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PHOTONICS magazine

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industrial laser systems, measuring instruments, optical components

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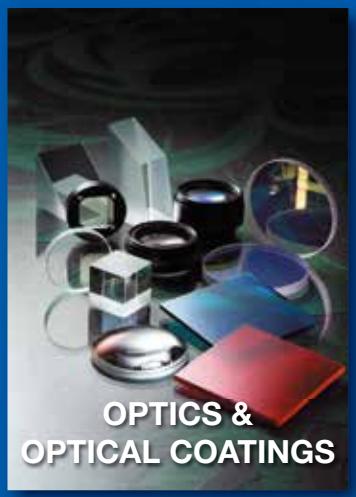

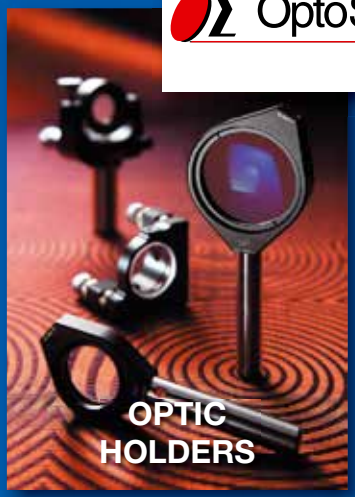

PYSER – SGI

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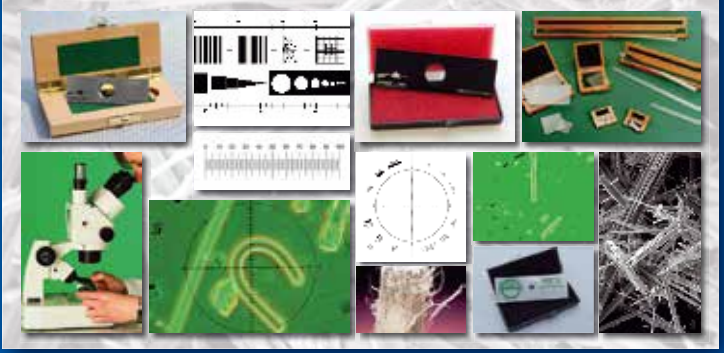

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Dear PhotonicsNL Magazine reader,

Benno Oderkerk

Welcome to the first magazine of 2021 for PhotonicsNL.

We have all experienced 2020 being a special year, which we will never forget and in which most events did not take place.
We are all very hopeful that 2021 will be the year that the world can open up again, thanks to the positive news of COVID vaccines, that are being rolled out.

For PhotonicsNL 2020 was a different year with the last physical event being the Photonics West in San Francisco in February, and from that time onwards the transition was made to on-line events, such as webinars.

Our general assembly, on 9th of September 2020, was a digital event and with many attendees the best one visited ever. It was really great to see a lot of known faces, it almost felt like a digital reunion. We are also happy that Pieter Kramer volunteered to strengthen our board as secretary. Welcome Pieter! In this way Sylvania is able to focus on the education portfolio. Read more about these board members further in the magazine.

The DutchPhotonicsEvent was changed to an on-line event with multiple webinars. Also an update of the HTSM Photonics Roadmap was finished in October. On the project side we are happy to announce that PhotonicsNL participates in a new EU project BestPhoRM21.

Finally, I would like to welcome our new members, QuiX and Addoptics that have joined our growing organization.

Please stay safe and healthy and find enough time to read this Magazine and get inspired.

Benno Oderkerk

Chairman of the Board
PhotonicsNL

Colofon

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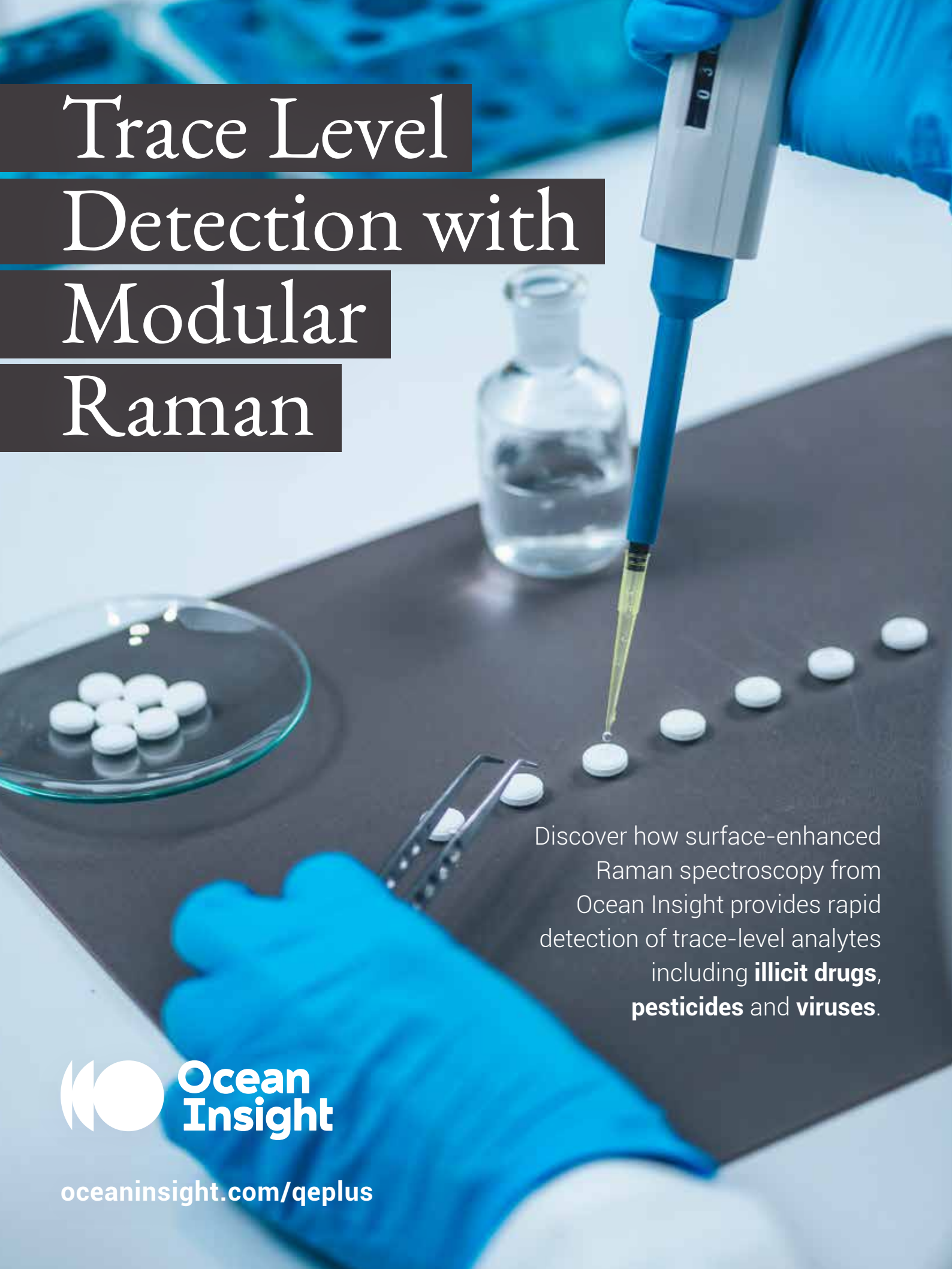

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Ron van der Kolk

Dear PhotonicsNL members and partners,

We started 2021 in the opposite way to 2020. Instead of being free, we started the year in a lockdown with work and school from home. Despite that, I hope to see the COVID restrictions disappear in the course of the year so that we can still make 2021 a prosperous year.

In this edition of the Photonics Magazine we like to look back to the second half of 2020, the first part of 2021 and to look forward to activities and possibilities later in 2021.

During the second half of 2020 the virtual meetings were in full swing. We worked together with our German partners from OptecBB and PhotonicsHub in various webinars and during the Photonics Days of Berlin.

Following the success of these webinars we then focused on our own digital conference of the DutchPhotonicsEvent during the fall and winter months. Together with our Program Committee we were able to organize five inspiring webinars. I absolutely want to thank the Program Committee and all the speakers that participated. Special thanks to you as the audience as well, for the animated discussions and interest that made this digital alternative almost feel like a live event. I kindly recommend you the article on these webinars in this edition of our Photonics Magazine.

In the coming months of 2021 we continue our digital course. We are preparing several digital collaborations within the Netherlands and also with our international cluster partners from Germany (OptecBB, PhotonicsHub, OptoNet) and France (Photonics France, Optitec, Photonics Bretagne). Aiming at meeting each other physically later in the year. At first we planned to do this at the end of June during the Laser World of Photonics in Munich but since this event has been postponed to next year, we hope for dedicated meetings in September and October.

We successfully ended the NextPho21 project, with a final review meeting in March. And in January we started the BestPhoRM21 project together with a European Consortium for the next 3 years. BestPhoRM21 has the goal to provide the critical strategic and logistic support to the new Horizon Europe Photonics Partnership, to develop and implement the R&I Photonics Strategy for Europe. You can read a special article about this project in this magazine.

Last but not least, we look at the next DutchPhotonicsEvent. Will this be the first physical event of 2021? Right after Summer Break would be a great time to finally be able to gather physically. Organizing the DutchPhotonicsEvent requires a thorough planning and organization, with you but also with the location and other external parties. We will of course keep you updated about the exact date and location.

With this said I wish you all a healthy and good spring and summer. Keep your spirits high and I look forward to meeting you again in future events.

Ron van der Kolk
Director
PhotonicsNL

Knowledge
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Online DutchPhotonicsEvent

With a long history of a yearly physical event, the DutchPhotonicsEvent 2020 went digital for the first time. Like for many other events we have been working hard to prepare an inspiring day with interesting topics. During this process we saw that it would be impossible to meet face-to-face and so we decided to bring the complete conference and the women in photonics event, to the Dutch Photonics community in digital form over the winter months.

