Mikroniek

PROFESSIONAL JOURNAL ON PRECISION ENGINEERING 2012 (VOL. 52) – ISSUE 3

Electron lithography • Precision-in-Business: VDL ETG Research
Measuring by vision • DGaO/PCN Joint Meeting: applied optics & photonics
Diamond, a measurement engineer's best friend • Measuring mirrors to the max
Dutch Robotics Strategic Agenda • First Martin van den Brink Award

MIKRONIEK IS A PUBLICATION OF THE
DUTCH SOCIETY FOR PRECISION ENGINEERING
WWW.DSPE.NL


Life science is all about bringing knowledge together
ALT was built on that
The most significant scientific breakthroughs of our time have been in fields where the disciplines of physics, chemistry and biology overlap. As a supplier of state-of-the-art laser and positioning technology, ALT recognises the power of inter-disciplinary thinking. We bring top-class products for research in the field of life science together; offering a wide range of high-quality products under one roof. This guarantees our customers receive the best of all possible worlds: excellent advice and superior tools. Efficient as well as comfortable. Making the world a little better, each and every day.
ALT
PUTS YOU IN POSITION
www.alt.nl

3

Mikroniek - 2012

In this issue

Publication information

Objective
Professional journal on precision engineering and the official organ of DSPE, the Dutch Society for Precision Engineering. Mikroniek provides current information about scientific, technical and business developments in the fields of precision engineering, mechatronics and optics.
The journal is read by researchers and professionals in charge of the development and realisation of advanced precision machinery.

Publisher
DSPE
PO Box 359, 5600 AJ Eindhoven (NL)
+31 (0)40 – 296 99 15 / 26 (tel/fax)
info@dspe.nl, www.dspe.nl

Editor
Hans van Eerden, hans.vaneerden@dspe.nl

Advertising canvasser
Sales & Services
PO Box 2317, 1620 EH Hoorn (NL)
+31 (0)229 – 211 211, gerrit@salesandservices.nl

Design and realisation
Twin Media bv
PO Box 317, 4100 AH Culemborg (NL)
+31 (0)345 – 470 500, info@twinmediabv.nl

Subscription costs

The Netherlands	€ 70.00 (excl. VAT) per year
Europe	€ 80.00 (excl. VAT) per year
Outside Europe	€ 70.00 + postage (excl. VAT) per year

Mikroniek appears six times a year.

ISSN 0026-3699

The cover photo (diamond-coated & polished probes) is courtesy of Diamond Product Solutions.

editorial

High Tech & Holland

Holland is very successful in the High Tech sector, but why? Definitely, the High Tech industry owes a lot to Philips and its history. Its focus on technical excellence in research and development labs combined with a focus on lifelong learning and extensive knowledge sharing provided the foundation for major OEMs and supply chain companies. But there's more.
A well-known mechatronics professor once stated that the Dutch mentality, egalitarianism and aversion to hierarchy (which holds for him too) played a major role in the country's success in the complex High Tech industry; an industry that requires cooperation between the various technical disciplines (optics, electronics, mechanics, software, etc.), between the various departments within a company (from research to operations), and last but not least, between different companies in the supply chain. Companies or communities with a more hierarchical tradition, where seniority, level of education or company ranking determine who is right or who is wrong, will have more difficulties benefitting from shared expertise and finding a combined optimum result. Being curious about the solution (space) and the problems other disciplines, departments or companies face, being able to respectfully question choices within other domains, accepting interventions and questions from colleagues from other domains and seeking a combined optimum system result together is essential in this industry; an industry that requires world-class expertise in each domain, but also the capability to cooperate.

These aspects also provide the foundation for the first DSPE conference on precision mechatronics on 4-5 September 2012, where technologists, designers and architects from different domains will meet to share ideas and learn from each other. In addition to high-level content, the conference will provide an opportunity for networking and sharing the enthusiasm for working in this challenging field.
This editorial's title hints at the recently founded Holland High Tech initiative, which aims to develop a unified international branding of our High Tech sector as the place to be when it comes to pragmatic total solutions for technological challenges (from system architecture to production). At the kick-off, one full slide was dedicated to the so-called Dutch Way of Working, based on the non-hierarchical way of working together, cross-over between technologies, inter/multidisciplinary cooperation within the high-tech sector and products that expand the borders of manufacturability again and again. Whether it's a new export product, a unique selling feature or just the way we do it, I'm sure that we'll see many exciting results from Holland High Tech based on the Dutch Way of Working during the first DSPE conference on precision mechatronics (see the programme on page 42).

Adrian Rankers, DSPE board member

Simultaneous control of 13,000 electron beams

Evolution in the chip industry closely corresponds with the development of new production equipment. Optical lithography suffers with both physical and financial constraints. Electron lithography could provide a solution. However, how do you switch every electron beam on and off 2.5 billion times per second?

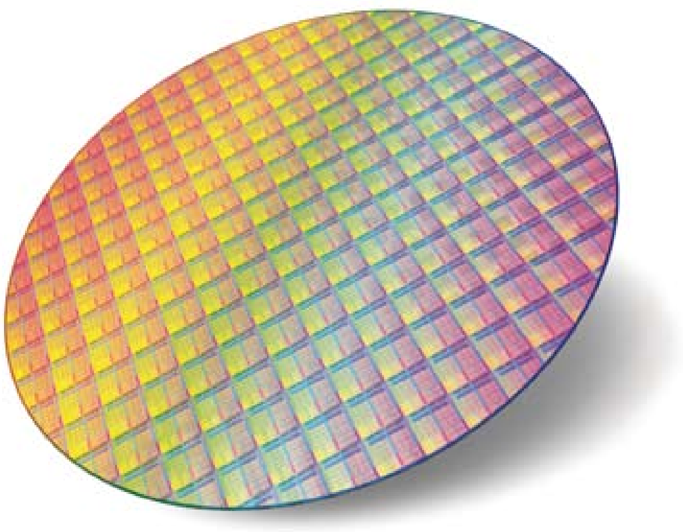
Lithography is the most important step in the production of chips, or integrated circuits (ICs). This process transcribes the chip pattern onto a silicon wafer. The wafer is coated with a light-sensitive lacquer that is exposed by a wafer stepper (a type of super projector). The wafer stepper projects a slide (known as a mask), then the wafer is moved up a fraction and another mask is projected onto the wafer, and so on until the entire wafer is full. Subsequently, the lacquer is developed and the wafer is etched.

In the computer-chip-manufacturing industry, there is a constant race to make everything smaller: finer details on a chip mean more functionality and greater speed. Wafer-scanner manufacturers come up with all kinds of ideas to project these finer details using light. In order to write finer details, light of a shorter wavelength is necessary. The next generation of wafer scanners will use extreme ultraviolet (EUV) light. The wavelength of EUV light is close to that of X-rays, at just 13.5 nm. This requires a complicated and entirely new machine design, using different materials and even more expensive masks or mirrors.

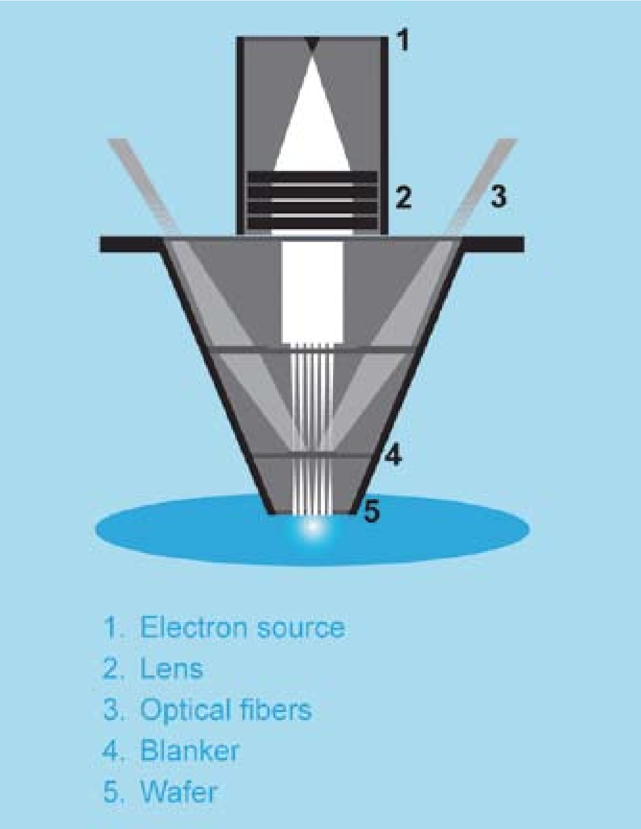
Editor's note

This article has previously appeared (in Dutch) in the Objective magazine published by Technolution.

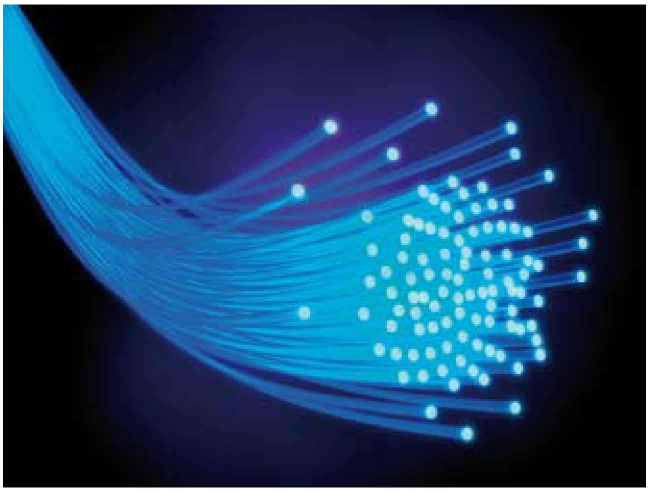
www.technolution.eu/objective



A silicon wafer full of chip patterns produced by lithography. (Photo: iStockphoto)



Schematic of the electron lithography set-up. A brief explanation is presented in the text.



