VISIONS OF THE FUTURE

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THE
FUTURE
BELONGS
TO
THOSE
WHO
CREATE
IT

FOREWORD

SPARK YOUR IMAGINATION

Some 15 years ago Holst Centre published ‘Roads into the Future’, in which our researchers, students and industrial design professionals shared their ideas and ambitions for the years to come. Leafing through this booklet with today’s knowledge it’s astonishing to see we have already realized so many of those ideas. The future we could hardly envision just 15 years ago is today’s reality.

These transformational times again ask for vivid visions, especially for challenging domains such as healthcare, society 5.0 and sustainability. Key technologies like edge AI, integrated photonics and sustainable electronics enable us to address many of today’s societal challenges.

But it isn’t just about these new technologies.

The future we desire starts with imagination and willingness to collaborate. Only then will our personal ideas and visions lead to breakthrough innovations with the social and economic impact we strive for.

That’s what this new publication ‘Visions of the Future’ is all about. We hope to spark your imagination and invite you to realize new ideas together.

Kathleen Philips & Ton van Mol
Managing Directors at Holst Centre

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INTRO

INTEGRATED PHOTONICS

In photonics, photons (light) are used to transfer and process information. In integrated photonics, photonic components are integrated into a microchip, following a manufacturing process that builds on that of a conventional electronic chip.

The properties of photonics and microchipes are combined, allowing information to be transferred and processed faster and more efficiently, saving energy. The impact is as revolutionary as the shift from printed circuit boards to microchips. Just as has been seen for microelectronics, the fabrication process of integrated photonics allows the cost-effective production of millions of identical chips.

Integrated photonics will be one of the new pillars in Holst Centre's strategy. Together with partners from the PhotonDelta ecosystem (including Eindhoven University of Technology, University of Twente, Photonics Integration Technology Center and other leading organisations), it aims to accelerate the development of the European industry around integrated photonics. In doing so, Holst Centre builds a bridge between universities and industry, implementing the technology of integrated photonics into every-day applications.

Integrated photonics will allow us to reach our goals and visions of the future: completely safe autonomous driving, fail-safe connectivity, and improve the efficiency & energy use of our data consumption. Goals we do not foresee to reach with electronics alone.

EDGE AI

Edge AI really means moving computing and sensing capabilities into the end nodes, such as sensors, actuators, and user devices, bringing smartness close to the user, as well as making human-machine interaction more intuitive and technically efficient. Most of the computation is done directly at the edge where the data is generated, instead of centrally in a cloud computing facility or private datacentre. Therefore, less data is transported over the network, which reduces the required bandwidth, latency and power consumption.

This enabling technology can be regarded as a broader ambition to make electronic devices in our environment smarter with respect to the interaction with humans. Edge AI will enable the development of smart, low-power Internet of Things (IoT) devices with an optimal user experience, and neural networks with augmented sensing capabilities using cameras, image sensors, radars and LiDARs, enriching our daily lives.

With a world-leading track record in the design of novel sensors for ultra-low power IoT, autonomous systems, and health applications, Holst Centre has an excellent position to excel in Edge AI technology. Our teams lead innovations in neuromorphic computing as well as wireless communication and sensing.

Holst Centre, located at the centre of a world-class high-tech systems environment, has the ambition to pioneer unique heterogeneous edge nodes, where edge AI, neural nets, and fusion methods are closely co-designed with the device innovations from adjacent technology programs. More than ever, innovation relies on multi-disciplinary design. Our research tracks enable unique opportunities for end-to-end innovations that contribute to solving the world's biggest societal challenges.

SUSTAINABLE ELECTRONICS

In our daily lives we have become more and more dependent on electronic devices. They assist us in everything we do: in our work, at home, to keep us healthy. With digitalization and AI on the rise, we expect a steep increase in the use of electronics, which will have a profound effect on our environment.

Sustainable electronics, designed to have a minimal ecological impact during their entire lifespan, can help overcome these challenges. These electronics are designed to have an inherently lower environmental impact during manufacturing, with minimal use of raw material, energy and water, due to their additive character. And at the end of their lifetime these electronics have the potential to be completely recyclable or even compostable. All these aspects are integrated in the concept of sustainable electronics, with the end goal of being fully environmentally circular.

At Holst Centre, we have over 10 years of experience in developing hybrid printed electronics (HPE). On top of the general advantages of HPE (flexibility, freedom of design and integration, new user interfaces, easier to produce, and robustness), this technology offers significant environmental benefits in all lifecycle phases.

With the same functionalities, hybrid printed electronics are lighter and more compact than traditional printed circuit boards (PCBs), enabling products with reduced weight and lower energy consumption. In addition, HPE contain fewer scarce materials than conventional electronics. Energy-efficient additive manufacturing ensures there is no waste. End-of-life, HPE offers significant recycling benefits over PCBs. Building blocks are increasingly recycled or bio-based, which further reduces the environmental impact.

We help partners with sustainable value creation by implementing printed electronics, and simultaneously rethinking the product design, manufacturing processes, disassembly and recycling strategies.