Dutch Photonics Event

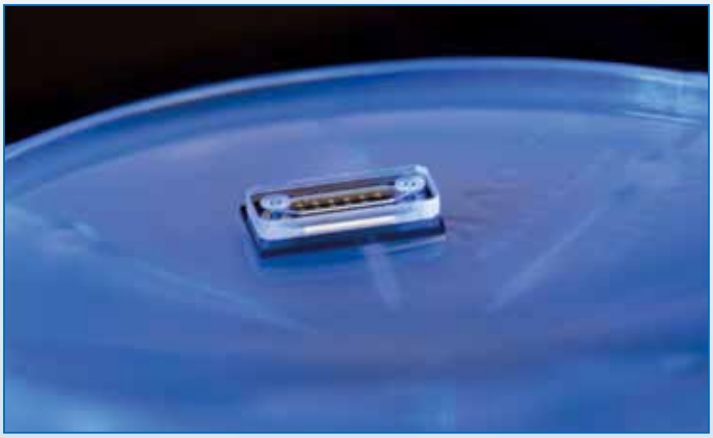
Together with our fantastic Program Committee we were able to build 5 successful webinars. Therefor we like to give special thanks to them: Erwin Bente (TU/e), Johannes de Boer (VU Amsterdam), Silke Diedenhofen (NOW), Frans Harren (RU), Femius Koenderink (Amolf), Herman Offerhaus (UTwente), Gerrit Polder (WUR), Eddy Schipper (RVO), Jorn Smeets (PhotonDelta), Carlas Smith (TUDelft), Bart Snijders (Dutch Optics Centre / TNO), Patty Stabile (TU/e), and Ruud Verdaasdonk (UTwente).

Throughout the year we (digitally) meet the Program Committee and talk with them about the latest developments in Photonics and various application areas. We are very happy with this collaboration, all their input and the important work that they do behind the scenes.

To provide the Dutch photonics community with inspiring insights in the different photonics areas we organized multiple webinars with different interesting, contemporary subjects:

- Photonics against COVID-19 (24 November 2020)
- Photonics for AgriFood (8 December 2020)
- Photonics in Healthcare (28 January 2021)
- Photonics and AI (9 February 2021)
- Women in Photonics (11 February 2021)

A virtual event is very different than a physical event, although after so many months of being deprived of physical events, we were still able to make something beautiful out of it together. We saw this confirmed in the big numbers of participants and the enthusiasm that they brought with them. We also noticed a great commitment during the plenary discussions after the presentations. Of course we don't want to forget to thank the speakers with their valuable contributions.



Biochip - Courtesy of Surfix BV

We started the webinar series with the topic that concerns us all: **Photonics against COVID-19**, held on 24 November 2020. With subjects from Integrated photonic sensors towards the detection of COVID-19 biomarkers to multiplatform diagnostics, we learned that photonics is priceless in our struggle against this virus.

Program:

Sonia Garcia Blanco	Twente University	Integrated photonic sensors towards the detection of COVID-19 biomarkers
Luc Scheres	Surfix	From photonics to diagnostics
Beate Stevens	AeroCount	Start-up pitch
Arno van de Kant	Spektrax	Beyond COVID-19, multiplatform diagnostics
Maarten Merkx	TU/e	Bioluminescent immunoassays in solution: no washing, less waiting

To find more information about the speakers and their presentations, follow this link:
http://bit.ly/SpeakersCovid-19

The second webinar **AgriFood for Photonics** was held on 8 December 2020. Within this webinar the speakers gave great presentations about hyperspectral camera's being the new eyes for precision agriculture and the food industry, we saw the newest ways of digital phenotyping, the state-of-the-art measurement possibilities of the NPEC facility and the right software to interpret these spectral images. With all these interesting topics we once more saw the confirmation of the importance of Photonics for Agrifood.

Program:

Wouter Charle	IMEC	Hyperspectral cameras: 'new eyes' for precision agriculture and the food industry
Rick van de Zedde	WUR	Measuring and understanding plants to improve performances - Large scale research infrastructure for plant sciences
Maurangelo Petruzzella	MantiSpectra	Start-up pitch
Grégoire Hummel	Phenospex	Real-time Assessment of Food Quality through Video Spectroscopy
Matthias Locherer	Cubert GmbH	Real-time Assessment of Food Quality through Video Spectroscopy
Pavel Paclik	perClass	Enabling practical spectral imaging solutions in Agri-Food

To find more information about the speakers and their presentations, follow this link:
https://bit.ly/SpeakersAgrifood

A big advantage of having our event online is that we were not dependent of a one day event but we could spread the event over several months. In 2021 we started with **Photonics in Healthcare** on 28 January. The subjects were very divers. Overall we learned that with the application of photonics there are many new possibilities in the development of healthcare.

Program:

Ruud Verdaasdonk	UTwente	The Myths about Mouth Masks unmasked: Real time air flow and droplet imaging to study effectiveness of personal protection in view of Covid-19 spreading
Terence Risby	Johns Hopkins University, Baltimore, USA	Photonics: A real time in vivo assessment of human homeostasis?
Peter Harmsma	Delta Diganostics	Biosensing: from proof-of-concept to product
Wouter Nagengast	UMCG	Fluorescence molecular imaging in diagnoses and treatment follow up
Stefan Lampaert	Confocal.nl	Rescan Confocal Microscopy in Live Cell Imaging

To find more information about the speakers and their presentations, follow this link:
http://bit.ly/SpeakersHealthcare

The fourth webinar in the DutchPhotonicsEvent series was titled **Photonics & Artificial Intelligence**, on 9 February 2021. Where over the last years the possible application of Artificial Intelligence increases in many areas, this subject guarantees almost endless possibilities. We were able to discuss this with a very skilled line-up of speakers and a big audience.

Program:

Babette Bakker	TNO	AI for safe autonomous systems
Soheil Jahanshahi	MYThronics	Start-up pitch
Patty Stabile	TU/e	Photonic integrated cross-connects for all-optical neural networks
Guy Verschaffelt	VUB	Photonic reservoir computing and its implementation using delay-based systems
Stefan Abel	Lumiphase	Start-up pitch
Bert Jan Offrein	IBM Zürich	Photonic signal processing for neuromorphic computing
Johannes Feldmann	WWU Munster/ University of Oxford	Towards brain-inspired photonic computing

To find more information about the speakers and their presentations, follow this link:
http://bit.ly/SpeakersAI

Traditionally, during the yearly DutchPhotonicsEvent, we organize a *'Women in Photonics Lunch',* a very successful event, and not just for women. Due to the impossibility of lunching together we named the webinar **Women in Photonics**. We found a very special date to organize this event, namely during the *'International Day of Women and Girls in Science'* on 11 February.

Four female speakers from different parts of the photonics field, and with different (lengths) of careers shared their experiences with the audience. And, as we always did during this event, there was plenty time for discussion with the attendees after the presentations.

Program:

Monique Schutten	Te Lintelo Systems	25 years living the photonics life
Laura Maddalena	TU Delft	NIR holographic stimulation with adaptive optics in living zebrafish embryos
Netsanet Tessema	TU/e	Career prospects in Photonics Research
Joanne Oh	TU/e	My journey in photonics

To find more information about the speakers and their presentations, follow this link:
http://bit.ly/SpeakersPhotonicsWomen

The Women in Photonics event was also a big success. In the future we will continue to organize it as part of the DutchPhotonicsEvent but probably not during lunchtime anymore. The lunchtime is seen as a valuable moment for all the men and women to be together and network simultaneously.

We look back with pleasure on this unique digital journey and on the collaboration with all of you involved. For the next edition of the DutchPhotonicsEvent we hope to be able to organize a physical event again. Will this be the first event of 2021 were we can meet in person? We really hope so and we will keep you informed!

peo electro optics

Lichtverdeling karakterisatie

Optische ingenieurs en systeemontwikkelaars staan continu voor de uitdaging van snelle veranderingen in ontwerp en complexiteit van componenten met achtergrondverlichting in de auto-, transport-, elektronica- en andere industrieën.

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(Voordelen gelden voor zowel de GL OPTICAM 2.0 als de 3.0; dikgedrukt betreft voor de 3.0 versie.)

Luminantie metingen:	GL OPTICAM **2.0** 4K TEC	GL OPTICAM **3.0** 4K TEC
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verlichte knoppen	✓	✓
instrumentenclusters	✓	✓
weg- en straatverlichting	✗	✓
buitenterrein verlichting	✗	✓
vliegveldverlichting	✗	✓

NIEUW • GL OPTICAM 2.0 4K TEC

Deze versie is speciaal ontworpen om de conformiteit en de prestaties van verlichtingscomponenten te controleren van o.a. moderne LED-, OLED-verlichtingsapparaten.

Totaaloverzicht: gotoPEO.com/opticam

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NIEUW • fotometrische lichtverdelingskarakterisering:

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Voordelen:

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Volledig overzicht: gotoPEO.com/licht

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PhotonicsNL news

Essential part of our association is the board. To keep our association lively, changes of the board are necessary every once in a while. Our secretary, Silvania Pereira (TU Delft), has indicated for a while that she aspires to have education in her portfolio which means we had to look for a new secretary. And luckily we got a positive response when we made an appeal to our members. Pieter Kramer from Laser 2000 Benelux was very enthusiastic about this position. So he became our new secretary. Pieter will be installed officially at the next general assembly of members and then our board is complete again.

But, who is Pieter Kramer?
Pieter studied Technical Physics at TU/e and since he started to work in 1988 this has always been with photonics, so he is very experienced.
In his career Pieter has had commercial functions in many different companies and institutes in the Benelux. Since 1999 he is commercial director of Laser 2000 Benelux.
Pieter is married with Helen since 1988, they have 3 grown up sons, all of them 'beta's' but no physicians…..

