:

- Has the technology been developed and validated to such an extent that it can be used in end-products?
- Are end-user markets ready to incorporate the technology into their products?

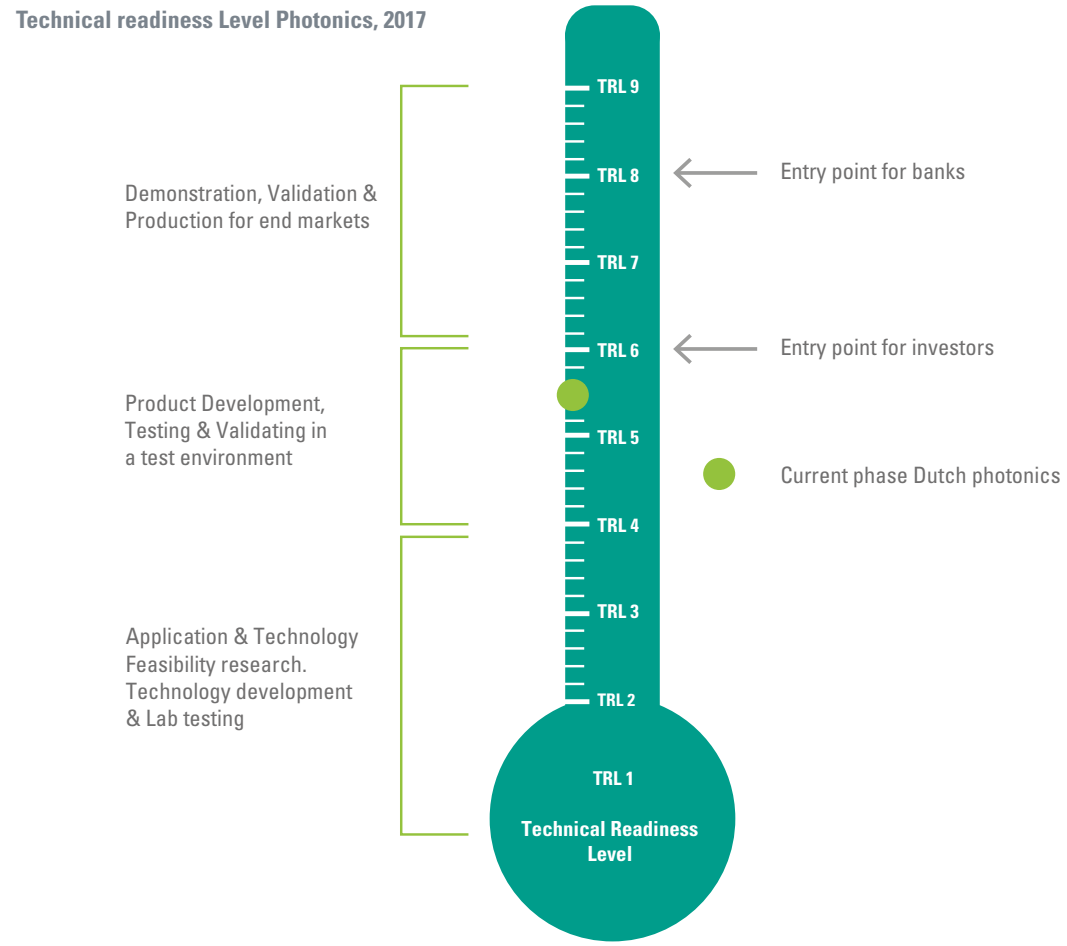
These questions can be answered by establishing the Technical Readiness Level (TRL). In April 2016, the Dutch financial daily newspaper *Financieele Dagblad* used a thermometer to determine the TRL of photonics in the Netherlands. According to the newspaper, the industry found itself at an average level of 4 and was therefore difficult to gauge by investors and other financiers. However, a growing number of businesses has since reached a turning point, with enough revenue growth and good profit prospects.

That said, not all Dutch photonics companies have reached this phase, which is why ABN AMRO Bank and PhotonicsNL put the TRL of the Dutch photonics industry somewhere between 5 and 6.

For their part, banks and investors will need to develop knowledge to be able to recognise the opportunities and risks of photonics. That will allow them to take effective financing decisions in the future.