HEALTH

Between 2015 and 2050, the proportion of the world's population over 60 years of age will almost double. Our ageing society will become more dependent on health services. At the same time, the number of caregivers is gradually diminishing. If we want to grow old, healthy and happy and keep healthcare affordable, preventive care is essential, with living and working environments that stimulate vitality.

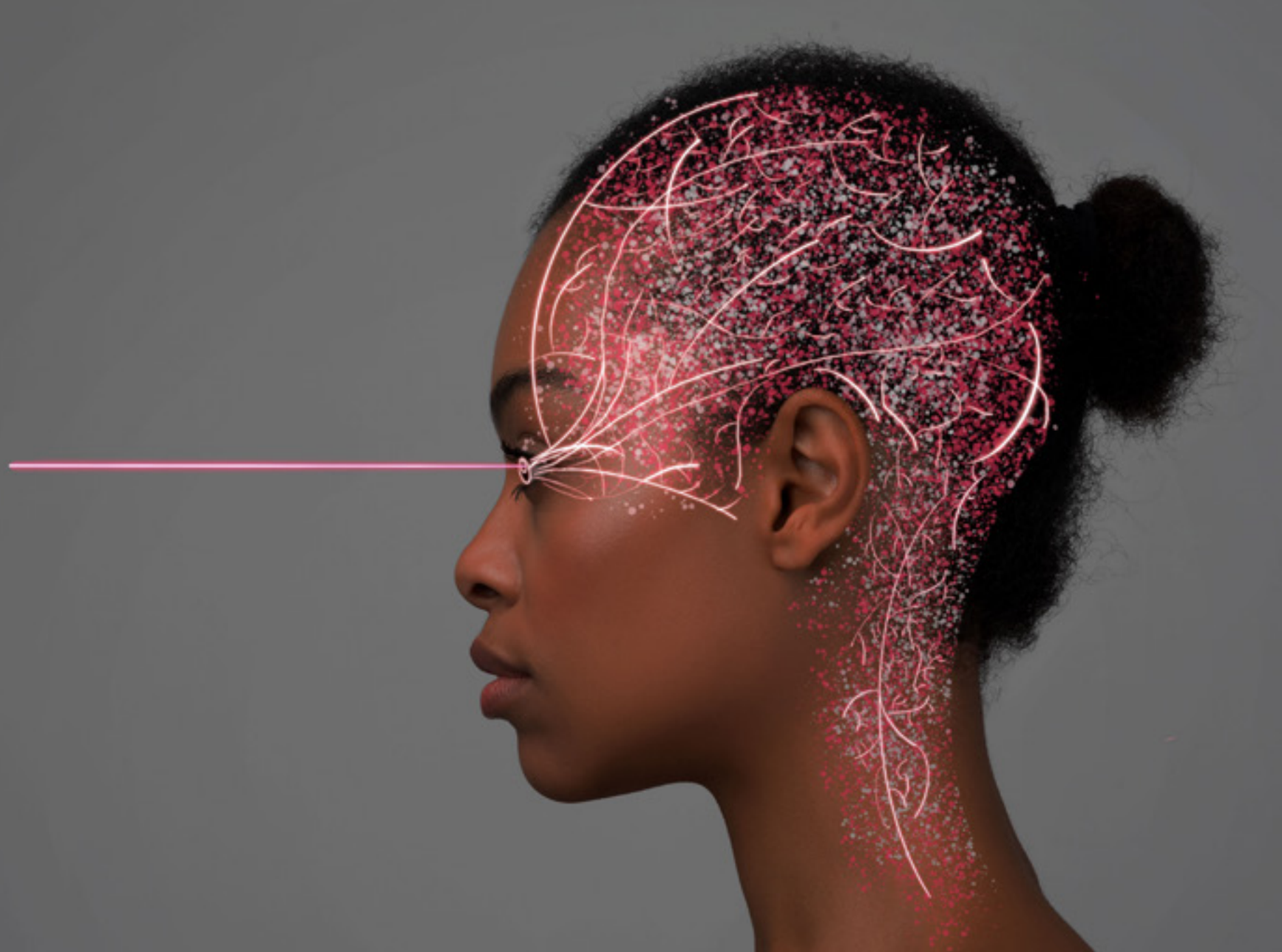

ECG
80
RESP
14
TEMP
SpO2
99
%
CO2
38
120/80
(93)
---/---
(10)
NIBP
120/80
(93)
Manual

Remote patient monitoring

In 2031 the Netherlands will face a shortage of around 100,000 caregivers in the field of healthcare. At Holst Centre, we aim to alleviate this issue by introducing wearables that can monitor all our vital signs continuously and communicate the results wirelessly to healthcare professionals. The five vital signs are our core body temperature, heart rate, breathing rate, blood pressure, and oxygen level & saturation (SpO2). Using photonics we can miniaturize the sensors while remaining comfortable to wear and enable reliable, high-quality data. In addition, this needle-free technology will enable us to analyze blood, and monitor such things as glucose levels and inflamation markers. With this remote patient monitoring technology, patients can remain in their familiar surroundings. Which subsequently helps to democratise healthcare: medical care for everyone, everywhere.