In the transition phase of *Photonics Cluster Nederland* and *PhotonicsNL*, around 2014, Pieter already has been part of the board. Unfortunately he had to give up after a short while because of too much busyness at work.
In that time PhotonicsNL was setting up an internal structure, Pieter remembers. Nowadays the association is more mature. A big challenge for any association, including PhotonicsNL, is offering added value for all PhotonicsNL members and, outside, also for the complete photonics world. From integrated photonics to medical/bioscience imaging and from agriculture to laser material processing. Because the added value can be different for everyone PhotonicsNL must continue to profile itself in many areas. This is year-to-year a very interesting challenge which Pieter would like to contribute to.
Would you like to contact Pieter? Send an e-mail to **pieter.kramer@photonicsnl.org**

And, how will Silvania fulfill her Education Portfolio?
Silvania thinks education is a very important theme within photonics and PhotonicsNL.
We must ensure that our future engineers get the right tools to be prepared to work in the photonics industry or develop further skills in the academia.
At PhotonicsNL we have a great opportunity to work on both sides of the coin: on one side, the photonics industry in the Netherlands. And on the other side, the young students who are currently working on projects or education programs related to photonics.
Silvania states that we could encourage students to become student members of PhotonicsNL. Let them present their work in webinars and have an active participation in our PhotonicsNL activities such as the Dutch Photonics Conference, DutchPhotonicsEvent and *Another* Day of Photonics. This will also benefit the industrial partners since they could learn what is being done in the universities and research centres in the Netherlands. A student chapter could be organised to let the students themselves think about new activities.
In a higher level, Silvania also plans to start a discussion between members of PhotonicsNL and Dutch universities/ applied universities (HBO) about the curriculum and training in photonics in the Netherlands. What is there already? What would we like to have? How can we as PhotonicsNL give a contribution to improve on this?
Would you like to contact Silvania? Send an e-mail to **silvania.pereira@photonicsnl.org**

Do you want to meet the other board members as well?
Visit our website **https://www.photonicsnl.org/about-us/our-organization/**

Activities review

While we all longed for physical meetings and events, unfortunately the state of COVID-19 did not allow us to organize these. We therefore continued our networking through online events, that also had their advantages.
As Dutch businesses continued, we organized these events to continue international interactions with the European photonics clusters that we came to work with for years. They play an important role as they are the network partners pre-eminently.
These events aimed to bring together scientists, engineers and end-users from the Dutch and German networks. There was sufficient room for discussion and virtual matchmaking. Hopefully these webinars were a stepping stone to physical meetings in the future.

With OptecBB (Berlin-Brandenburg) we organized two webinars:

Optical technologies for quality and safety aspects in the AgriFood chain

Speakers:

Dr. Oliver Schlüter (Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Germany.
Photonics along the postharvest chain of perishables: plasma application and quality monitoring

Dr. Maurangelo Petruzzalla (Eindhoven University of Technology, The Netherlands)
Integrated Near-Infrared Spectral Sensors to measure quality along the food production chain

Photonic System Integration and Programmable Photonics

Speakers:

Dr. Henning Schröder (Fraunhofer IZM, Germany)
Photonic System Integration using glass structuring technologies

Dr. Oded Raz (Eindhoven University of Technology, The Netherlands)
Programmable photonics

With PhotonicsHub (South Germany) we organized two webinars:

Silicon Photonics

Speakers:

Dr. Anna Lena Giesecke (AMO GmbH, Germany)
Customized Silicon Photonics

Douwe Geuzebroek (LioniX International, The Netherlands)
Silicon-Nitride Photonic ICs, and why a PIC is more than a chip.

Nazanin Shafiee (SMART Photonics, The Netherlands)
InP Photonic Integrated Circuits - Datacom, yes, but there is more…

Optomechanical Systems

Speakers:

Jaroslav Hopp (Meopta - optika, s.r.o., Czech Republic)
STOP analysis integration into the opto-mechanical tolerancing process

Jos Klippert (Nedinsco B.V., the Netherlands)
One stop shop

Frank Ernst (NTS Optel, the Netherlands)
Optical system development: Your vision our optical solution

Christian Buss (TRIOPTICS GmbH, Germany)
Ultra-precision centering turning for high-performance optical assemblies

Photonics Days Berlin Brandenburg:

With our eastern neighbours being important (photonics) business partners it is always attractive to find meaningful ways to collaborate. OpTecBB e.V, Cluster Photonics Berlin Brandenburg and the Enterprise Europe Network Berlin-Brandenburg organized the online edition of the 3rd Photonics Days Berlin Brandenburg in October. PhotonicsNL has collaborated in creating the inspirational program and therefore several Dutch speakers were involved.

This international innovation Conference in Berlin brought the regional and international photonics community together again. In this 4-day event participants from different sectors and regions were connected, so that they could cooperate in innovation and create value for new Photonics-based value chains together. During these days various photonics topics were on the program among other things new trends, innovations, one-to-one video meetings and a virtual matchmaking event.

Berlin Brandenburg is one of the innovation hotspots in diverse fields of photonics, optics, microsystems technologies and quantum technologies. Berlin Brandenburg is also a start-up hotspot in digital and also photonics-based technologies.
One of the highlights of the Dutch contribution in the Photonics Days was the opening speech by our Ambassador of the Kingdom of the Netherlands Wepke Kingma. Stating that the Dutch government sees photonics as one of the key enabling technologies to tackle societal challenges and that it is a field that cannot do without international cooperation. Other highlights were the presentation by QuiX during the webinar "Entrepreneurship in Quantum Technologies" and last but not least the PIC workshop organized by PhotonDelta, LioniX International, PHIX and Fraunhofer Germany.

Nanometrology on a photonic chip

Tianran Liu • Federico Galeotti • Rob van der Heijden • Andrea Fiore
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Introduction

Optics is widely used in demanding metrology applications, as it enables non-contact measurements with high signal-to-noise and large bandwidth. The most illustrative example is the Laser Interferometer Gravitational-Wave Observatory (LIGO), which achieves an astounding displacement imprecision of ~10^{21} m/(Hz)$^{1/2}$ [1] – implying that it can measure the motion of a mirror with a resolution six orders of magnitude smaller than the proton radius. While interferometry excels in measuring phase shifts from moving objects, it is demanding in terms of stability of the set-up and specifications of the laser source, and simpler methods are often used. An important practical application case is atomic-force microscopy (AFM), where the cantilever oscillation on a surface is measured by the optical beam deflection method using a quadrant detector (see Fig. 1(a)). Despite its simplicity, this approach achieves displacement imprecisions down to few tens of fm/(Hz)$^{1/2}$, enabling high-speed surface profiling with sub-nm resolution – a key requirement for semiconductor metrology as feature sizes are scaled to the nanometer range. Wide-scale application of AFM in chip production is however hampered by the sequential character of the measurement, which makes the imaging of large areas unfeasible. For this reason, parallel AFM systems have been developed, such as the QUADRA system commercialized by the TNO spin-off NearField Instruments [2]. A massive parallelization would however require monolithic integration of a large number of cantilevers, optical sources and detectors (see Fig. 1(b)) – this is challenging with the beam deflection method due to the required cantilever-detector distance. This observation has motivated research into integrated nano-opto-electro-mechanical systems (NOEMS) [3], where tiny displacements of moving parts can be detected using integrated optical circuitry.

Resonant cavity operation

Very low noise floors can be obtained by employing nanophotonic cavities, e.g. based on photonic crystals, where the mechanical displacement of one part of the cavity produces a wavelength shift of its narrow resonance [4]. In nearly all demonstrations of nanomechanical sensing, however, external lasers and detectors are employed, greatly limiting the scalability. Our group recently investigated the integration of detectors with cavity-based sensors and their application as nanomechanical sensors [5,6]. The heart of the sensor is a photonic crystal cavity (PhCC) etched in a thin (~200 nm) semiconductor membrane, as is visible from the Scanning Electron Microscope (SEM) image in Fig. 2(a). Manufacturing occurs through state-of-

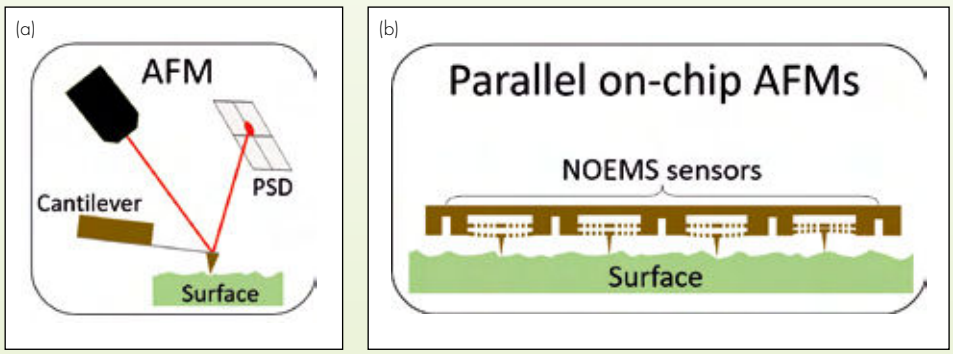

Figure 1: (a) Schematics of optical beam deflection method. (b) Schematics of parallel NOEMS readout

the-art semiconductor nanofabrication technology in the NanoLab@TU/e cleanroom. Light is confined to the membrane by total internal reflection. Within the membrane, light is confined to a "defect" in a regular array of holes, the photonic crystal, that coherently reflects light back into the defect. In this way a resonant cavity is created, with a sub-nanometer linewidth $\Delta\lambda \sim \lambda/Q$, corresponding to a quality factor Q of several thousands. For the displacement sensor, two identical membranes are made in close proximity (~200 nm), so that the cavities interact through their evanescent fields. The lower membrane is visible in Fig 2(a) through the trenches in the upper membrane. The resonant wavelength shifts with the separation between the membranes, which is exploited for the displacement sensing. The upper membrane is configured as a photodiode, with incorporated Quantum Dots as absorber. The photocurrent is strongly enhanced at the resonant wavelengths, see Fig. 2(b) and with wavelength depending on membrane separation, the photocurrent is a sensitive measure of the displacement.

By careful design of the suspension of the upper membrane, see Fig 2(a), it becomes compliant and deforms under applied force. When the excitation laser wavelength is kept fixed at a wavelength somewhere on the slope of the resonance peak, see the red line in Fig. 2(b), the photocurrent varies with the membrane separation. From the experimental value of the noise current, after conversion to an equivalent displacement of the membrane, a displacement noise floor of 7 fm/Hz$^{-1/2}$ was obtained for operating frequencies above 15 kHz. This compares well, or even favourably, with the best standard AFM specifications. It is still limited by intensity fluctuations of the laser. Fundamentally, it would be limited by fluctuations in the number of photons, the photon shot noise, which is dependent on laser power. It is estimated that ultimately a noise floor below 1 fm/Hz$^{-1/2}$ would be achievable.