The electron beams are switched on or off by pulses of light, provided by the pattern streamer via optical fibres. (Photo: iStockphoto)

Lithography using electron beams

Another way to achieve finer details is to use a different 'light source'. MAPPER Lithography uses electron beams to carry out the 'exposure'. Electron beams can write smaller structures than light beams. This technique works without masks, which results in considerable savings. Using a raster scan, the pattern is written onto the wafer by a large number of electron beams.

Experiments with this technique have been performed since as far back as the 1960s. The main obstacle was the speed. At the time, the electron beam functioned as a plotter that wrote patterns at an exasperatingly slow speed. In order to increase the speed, MAPPER Lithography, based in Delft, the Netherlands, developed a device that uses 13,000 beams, each of which writes part of the pattern.

Blanker and beam

MAPPER creates this large number of beams by aiming one large electron beam at a silicon slice that contains 13,000 holes. Under this slice is the blanker, which is a similar slice containing holes that enables the beams to be switched on and off. The holes in these slices are etched incredibly accurately – to the nanometre – creating 13,000 beams of equal size and therefore equal intensity. Electric lenses bend the beams in one dimension. Every beam can write lines of pixels that are 2 µm in length and 3.5 nm in width. The wafer moves under this beam, creating a 2µm-wide strip. All 13,000 beams together achieve a maximum chip size of 13,000 x 2 µm = 26 mm. This is a standard size in the chip industry. An animated film depicts this process [1].

Exposure and watercolours

Writing a pattern with electrons can be compared to painting with watercolours. Every electron that hits the lacquer leaves a mark. The beam has a diameter of 25 nm and can be positioned to an accuracy of 3.5 nm. It is like making a finely detailed sketch with a thick paintbrush. This is possible because you push down the brush slightly for just an instant, then move it slightly and push it down slightly again. Only the sum of a number of exposures provides a dose sufficient to make the lacquer dissolve during development. In this way, it is possible to position the image in the wafer's photolacquer to a degree of accuracy better than 3.5 nm.

Pattern streamer

The electron beams remain permanently switched on, although they can be interrupted by optically-driven switches on the blanker. Every beam can be individually switched on or off. By switching the beam on or off at the right moment, a pattern is created. The switches are operated with pulses of light. These are provided by the pattern streamer – a computer that controls all of the electron beams in real time – via 7,800 optical fibres. The mask that is projected onto the wafer is saved in the pattern streamer as a bitmap with a size of 1.2 Gbyte per 2µm strip. This original bitmap is corrected for each chip, for example, to correct for the shifting or rotating of the wafer on the stage. However, the machine itself also has errors, e.g. beams can be slightly crooked. In such cases, the

An enormous amount of electronics is needed to control 13,000 beams. Twelve FPGAs, each controlling five electron beams, fit onto one board. This board was developed by MAPPER's technology partner, Technolution, based in Gouda, the Netherlands.

system measures where the crooked beams touched the wafer and which shift and scaling results in the data being exposed in the correct place. It moves the original bitmap to create a new bitmap, with a higher resolution. This process is called resampling – an intensive calculation produces a great deal of data (around 2.5 Gbit per second per strip). The very short time between measurement of the errors and the exposure of the corrected bitmap makes it necessary to carry out these calculations in real time.

Redundancy

All material and process attributes will soon be known. These have already been processed during creation of the mask, even before the data is transmitted to the pattern streamer. The streamer processes only real-time corrections for machine-dependent aspects such as temperature and beam errors. When using 13,000 beams, the natural assumption is that one or two will be defective. This is why the number of beams is 2% higher. The machine can work out for itself which ones are defective. The fact that there will be defective beams is combined with another important design choice: around half of the 13,000 beams are controlled using two steps. For the second step, the wafer is shifted slightly from the position in the first step in order to avoid defective beams from the first step during 'exposure'. An additional advantage is that this almost halves the size of the pattern streamer, resulting in significant savings.

Calculation power

Resampling is carried out using programmable logic, FPGAs, but they cannot handle a speed of 2.4 Gbit per second. This is why the data path has been divided into twenty parts per electron beam, each of which operates at 125 MHz. One FPGA can control five electron beams. You therefore need an enormous amount of electronics to control 13,000 beams, even when using two steps; see the box. The pattern streamer comprises the size of two filing cabinets – it is for this reason that the machine was developed in phases.

Demo machines

There are already two demo machines in operation. With 110 channels, these machines are capable of writing small

Big numbers for pattern streamer electronics

One FPGA can control five electron beams. Twelve FPGAs fit onto one board. Twelve of these boards fit on one rack. Four other boards are then added together with hard disks and a computer in order to control the whole thing. The masks of the chip in production are saved on the hard disks and depending on the step, a specific mask is transferred to the RAM memory.
One rack is sufficient for 720 channels. In order to control half of the 13,000 beams per step, a total of eleven racks are needed. Eleven racks actually gives the pattern streamer over 6,500 channels (the minimum number of channels required).
The mapping between the channels and the beams is flexible. By correctly assigning the beams to the channels, it possible to create a complete exposure even if some of the channels of the pattern streamer or the fibres of the connection are defective.

Matrix 10.10, consisting of ten Matrix 10.1 machines side-by-side, will expose a combined total of 100 wafers per hour.

test patterns and are large enough to show that a series of separate beams are capable of writing one coherent pattern (beam stitching). One of these machines is at a research lab in Grenoble, and the other is in a production clean room at TSMC in Taiwan. The second machine in particular is generating a great deal of interest – TSMC is using it to develop opportunities to apply electron lithography to its processes.

Scale

Speed is an essential aspect in the production of ICs. One of the most important attributes is the transfer speed of machines (the number of wafers that can be processed per hour). At the moment, MAPPER is working on a machine that can expose ten wafers per hour, named Matrix 10.1. In order to limit initial costs, a 1-wafer-per-hour machine – Matrix 1.1 – is currently being built. This machine's data path (the pattern streamer and the blanker) has been limited to 1,300 beams. By exposing every wafer 20 times using this machine, a 1-wafer-per-hour machine is created.

Eventually, Matrix 10.10 will consist of ten Matrix 10.1 machines side-by-side, which will expose a combined total of 100 wafers per hour. Even with all of the peripheral equipment, Matrix 10.10 is still smaller than an EUV machine.

System design

The pattern streamer's eleven racks for the Matrix 10.1 are roughly the same size as the rest of the e-beam machine. With ten machines, you need ten pattern streamers. They will be located in the service area above or below the clean room, where a less strict chemical classification applies. A thick bundle of 7,800 optical fibres will run through the floor to the machine.

The other electronic equipment required to operate the machine must be kept as close as possible: if the distance between them is too great, the signals from these measuring and control devices are delayed. Distance does not affect the pattern streamer, as all of the signals from the pattern streamer are subject to the same delay, which the machine's main control unit corrects. This tells the wafer stage and the pattern streamer what to do. A precise clock provides the basis for the actions: you begin at this time, and you begin ten milliseconds later.

Multi-stage development

Multi-stage development spreads the risk. Furthermore, an entire machine with all of these parts would be too expensive. Costly FPGAs and memories are currently essential to achieving these speeds. However, the developers know that over time, prices fall and performance increases: a universal law of nature in the chip industry. By the time that MAPPER starts building Matrix 10.10, other FPGAs will have been developed that can do more and cost less. And for the fully developed machine, you could even use ASICs (application-specific integrated circuits). By using a step-by-step approach, this innovative technology will help develop a machine that transcends the limitations of optical lithography.

Reference

[1] www.mapperlithography.com (select Technology)

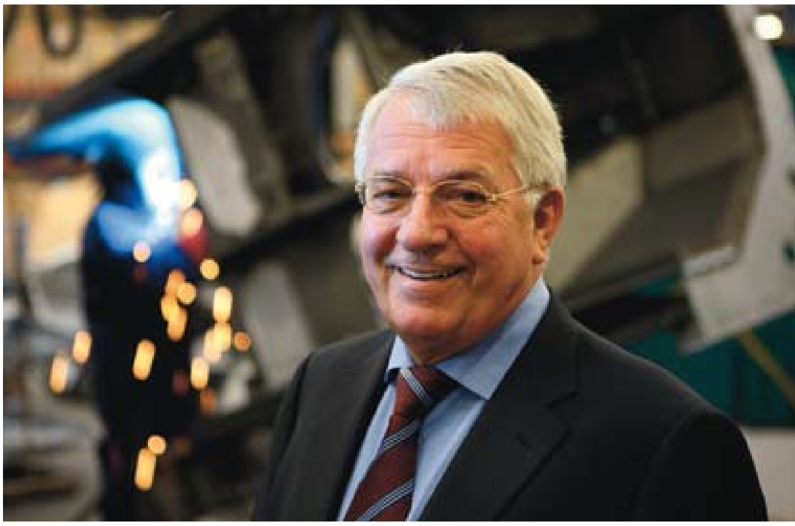
More information

www.mapperlithography.com

Wim's research department

It was a remarkable industrial transaction in 2006, to say the least: the transfer of the Enabling Technologies Group (ETG) from Philips, the renowned high-tech electronics multinational, to the VDL Groep, the "manufacturing powerhouse" of the Netherlands. Since then, VDL President Director Wim van der Leegte has taken a keen interest in the research activities at VDL ETG. "He regularly pays us a visit to take a look in our labs," says Jadranko Dovic, managing director of VDL ETG Research. DSPE members were invited for a visit in May this year.