Personalised diagnostics

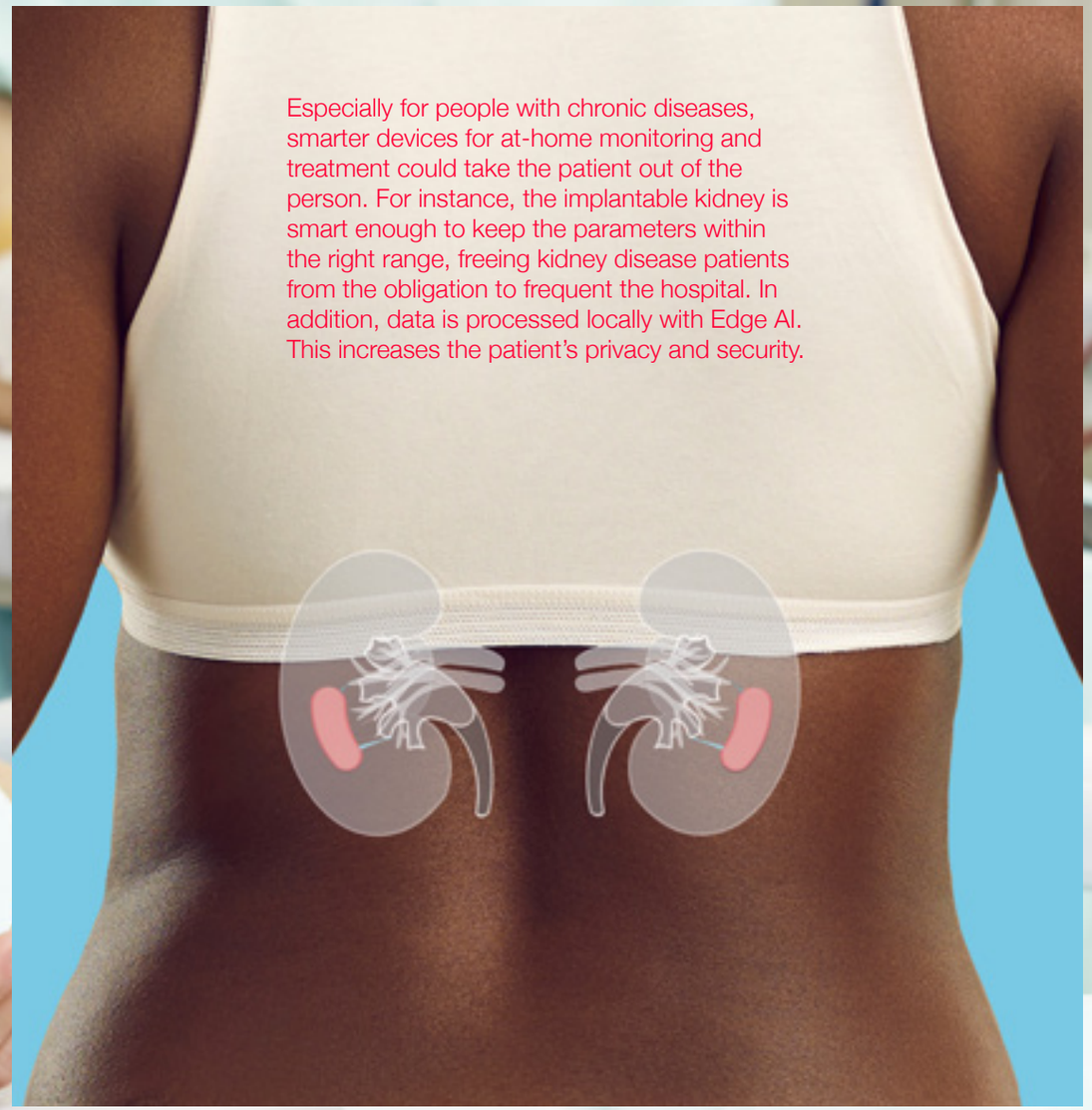
Another direction for health applications with integrated photonics is 3D scanning and Optical coherence tomography (OCT). OCT is a non-invasive optical imaging technique that uses low-power infrared laser light to image up to 2 mm beneath the skin surface.



Closed-loop therapeutics

With its Autonomous Therapeutics research programme, Holst Centre aims to develop autonomous implanted and ingestible devices that respond immediately to changes in a person's health condition, much like the current pacemakers. For example, with the use of Edge AI, neurostimulators can instantly adapt to pain and inflammation flares. Early-warning wearables and implants are able to detect inflammation at an early stage, leading to shorter hospital stays and reduced health costs.

Especially for people with chronic diseases, smarter devices for at-home monitoring and treatment could take the patient out of the person. For instance, the implantable kidney is smart enough to keep the parameters within the right range, freeing kidney disease patients from the obligation to frequent the hospital. In addition, data is processed locally with Edge AI. This increases the patient's privacy and security.



Wearable ultrasound

The next generation of skin patches will not only be able to monitor the vital signs of people but also be used for real-time imaging of deep lying tissues, organs and blood flow, in a safe and non-invasive way. Medical ultrasound is already the most widely used medical imaging modality in terms of number of images created annually and this will increase even further as applications of medical ultrasound outside of clinics are emerging, such as preventive inspections at the general practitioner or monitoring in the home environment (e.g. of pregnant women). The combination of high performance, low cost, scalability, flexibility and lead-free components makes Holst Centre's technology uniquely suited for these new applications.