Demonstration of AFM imaging

For use as a real AFM, the sensor still needs a tip. This is added as a post-processing step by means of Electron Beam Induced Deposition (EBID), in which a focussed electron beam dissociates molecules from a precursor gas at the desired growing location. The tip created in this way, see Fig. 2(a), is 1 - 2 µm high, has a tip radius of curvature of ~30 nm, and is made from a Silica-Carbon composition. A custom-made AFM head containing the PhCC as sensor with a lensed optical

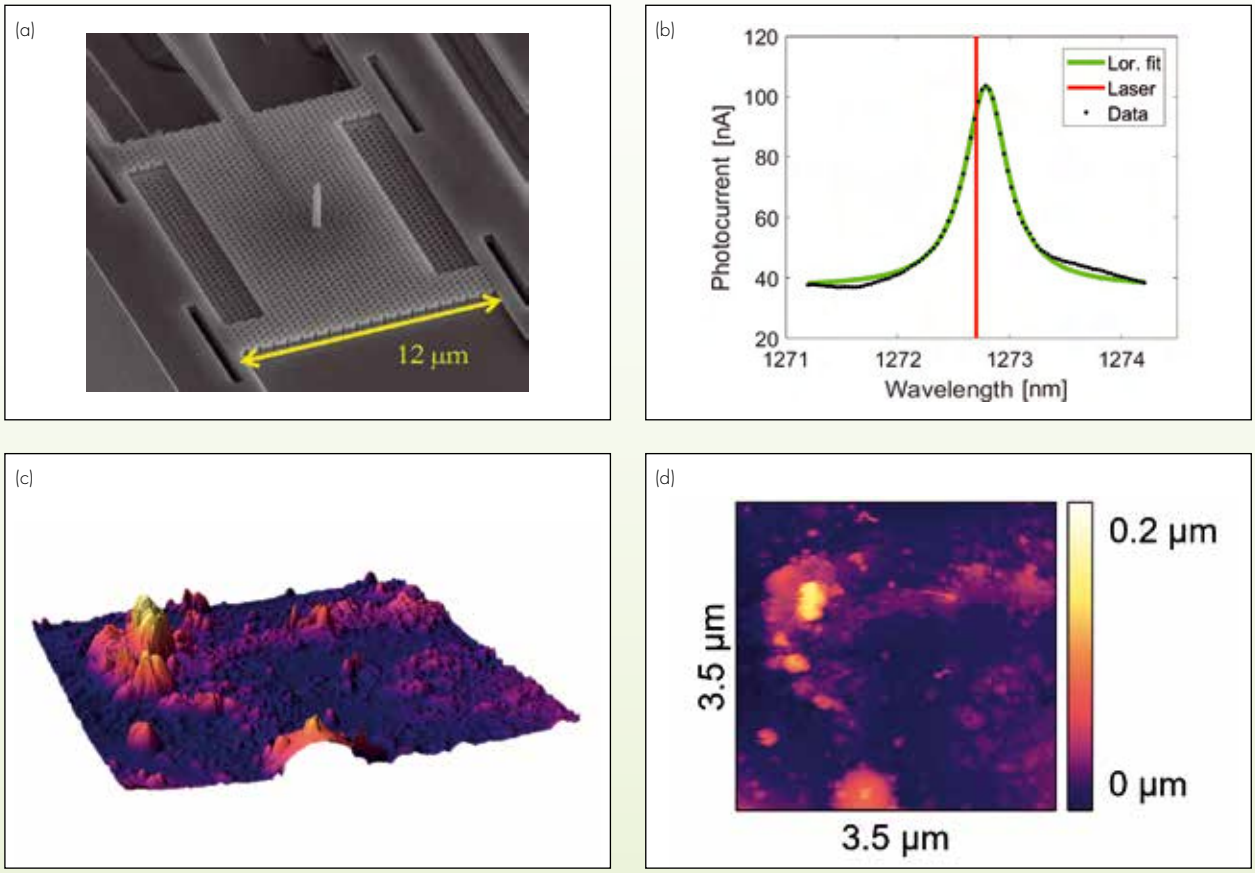

Figure 2: (a) Photocurrent spectrum of the cavity resonance. (b) SEM image of the double membrane photonic crystal cavity equipped with the AFM tip. In (c) and (d) AFM image obtained with the NOEMS sensor.

fiber for excitation, was installed in a commercial AFM, using its standard feedback controls and sample scanner. The surface profile obtained by imaging a colloidal particle cantilever is reported in Fig. 2(c) and (d), showing the proof of principle of the PhCC with integrated photocurrent sensor replacing the OBD method with quadrant detector. In this form, the sensor could already be useful as a stand-alone head to reduce the cost and complexity of AFM systems, increase scan speeds because of its small size and exploit its superior displacement imprecision.

The next step is the integration of the laser source and the parallelization of the system. However, the narrow resonance associated to a cavity makes this integration challenging, as a laser with precisely controlled wavelength and low phase noise is needed. Additionally, it strongly limits the dynamic range, as displacements of more than a few nm will bring the cavity completely off resonance with the laser. For these reasons, we also investigated a solution which would enable high-resolution on-chip nanomechanical sensing while providing a broad spectral response and a dynamic range of few tens of nm.

Directional coupler configuration

We chose a three-dimensional directional coupler structure (Fig. 3), where the vertical displacement of a moving arm modifies the interference among the different modes, leading to a change in the relative transmission in the two output waveguides.

The starting concept is a standard two-waveguide directional coupler etched on the lower membrane. Due to the overlap of the evanescent fields, the light periodically switches between the waveguides. Depending on the waveguide length and/or

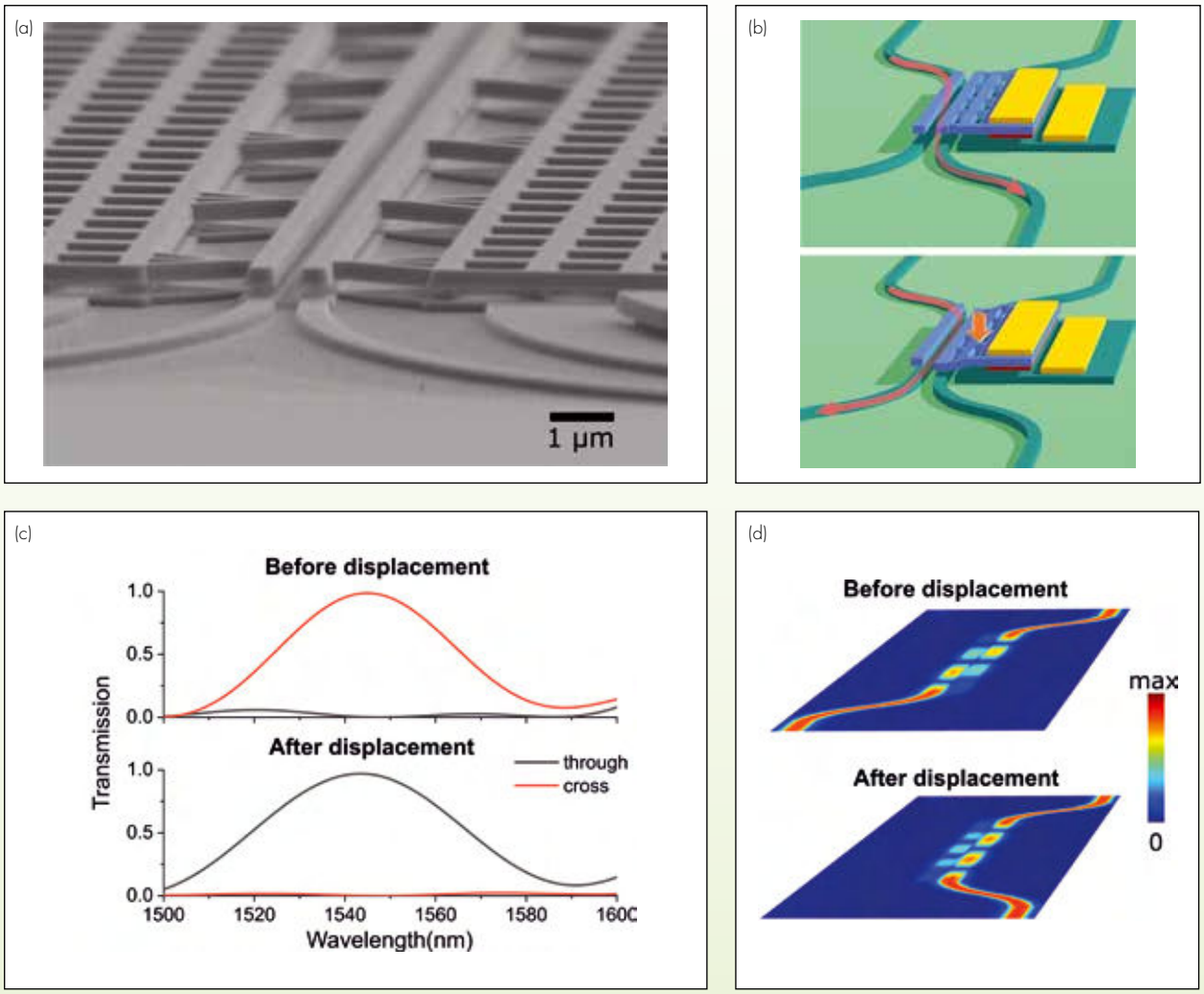

Figure 3: a) Scanning electron microscope image of the three-dimensional directional coupler structure. (b) Schematic illustration of light passing through the directional coupler before (up) and after (down) actuation. (c) Simulated transmission and (d) electric field in the coupler before and after actuation. (*From Ref. 8*)