The DSPE PiB day on 10 May attracted a decent crowd to the High Tech Campus Eindhoven, the Netherlands, where VDL ETG Research is housed with some 90 FTEs. In his introductory talk, Jadranko Dovic described the company as "a mechatronics workshop predominantly active in the early stages of product development, playing a front role in the value proposition of the ETG organisation". Besides a broad array of technological competences, VDL ETG and VDL ETG Research core competences include co-development and project management. These were addressed at the PiB day by Ton Peijnenburg, Development Manager at VDL ETG. See the box on page 10 for a profile on VDL ETG.



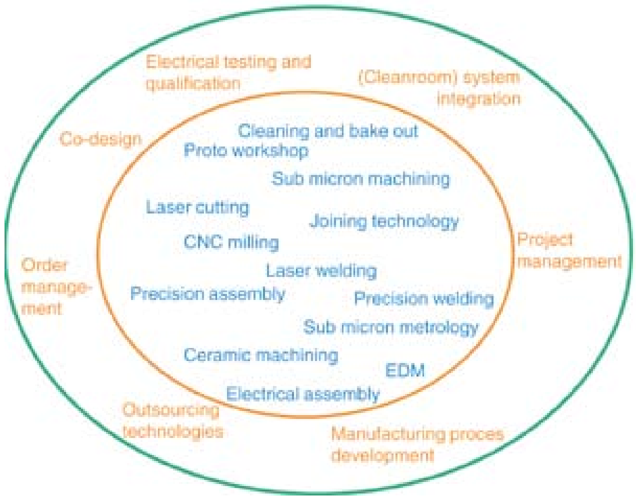
Wim van der Leegte, President Director of the VDL Groep and figurehead of the Dutch manufacturing industry.

Concurrent prototyping

At the High Tech Campus Eindhoven, VDL ETG Research is close to high-tech R&D projects and shared resources, as well as to start-up and spin-off companies that might benefit from its services. VDL ETG Research's mission is to support R&D activities of new as well as established (international) customers with a fast and flexible supply – with a focus on quality, cost control and on-time delivery – of prototypes and pilot series, from mechanical (precision) parts to mechatronic system integrations. The underlying vision, Dovic explained, is that reducing the time to market of a new generation of products is key to the success of high-tech OEMs. To that end, VDL ETG Research employs concurrent prototyping (see the diagram). This approach – especially when combined with the co-development role – requires high-level project management competences, which are all available at VDL ETG Research.

Hardware solutions

Finally, Dovic summarised the types of hardware solutions VDL ETG Research delivers to its customers:



VDL ETG Research's core competences in concurrent prototyping.

- First-line hardware support for R&D at the High Tech Campus.
- Precision parts manufacturing (see below).
- Core technology products (such as the magnetic actuators assembled in the Actuator Competence Centre).
- Mechatronic system integration (involving wafer stages and other complex modules).

Ultra-precision

Mathieu Breukers, Department Manager UPT & Metrology, gave a presentation on ultra-precision parts for science (UPT stand for Ultra High Precision Technology). VDL ETG is committed to science & technology, Breukers explained, because of the synergy that can be expected with future activities in its "mainstream" markets, and because of the technology drive that is provided by the highly demanding science & technology market. And yes, "VDL ETG is aware that investments will only pay off in the long run." VDL ETG Research and VDL ETG Projects collaborate to serve the science & technology market.

Breukers went on to discuss the core technology competences in the ultra-precision area. These include (ultra) high precision machining, vacuum technology, welding and vacuum brazing, metrology, and clean room assembly. In general, the specifications that can be achieved are better than 5 nm surface roughness and 1 µm accuracy. Typical examples are 0.2 µm straightness over 300-mm guideways, and 10 µm flatness over 900 mm of 4-mm thick plate.

Best practices

VDL ETG Research covers various areas of science & technology, such as fundamental research, space, medical and energy. Breukers presented some appealing best practices, such as prototype structures manufactured for the CLIC (Compact Linear Collider), which is being developed by CERN as the successor to the Large Hadron Collider, currently the world's most powerful particle accelerator. For CLIC, VDL ETG Research manufactured discs that constitute the core of the accelerator structures, and is planning to take care of assembly. Based on this prototyping effort, VDL ETG is committed to investing in new skills (including pallet machining and on-machine metrology), people and infrastructure to accommodate series production of large numbers of core parts and assemblies.

VDL ETG: from research to series manufacturing

VDL Enabling Technologies Group (ETG) is a tier-one contract manufacturing partner. International customers are leading high-tech Original Equipment Manufacturing companies and users of advanced production lines. VDL ETG delivers mechatronic solutions in a variety of markets: semiconductor capital equipment, thin-film deposition equipment for photovoltaic solar systems, analytical instruments, medical systems, aerospace & defence parts and systems, and mechanisation projects. Services include prototyping (VDL ETG Research), customer-specific factory automation projects (VDL ETG Projects) and series manufacturing of "high-mix low-volume" products at all other VDL ETG locations: Eindhoven and Almelo (the Netherlands), and Singapore and Suzhou (China).

Under the Philips flag, ETG became a worldwide supplier of advanced mechanical components, modules and complete systems. In 2006, ETG was taken over by the VDL Groep, a Dutch conglomerate that currently comprises some eighty companies focused on the development, production and sale of semi-finished products, buses & coaches and other finished products. VDL's subcontracting division, which includes VDL ETG, specialises in metalworking, mechatronic systems, plastics processing and surface treatment.

VDL ETG Research is concerned with parts manufacturing and system integration of mechatronic modules for high-tech OEMs. Its goal is to support R&D teams during the initial phases of a product's lifecycle by means of co-development and by supplying prototypes, functional models and test rigs. The company boasts world-class specialised workshops and a ditto metrology department. VDL ETG Research is part of the open innovation eco-structure on the High Tech Campus Eindhoven, which comprises a variety of high-tech facilities. Its service offering is completed with the transfer of a product to a VDL ETG location for series manufacturing, including the required manufacturing processes.

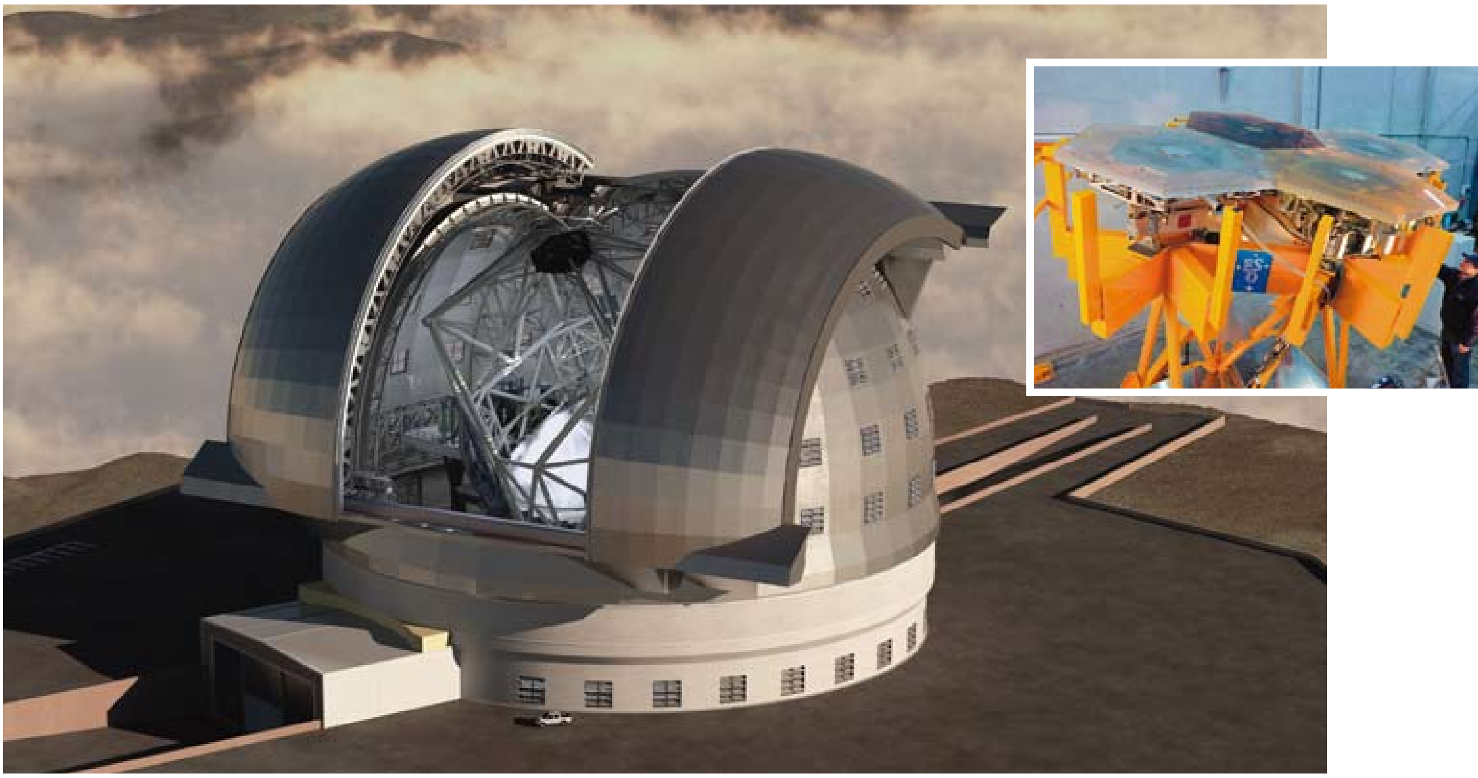
www.vdletg.com

For CLIC, VDL ETG Research manufactured discs and couplers.