Currently, medical wearables for vital sign monitoring are mainly single-use products, creating a lot of waste. With a future of millions or even billions of wearable devices used, like the wearable ultrasound patch and the patch for vital sign monitoring, it is important to consider their environmental impact. They should be made recyclable or even biodegradable. And in addition, use additive manufacturing-based production technologies to create not only a healthy but also a sustainable future.

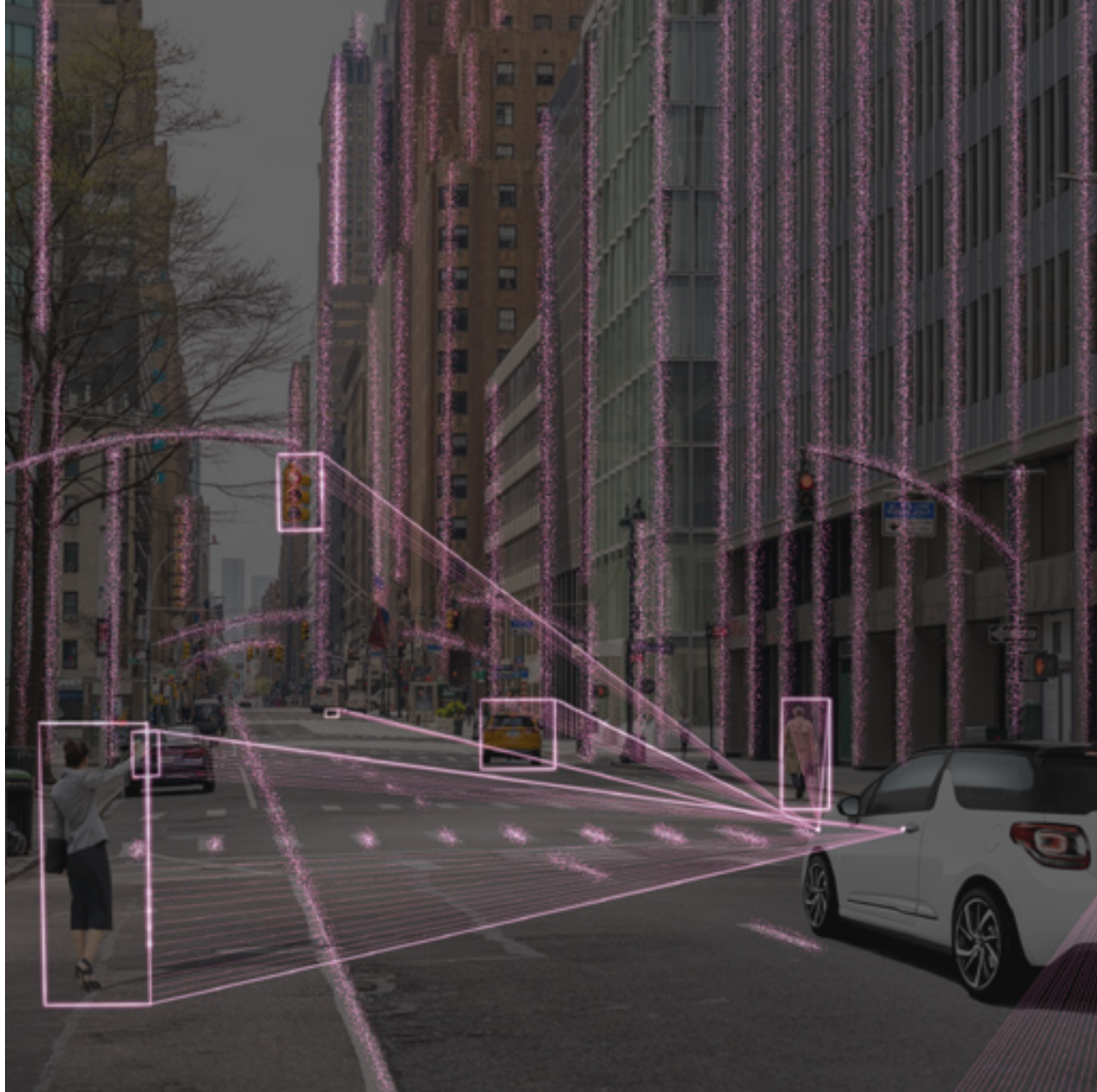
SOCIETY 5.0

In this human-centred vision of society, we strive for economic growth whilst solving societal challenges. Our industrial productivity, particularly here in Europe, is compromised by an ageing society and a tight labour market. Both trends are likely to continue or even intensify in the near future. At the same time, promising solutions for automated transport, Internet of Things, and advanced hybrid working solutions are compromised by limitations of our networks, devices, and data centres.

Superhuman autonomous driving

For safer autonomous vehicles, we need LiDAR (Light Detection And Ranging) applications to continuously scan the surroundings of the vehicle. Integrated photonics helps to miniaturize LiDAR technology and bring down manufacturing costs, enabling the broad use of this technology in affordable connected and automated vehicles.