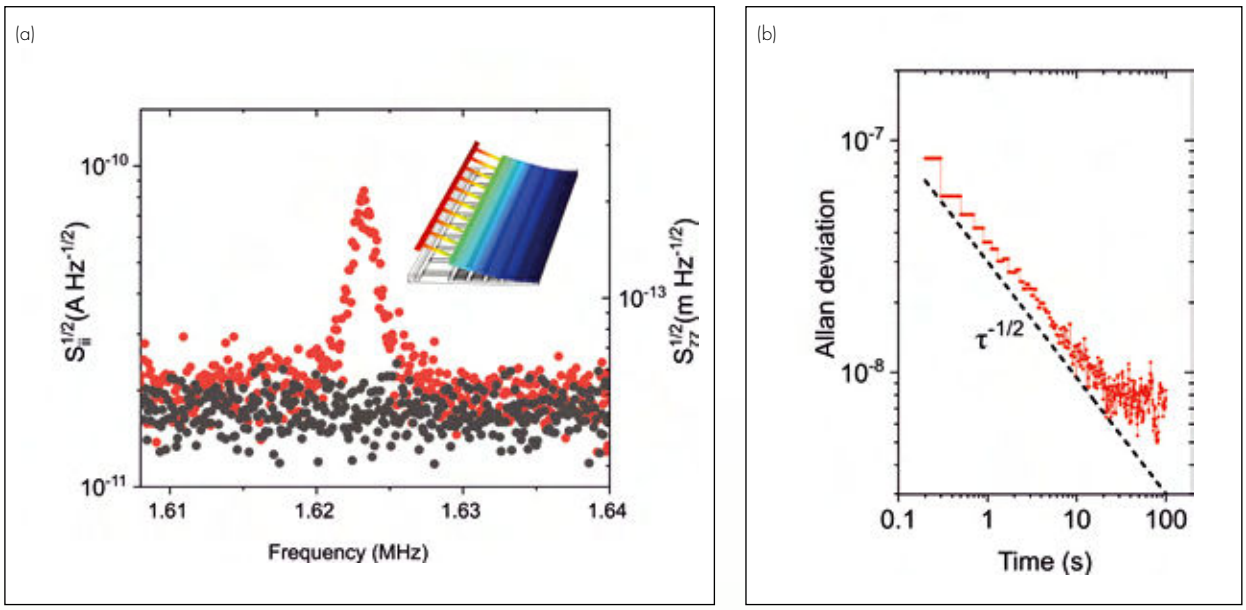

Figure 4: (a) Measured spectral density of the photocurrent (left axis) and of the corresponding displacement (right axis) with laser source turned on (red circles) and off (black circles), showing a peak corresponding to the Brownian motion of the fundamental mechanical mode in vacuum. Inset: Calculated mode shape of the fundamental mechanical mode of the cantilever. (b) Allan deviation as a function of integration time. The slope follows an inverse square root dependence on the integration time ($\tau^{-1/2}$), which implies that additive phase noise dominates the frequency stability, until systematic drift takes place when the integration time is close to 100 seconds. *(From Ref. 8)*

the effective refractive indices, input light in one branch can be precisely distributed over the two output waveguides. The effect of the sections hovering at variable distance over the lower waveguides is to change the effective refractive index, making the distribution over the two outputs dependent on the distance between the top and bottom sections. The simulated results for two different separations are shown in Fig. 3(c) and (d), showing that the structure can be exploited as a displacement sensor. In contrast to the resonant cavity, Fig. 2(b), the changes occur over a much larger wavelength range.

The structure is fabricated in the Indium Phosphide Membrane on Silicon (IMOS) platform developed at TU/e [7], where also lasers and detectors can be integrated with a small footprint. In our first demonstration [8], photodiodes were integrated on the two output waveguides, while an external laser was used. By measuring the RF spectrum of the photocurrent, we easily identify a peak at the mechanical frequency of the cantilever (~1.6 MHz), corresponding to the Brownian motion at room temperature, see Fig. 4(a). The noise floor in the measurement provides the displacement imprecision of this sensor, 45 fm/(Hz)$^{1/2}$, limited by parasitic electrical noise and the limited on-chip power, leaving ample room for improvement. Due to the non-resonant mode of operation, the device displays a very wide optical bandwidth, see Fig. 3(c) – the peak related to Brownian motion was observed for laser wavelengths ranging from 1520 to 1600 nm.

Operation as mass sensor

An actuator was also integrated in the cantilever, which employs the electrostatic force in a reverse-biased p-i-n junction formed between the top and the bottom membrane. This additional functionality allowed us to test the operation under a relatively large oscillation amplitude of >30 nm, corresponding to a dynamic range of over 50 dB in displacement sensing. The combination of on-chip actuation and sensing also opens the way to the measurement of the mechanical oscillation frequency with high accuracy. The measurement of the Allan's deviation (Fig, 4(b)), which is a standard measure for the frequency stability of an oscillator as a function of integration time τ, shows that a relative frequency fluctuation $\Delta f_m/f_m=3.6\text{x}10^{-8}$ is obtained for τ = 1s in this integrated nano-opto-electro-mechanical system. The high frequency resolution makes it possible to measure tiny changes in the mechanical oscillator, due for example to deposited mass. From the elementary expression of a mechanical resonance frequency $2\pi f_m=\sqrt{k/m_{eff}}$, with k the spring constant and m_{eff} the effective mass of the cantilever, and inserting measured values for k and m_{eff}, the frequency resolution leads to a mass resolution below 0.1 fg, making it for example suitable for the detection of ultrafine particles in the <100 nm range, if comparable mechanical Q factors can be obtained at ambient pressures.

Final remarks

The wide optical bandwidth and the use of a photonic integration platform, where lasers are available [7], opens the way to the integration of laser, optomechanical transducer and detector on the same chip. The resulting integrated sensor is expected to display the shot-noise-limited performance typical of optomechanical sensors, with displacement imprecisions down to the fm/$(Hz)^{1/2}$ level, while avoiding the complications and costs related to input/output optical coupling. This would also enable the massive parallelization of optomechanical sensors, as needed for high-speed AFM imaging, but also in other areas such as photoacoustic imaging. The combination of photonic integration and micromechanical systems has the potential to greatly broaden the application scope of optical sensing.

Acknowledgments

The results of Figs. 2(c) and 2(d) were obtained in collaboration with TNO at TNO-Delft. We would like to thank our collaborators in this project: Yuqing Jiao, Gustav Lindgren, Abbas Mohtashami (TNO), Frank van Otten, Francesco Pagliano (nanoPHAB & TU/e), Maurangelo Petruzzella (nanoPHAB & TU/e), Vadim Pogoretskiy, Hamed Sadeghian Marnani (TNO & TU/e), Ivana Seršić Vollenbroek, René van Veldhoven and Žarko Zobenica. ◆

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Federico Galeotti was born on 26-02-1990 in Rome, Italy. He studied physics at the "Sapienza" Universitá di Roma, Rome, Italy where he received in 2012 the Bachelor degree with a thesis on computational models for holographic optical tweezers. Then, in the same university, he carried out his Master's studies with a curriculum in condensed matter and he graduated in 2016 with a thesis on the adiabatic compression of surface plasmon polaritons for self-propulsion of metallic nanostructures. In 2017, he started at the Eindhoven University of Technology a PhD project on the development of an integrated nanoscale displacement sensor, of which the results are briefly presented in this letter.
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Update of the HTSM Roadmap

Ron van der Kolk en Petra Wicherink

We are happy to present you the Photonics Roadmap 2020. After months of intensive writing with the writing team (Hans van den Vlekkert - LioniX International (Chair), Bart Snijders – Dutch Optics Centre/ TNO, Ewit Roos - PhotonDelta, Paul Schuddeboom - NWO TTW, Silke Diedenhofen - NWO ENW, Eddy Schipper - RVO, Ron van der Kolk - PhotonicsNL) we are very content with the update of the Roadmap Photonics 2018 we made with the team and all the input we received from the universities and companies. Almost the entire document has been rewritten and we would like to keep it a living document that we can use for various purposes, such as future projects & activities and coordinated actions towards our Ministry and the European Commission.

The previous HTSM Roadmap Photonics, from 2018, needed an update as during the last 3 years there have been some important developments in the world, in the Netherlands and in the field of photonics in particular. Since 2018 the Photonics Roadmap is based on the Societal Challenges as described by the Dutch Top Sectors. In 2020 we have been working hard to work on this update with the writing team.

The photonics ecosystem in the Netherlands has evolved since the last Roadmap. Through cooperation at national level important steps forward have been made: The National Photonics Agenda, the higher TRL level of integrated photonics with PhotonDelta and the further clustering of the optics community with Dutch Optics Centre. And the bridging of photonics, as an important enabling technology, with other application areas and technologies, for example Quantum and Artificial Intelligence. Last but not least the strengthening of Dutch Photonics with international partners.

Compared to the previous Roadmap this updated Roadmap will give a more extensive overview of the role of Photonics for Societal Challenges. Addressed by the link with other technologies and applications. This Roadmap is especially focused on the Research Agenda for the Netherlands but we realize that the valorization of research to business is an essential aspect to tackle the societal challenges which get attention with valorization aspects.

The updated roadmap shall be used in the upcoming years. It will strengthen the position of photonics for the photonics ecosystem, the government as well as investors so we can make the next necessary steps. The roadmap can be found on the HollandHighTech website **https://www.hollandhightech.nl/photonics**.
You can also find the other HTSM roadmaps for the different topics on this page:
https://www.hollandhightech.nl/technologies.

