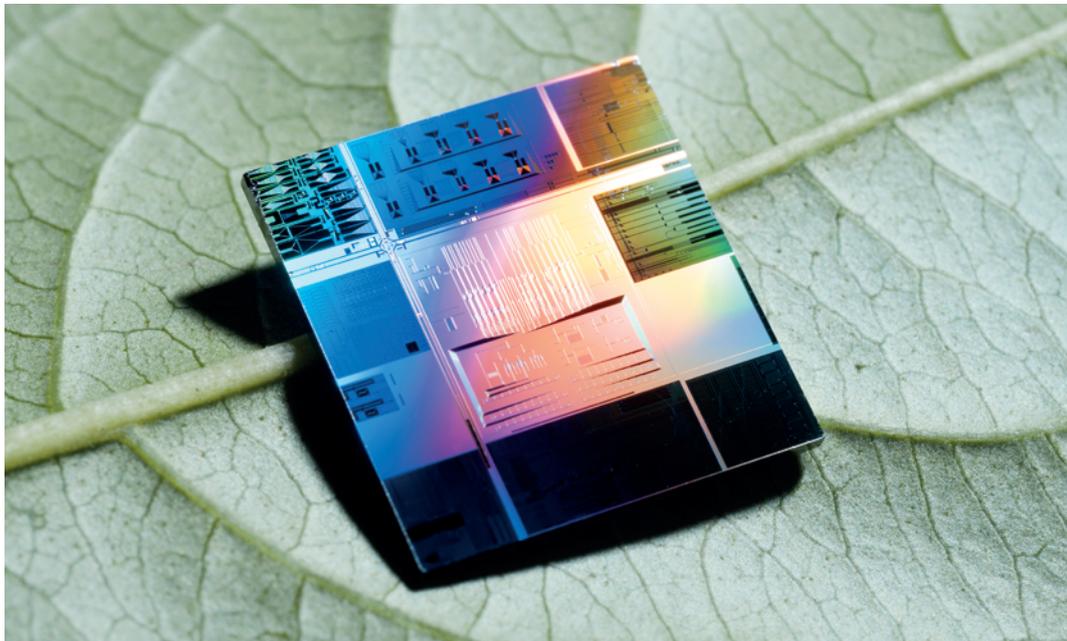


NANOPHOTONICS SAVES LIVES!



A photonic chip contains dozens of biosensor elements

TNO innovation
for life

A patient visiting the doctor hopes for a straightforward diagnosis and for a well-defined treatment towards fast recovery. However, in many cases diagnosis requires analysis of a blood or urine sample by a specialised lab. This can take several days at high expenses, leaving a worried and ill-feeling patient waiting. At TNO we are working on technology to provide fast and affordable diagnostics at the general practitioner, with the purpose of health care cost reduction, and the potential to save lives.

Nanophotonics is an emerging technology that finds more and more applications in daily life. It deals with the manipulation of light, using optical components that have feature sizes smaller than a wavelength.

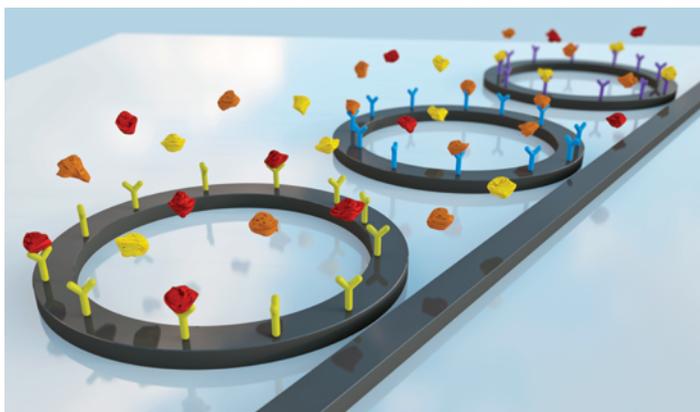
Nanophotonics at TNO is focused on two branches: Integrated Photonics and Metamaterials.

- Integrated photonics is the realisation of optical functionality on a chip, using fabrication technologies well-known from the electronics industry. It enables fast, multiple parallel measurements on a small sample. For example, small and sensitive sensors can determine the presence or absence and the concentration of a range of biomarkers in a tiny droplet of blood.
- Metamaterials are artificially assembled materials that interact on a nanoscale with electromagnetic radiation such as light or radar signals. Metamaterials

can enhance performance and reduce the size of current optical applications. Even more, metamaterials can enable new functionalities that are impossible to achieve with classical materials.