Another best practice is the mirror base module for the Extremely Large Telescope (ELT) at the European Southern Observatory. This largest telescope in the world will consist of nearly 1,000 hexagonal mirror segments, each positioned with nanometre accuracy, that will work together to form a 39-m parabolic whole. Each mirror segment is supported by a frame. Prototypes of this frame were developed by TNO and manufactured by VDL ETG Projects.

Highlights

The PiB day programme was concluded with a tour of various highlights of the VDL ETG Research organisation, such as the Actuator Competence Centre, the metrology department and the ultra-precision tool shop. Afterwards, during an informal get-together, the conclusion was that Wim van der Leegte had bought himself a world-class research and prototyping department back in 2006, and that another highly interesting Precision-in-Business day had come to an end.



VDL ETG Projects manufactured prototypes of the mirror support frame for the ELT.

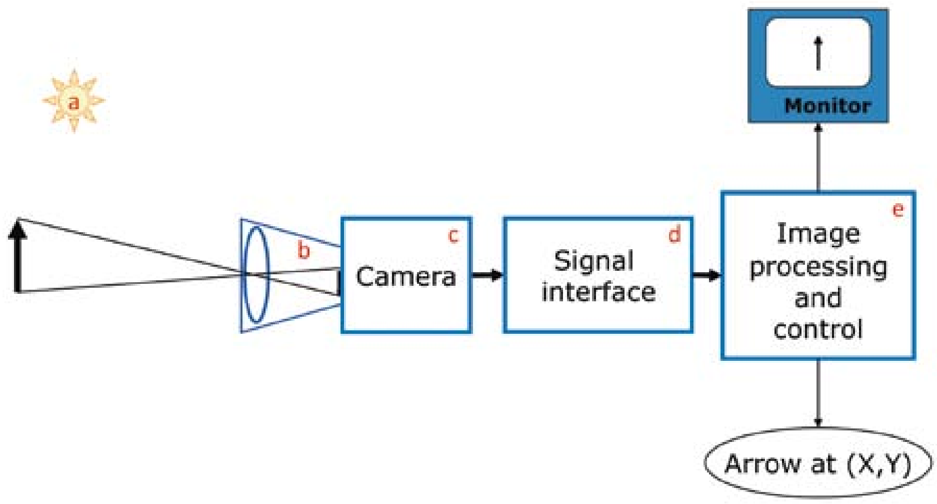
Measuring by

Digital vision may be a highly valuable tool for automatic position measuring in mechatronic systems, and cameras, lenses and sensors may be indispensable components in a digital vision chain. One might also say that the best objective resolution is essential to acquire the highest measuring precision. This article, however, explains that too high a lens resolution is one of the pitfalls on the design road to a vision measuring system.

• *Wim Hoeks and Frans Zuurveen* •

The combination of digital imaging and automated image interpretation offers a flexible solution to many measurement challenges. However, in-depth knowledge of the interaction between the key components is required for top performance of such systems.

Figure 1 shows the components in a digital vision system. The camera includes a semiconductor image sensor, CCD or CMOS. The computer is equipped with software for image processing, interpretation and display. This set-up is designed to provide the client with information extracted from the image. The client is shown as an ellipse in the bottom part of the figure; the display is optional. The display is only used during system set-up and configuration in embedded applications.



(a) Illumination.
(b) Lens.
(c) Camera with image sensor.
(d) Interface with analogue and digital electronics.
(e) Computer.

Figure 1. The components in a digital vision system. In the ellipse: client receiving the X, Y position result.

input	115	116	117	118	119	120	121	122	123	124
106	45	41	41	40	40	43	42	42	49	63
107	45	41	42	41	42	42	42	43	50	65
108	43	39	40	38	40	40	39	43	50	63
109	43	43	42	41	39	39	40	43	50	60
110	42	41	43	42	42	42	42	45	48	59
111	44	45	45	47	47	45	47	49	48	61
112	51	52	53	59	58	56	56	61	62	70
113	63	63	64	63	69	69	73	79	79	83
114	73	73	69	76	79	80	83	89	91	94
115	81	77	78	81	87	84	88	90	96	95
116	83	77	79	84	90	87	88	93	97	97
117	81	81	82	83	87	89	88	91	96	98
118	83	83	80	84	88	89	89	93	96	98
119	83	86	84	84	87	90	90	93	98	100
120	90	87	86	87	89	89	89	96	99	97

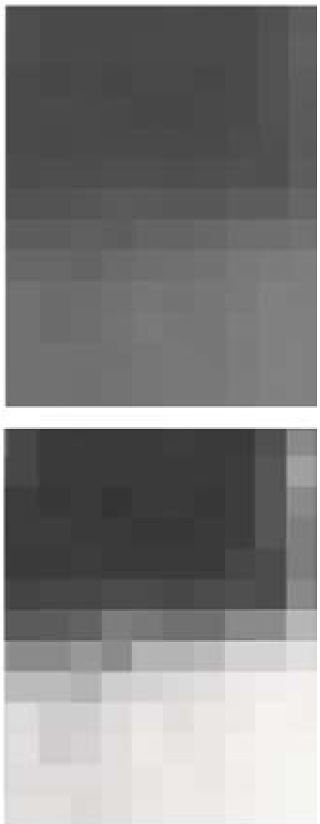


Figure 2. Schematic representation of the image data array in the computer memory. A display of this data is shown on the top right-hand side. The greyness of each square represents the intensity of light on that pixel. Bottom right: enhanced greyness for better visibility.

The image sensor consists of a high quantity of light-sensitive pixels, arranged in rows and columns. When the magnification of the lens is accurately defined, the sensor can be considered as a two-dimensional scale for measurements in the object (left arrow in Figure 1). Every pixel measures the intensity of the light reaching the pixel. This intensity is digitally quantified and stored in the computer memory (see Figure 2). The computer processes this data to extract the information on the object.

Measuring distance, e.g. to find two opposite edges and compute the distance between them, is a typical task for computers. For maximum accuracy, the intensity profile is

Authors' note

Wim Hoeks is a vision system specialist at the NTS-Group in Eindhoven, the Netherlands. The NTS-Group develops, manufactures and optimises high-grade opto-mechatronic systems, modules and components for international machine builders to accelerate their production processes. The group comprises various operating companies based in the Netherlands, the Czech Republic, Israel and China. NTS Systems Development, NTS Mechatronics, NTS Motion Systems and NTS Precision are based in Eindhoven.
Wim Hoeks has designed and implemented various vision systems for inspection, two-dimensional measurement, three-dimensional measurement and colour measurement. His past experience includes writing and running courses on image interpretation and signal processing. Frans Zuurveen is a freelance text writer who lives in Vlissingen, the Netherlands.

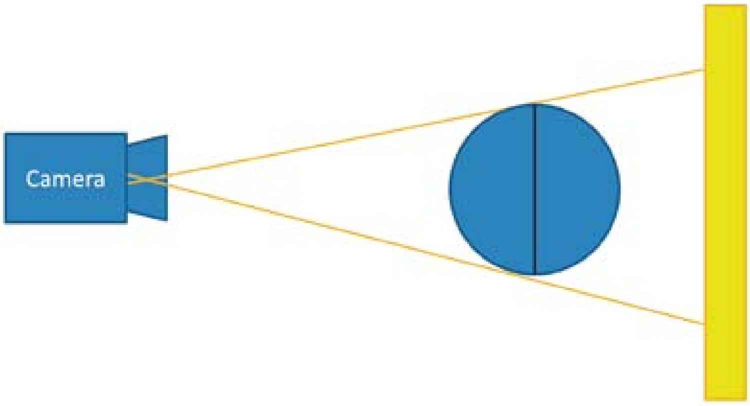


Figure 3. The image of a cylinder is formed by the tangent rays. The yellow bar on the right-hand side represents backside illumination.