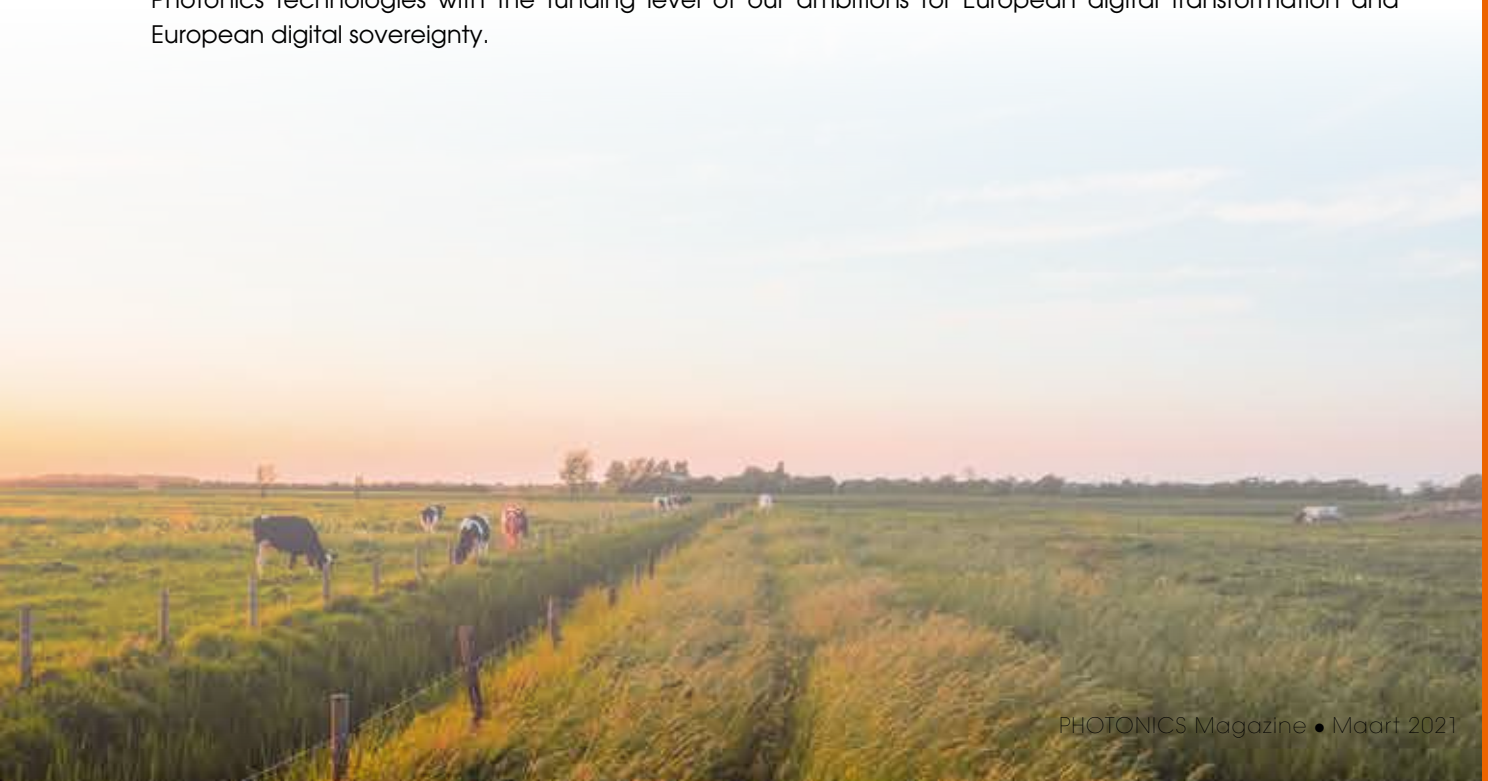
Photonics positioning in Horizon Europe

Ron van der Kolk en Petra Wicherink

In the last years there has been a discussion in the Horizon Europe work program about photonics. Currently photonics technologies are being recognized as essential to support and advance four over-arching European Union objectives: the digital transformation of Europe industry; achieving the European Green deal and a sustainable EU future; the establishment of a future sovereign and resilient European digital infrastructure and, strengthening strategic value chains across key sectors.

In 2020 we have been able to successfully take coordinated actions towards our Ministry and the European Commission. By giving the right insights we were able to support our Ministry in reaction to proposals from the German BMBF (Federal Ministry of Education and Research) and the European Commission. The joint effort has successfully led to a dedicated orientation topic on Photonics.
This separate topic for Photonics is critical, because it avoids being mixed up with other topics. In other words, without a separate "orientation topic" on photonics, we would not have a separate call area and budget line (like the Photonics KET Calls in Horizon 2020), but would have to ask other Horizon Europe program areas if they would be willing to take up our call priorities. In collaboration with other member states we were also able to make additions to the Horizon Europe Program document of the European Commission. This may sound like a nuance, but it will likely have a serious impact.

Although we are happy with the procedures and steps that were taken in 2020 for the European Photonics Partnership, we have to continue this important work with our European Partners and Photonis21 for the future of photonics within the Horizon Europe framework. Because despite the clearly recognized strategic importance of Photonic technologies for the future economic competitiveness and security of Europe, the Photonics21 Association has learned of the intent of the European Commission to cut a part of the support for the Photonics partnership in the Horizon Europe program 2021-2027. Together we aim to provide the Photonics technologies with the funding level of our ambitions for European digital transformation and European digital sovereignty.



New project BestPhoRM21

Ron van der Kolk

At the beginning of 2021 we started a new project: BestPhoRM21, together with a European consortium, consisting of the European Technology Platform Photonics21, Secretariat VDITZ and 13 other National Technology Platforms like ourselves. Together we represent the full photonics industry, Research and Technology Organizations (RTOs) and Cluster landscape in Europe.

What led to this new project?

We stand on the brink of an industrial and societal revolution that will fundamentally change the way we live and work. In its scale and complexity, the transformation will be unlike anything humankind has experienced before. Digitalization, increasing scarcity of resources and climate change will completely change business models and dramatically disrupt the industry. All the more the current COVID 19 crisis shows clearly how vulnerable economies are that do not manage to have strategic value chains and technological sovereignty to respond to these challenges.

The President-elect of the European Commission, Ursula von der Leyen, stated in her inaugural address to the EU Parliament that "Europe must lead the transition to a healthy planet and a new digital world" and for this to happen Europe has "to achieve technological sovereignty in some critical technology areas". Photonics is one of these critical technologies that are "essential key enabling building blocks for the digital transformation of Europe which will be based on deep technologies" stated the European Investment Bank in its report on "Financing the digital transformation". The development of photonic core technologies and their use and spill over in many different fields of application, will be essential for implementing the priorities of the new EU Commission. This is also re-iterated by a recent letter of the Nobel Laureates, Gérard Mourou, Stefan W. Hell and Theodor W. Hänsch to the EU Commission stating "Photonics is simply essential for powering the future European digital economy". Also, the European "Green Deal" will very much depend on progress in Photonics.

In the digital world Photonic sensors will provide the "eyes and ears" to digital manufacturing and smart farming. 3D printing is key to zero failure and one lot size production in manufacturing networks, avoiding waste and excessive use of raw materials. Optical high-speed networks enable connected mobility, transport and life. Overall, global data traffic has been doubling every 2–3 years over the past 15 years. We will enter a new era in which trillions of objects and billions of human users are connected. Data-center electricity use is likely to increase about 15-fold by 2030, to 8% of projected global demand. Photonics solutions can help cope with the increasing data traffic and significantly reduce the energy consumption per processed bit. Smart connectivity will be the foundation of this new digital world: always available, intrinsically secure, and flexible scaling is the pre-requisite for zero-downtime in a terabit economy. Highly integrated, accurate and fast photonic sensors with multi-sensor data fusion are the senses of the digital society. These will feed new Artificial Intelligence algorithms to enable Autonomous Driving, Smart Cities, Industry 4.0 as well as a comprehensive understanding of our climate or breakthroughs in medicine and healthcare. In Agriculture, drones equipped with photonic sensors empowered by AI will be used to analyze the growth status of plants and weeds and reduce the use of fertilizers and herbicides to a minimum. Solar fuels could one day become a realistic option for the energy supply of mankind. Mobile, portable photonic point-of-care devices will continuously measure medical conditions and

infections and detect diseases through the application of AI algorithms, enabling more efficient treatment to save the lives of thousands of people.

To this end, the European Commission and the European Technology Platform Photonics21 are establishing the "Photonics Europe" Partnership in the next framework program "Horizon Europe". The European photonics industry, represented by Photonics21, is committed to increase every Euro spent by the EU Commission in the partnership with 5 Euros of industry investment in research, innovation and manufacturing in Europe. The "Horizon Europe Photonics Partnership" between the EU Commission and Photonics21 will create a level playing field.

Goals and impact of the BestPhoRM21 project

The BestPhoRM21 project will provide the decisive support to the Horizon Europe "Photonics Partnership" by developing and implementing an European Photonics Industry strategy.
The BestPhorm21 project has 4 major goals, each with their own intended impact.

1. Support an industrial strategy for photonics in Europe by preparing a Community-driven strategic roadmap for photonics, involving more than 3000 experts from industry and RTOs.

   Impact of this is guiding the European Photonics Partnerships investments in re-enforcing strategic photonics value chains in Europe and channeling the European photonics industry's investment along a joint R&I strategy.

2. Strengthen the link to end users industry by preparing 'photonics enabled' end user industry roadmaps involving 700 end-users industry and photonics experts.

   Impact of this is guiding 'Horizon Europe' investments towards joint calls between photonics and end users industry program sectors and reinforcing and building new value chains between photonics and key industrial sectors across Europe to digitally upgrade their products and services.

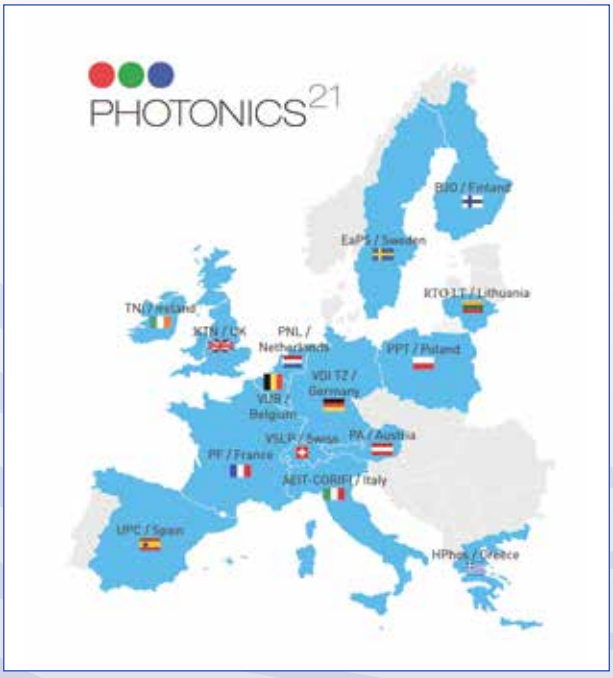
3. Trigger cross-member state and cross regional investments in photonics, linking these to the European photonics strategy.