Event-based cameras with high-speed and high dynamic range scenes, radar and LiDAR will enable a higher rate of autonomy and safer driving. Edge AI can combine and process all this sensory data locally, for advanced decision-making; not only replicating human driving, but offering better-than-human safety and driving capabilities. The low latency advantage of Edge AI is crucial for a quick response, for instance when a pedestrian steps onto the road.



Meeting in the metaverse

Hybrid working has the future, but to truly connect with co-workers current video conferencing systems fall short. At Holst Centre we envision a future without screens, in which you can connect directly with others in the metaverse. In this virtual world, an interconnected network of 3D spaces, people can interact with each other in a very realistic way using augmented and virtual reality (AR/VR). Instead of glasses, imagine you could use a contact lense to meet in the metaverse.

At Holst Centre we are developing wireless communication and powering systems, with hybrid integration solutions for flexible materials and chip design. For next-to-real experiences, we are working on advanced sensing and positioning technologies, so people will apppear ‘live’ as themselves in the metaverse.

Immersive learning

Our industrial productivity, particularly here in Europe, is compromised by an ageing society and a tight labour market. Both trends are likely to continue or even intensify in the near future. Smart cobotics, enhanced with the use of Edge AI, could be part of the solution, enabling a fully integrated interaction between humans and robots. Next-generation Edge AI cobots could safely assist employees with tasks that require additional power or precision. Operators use flexible foil glasses with immersive capabilities for augmented functionalities. At Holst Centre we specialize in hybrid integration of flexible materials and chip design for such devices.

Decision support by Edge AI

In emergency situations every second counts. The use of drones will become more practical to quickly establish an overview of the scene of an accident and understand what kind of help is needed. Drones will become more intelligent; not only can they navigate themselves using advanced radar and LiDAR. At the accident scene they are capable of understanding the situation, transforming raw input data from multiple sensors into intelligence, using Edge AI. With local data handling as a privacy and security benefit, emergency services can optimize their activities,

Within the next 30 years, the world's population is expected to increase by nearly 2 billion people to almost 10 billion in 2050, which makes it extremely challenging to meet climate goals. One of our biggest environmental challenges is e-waste. Our dependence on electronic devices already has a profound environmental impact, with 54 million tonnes of e-waste produced every year. Polluting mining activities for scarce resources, together with the growing energy need to produce and power these devices, makes the impact on our planet even worse.

Energy storage

Batteries are key to enabling the energy transition and will be the dominating technology for the next generation of transport systems. However, to become safe, sustainable, and fast-charging with higher storage capacity, they need further improvement.

Holst Centre explores ways to significantly improve these existing lithium-ion batteries such that they are intrinsically safe, have double the capacity, and charge within 10 minutes. This is done by creating a new and innovative battery structure and leveraging our key expertise. Such as our ground-breaking spatial Atomic Layer Deposition (sALD), which is depositing ultra-thin layers of material on diverse, smooth, or complex porous surfaces with incredible control.

As such, we believe that improved batteries pave the way to a greener, healthier future.

The availability of large quantities of affordable green hydrogen will be essential for the energy transition to succeed. In tomorrow's society we need hydrogen for storage and transportation of renewable energy, as fuel to power trucks, ships, and cars, and as a base material for industrial processes. At Holst Centre, we believe that electrolysis will become an important key technology in our future energy system, especially for the Netherlands. It enables us to fully exploit the wind energy potential in the North Sea.