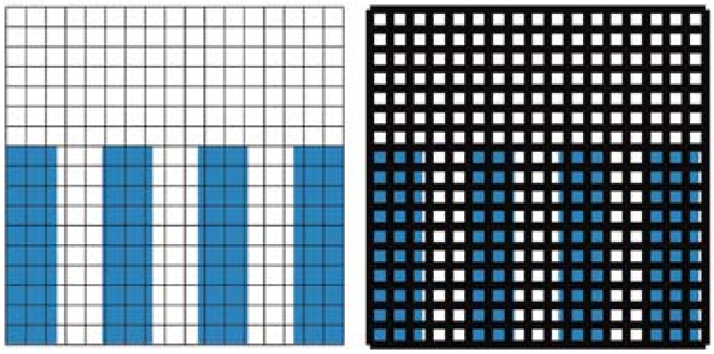


Figure 4. When imaging periodical structures on a theoretical sensor (left), the structures are not distorted. Moiré patterns are, however, visible with a practical sensor with a fill factor of < 100% (right) because of too much image detail.

interpolated between successive pixels. Most commercially available computer software packages for image interpretation support these so-called ‘subpixel calculations’, resulting in 3σ image position inaccuracies of about 0.1 pixel.

However, to reap the benefits of this subpixel technique, the way in which the image was formed has to be taken into account. When imaging a cylinder, for example, the image on the sensor looks like a bar. The pivotal question is whether the width of the bar can be regarded as an exact representation of the cylinder diameter. For a normal lens, all image-forming light rays have to pass through the centre of the lens. Therefore, the rays running at a tangent to the cylinder result in an image that is somewhat smaller than the maximum cross-section of the cylinder (see Figure 3). Besides this, other imaging artefacts have to be taken into account.

Highest resolution?

The pixel dimensions in sensors correspond to the general trend of integrated semiconductor circuits becoming smaller and smaller in size, while at the same time increasing the number of functions they can perform. About ten years ago, the pixel pitch of a typical image sensor amounted to 10 μm. A current typical example is a 5-megapixel sensor with 2448 x 2048 pixels with a pixel pitch of 3.45 μm. It is logical to think that the lens resolution has to be related to the pixel dimensions or at least that it should greatly surpass their magnitude. Some lens manufacturers label some of their lens series as megapixel lenses. As all the other specifications are the same, this label is confusing, because it is actually the pixel dimension rather than the amount of pixels that is the main factor to consider. This statement is illustrated in Figure 4.

The sensor is structured periodically, of course. The popular representation is shown on the left in Figure 4, where the pixels fill the sensor area with an infinite thin line separating the pixels. In practice, the pixel pitch is somewhat larger than the pixel dimension, as illustrated on the right in Figure 4. The thick black lines separating the pixels represent the non-sensitive area for pixel control and readout. The relative portion of the sensor that is light sensitive is called the fill factor. The theoretical sensor on the left in Figure 4 has a fill factor of 100%, the practical sensor on the right has a fill factor of 25%. Image sensor manufacturers are trying to increase the fill factor as much as possible, with peak values of 80%.

Fill factor consequences

The following analysis applies to all image sensors, unless they have a fill factor of exactly 100%. Let us assume that a lens with an infinitely good resolution is used to project a periodic blue structure onto the image sensors (see bottom half of Figure 4). On the theoretical sensor with a 100% fill factor, the blue bars seem to be equally wide. On the practical sensor, the first bar fills two pixels completely and about 75% of one pixel. For the next blue bar, only two pixels are filled, even though the projected bar is as wide as the first one. The third bar corresponds with a coverage of 2.5 pixels, and the bar on the far right seems to be as wide as the first one.

These effects are called Moiré interference. They always occur when working with lenses that have a higher resolution than the sensor, with image-distorting fringes as the unwanted result. This Moiré interference effect can be avoided by using a somewhat lower lens resolution.
Why bother with a few applications with repetitive structures? Take another look at the blue bars at the bottom right in Figure 4. Imagine that the four blue lines are four independent measurements. For these four measurements, three different width values were derived: 2.75 pixels, 2 pixels and 2.5 pixels. The accuracy of this simple visual evaluation is problematic.

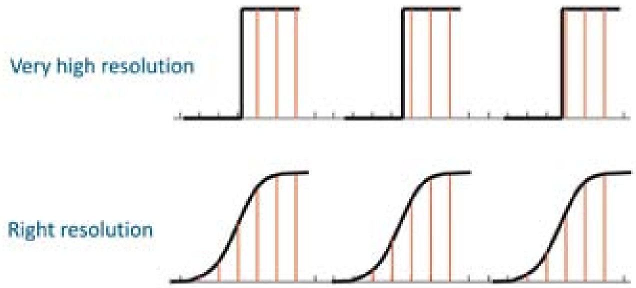


Figure 5. One-dimensional illustration showing effects of small object displacement. Black lines: intensity profile of the image projected onto the sensor. Red lines: measured light intensity on one pixel. A high-resolution lens (top picture) prevents interpolation. A lens resolution matching the sensor resolution enables interpolation (bottom picture).

Interpolation

Commercial vision software packages promise a higher accuracy. They can make this claim based on an interpolation of the grey values of the pixels close to the dark-to-bright transitions. Too high a lens resolution invalidates the assumption underlying the interpolation between two successive pixels (see Figure 5).

When moving the object within one pixel pitch (the three steps shown from left to right in Figure 5, top), the measured quantities of light (red lines) do not change when the imaging lens resolution is much greater than the dimension of one pixel. The position measurement inaccuracy then amounts to one pixel because of the impossibility of interpolating between pixels (top part of figure). When measuring distances, the inaccuracy can even increase to two pixel pitches.

When the lens resolution corresponds to the pixel resolution of the image sensor, the measured quantities of light change with the slight movement of the object (bottom part of figure). The image processing software is then able to interpolate between the pixels, i.e. it can reconstruct the original black profile (see Figure 5). The

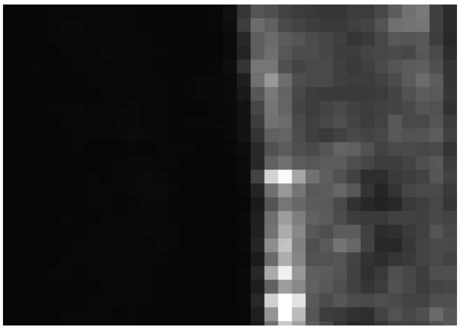


Figure 6. Edge artefacts due to the occurrence of highlights distort the measurements. Grey rectangles correspond to measured light intensities on pixels.

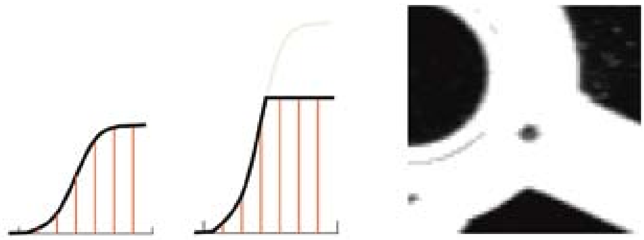


Figure 7. Light intensity measurement error due to overexposure.

position is calculated from that interpolated profile, resulting in a position measurement inaccuracy of about 0.1 pixel pitch.

Other artefacts

There are some other artefacts that may distort position measurements by vision. Figure 6 illustrates the occurrence of highlights during laser welding, which cause unwanted edge effects. The reflection of the illumination depends on local variations in the metallic surface: a local curvature may result in a locally higher intensity. An edge position measurement on the top part of Figure 6 will probably provide the right result, but the highlights in the bottom half confuse the edge position measurement algorithm discussed above.

When illumination is not configured properly for highly reflective materials like metal or glass, the highlights can result in local overexposure. Figure 7 shows how overexposure influences measurement results. The local intensity exceeds the cut-off sensitivity of one pixel, resulting in an intensity measurement error. This error can be as large as a multiple of pixels, depending on the lens quality and the degree of overexposure. Or in simpler terms: the flat cut-off sensitivity erases vital information. Therefore, overexposure must be avoided.

One solution may be to modify the illumination design, with the aim of changing the contrast in the image. Please note that this is not the same as reducing the illumination intensity, which may conceal information in the dark parts of the image. Another method to overcome illumination problems is to select a camera that has a sensor with pixels having a non-linear characteristic. In this case, the amplification factor decreases with increasing intensity.

Telecentricity

One problem that is inherent in lens imaging is perspective deformation, i.e. the imaging factor changes with object distance (see Figure 8). If product positioning errors occur, the error in the distance from the object to the camera then results in a measurement error. Also, if the features of the object happen to be at different distances from the lens, the distances between those features in the image will not represent the true distances.

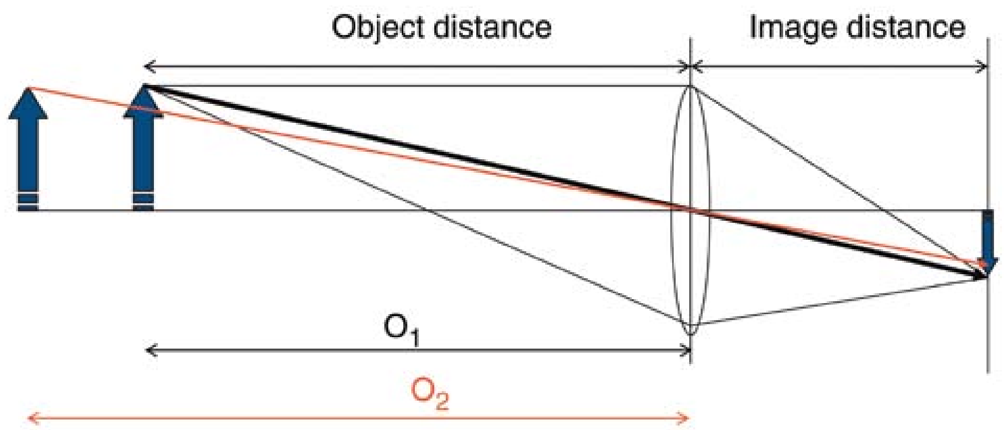


Figure 8. Perspective deformation: the imaging factor changes with object distance. The imaging error is equal to $(O_1 - O_2)/O_1$ for large object distances (object distance >> image distance).

