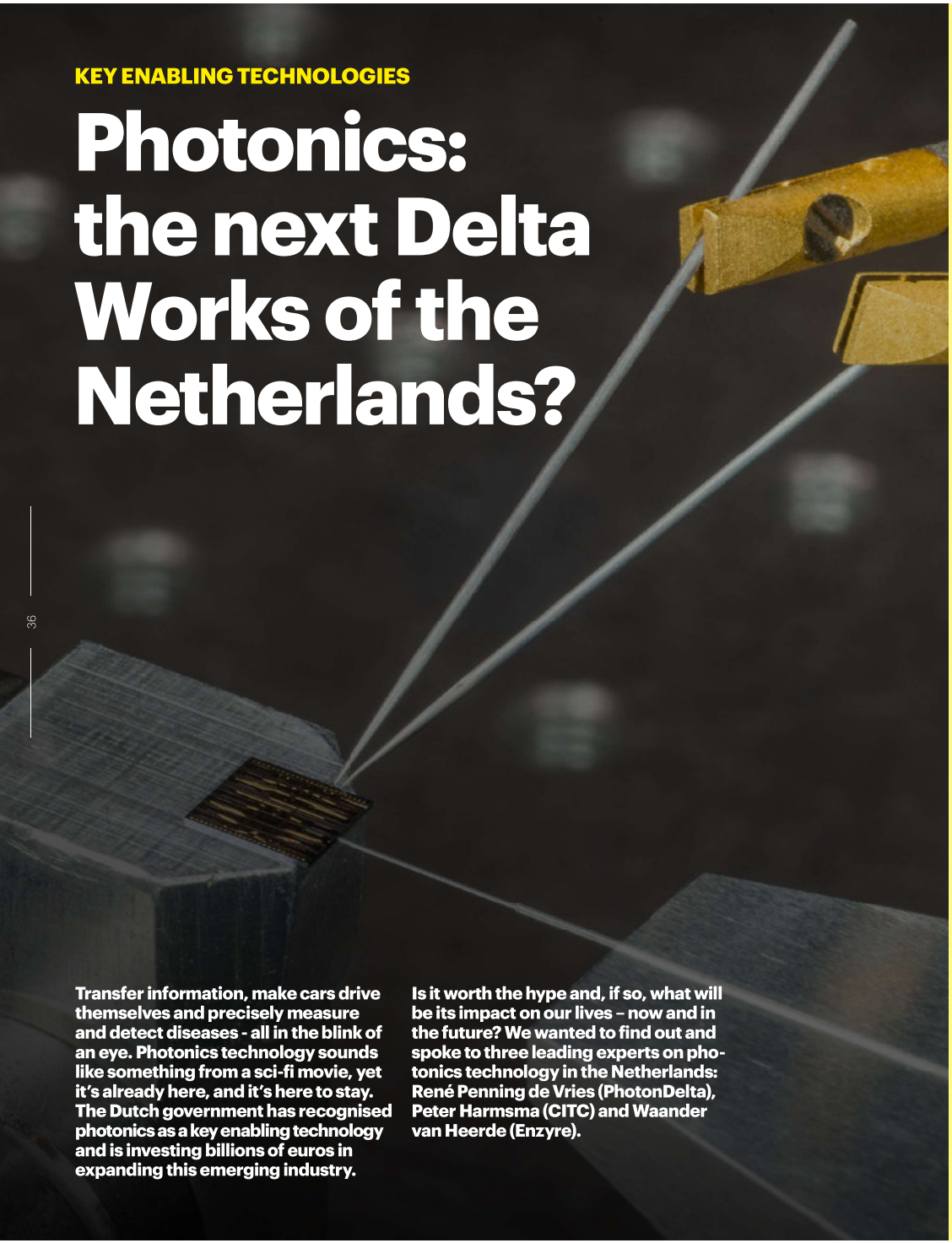
KEY ENABLING TECHNOLOGIES

Photonics: the next Delta Works of the Netherlands?



Transfer information, make cars drive themselves and precisely measure and detect diseases - all in the blink of an eye. Photonics technology sounds like something from a sci-fi movie, yet it's already here, and it's here to stay. The Dutch government has recognised photonics as a key enabling technology and is investing billions of euros in expanding this emerging industry.

Is it worth the hype and, if so, what will be its impact on our lives – now and in the future? We wanted to find out and spoke to three leading experts on photonics technology in the Netherlands: René Penning de Vries (PhotonDelta), Peter Harmsma (CITC) and Waander van Heerde (Enzyre).

In a sense, photonics is similar to electronics. Except electronics use electrons to transfer information – bits and pulses of electricity – where photonics uses photons, light. Light is weightless, travelling almost without any resistance. Electricity on the contrary, is heavier and encounters more bumps in the road as it travels through our cable-network. This makes photonics way more energy efficient and faster. Does that mean photonics is taking over from electronics? "No," says René Penning de Vries, "but there is massive potential for the photonics industry."

