IDEAS THAT SHAPE SOLUTIONS

Achieving ever higher accuracy in inspection and metrology depends on the interplay between light wavelength and advanced opto-mechatronic systems. This dynamic continues to push the boundaries of what the high-tech industry can deliver, as was demonstrated at the DSPE Knowledge Day that was organised end of October at NTS Optel in Nijmegen (NL). Topic of the day was "Opto-Mechanics – Ideas that Shape Solutions". Industry speakers presented real-life cases, showing how ideas can be transferred into practical solutions, ready to go to market.

The Knowledge Day at NTS Optel (Figure 1) attracted some 40 participants and was opened by managing director Leon Hol and DSPE president Hans Krikhaar (Figure 2). Hol gave a short introduction of his company. NTS Optel is a solution provider that develops and assembles complex optical, laser and opto-mechatronic tooling, systems and modules. It is part of NTS, a first-tier contract manufacturer of (opto-) mechatronics solutions in the semiconductor and analytical market, with 1,800 staff and a manufacturing footprint and market presence in Europe, Asia and the US.

NTS Optel location in Nijmegen.

Defence-grade optical wireless communication

Luis Oliveira, CEO and co-founder of Aircision, kicked off the presentations with his topic on defence-grade optical wireless communication. Aircision is a spin-off company from TNO's free-space-optics activities.

Current military communication systems, working on radio frequencies, are vulnerable to jamming, and transmissions are easily intercepted. The solution is to use laser beams for communication. To that end, Aircision develops and builds high-capacity free-space-optics systems that can be deployed fast, cover long distances and are highly secure. Their focus is on establishing links between ground-based communication terminals over a range of up to 5 km, at first instance for application on the battlefield, for communications between operational units (troops, tanks, etc.) and operating bases.

Other parties in the Dutch free-space-optics ecosystem develop complementary systems to cover communications between ground-based terminals and airborne platforms, such as satellites, airplanes and drones, and inter-platform communication over hundreds to thousands of kilometers.

Opening of the event.
(a) Leon Hol, managing director of NTS Optel, welcomed the participants.
(b) DSPE president Hans Krikhaar gave a brief overview of the activities of his society for and by precision engineers.

EDITORIAL NOTE

This report was based on the various presentations.

Aircision develops the required optical heads for bidirectional communication as well as baseband units for network management. Given the range of up to 5 km, precision optics and alignment tools are required, including fast steering mirrors and smart control algorithms, which embody the key IP of Aircision. After years of development and testing (Figure 3), April this year, a world record link of 5.7 Tbps over 4.6 km was established in Eindhoven (NL), together with the High-Capacity Optical Transmission Laboratory of Eindhoven University of Technology. To achieve this, advanced modulation techniques and photonic integration were employed in the modular system design.

The war in Ukraine shows the impact of compromising communication, so Aircision's technology for secure communication is extremely topical. Besides defence, the company is investing in new areas of research to improve its product and expand to other promising application areas, such as telecom, private networks, quantum key distribution, adaptive optics and photonics.

Test of an Aircision system on top of a high building to ensure line-of-sight communication.

Low-noise digital holography sensor

Next, Shimpei Matsuura from the Mitutoyo Research Center Europe in Best (NL) talked about the development of a low-noise digital holography sensor for precision metrology. In digital holography, using a reference wave, a wavefront from an interference image is recorded to obtain height information. As the phase information is wrapped within [-π ,π], detectable height differences are limited to ~350 nm when using a visible-light (red) laser. Using multiple wavelengths helps to extend the wrapping limitation to lower values.

For precision metrology application, reliable dimensional accuracy (of flatness, z-scale accuracy, etc.) has to be achieved, for which Mitutoyo had to address several challenges. To tackle the vibration sensitivity of a digital holography sensor, a vibration-robust algorithm was developed. Laser-wavelength drift was countered with an on-the-fly wavelength-compensation algorithm. Reduction of coherent noise in the imaging system was achieved with high-speed modulation and a unique optical design, Matsuura claimed.

He presented a prototype sensor (Figure 4) with a Z-range of ~150 µm, a field of view of 14 mm x 10 mm, a pixel resolution of 4 µm, and a dimensional resolution of ~0.2 µm (flatness) and ~0.06 µm (Z), respectively. Vibration resistance was better than VC-B (0.56 µm @ 10 Hz). Next, he discussed various application examples, such as measuring step-height repeatability in VLSI structures, and micro-bump detection and characterisation (topography, height distribution) in ball-grid arrays, for quality assurance in advanced packaging. Other applications include inline defect/particle detection, and validation of highest-grade cleanliness of mechanical surfaces such as vacuum flanges.