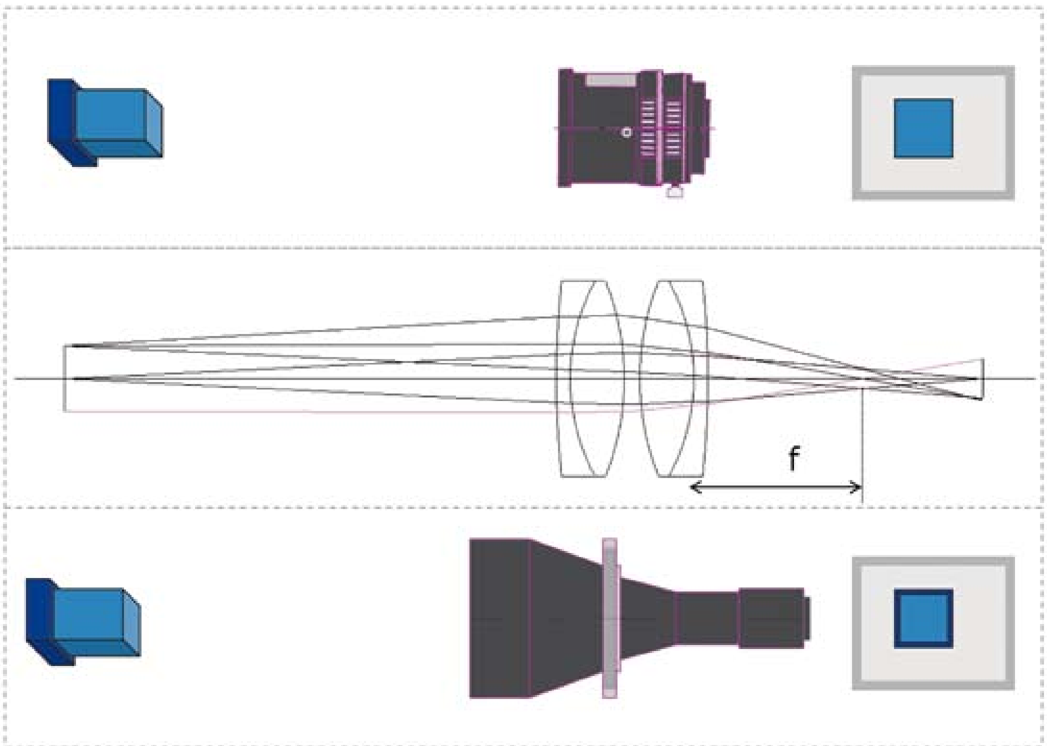


Figure 9. Imaging with a standard objective (top part) or with a one-sided telecentric objective (bottom part). The middle graphs show the telecentric path of the light rays. Top right sensor image: dark blue support of the block becomes invisible. Bottom right sensor image: dark blue support stays visible thanks to telecentricity.

This error can be eliminated by using a telecentric objective. The problem explained in Figure 3 can be solved by using a telecentric lens as well. Telecentricity may be one-sided or two-sided. For vision applications, telecentricity at the object side is only sufficient for eliminating perspective errors in a limited object distance range.

One-sided telecentricity may be regarded as the seeming position of a virtual entrance diaphragm at infinity, which causes parallelism of beams entering the lens with respect to the optical axis of the imaging lens (see Figure 9). Such a virtual diaphragm at infinity is achieved by mounting a real diaphragm in the back focal plane of the front lens of the objective.

The high price of a telecentric objective is one of its key disadvantages; it is 5-10 times more expensive than a standard lens. This price difference is understandable in part given that the objective diameter has to be considerably larger than the object dimensions.

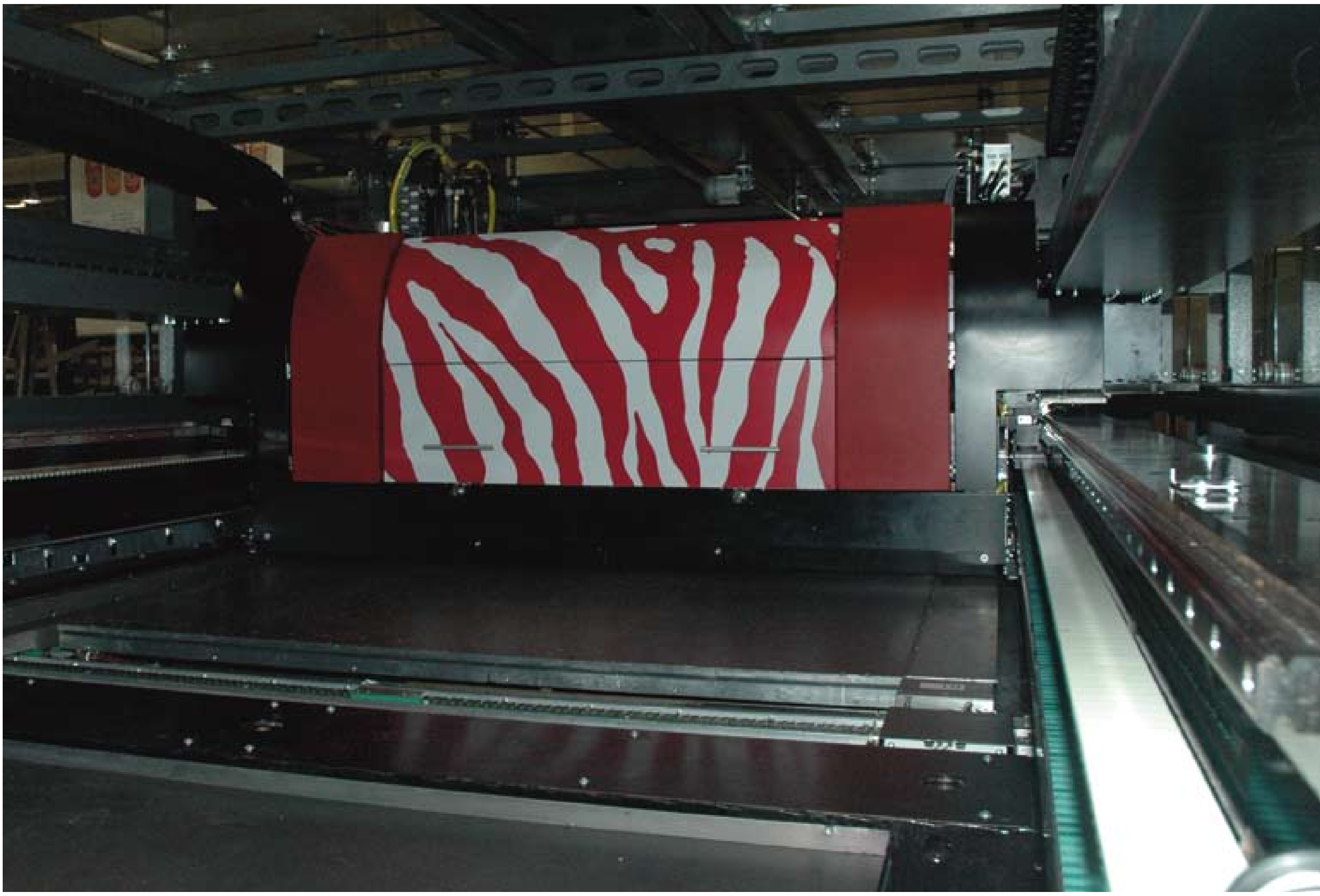


Figure 10. The :M-Press Tiger printhead shuttle supports a printing width of 1.6 m. It travels more than 2.6 m forward to enable printing over the full specified area.

Application model

The NTS-Group has a proven track record in designing and producing inkjet printers for OEM customers. The ink deposition accuracy [1] of these industrial inkjet printers is very specific. This accuracy is guaranteed because vision applications that support calibration and performance monitoring have been embedded.
Some of the typical vision tasks that printers carry out include the alignment of a printhead with the motion platform, the mutual alignment of printheads in multiple printheads, and the alignment of printheads in relation to the substrate. An existing pattern on the substrate that the printheads need to align to can complicate this last task. Another vision task is the monitoring of print quality. In all of these cases, position information has to be measured in the printed pattern, and cannot be measured in any other way.

One example of such a printer is the Agfa :M-Press Tiger, an inkjet printer for print sizes up to 1.6 x 2.6 m^2. With 64 printheads, the throughput of the :M-Press Tiger can be as large as 770 m^2 per hour. At its best, the Tiger provides a print quality with a resolution of 1260 x 720 dpi. The NTS-Group developed a special digital printer motion platform for this application (see Figure 10). The printhead shuttle deposits ink droplets within a 10 µm accuracy.

To conclude

An accurate and reliable vision system for object position measurements requires expert knowledge of the imaging process. That knowledge helps prevent pitfalls, like working with too high a lens resolution. Thanks to the proper conditioning of the imaging process, very high accuracies can be attained for complete systems, with a 3σ accuracy in the order of a few microns.