Figure 19

Technical readiness Level Photonics, 2017



Source: FD, 2016, ABN AMRO

List of Dutch photonics companies

			Application areas:			
Company name	City	Components/products	Biophotonics	Integrated Photonics	Imaging/ Sensors	Other
2M Engineering	Valkenswaard	Sensors, optical components			■	
Acal BFI Netherlands	Eindhoven	Optical components				■
Adimec Advanced Image Systems B.V.	Eindhoven	Camera's, lenses			■	
Admesy B.V.	Ittervoort	Spectral camera's			■	
Anteryon B.V.	Eindhoven	Lenses, mirrors, lasers, optical modules	■		■	
Artinis Medical Systems B.V.	Elst	Medical imaging	■		■	
ASML N.V.	Veldhoven	Lithography systems				■
Avantes B.V.	Apeldoorn	Spectrometers			■	
Bird Control Group B.V.	Delft	Laser applications bird control				■
Bright Photonics B.V.	Eindhoven	Photonics Integrated Circuits (PICs)		■		
Coherent Europe B.V.	Utrecht	Lasers, optical components				■
Confocal.nl B.V.	Amsterdam	Microscopy	■		■	
Cosine Group B.V.	Warmond	Optical systems & instruments	■		■	
DCD International B.V.	Eindhoven	LEDs, fiber optic components				■
DEMCON B.V.	Enschede	Optical systems & instruments	■		■	
DiagnOptics Technologies B.V.	Groningen	Spectrometers	■		■	
Diamond Kimberlit	Almere	Fiber optics/connectors				■
EFFECT Photonics B.V.	Eindhoven	Photonics Integrated Circuits (PICs)		■		
Flexible Optical B.V.	Rijswijk	Adaptive mirrors			■	
Forensic Technical Solutions B.V.	Amsterdam	Spectral imaging	■		■	
Genexis B.V.	Eindhoven	Modems/routers/ICT		■		■
Hittech Multin B.V.	Den Haag	Opto-mechatronics			■	
Innoluce B.V.	Nijmegen	Laser scanning modules			■	■
Kipp & Zonen B.V.	Delft	Optical radiometry			■	
Lambert Instruments B.V.	Groningen	High-speed camera's (FLIM)	■		■	
Laser2000	Vinkeveen	Distributor optical components				■
LioniX International B.V.	Enschede	Photonics Integrated Circuits & sensors	■	■	■	
Lumileds Netherlands B.V.	Eindhoven	LEDs				■
Luxexcel Group B.V.	Eindhoven	3-D printing, lenses			■	
Mapper Lithography B.V.	Delft	Lithography systems				■
ma2medical	Amsterdam	Provision of medical services	■			■
Melles Griot B.V.	Didam	Distributor optical components				■
Microvision Medical Holding B.V.	Oss	Clinical microscopy, imaging systems	■			
Milabs B.V.	Utrecht	Imaging systems	■			
Molenaar Optics	Zeist	Distributor optical components				■
Nedinsco B.V.	Venlo	Optical systems & instruments			■	

Newport Spectra-Physics B.V.	Utrecht	Optical components, lightsources					■
NTS Optel B.V.	Nijmegen	Optical instruments	■		■		
Ocean Optics B.V.	Duiven	Distributor optical components	■		■		
Oldelft Benelux B.V.	Veenendaal	Medical imaging systems	■		■		
OMT Solutions B.V.	Eindhoven	Optical components, lightsources			■		
OPTICS11 B.V.	Amsterdam	Microscopy & sensors	■		■		
Optiqua/Optisense B.V.	Enschede	Sensors	■		■		
Perdix Analytical Systems B.V.	Wijchen	Analytical instruments	■		■		
Philips Lighting N.V.	Eindhoven	LEDs, lenses, mirrors					■
Philips Medical Systems Nederland B.V.	Best	Imaging systems	■				
PhoeniX Software B.V.	Enschede	Design software Photonic Integrated Circuits (PICs)		■			
PHOTONIS Netherlands B.V.	Roden	Detectors, sensors & camera's			■		
Picusled B.V.	Son en Breugel	LEDs					■
Promis Electro-Optics B.V.	Wijchen	Spectrometers, camera's					■
PR Sys Design (PerClass)	Delft	Software voor Spectral Imaging	■		■		
Quest Innovations B.V.	Middenmeer	Spectrometers, camera's	■		■		
RiverD International B.V.	Rotterdam	Raman spectrometers	■				
Sensor Sense B.V.	Nijmegen	Optical gas detectors	■		■		
Settels Savenije Advanced Systems B.V.	Eindhoven	Opto-mechatronic systems	■		■		
Single Quantum B.V.	Delft	Optical detectors			■		
SMART Photonics B.V.	Eindhoven	Photonic Integrated Circuits (PICs)		■			
Sumipro Submicron Lathing B.V.	Almelo	Optical lenses, mirrors					■
Technobis Group B.V.	Alkmaar	Sensoren, Photonic Integrated Circuits (PICs)		■	■		
Tegema Groep	Son en Breugel	Opto-mechatronic systems			■		
TeledyneDALSA	Eindhoven	Camera's			■		
Te Lintelo Systems B.V.	Zevenaar	Distributor optical components					■
Thales Nederland B.V.	Hengelo	Camera's, opto-electronic systems			■		■
Unitron Group B.V.	IJzendijke	Optical/medical instruments	■				
Van de Loosdrecht Machine Vision B.V.	Buitenpost	Camera's/vision			■		
Vision Hardware Partner	Almere	LEDs, vision					■
Vision Light Tech B.V.	Uden	LEDs, lenses, mirrors					■
VTEC Lasers & Sensors Ltd.	Eindhoven	Lasers, sensors, modules					■
Water Insight B.V.	Wageningen	Spectrometers	■		■		
WimOptik B.V.	Geldrop	Optical design					■