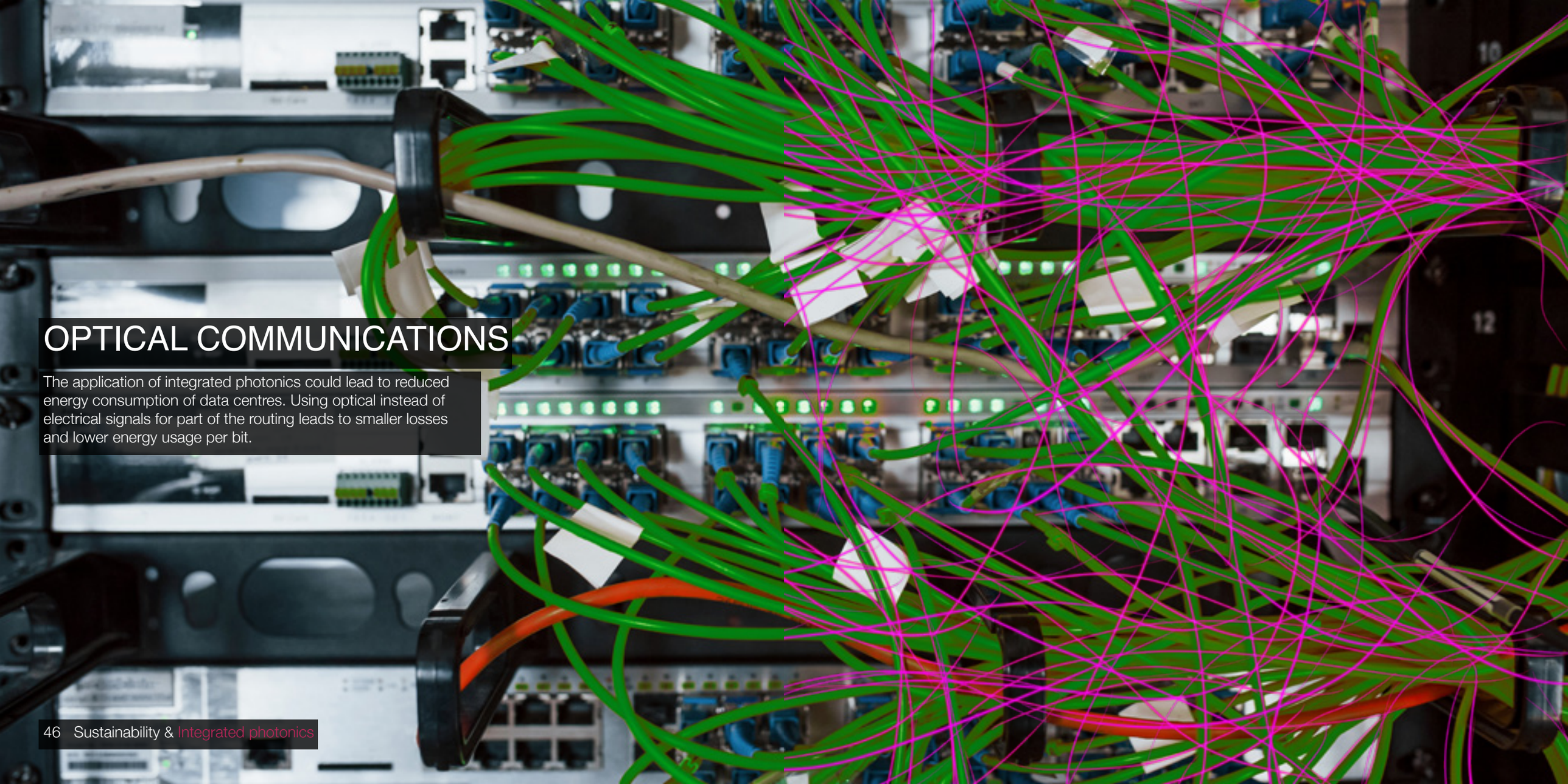
Holst Centre uses its proven thin-film electronics processes to develop next-generation electrolysers. By depositing ultra-thin layers of catalyst material on 3D microstructures, we can significantly reduce the required amount of critical raw materials, reducing our foreign dependency, and create highly efficient electrolysers.

Recyclable electronics

Electronic scrap is a fast-growing global issue. Already we produce 54 million tonnes of e-waste every year and most of our discarded electronic devices end up in landfills. More specifically, medical wearables are mainly single-use, creating a lot of waste. With a future of millions or even billions of health patches used, it is important to make the change to recyclable or biodegradable patches to create not only a healthy but also a sustainable future.

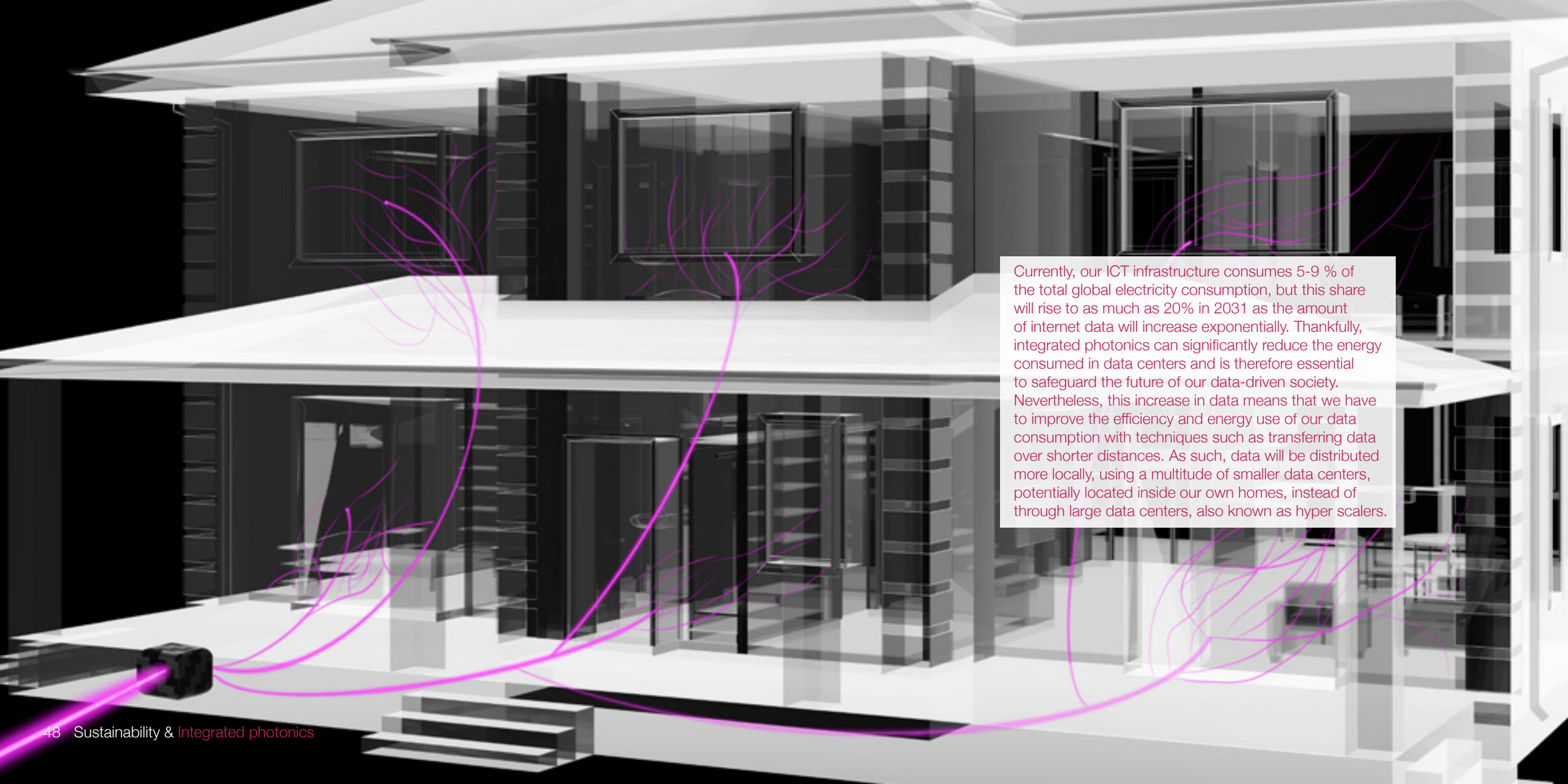
At Holst Centre we introduce design-for-recycling principles to hybrid and printed electronics. We work for instance on debonding layers that make it possible to easily and energy-efficiently separate the metals and the electronic chips from the plastic parts. One goal is to recycle and re-use 90% of the scarce silver from the circuitry.