Reference

[1] M. Curvers, B. de Swart, and J. Gunsing, “What has to be accurate, what can be inaccurate?”, *Mikroniek*, Vol. 51 (1), pp. 12-20, 2011.

Applied optics and

There definitely was an "Eindhoven touch" to the DGaO/PCN Joint Meeting held from 29 May to 2 June 2012 in Eindhoven, the Netherlands. The event featured the 113th Annual Meeting of the German Society of Applied Optics (DGaO), co-organised by the Photonics Cluster Netherlands (PCN). The programme of the meeting at Eindhoven University of Technology included lectures on illumination optics and optical lithography, topics that represent the world's market-leading companies from the Eindhoven region, Philips Lighting and ASML, respectively. Other prominent themes were integrated optics and camera systems.

The DGaO/PCN Joint Meeting in Eindhoven attracted some 250 participants, the majority of whom came from the Netherlands and Germany. In total, they delivered nearly eighty presentations and presented some fifty posters; see Figure 1. The meeting was sponsored by thirty companies and organisations, and over twenty took part in the exhibition.

Figure 1. Impression of one of the poster sessions.

LEDs and lithography

The opening lecture, on trends in LED illumination, was delivered by Peter Duine, LED Business Architect at Philips Lighting. LEDs are not just another light source, Duine stated, capable of even more energy saving than most existing ones. No, their optical and electrical characteristics offer previously unthinkable, unprecedented application possibilities. The optics needed to shape and distribute light in the desired distributions will play an increasingly important role in general energy-efficient lighting. In his trend story, Duine devoted special attention to how LED illumination will change the entire lighting business, moving from components to solutions.

The next lecture featured optical lithography as "a key enabling technology for our modern world". Reinhard Voelkel, CEO at Swiss company SUSS MicroOptics, reviewed the evolutionary development of optical lithography and briefly discussed options for the future. Later on during the lecture programme, Heiko Feldmann, Principal Scientist at Carl Zeiss SMT, Oberkochen (Germany), sketched the development of optical systems for lithography, showing how increasing demands are driving new design principles, including the latest mirror systems for EUV lithography. Innovations involve such areas as system layout, optical and mechanical design, as

photonics join forces

well as optical metrology, optics production and coating technology.

Diamond machining of mirrors

The Fraunhofer Institute for Applied Optics and Precision Engineering, Jena (Germany), tackled the subject of manufacturing technology in a lecture on diamond machining of aspherical and freeform mirrors. Modern servo-assisted techniques allow the fabrication of off-axis mirrors in the centre of the turning axis. The expected benefits are reduction of the surface shape deviation resulting from centrifugal force and the chance to correct non-rotationally symmetric errors. A hybrid fabrication process was presented that comprises diamond freeform turning and diamond milling in one and the same ultra-precision set-up for manufacturing of freeform.

Optics in nature

The special symposium on optics in nature covered a fascinating subject. Prof. Gerrit Kroesen, the conference host at Eindhoven University of Technology (TU/e), talked about natural light sources such as the sun, stars, lightning, the Aurora, sprites, etc., all based on plasmas (ionised gases). When electrons are accelerated in an electrical field, they can get enough energy to excite atoms and molecules, which then emit photons. The trajectories of electrons, and of cosmic radiation, are altered by the presence of magnetic fields. This is, for example, visible as the moving light patterns near the earth's magnetic poles. In his lecture, Prof Kroesen demonstrated the influence of magnetic fields by performing gas discharge physics experiments; see Figure 2.

Editor's note

This report was drawn up in collaboration with Dr. Stefan Bäumer, Senior Principal Engineer Optics at Philips Lighting, who chaired the meeting and whose input is greatly appreciated. The proceedings of the DGaO/PCN Joint Meeting are available online.

www.dgao-proceedings.de

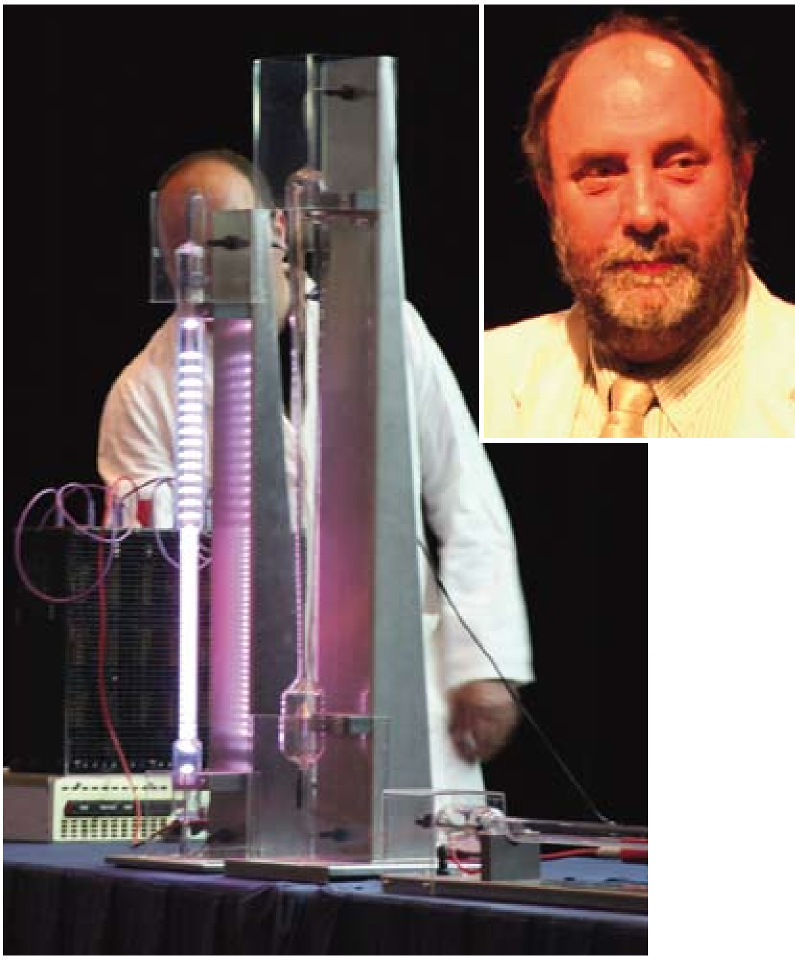


Figure 2. Prof. Gerrit Kroesen, TU/e, performed gas discharge physics experiments to demonstrate optical phenomena in nature based on plasmas.

Prof. Peter Vukusic, University of Exeter (UK), talked about light and colour manipulation in biology; see Figure 3. Photonic bandgap structures in many animals and plants suggest broad innovation in nature's use of materials to manipulate light. In certain butterflies, long-range visibility of up to 1 km is attributed to nano- and micro-structures formed by discrete multilayers of cuticle and air. This contrasts with other butterfly photonic structures designed for camouflage that not only produce strong polarisation effects but also create additive colour mixing using highly adapted geometries. In his lecture, Prof. Vukusic presented

Figure 3. Prof. Peter Vukusic, University of Exeter (UK), discussed light and colour manipulation in biology.

some exciting recent discoveries that reflect nature's optical design ingenuity.

Besides these two exciting lectures there were four other contributions on optics in nature. These covered everyday optical phenomena like rainbows and halos, interesting reflection phenomena on water surfaces, as well as optical illusions and how they can help in modern diagnostics, and the influence of light on our circadian system.

Camera systems

A more industry-oriented topic at the meeting was camera systems. Jochem Herrmann, Chief Scientist at Adimec Advanced Image Systems in Eindhoven, gave an overview of camera systems for machine vision applications. He discussed camera types (such as CCD, CMOS, line scan, area scan), important camera characteristics, interface standards and future trends. In addition, he described some high-end applications in more detail, including how system accuracy is influenced by the optical system.

Fraunhofer Lecture

During the conference banquet at the DAF Museum in Eindhoven, the prestigious Fraunhofer Lecture was delivered by Jos Benschop, Senior Vice President Technology of ASML. His subject, naturally, was optical lithography. Moore's Law dictates that every 18 months the number of transistors on an integrated chip doubles. This is first and foremost enabled by optical lithography printing ever smaller transistors on an integrated circuit. ASML is market and technology leader in this multi-billion euro industry. Using 193-nm light and immersion optics with numerical aperture of 1.35, state-of-the art immersion scanners print 40-nm wide lines on a 300-mm resist-coated silicon wafer. Extreme Ultra Violet (EUV) scanners are now printing lines below 20 nm. The productivity of these optical lithography scanners has increased steadily over the last decades. The combination of sub-nm precision and high acceleration continues to push the envelope of optics and sensor technology.
After an introduction to IC fabrication and the role of lithography, Jos Benschop explained how lithography, and optics used for lithography, has evolved over the years, enabling a cost-effective continuation of Moore's law.

DGaO & PCN

The Deutsche Gesellschaft für angewandte Optik (DGaO, German Society of Applied Optics) was established in 1923 and has been an autonomous branch of the European Optical Society (EOS) since 2004. Today, DGaO has over 600 private members, half of them from industry and half from the academic world, as well as some 50 corporate members. The objective of DGaO is to promote developments in the field of applied optics. To that end, DGaO organises thematic working groups, provides opportunities for information exchange, supports national and international networking, and contributes to German technology and R&D agendas. One of the highlights of the DGaO society's activities is the annual meeting, which is organised abroad once every three to five years.