Conclusions

Key technology of the future

The population is ageing, not just in Netherlands but all over Europe. The number of elderly people proportional to the people in work is increasing. We are living longer thanks to better healthcare and a healthier lifestyle and diet. Paradoxically, we also need more healthcare. The question is whether new technologies can keep our healthcare affordable and reduce the physical and mental strain on patients. Biophotonics has led to more compact and cheaper medical devices, which we will eventually be able to use at home. In fact, more and more medical devices are arriving on the market that allow data between patients and doctors to be exchanged over a fibre optic network.

Expectations are that by 2020 every citizen across the globe will have an average of 3.5 devices at home connected directly to the Internet. Our current armoury of data centres will not be able to handle that pressure. KPN's CTO Erik Hoving commented in the *Financieele Dagblad*: "Without photonics the Internet will grind to a halt." He was referring to the high energy use of data centres, which in ten years' time is set to equal today's total global energy consumption. Integrated Photonics may provide a solution by offering fast and energy-sufficient photonic chips. Although still expensive, this emerging technology has great potential.

The Netherlands goes photonics!

Despite its variety of potential uses, photonics is not that well-known among the public. A shame, really, given its importance to the economy. The production of photonic components is worth just under 200 billion euros worldwide. Compared with global market leaders Asia and the US, the Netherlands holds only a small share of the market, with 160 businesses, knowledge centres and educational establishments being involved in photonics and generating just under 2 billion euros in revenue. Being small does not mean that one is irrelevant, though. On the contrary, the Dutch photonics industry is leading the way in terms of research and development of advanced applications. In fact, the Netherlands is home to business across the entire value, which is unique. Plus, they are working together closely to maintain their competitive edge and expand their operations.

Conclusions

Because the Dutch ecosystem is small, it is also fragile. Our market survey shows that Dutch businesses have grown significantly in the past six years and harbour serious growth aspirations. However, respondents also indicated they needed more funds to make their dreams come true. They also expressed concern about the availability of highly skilled staff. Advertising photonics as a technology and an industry would be a first step towards addressing this issue. Finally, respondents cited as the key to success more extensive collaboration between themselves and with other stakeholders. So here are a few top tips for all those involved in the Dutch photonics industry.

Recommendations for all photonics stakeholders

Businesses: step up your collaboration efforts

Our market survey shows that the main focus of Dutch photonics companies is on foreign customers. So there is little competition in the Netherlands and partnerships could be set up across the value chain. This holds true for the industry itself and for supporting initiatives such as the Dutch Optics Centre and PhotonDelta. However, it is important that projects and communications are coordinated more effectively. As an umbrella organisation, PhotonicsNL seeks to incentivise collaboration. Attending joint events such as Photonics West in San Francisco and Laser World of Photonics in Munich is one of many ways to forge partnerships.

Government: time for a broad vision of technology

The Dutch government's top-sector policy concentrates too little on photonics. Fortunately, however, photonics has been labelled a key technology by the High Tech Systems & Materials (HTSM) top sector. In other top sectors, such as Life Sciences & Health and Agri & Foods, photonics could open up new opportunities as well. That is why we recommend that the top sectors work together more closely and focus more on new technologies. If other top sectors take an interest, the government is more likely to make funds available to the photonics industry.