By adding a debonding layer specifically designed for HPE, we can easily and efficiently remove the bulk of the plastic during disassembly. Without compromising durability we're able to recycle up to 90% of the part's weight and re-use the scarce silver from the circuitry. Moreover, any surface-mounted device can separately be recovered and disposed off responsibly. Building blocks are increasingly recycled or bio-based, which further reduces the environmental impact.



OPTICAL COMMUNICATIONS

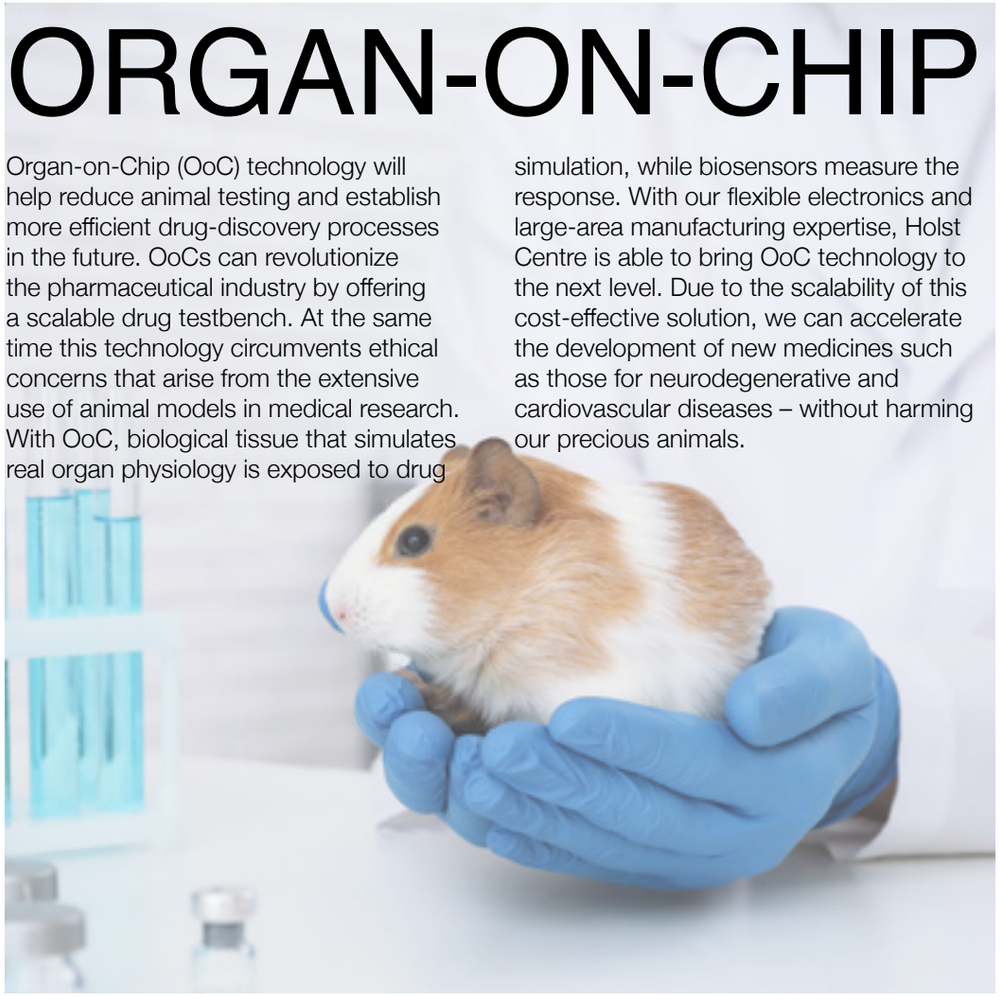
The application of integrated photonics could lead to reduced energy consumption of data centres. Using optical instead of electrical signals for part of the routing leads to smaller losses and lower energy usage per bit.