   Impact of this is initiating cross-member state calls with sufficient funding volume and interregional investment projects.

4. Providing access to risk finance for photonics start-ups and SMEs in their critical growth phases through 'blended finance' (European Investment Council), 'Venture Capital' (dedicated VC events) and 'Venture debt' product (European Investment Bank).

   Impact here is to improve access to venture financing for photonics start-ups and SMEs by disseminating 3 types of (partly new) venture products in the different stages of the early company life cycle. BestPhoRM21 will involve more than 300 start-ups and SMEs.

Photonics21 and the EU Commission start a partnership on photonics in Horizon Europe. BestPhorm21 provides the logistical and strategic support to this partnership.



The BestPhorm21 Consortium consists of the Photonics21 Secretariat and 14 National Photonics Technology Platforms and Associations representing more than 14 regional photonics clusters.

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http://bit.ly/photonics-calendar

Photonics West 2021
6 - 7 March
http://bit.ly/PhotonicsWestMarketPlace
Instead of a physical event you can join the Digital Marketplace of Photonics West. Find the best solutions, components, instruments, and system providers from around the world. Watch product demonstrations, connect in one-on-one conversations with company representatives, enter giveaways, and find partnerships that will advance your work.

Hannover Messe Digital Edition
12 - 16 April
http://bit.ly/HannoverMesseDigital
Become an exhibitor: New Visibility. New Leads. New Business.
With features such as exhibitor live streaming, matchmaking, business dating and new opportunities for digital product presentation, the HANNOVER MESSE website is expanded into an industry networking platform for you.

Photonics France Online Meetings #3
11 May
http://onlinemeetings.photonics-france.org/
PhotonicsNL will be partner on this day dedicated to photonics and its application markets with business meetings on a European scale, between principals and suppliers of the photonics sector, completed by webinars on products and services. More than 200 French and European companies are expected to attend: major prime contractors, technology and service providers, investors, institutions, public and private partners, congress visitors.

HTSM online Voorjaarsevenement

31 May

https://www.hollandhightech.nl/agenda/voorjaarsevenement-2021

In the HTSM internationalization approach, the country plans Germany and France are a strategic tool. This formulates opportunities for the HTSM subsectors. And they provide direction for closer public-private cooperation.
The aim of the spring event is to inspire the HTSM partners and supporters on needs for solutions in the field of Energy, Sustainability and Digitization (in Germany and France), to make them enthusiastic about the (overall) market and innovation opportunities for Dutch high-tech in Germany and France. From the mouth of experienced experts. With practical translation into 'What' s in it for them' for entrepreneurs, mostly SMEs.

PIC International Conference

Brussels, 15 – 16 June

https://picinternational.net/

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Laser World of Photonics

Postponed until 26 – 29 April 2022

http://bit.ly/LaserWorldMunichPostponed

Join the Holland Avenue at the 2022 edition.
For information and participation, send an e-mail to ***petra.wicherink@photonicsnl.org***

'*Another* Day of Photonics' with Start-ups

https://www.photonicsnl.org/day-of-photonics/

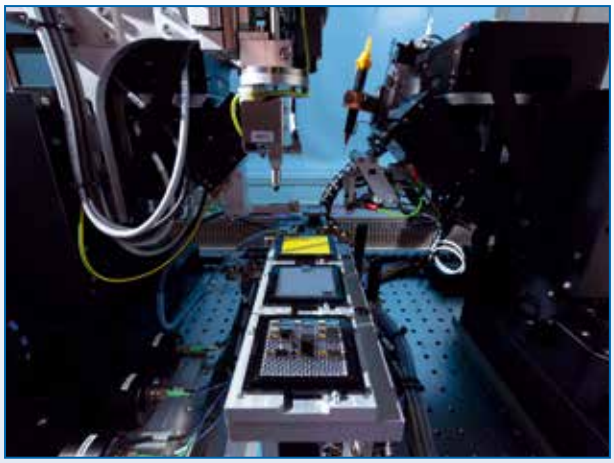
We plan to organize 'Another Day of Photonics' in spring, where the photonic start-ups play a central role. We will see various pitches from start-ups. We will invite market-experts and of course, the knowledge of the already experienced SME's, being part of PhotonicsNL.
Furthermore we will collaborate with PhotonDelta on this day, as they have defined a program to support start-ups interested to leverage the established integrated photonics supply chain. The program provides participants with access to coaching, market and funding for (pre)seed-stage start-ups.
You will hear from us soon with a more detailed program.

News from our members

Ron van der Kolk en Petra Wicherink

- **ficonTEC and PHIX partner to enable high-volume manufacturing of multi-chip photonic modules**

Dutch photonics packaging foundry PHIX BV and German machine manufacturer ficonTEC Service GmbH have combined their expertise in a symbiotic partnership. While ficonTEC is supplying PHIX with automated machine tools for hybrid chip-to-chip (chiplet) assembly using active alignment, PHIX is offering process development and contract manufacturing to ficonTEC customers. This easy access to flexible automated photonics assembly services and process knowledge allows for a seamless scale-up to high volumes.
https://www.phix.com/ficontec-partnership-chiplet-manufacturing/



- **PHIX welcomes new investor PhotonDelta**

With the addition of PhotonDelta as a shareholder, PHIX further secures its position as a leading packaging and assembly foundry within the European integrated photonics ecosystem. PhotonDelta also provides PHIX with long term financing for equipment purchases necessary to ramp up production of optoelectronic modules. This is made possible by PhotonDelta's funding partners: Brainport Development and The Province of Overijssel.
https://www.phix.com/phix-welcomes-photondelta/

- **Te Lintelo Systems have moved to their new office**

After a complete rework of the building, with changes made especially for Te Lintelo System, they were are able to move into the ground floor of their building. With their new office they will occupy >350 m2 floor space. They carried out a complete renovation conform their own specifications, where they took into account a healthy work environment. Including a state of the art lighting system and plenty of workspace to work according to all COVID-19 guidelines for offices.
http://bit.ly/TLShasmoved

te lintelo systems bv
photonics, our passion!
35 YEARS

member

- **Avantes appoints new CEO**

Avantes B.V., world leader in the field of spectroscopy, has appointed Pierre Warffemius as CEO as of September 14 2020. With this appointment, the international company enters a new phase in which the focus will be on continuous growth in additional products and markets.
During his career, Pierre Warffemius (55) has fulfilled various management positions with companies in the fields of biotechnology and graphic arts. His last position was CEO of SynCo Bio Partners B.V.. He has extensive experience in the professionalization of expanding technology-oriented businesses. As CEO of Avantes, he will be focusing on further growth and professionalization of the company
https://www.avantes.com/news/avantes-appoints-new-ceo/

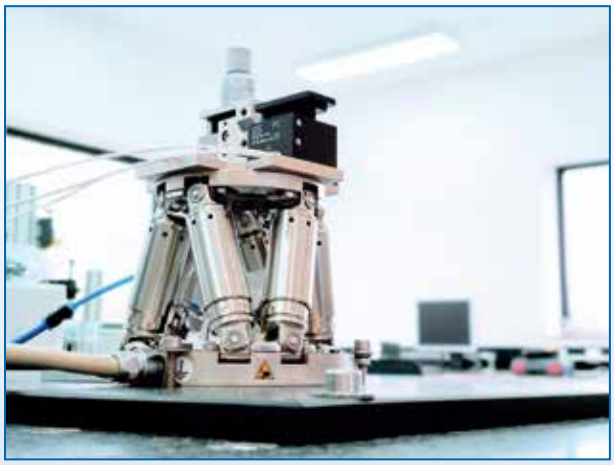
- **World Premier: AIM Academy (MIT) and PhotonDelta present the IPSR-I 2020**

The 2020 Integrated Photonics System Roadmap – International (IPSR-I), a global reference document that reveals the full potential of integrated photonics, has been released jointly by MIT's Initiative for Knowledge and Innovation in Manufacturing (IKIM) in Cambridge, which runs the AIM Photonics Academy project and PhotonDelta, based in Eindhoven, Netherlands. It charts the technology development of various branches of integrated photonics over the short, medium and long term. The authors of the IPSR-I describe the revolutionary advancements that integrated photonics will bring to the world, transforming industries and tackling global societal challenges in the years to come.
https://www.photondelta.com/news/ipsr-i-launch/

- **Start of Photonics Assembly Consortium: PODIUM**

A unique ecosystem to accelerate and standardize the packaging of integrated photonics Today Chip Integration Technology Center (CITC), Tegema, PI (Physik Instrumente) and PHIX released their new Photonics Assembly Consortium called PODIUM, funded by PhotonDelta and CITC. The name PODIUM refers to PIC Open Development Infrastructure for Universal Markets. The consortium runs a program in which optical termination technology, assembly and packaging is developed for a wide range of integrated photonic applications. As a Key Enabling Technology, photonics is the driver in many relevant innovation innovations, for example data communication - saving lots of energy - and medical technology - saving lives.
https://www.citc.org/photonics-assembly-consortium-podium/

PODIUM
PHOTONICS ASSEMBLY CONSORTIUM



- **Technobis' integrated photonics activities become PhotonFirst**

To enable fast and focused growth, the integrated photonics sensing activities of Technobis will change their name to PhotonFirst and operate independently from its 'mothership' Technobis Group as of January 1st. Daan Kersten will be heading PhotonFirst as its first CEO. As he announced when he joined the team three months ago, the photonics activities will be expanded aggressively, both in scope and size, as well as geographically. Besides the renowned interrogator systems, PhotonFirst will expand its value chain position to include sensors and application development, essential to be able to offer end-to- end solutions to its worldwide customer base. The company will continue to focus on demanding end markets like aerospace, medical, mobility and high-tech equipment, where innovation is key to stay in the lead.
https://www.photonfirst.com/technobis-ips-becomes-photonfirst

PHOTONFIRST
Integrated Photonics Sensing

New members

This year we welcomed QuiX and Addoptics as new members.