René Penning de Vries, Chairman of the supervisory board at PhotonDelta

As with every emerging technology, photonics needs a driving force to feed its growth. One of those forces is PhotonDelta, an industry accelerator for integrated photonics. René is Chairman of the supervisory board, dedicated to building and nourishing an ecosystem capable of pushing photonics forward.

Why photonics?

"Developing better photonics is not just about improving existing technology. It's about preparing for the future. The world is changing, and industries come and go. We already see jobs in the fossil fuel and steel industry disappearing as climate change becomes a more pressing issue. Photonics technology could enable the industrial innovations we need to face the challenges of the future and to further boost a more advanced and sustainable economy."

What opportunities and challenges do you see for the industry?

"The growth potential is enormous. This means there is a big pie, and everyone is coming for a piece. There used to be companies with all the expertise to develop new technologies in-house. Those days are gone. Even big companies like Philips need others to keep up. New companies often focus on making a living for themselves and staying afloat in a competitive market. To innovate at a higher pace, cooperation is more fruitful. Skilled personnel, in particular, is something everyone is looking for. If the industry is to move forward, nourishing a healthy ecosystem is a must. Companies will have to make compromises and cooperate. On the other hand, funding will do much good for the sector."

What's there to win for the Netherlands?

"Several contenders worldwide are looking to become top-dog in the photonics industry. With this kind of technology, it's basically - 'the winner takes all' - you have to be part of the top countries in the world to generate enough revenue to turn it into a profitable business. There's a lot of knowledge and the right infrastructure in the Netherlands. The Dutch government recently invested 1.1 billion euros, actively helping innovative photonics companies. The province of Gelderland and other high-tech organisations are also involved, with a common goal: strengthening the Dutch high-tech industry's position. So, we have the companies, the knowledge, and the people to create a worldwide impression. Now let's make it happen!"

Peter Harmsma, photonic packaging at TNO and CITC

Moving from the bigger picture of photonics and its possibilities, one step closer towards its application. Peter Harmsma has over 20 years of experience in the world of photonic packaging. "The packaging makes up about 60 to 80 percent of all production costs of chips. By applying photonics technology in this process, we enable a massive saving potential and open up a world of possibilities to apply the technology on a larger scale and make innovative solutions more affordable to everyone."

What is packaging about?

"Most importantly: you can't do anything with just a chip. Regardless of the amount of photonic technology used for a chip, you need to integrate it into a box that is ready for use, including all the necessary wiring. That's what packaging is – making sure companies that need chips for their products, are actually able to use them."

And why is that relevant for the application of photonics?

"If you use photonics in chips, light needs to go in and out. That's much more complicated than when you only use electronics, where you can use simple wires to move electricity in and out. On top of that, the placement tolerances for photonic chips are on a micro level – which is complicated. But that's not all, because the most important challenge is making all of this affordable."

How can we make that happen?
"Standardisation is key. If we can produce in greater volumes, the unit price will decrease. At the same time, demand will only grow if the price goes down. It's like a 'chicken or the egg'-debate. How can we realise standardisation? The European Union opts for 'the chicken', in other words, demanding that companies apply the same standards. This can be difficult sometimes, as photonic technology has many different flavours. Each flavour has its specific requirements, and combining flavours for a specific application is possible. That's why there's enough work to be done on improving the packaging. Because it comes down to this: photonics has massive potential, but its true potential will only be unlocked if we can lower the cost of packaging!"

21st century smoke signals

Photonic technology detects, generates, transports and processes light to transfer information and data. How? The easiest way to understand photonics is by comparing it to smoke signals invented by the native Americans. Those smoke signals were made by covering a fire with a blanket and taking it off again, thus releasing one or more puffs of smoke. Each puff contains a bit of information; together, these puffs construct a message. Nowadays, we can do the same with light. There are massive transatlantic optic cables through which information is exchanged, but instead of puffs of smoke, it's flashing light signals.

Waander van Heerde, Chief Scientific Officer at Enzyre

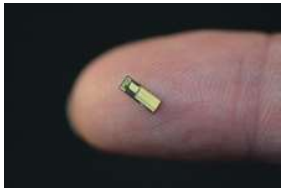
One of the companies that's hopeful about the possibilities of photonics, is Enzyre. As Chief Scientific Officer, Waander looks for ways to make their near-patient diagnostics, focused on blood coagulation, even cheaper and with smaller margins of error. "Photonics may hold the key to finding a solution which will improve the lives of many haemophilia patients in the future."

Why is Enzyre working on the application of photonic technology?
"First and foremost: it's a bright prospect for the future. There's a mutual interest between research groups focused on photonics and us at Enzyre. That's because we have a product that requires sensor technology. It's an actual application for researchers and it's promising because of the possible benefits of applying photonics."