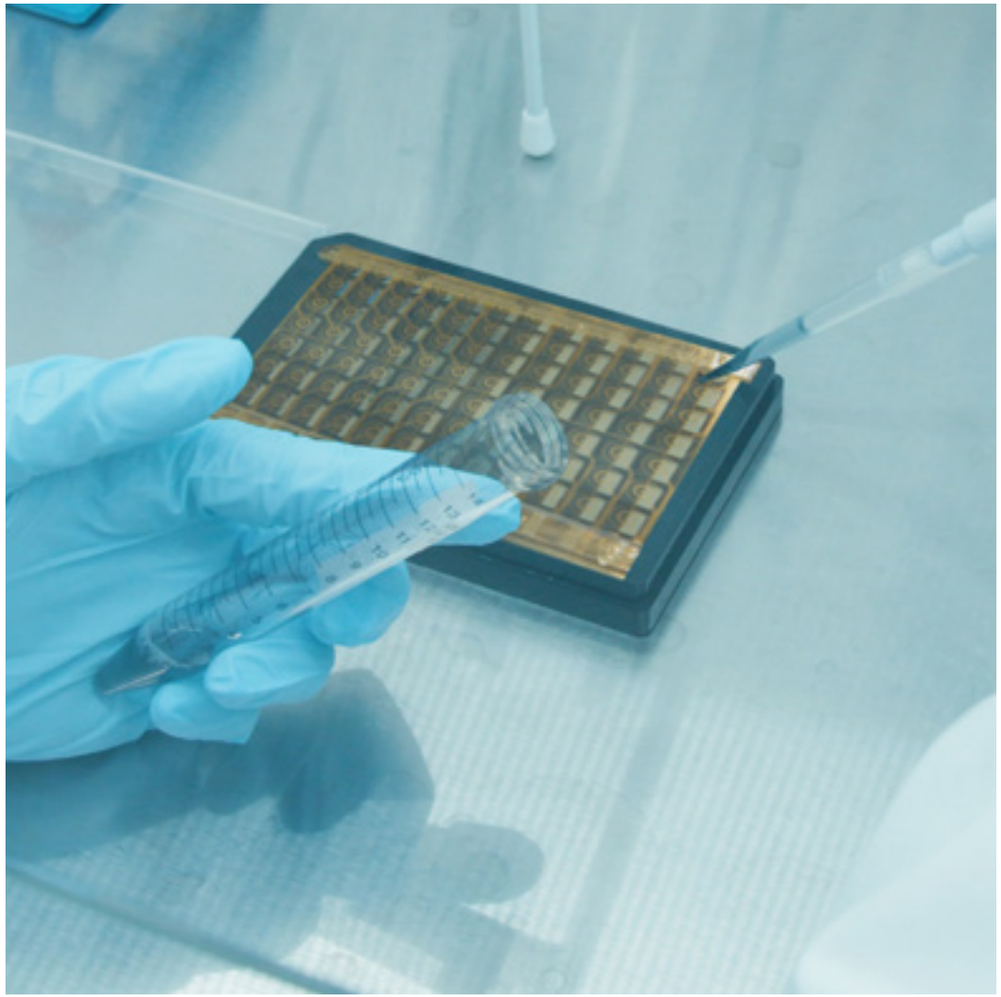


Currently, our ICT infrastructure consumes 5-9 % of the total global electricity consumption, but this share will rise to as much as 20% in 2031 as the amount of internet data will increase exponentially. Thankfully, integrated photonics can significantly reduce the energy consumed in data centers and is therefore essential to safeguard the future of our data-driven society. Nevertheless, this increase in data means that we have to improve the efficiency and energy use of our data consumption with techniques such as transferring data over shorter distances. As such, data will be distributed more locally, using a multitude of smaller data centers, potentially located inside our own homes, instead of through large data centers, also known as hyper scalers.

ORGAN-ON-CHIP

Organ-on-Chip (OoC) technology will help reduce animal testing and establish more efficient drug-discovery processes in the future. OoCs can revolutionize the pharmaceutical industry by offering a scalable drug testbench. At the same time this technology circumvents ethical concerns that arise from the extensive use of animal models in medical research. With OoC, biological tissue that simulates real organ physiology is exposed to drug simulation, while biosensors measure the response. With our flexible electronics and large-area manufacturing expertise, Holst Centre is able to bring OoC technology to the next level. Due to the scalability of this cost-effective solution, we can accelerate the development of new medicines such as those for neurodegenerative and cardiovascular diseases – without harming our precious animals.





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