INTEGRATED PHOTONICS APPLIED

Integrated photonics has its roots in telecommunication, and is now also recognised as a key technology for sensing applications. A vast number of sensor elements can be integrated on a single chip, each element being highly sensitive to the optical parameters of its immediate vicinity. This vicinity is typically a selective coating that responds to the presence of a specific gas, or a layer of biological antibodies to which only specific biochemical molecules will bind. A tiny sample volume suffices to address all sensor elements on a small chip, and to provide a (bio)chemical 'fingerprint'.



On-chip ring resonators functionalised with antibodies to detect multiple biomarkers within a few minutes at point-of-care

The first common applications of nanophotonic sensing are expected in Point-of-Care diagnostics, aiming to reduce health care costs, and to potentially save lives in emergency situations. At TNO we have already demonstrated two-minute detection of clinically relevant concentrations of Alzheimer biomarkers using nanophotonic sensing. Other promising case studies concern the fast detection of sepsis, and analysis of cardiac markers. In addition to the health care context we envision environmental sensing applications, such as monitoring greenhouse CO₂ levels, and real-time analysis of car and factory exhaust gases. The sensor information is vital for process optimisation and pollution reduction. Measurement of physical parameters such as (sub-mK) temperature, pressure (sound and ultrasound) and flow can be integrated in these sensors, optionally in multi-channel arrays for directional selectivity.

The read-out unit for these nanophotonic sensors should be mobile phone-sized and priced. To achieve that goal, TNO actively pursues implementation of the optical parts of the read-out unit in nanophotonic technology, while observing compatibility with other sensor types such as Fiber Bragg Gratings (FBGs).

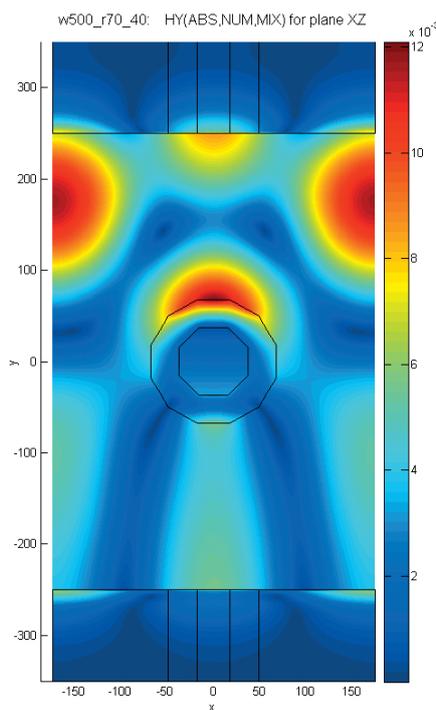
METAMATERIALS APPLIED

The applications of metamaterials are still in their early stages. A first example of using the properties of metamaterials is to enhance solar cell efficiency. Nanosized features reduce the reflection of the solar cell surface and embedded metamaterials redirect solar radiation for enhanced absorption. Nanosized features can also be applied to create polarisation sensors and give materials anti-reflex properties. Another widely discussed feature of metamaterials is that they can focus light beyond the known diffraction limit. Using

this so-called super-lensing property, new applications in imaging and sensing can be explored. It is expected that more novel application and sensor enhancements will be possible applying this new class of materials.

WHY TNO?

TNO has a considerable track record in nanophotonic system design. We are building a unique sensor platform that can be used for a wide range of applications. Several of our systems have been used and tested in industrial environments. Besides nanophotonic integration TNO is pioneering with applications in the area of metamaterials aiming to bring this new technology to a more industrial level as well.



The interaction of a glass-silver nanoparticle (70 nm core diameter) with the electromagnetic wave is simulated. The magnetic field strength for a plane wave incident from the top is displayed. Simulations are FDTD based

At TNO we bring together an in-depth knowledge of the different technologies involved, combined with application knowledge. We are able to make the translation between academic research and practical application, requiring a broad understanding of manufacturing and tolerances. TNO has vast system engineering know-how and is member of an eco-system of nanophotonics manufacturers. Certain processes can be done at TNO in our large state-of-the-art cleanroom facilities, and for other processes we team up with excellent third parties.

TNO

TNO is an independent innovation organisation that connects people and knowledge in order to create the innovations that sustainably boost the competitiveness of industry and wellbeing of society.

TNO works for a variety of customers: governments, the SME sector, large companies, service providers and non-governmental organisations. Working together on new knowledge, better products and clear recommendations for policy and processes. As a ‘knowledge broker’, TNO advises her customers on finding the optimum solutions that are geared precisely to the questions they have.

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