QuiX

Founded in 2019 QuiX offers a plug-and-play integrated and reconfigurable light-based quantum processor that accelerates the way to a quantum future. Quantum computing will revolutionize the way of processing information as we know it. Integrated photonics is a key enabling technology for light-based quantum computers as it allows us to realize reconfigurable quantum processors that process single photons in a stable, accurate and fast way. At QuiX, they offer both integrated photonic processors and bespoke integrated devices for quantum photonics, based on the proprietary TriPleX platform.

https://www.quix.nl

Addoptics

In September 2018, Joris Biskop and Lucas Klamer founded Addoptics; a high-tech company offering flexible manufacturing service for prototyping and series production of custom optics. Addoptics reduces the manufacturing time from 6 weeks to 6 days, by means of an innovative approach that revolves around 3D printing and vacuum casting technology. Not only does this make custom optics manufacturing cost effective but also closer to achieving environmental sustainability within this field. In March 2020 Addoptics formed its base, and started manufacturing in the BlueCity, Rotterdam. BlueCity is an international icon of the circular economy, a national platform for entrepreneurs, and a very visible local accelerator that empowers entrepreneurs and inspires citizens.

https://www.addoptics.nl

Photonics News Highlights

Ron van der Kolk en Petra Wicherink

• Optica Business School

A consortium led by The Dutch Optics Centre has received a subsidy from the Ministry of Agriculture in the context of the SLIM scheme ("incentive scheme for Irish and development in SMEs and specifically for large companies in the agricultural, catering or recreation sector"). Social Affairs for the start-up of the Optica Business School. In a collaboration between the optical groups of Delft University of Technology (TUD), The Hague University of Applied Sciences, the Leiden Instrumentmakers School (LIS) and TNO, the Optics Business School will offer optical training at different levels to people from the Dutch business community. In addition to the aforementioned institutions, four companies are partners in the project, namely Admesy, Hyperion, Internet & Inkjet technologies, and Optisc11.

The grant of 226 kEuro for 2021 is intended to enable the start-up of the Optics Business School. An extension of the subsidy for an additional year is possible. After the start-up phase, the Optics Business School has to support itself.

http://bit.ly/BedrijfsschoolOptica

• Steven van den Berg professor of Photonics at The Hague

University of Applied Sciences The Hague University of Applied Sciences will start a new Photonics research group on 1 January 2021. Steven van den Berg has been appointed as lecturer for this newly set up research group.

The Applied Physics program has had a photonics graduation profile for years and there are already partnerships in the field of practice-oriented research with various institutions and companies that are active in this field, such as TNO, TUDelft, greenhouse horticulture and various high-tech SMEs, such as Technobis.

One of the intended application areas of the Photonics research group is the manufacturing industry. South Holland has the highest concentration of high-tech manufacturing companies in the Netherlands. The nearly 104.000 employees and more than 16.000 companies that work on High Tech Systems & Materials are important for the competitive

strength of South Holland. There is a high demand for skilled technicians and knowledge to capitalize on the economic opportunities of the smart industry. Other areas of application for the professorship are in the field of Health and Energy & Environment.
With the appointment of Steven van den Berg, who has a broad background in the field of photonics, optics and metrology and has a large network, The Hague University of Applied Sciences wants to give an impulse to the development of knowledge in the field of photonics for both the innovation of the own study programs as for the industry, and education, research and industry can be firmly linked.

http://bit.ly/HHSPhotonicsGroup

- **Pilot Innovatietraineeship**

Fontys is looking for SMEs who want to participate in the project 'Pilot Innovatietraineeship'.
Are you an innovative SME? Do you want support from and cooperation with Fontys Hogescholen? And do you want to get in touch with high-potential graduates? Then participation in the Innovation Traineeship pilot might be something for you.
The aim of the innovation traineeship is to increase the innovation capacity of SMEs and to strengthen the research relationship between Fontys and SMEs.
An innovation trainee (graduate of Fontys Hogescholen) conducts practice-oriented research at an SME company for 1.5 years, first six months as a graduate and after graduation as an employee of the company. The trainee is supervised throughout the research at Fontys.
Start of this project is February 2021 and it will end in September 2022.

https://bit.ly/FontysTraineeship

- **Jobs from our members**

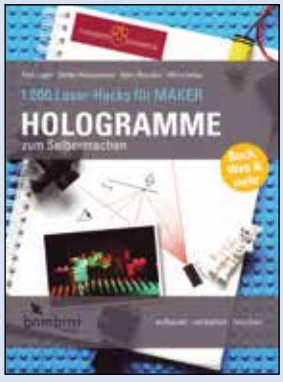
Job openings at PhotonicsNL member companies and organizations.

https://www.photonicsnl.org/our-members/member-jobs/

Making holograms by applying a building system

Jan M. Broeders
An den Eichen 6
D-46325 Borken-Burlo
Germany
www.optischefenomenen.nl

In the section Book Review Jan Broeders discusses a book related to photonics every quarter. Books with a focus on physics, but also books more related to a psychological approach of optical perception, are being discussed in detail. Next to actual content a guidebook is being given for the use of the book in educational settings.



Stamps are provided with holograms to make them extra attractive to collectors.

Holography is a three-dimensional imaging and recording technique, the first image phenomena that were proposed in 1947 by the Hungarian / British engineer Dennis Gabor (1900-1979). He described the method of recording and reconstructing an object in three dimensions. Gabor originally researched the improvement of the resolving power of electron microscopes. When evaluating the image on the photosensitive film material exposed by the light from the mercury vapor lamp, the phenomenon of a three-dimensional image occurred. The concept of ology ram was born.

Only with the arrival of laser light from 1960 production of commercial holograms was started. Initially for manufacturing and industrial applications and later for a range of commercial applications and for a wider audience, holograms were manufactured.

Currently, the application of holographic materials and holograms can no longer be ignored in our current society and in daily life. Holographic processes and systems and holograms have applications in science and research, economics and technology, art and culture and in medicine. Holograms fascinate more and more people every day around the world, but few can explain how they work or how they are recorded on the image carrier.

The special thing about this is that three-dimensional objects and other objects can be reconstructed on two-dimensional film material. In addition to the so-called image holograms, there is a wide range of applications in science and technology. These include, for example, holograms as security functions on banknotes and cards, passports, holographic data storage, wavelength filters in optical data transmission or in the holographic head-up displays. Since there are special requirements (high stability, coherent radiation, darkness,...) associated with the recording of holograms, it is understandable that the holographic experiments can only be performed with very expensive optical and optomechanical components and laser sources.

However, is it possible to realize usable holograms at low cost and with relatively little effort? Yes!, that is now possible. With the help of the contents of the book "Hologramme zum Selbermachen" it is indeed possible to work individually or with a group in a simple informative manner with the indicated materials, constructions and instructions. The richly illustrated book starts with an extensive manual and explanation of the structure of this learning and experimentation book.

The book is part of the series of books for experimenting and learning with current topics from the photonics industry. "Do it yourself" is central to all publications. The main materials for the building structures are designed and manufactured from LEGO parts. The instructions are presented step-by-step in a variety of illustrations and accompanying texts. The book's compilers call each new step a "laser hack", and the book contains 33 of them. In a multitude of special boxes, information is provided on associated physical details and clues follow on details of the "laser hack" discussed.

In the introduction, initiator Felix Lager indicates that it should be possible to implement the whole for an amount of around 250. To complete the picture, a website is available with information about orders, set-up, settings and many tips for the successful conduct of the experiments with the very valuable publication for optics studies.

ISBN 978-3-946496-13-7, "Hologramme zum Selbermachen", Felix Lager, Stefan Klompmaker, Björn Bourdon en Mirco Imlau, Bombini Verlag, 2019, 149 pages, € 14,95.

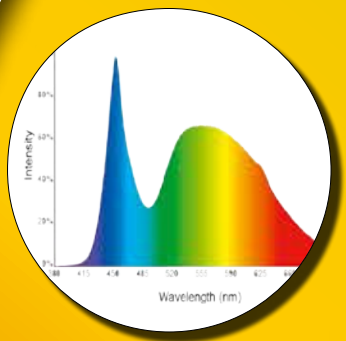
LASER 2000

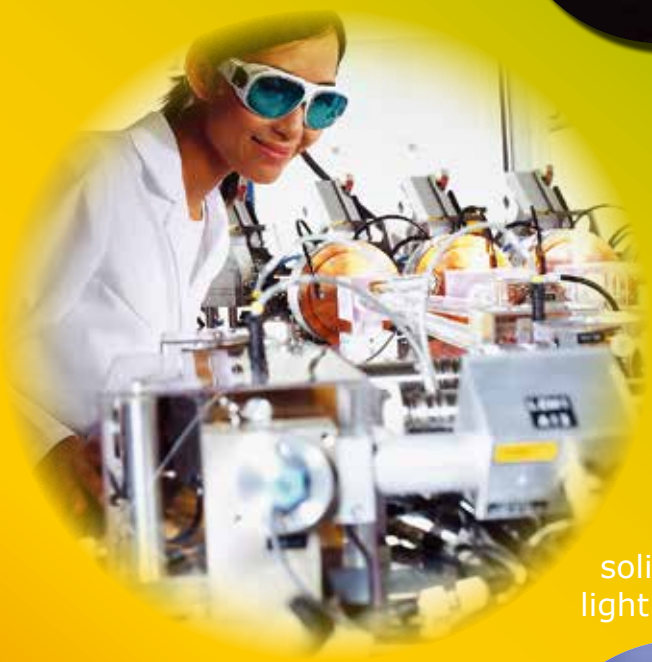
Lasers and Photonics...

tunable fs lasers

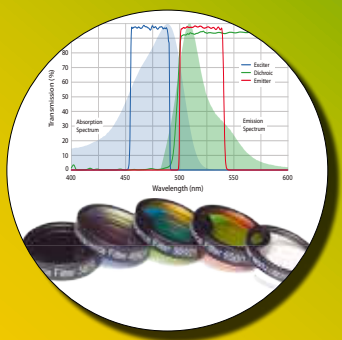
diode and DPSS lasers

light metrology





fluorescence and bandpass filters



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