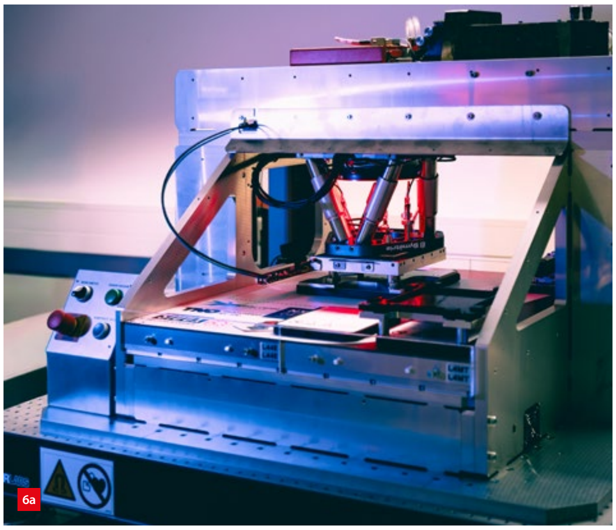
Matsuura concluded with expressing his curiosity about other opportunities for this advanced metrology solution, and inviting his audience to bring forward potentially viable applications.

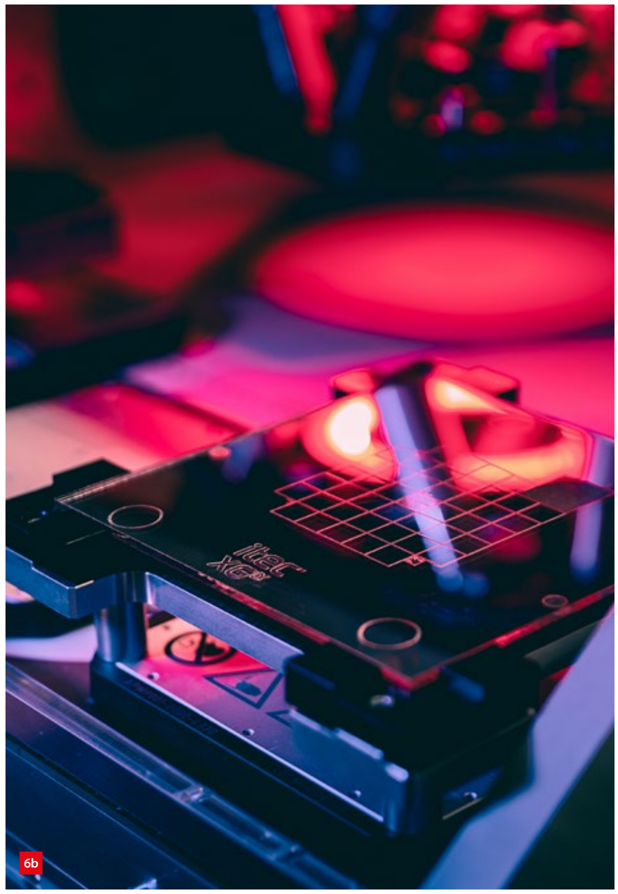
Mass-transfer equipment

Joep Stokkermans, R&D director of ITEC, talked about robust, high-throughput, high-yield, low-cost-of-ownership mass-transfer equipment. ITEC, located in Nijmegen, was established in 1991 as the equipment department of Philips Semiconductors, and has been a separate entity under Nexperia since 2021. It develops and builds high-productivity assembly, test, inspection and smart manufacturing platforms, targeting mass-volume semiconductor manufacturing. ITEC's equipment applications include the mass transfer of microLEDS (Figure 5) and photonic chiplets. For these, the ITEC roadmap features the XG NXTGEN chip assembly lab tool and industrial platform.

Rendering of the Mitutoyo digital holography sensor.

Joep Stokkermans of ITEC discussed mass-transfer equipment, such as for microLED displays.





ITEC's XG alpha system.
(a) Overview.
(b) Close-up of the substrate carrier.

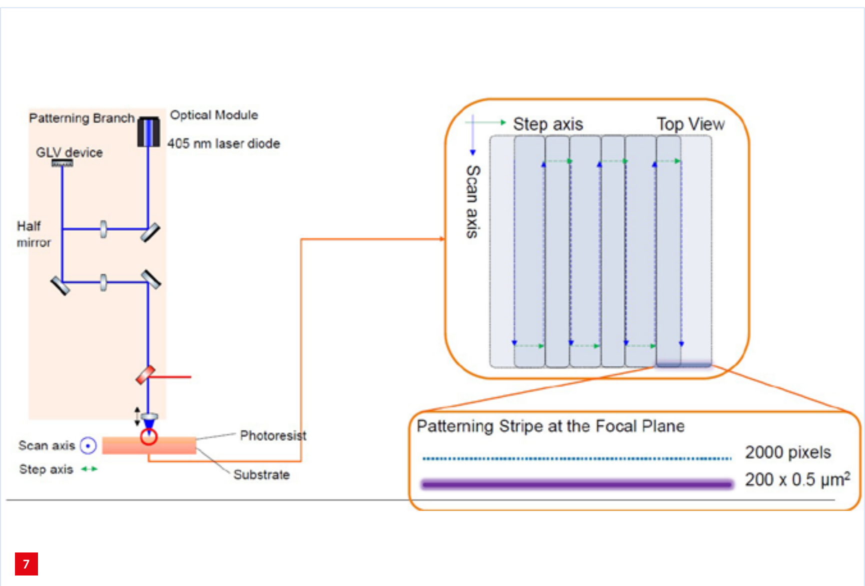
The XG project is part of the NXTGEN Hightech programme, where ITEC is developing laser technology of TNO/Holst Centre for chip assembly. The technology concerned is LIFT, laser-induced forward transfer of components between substrates in proximity, involving interconnect printing and component transfer using laser pulses. As a consequence, Stokkermans noted, the equipment contains more and more optics, for power-efficient and accurate operation.