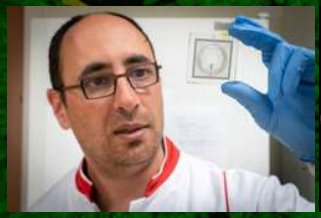
How could photonics improve your innovation?
"We measure biomarkers in blood cells for haemophilia patients. They use our product to monitor whether they're at risk of bleeding wherever they are. We make use of sensor technology that requires a lot of energy. As we want to make it as easy as possible for patients to carry the product around, it's crucial to ensure it's small enough. That's where we can use photonics. Firstly, electronics require more energy than photonics. Secondly, a lot of heat is released when you use electronics. If we can replace that with photonics, we can create an even smaller product."

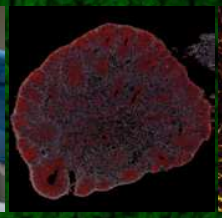
What do you expect from photonic technology in the future?
"We expect photonics to enable us to improve our product in many ways. More energy-efficient and smaller. Heat is one of our primary concerns at the moment, as we have to diagnose at 37 degrees Celsius. Currently, our product is a bit larger than we ideally would like, because it has to be able to deal with the heat exerted in the process. For this and many other applications, photonics has the potential to make a real difference."

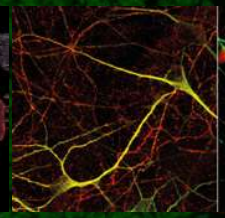
The experts agree that photonics is a big fish, ready to be caught. But for the photonics industry in The Netherlands to grow into something like the Delta Works – an innovation that has changed the course of the Dutch technological and societal history - circumstances need to be just right. And it looks like all the necessary boxes are ticked. "We should look at our country as one big campus, housing all relevant players," René Penning de Vries concludes. "Only through sharing knowledge, working together, growing and nurturing a healthy ecosystem, will we see photonics become one of the key industries in the Netherlands very soon."

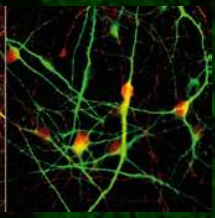


Personal healthcare through braincells on a chip









It's alive! Professor Nael Nadif Kasri has found a way to turn skin or blood cells into brain cells. "Twenty years ago, we thought that what we are doing right now, was absolutely impossible."

WE ARE ALREADY ON OUR WAY FROM ORGAN-ON-A-CHIP TO HUMAN-ON-A-CHIP

Nael is a professor of Medical Neuroscience at the Radboud University in Nijmegen. He researches the electrical activity from braincells, to understand neuronal communication and unravel its underlying mechanisms. With his research group in Nijmegen, he took huge steps in the further development and application of a technology to grow brain cells, on a chip! First, he takes skin cells and turns them into stem cells. With those stem cells he can then make any kind of body cell he wants. The advantage of this brain-on-a-chip technique? Nael: "The cultured brain cells contain exactly the same DNA as that of the patient. In such a culture dish we can see exactly what goes wrong in that individual patient. It is even possible to test a certain drug with these brain cells to see if they work against the condition of the individual patient. This allows us to provide better, faster and more efficient healthcare."

Human-on-a-chip

In recent years, the technology has undergone explosive growth. Heart, liver, muscle, intestines, cancer, eyes, blood vessels; they are all already being cultured on a chip. Not only in a Petri dish but also in miniature organs that are artificially grown. Nael: "Thanks to new techniques, individual chips can now also be linked together, making increasingly complex networks possible, such as gut-brain-on-a-chip or eye-brain-on-a-chip. We are already on our way from organ-on-a-chip to human-on-a-chip."

Healthcare of the future

In the Netherlands almost all research groups work together in the Institute for human Organ and Disease Model Technologies (hDMT), where Nael himself coordinates all brain-related initiatives. In one of the projects, he is investigating Dravet syndrome, a severe form of epilepsy that occurs in young children and is difficult to treat. Often, finding the right drug is a matter of trial and error, which means that a lot of time is lost before the right drug is found. "By culturing brain cells, we can test the twenty or so available drugs at once", says Nael, "So we can find the optimal drug much faster."

Finding the right combination

The initial results look good, but Nael also points out an important issue. "Is what we find in our cultures also reliably translatable to the patient? Human brains are made up of about 100 billion cells, some of which are quite different from each other. Neurons, astrocytes, microglia, for example, are brain cells that not only look different, but also function differently. So, in the culture for Dravet syndrome, we have to grow the right combination of brain cells that are involved in the disease in the patient. Otherwise, we will not get useful data. Luckily, we have mastered the cultivation of a brain-on-a-chip that contains many different brain cells and the results are becoming more and more reliable."