Education: no top position without top talent

The photonics industry is looking for university graduates with a background in technology. It is not yet clear whether universities can meet current and future demand and what skills students need to have exactly. What is clear, though, is that there are many challenging job openings for young people across this industry. However, it would seem to us that the social and economic potential of photonics has not fully permeated higher education. So, we recommend that universities invest more in photonics and do more to advertise this field among students. To do so, they may use the results of the new "Human Capital Roadmap" currently being drawn up by PhotonDelta, Berenschot, and the Fontys Universities of Applied Sciences.

Lenders and investors: provide multiple financing

Our survey shows that there is a need for financing to fund the above-average growth rates in the photonics industry. Financiers will need to have an in-depth understanding of the industry and individual companies in order provide those funds. Hopefully, this report will make a contribution. Given the current development phase and complexity of photonics, ABN AMRO expects the value chain to require tailored financing on a case-by-case basis. We also believe that banks, investors and local and central government will need to work together to provide photonics companies with suitable financing programmes. Stacked financing would appear to be the answer.

ÉPRISE: example of a public-private partnership

The European Commission supports initiatives that encourage collaboration between European knowledge centres and innovative SMEs. This is done through CSA projects as part of the Commission's Horizon2020 programme. CSA is short for "Coordinated Support Actions." As far as photonics is concerned, several successful projects are ongoing, such as the ÉPRISE* project, which supports partnerships in Health & Life Science, Medicines and Agro & Food Tech. Similar cluster organisations can be found in nearly all European countries. The Dutch counterpart is PhotonicsNL.

Launched in January of this year, ÉPRISE builds on the successful OASIS* project, under whose auspices an EU-wide network was set up consisting of eighty universities, knowledge centres and facilities and some 180 SMEs operating in the Biophotonics industry. The purpose of ÉPRISE is to encourage collaboration between European SMEs and so to generate new business. Regional and transnational B2B workshops will be hosted as part of the project over a period of 2.5 years. We invite Dutch photonics companies and businesses from the other sectors mentioned to sign up to this project.

* ÉPRISE is short for "Empowering Photonics through Regional Innovation Strategies in Europe."

**OASIS stands for "Open the Access to Life Science Infrastructures for SMEs."

About this publication

This report is published by PhotonicsNL and ABN AMRO. The report was commissioned by ABN AMRO Sector Advisory.

How to contact us
David Kemps on +31 (0)6 30 33 20 43 or at david.kemps@nl.abnamro.com
ABN AMRO, Sector Banker Manufacturing

Guus Taminiau on +31 (0)6 28 61 53 34 or at guus.taminiau@photonicsnl.org
Director of PhotonicsNL

Authors
Guus Taminiau (PhotonicsNL)
Petra Wicherink (PhotonicsNL)
Kim Markwat (PhotonicsNL)
David Kemps (ABN AMRO)
Roderick Vos (ABN AMRO)

PhotonicsNL
Vereniging PhotonicsNL's overall aim is to raise awareness of the social and economic importance of photonics among companies, educational establishments, policymakers, central and local government, and the public at large. A not-for-profit association, PhotonicsNL seeks to be the umbrella organisation for all stakeholders involved in photonics in the Netherlands. It also wants to be the main national portal to Europe for innovative Dutch SMEs operating in the photonics industry. For more information, go to the website at photonicsnl.org Or contact Petra Wicherink at petra.wicherink@photonicsnl.org

Editors
Tekstwerf

Translation
BB&TW Financial Language Services

Illustrations and design
Kollerie Reklame-advies & Promoties

Photography
Shutterstock, PhotonicsNL

Distribution
insights.abnamro.nl/

References:

1. Cisco (July 2016), The Zettabyte Era, Trends and Analysis
2. Photonics21 (February 2017), PPP impact report 2017, Jobs and Growth in Europe – Realizing the Potential of Photonics
3. Photonics21 (June 2015), Photonics Industry Report 2015, The current situation
4. SPIE (April 2016), 2016 Photonics Market Update
5. Dutch Ministry of Economic Affairs and Berenschot (January 2010), IOP Photonic Devices, *Tweede Meerjarenplan*
6. *Financieele Dagblad* (April 2016), *Hightech sector koestert grote verwachtingen van nieuwe technologie (High-tech sector has high hopes of new technology")*

abnamro.nl