The new technology is flexible, suiting any standard substrate and component material, is able to correct substrate inaccuracies, features an adaptable aperture to adjust the laser spot to component dimensions for enabling selectivity, and reduces optical artifacts without compromising on productivity. The alpha lab tool (Figure 6) can accommodate panel sizes up to 200 mm, and process dots and chips down to 40 μm size, with 100% inline inspection and a die-attach accuracy of ±5 μm (3σ). The industrial platform can even achieve ±1 μm (3σ) for dies down to 10 μm in size that are directly processed from a 4" to 12" wafer onto a web or panel of 50 mm to 600 mm width. The launch of the new platform is expected in 2027/2028.

Multi-beam laser lithography

Ilian Plompen, optical engineer at Raith Laser Systems in Eindhoven, talked about multi-beam laser lithography. His company provides maskless laser beam lithography systems that offer the highest resolution in the market. It is part of Raith, specialist in maskless nanofabrication and characterisation systems and solutions.

First, Plompen discussed possible writing strategies, comparing single-beam (Picomaster) with multi-beam (Picomaster XF) writing strategies; see Figure 7. The two Raith systems offer writing speeds at best resolution (300 and 600 nm, respectively) of 2.7 mm²/min vs. 560 mm²/min, with the XF producing 2.048 spots simultaneously.



Raith Laser Systems' multi-beam exposure strategy.

A crucial component of the XF is the grating light valve (GLV), an electronic MEMS device that enables raster scanning a pattern onto a wafer. The GLV is an actuated mirror array with 2.048 'pixels', each composed of two ribbons; a static/bias ribbon and an active ribbon. When no voltage is applied to the active ribbon, only specular (regular) reflection occurs (bright state). With a voltage applied, an offset is created, which causes diffractive effects that are used to control illumination per individual spot on a patterning stripe. In this way, a 405-nm laser diode can create exposure lines of 200 μm length and 0.5 μm width.

Development of a focusing system

The last presentation was given by Hugo Kok, D&E manager and optical system architect at NTS Optel, on the development of a focusing system for semicon applications. For dynamically focusing a laser beam onto a target, he discussed real-time considerations such as bandwidth, latency and accuracy. For example, when a substrate with a 1 μm/mm (local) wedge is scanned with 1 m/s, a control-loop latency of 1 ms will introduce a 1 μm error.

Several measurement options were considered, including grazing incidence triangulation, coherent tomography in either the time or the spectral domain, and chromatic confocal measurement. The latter option was chosen, because NTS wanted to measure through the lens and be able to distinguish between the top and bottom surface.

For hyperchromatic optics, a white-light source is required. A warm white LED was tested, but its intensity was too low, so a search for an alternative was initiated. A super-continuum source yielded high intensity but came with some disadvantages: high cost, spectral roll-off in the blue, intensity not adjustable (only the pulse frequency). A laser-driven xenon lamp was found to display a flat spectrum and an intermediate intensity. Ultimately, a laser-excited remote phosphor source was selected for its compactness and low cost. Its intensity was four times that of an LED lamp, while it exhibited a typical, non-flat LED spectrum. As a consequence of the narrower spectrum, a new spectrometer was needed.

Kok also dwelt upon the design of the focus actuator. When the bearings that had been selected kept failing, a flexure design was made, with due control of any parasitic movements. The original design was asymmetric, so as an alternative a balanced design with three voice-coil actuators was made. The project was successfully finished last year. "Two prototypes were built and validated. The complete machine of which the focusing system is a part, was brought up and running and successfully tested."

Tour and drinks

The day was concluded with a tour of the NTS Optel premises, featuring the cleanroom, the optical labs and the assembly facilities. Among the products featured were a qualification bench for laser-beam-quality metrology systems, alignment modules for aligning metrology frames, eye-surgery equipment for illuminating the back of the eye, an optical tester, a laser-scribe module, and a navigation camera for an electron microscope. With drinks and networking, a successful DSPE Knowledge Day was concluded; the hospitality of NTS Optel was greatly appreciated.

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8


Impressions of the tour.