Photonics Cluster Netherlands (PCN) aims to become the preeminent Dutch platform for knowledge transfer in photonics for high-tech companies and at all levels of education. Last year, PCN supported the launch of www.dutchphotonics.nl as *the* website for distributing photonics-related information and presenting the activities of the IOP Photonic Devices research programme, funded by NL Agency. The website also contains an online version of the Dutch Photonics Company Guide. PCN participates in a growing network of international photonics clusters and initiatives that play an important role in promoting photonics as an enabling technology, e.g. Photonics Cluster UK, EOS, SPIE, Photonics 21, etc.

www.dgao.de
www.photonicscluster-nl.org
www.dutchphotonics.nl

Moore's law in photonics

More on Moore's law was presented on the last day of the meeting (Saturday!) by TU/e professor Meint Smit. He talked about Moore's law in photonics, because the complexity development of photonic ICs shows a similar development as Moore's law in electronics. Smit reviewed the development of photonic integration technology in the past decades and discussed similarities and differences between photonic and microelectronic integration. So far, the main driver for photonic integration has been telecommunications. But new developments in photonic integration will bring the costs of photonic ICs down to a level where they become attractive to SMEs for a broad range of applications, including interconnect, sensors, metrology and health. From that perspective, Smit shared his vision on the future development of photonic integration. It was a fitting end to a highly interesting (scientifically as well as socially, see Figure 4) meeting.

Figure 4. The meeting programme included an excursion to Den Bosch, with a social event at the Oranjerie.

A measurement

Thirty years ago, tools were already being coated with diamond. More and more exotic materials like reinforced carbon and special aluminum were being used in the aerospace industry, and when these were processed using the existing tools, the tools did not last very long. Since then, there has been an increase in the use of tungsten carbide tools, which have been coated with diamond. Another interesting diamond-coating application that has emerged are measuring probes; these have the lowest possible friction coefficient combined with the best output signal, plus they do not wear and do not run the risk of the sphere falling off.

• *Wim Nelissen* •

In general, there are three types of layers that can be deposited onto other materials:
1. Metal-ceramic coatings like TiN, which are used on tools, etc.
2. Diamond-like coatings (DLC).
3. Real diamond coatings (nano- or microcrystalline; see Figure 1).

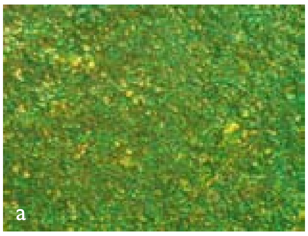


Figure 1. Real diamond coatings.
(a) Nanocrystalline.
(b) Microcrystalline.

Diamond coatings were initially rather rough (like the microcrystalline diamond coating shown in Figure 1b). This rough coating meant that there was a significant edge

Author's note

Wim Nelissen is the owner of Diamond Product Solutions, which he founded in 2008. Before that, he spent 23 years working in the diamond industry at Element Six in the Netherlands. His work there involved processing CVD (Chemical Vapour Deposition) diamond into extreme properties. Products included high-power CO_2 windows and single-crystal spheres for SIL (solid immersion lens) applications.
With Diamond Product Solutions, Nelissen started developing applications, a key part of which are diamond and diamond coatings. More often than not, the extreme properties of diamond are only needed on the contact area of the application. Diamond Product Solutions has in-house equipment to polish diamond and diamond coatings into any shape and specification.

info@diamondproductsolutions.nl
www.diamondproductsolutions.nl

rounding at the cutting edge, making the mill rather blunt, and because of that the cutting forces during milling were high. The tool lasted longer, but due to the increase in cutting force, the surface quality of workpieces was rather low. Nowadays, diamond-coating companies can grow much smoother coatings like the nanocrystalline diamond coatings (see Figure 1a). Diamond coatings can be grown on materials such as WC, Si, SiC, and Si_3N_4. Given that tungsten carbide can now be ground into any possible shape, it has become the most commonly used material in the tool industry.

There are three major steps when growing an adhesive diamond coating onto tungsten carbide:
1. Etching the cobalt out of the surface structure.
2. Seeding the etched tungsten carbide with nanocrystalline diamond particles.
3. Growing the diamond coating.

When sintering tungsten carbide tools, cobalt is added as a catalyst. However, when growing diamond onto the tungsten carbide tools, this cobalt has to be removed to a certain depth. Etching the cobalt out of the surface structure is important because otherwise the adhesiveness of the diamond coating will be poor. After this, the seeding is done. The tools requiring a diamond coating are submerged into an alcohol kind of liquid which is full of nanocrystalline diamond particles. The ultrasonic movement of the particles in the liquid causes the nanocrystalline diamond particles to stick to the surface of the tungsten carbide.

The tools are then put in the HF-CVDD (Hot Filament Chemical Vapor Deposition Diamond) furnace. The chamber is heated to ~850 °C, after which the tools are exposed to methane and other gases. At that temperature, the methane (CH_4) splits into C and H, and the carbon grows onto the seeded nanocrystalline diamond particles. The usual diamond-coating thickness used for tools nowadays is 6-8 micron, which is much thicker than a DLC or TiN coating.

After the coating has been grown onto the tool, the base is provided for the new Diamond Product Solutions product, i.e. the diamond-coated & polished (micro-) CMM measuring probe.

Measuring probes

A measuring probe normally consists of two parts: the shank and the sphere, which is generally a sapphire sphere. The sphere is usually glued to the shank. However, a different concept was developed for the new diamond-coated & polished probe. The shank and sphere are ground from one piece of tungsten carbide (see Figure 2), ensuring

Figure 2. Diamond-coated probes.
(a) 10-mm diameter probes; the one on the right has been polished.
(b) 0.2-, 1-, 3-, 5- and 10-mm probes ready for use.

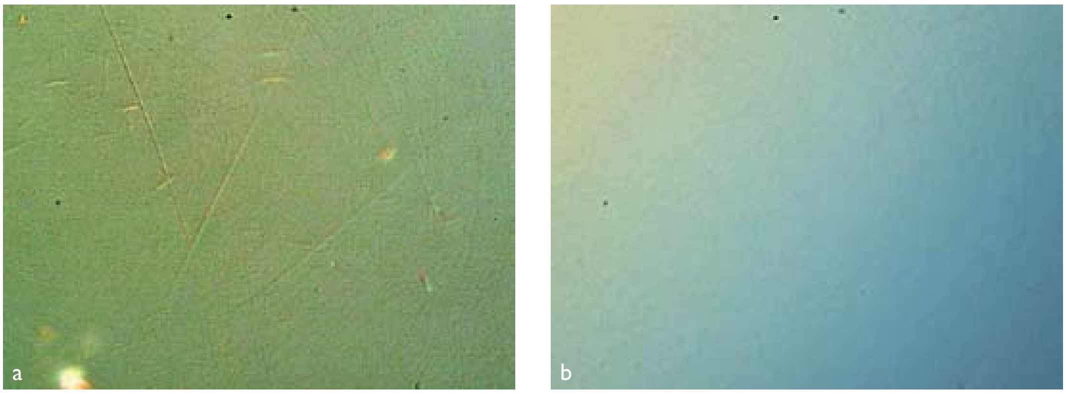


Figure 3. Comparison of surfaces at 1,250x magnification.
(a) Sapphire.
(b) Diamond, R_a < 0.79 nm (polished with diamond).

that the sphere can no longer fall off the shank and that there is no glue hysteresis.
This is of particular interest when making micro-CMM probes with a diameter of 0.2 mm or 0.3 mm. After the probe (shank and sphere) has been ground, it is given a nanocrystalline diamond coating. This is done using the HF-CVDD technology mentioned before. The result is a real diamond coating which is as hard, if not harder, than natural diamond. Natural diamond has a monocrystalline structure which has soft directions. In the diamond world, there are so-called two-point, three-point and four-point orientations. The two-point orientation is soft compared to the other orientations. Therefore, it is difficult to make probes with a form accuracy that is better than G10 (G10 or Grade 10 is a measure for the total sphere shape compared to a perfect sphere; G10 means a form accuracy < 250 nm, G5 means a form accuracy < 125 nm, etc.). The nanocrystalline diamond coating is a polycrystalline diamond coating with random two-, three- and four-point orientations in the bulk material. This means that it can be polished to extreme smoothness and with a form accuracy better than G5.

Once the diamond coating has been grown onto the probe's tungsten carbide sphere, it is polished. Ever since diamond has been polished, people have known that diamond can only be polished with diamond. Over the last three years, however, Diamond Product Solutions has taken this technology to a higher level with the following results:

1. Very low roughness; using an AFM (Atomic Force Microscope), Metas in Switzerland measured an R_a of 0.79 nm.
2. Sapphire probes are polished with grains harder than sapphire itself, which means that they have scratches and digs on the surface (see Figure 3). This is not the case with a diamond surface, which has a very even surface structure; and because it is the hardest material possible, it can be very smooth, as has been proven (see Figure 4).
3. PTB and Metas have measured a form accuracy at the equator as low as 30 nm on a 3-mm probe. Total form accuracy of the sphere is better than G5, and this continues to improve.
4. Diameters possible from 0.2 mm to 10 mm.

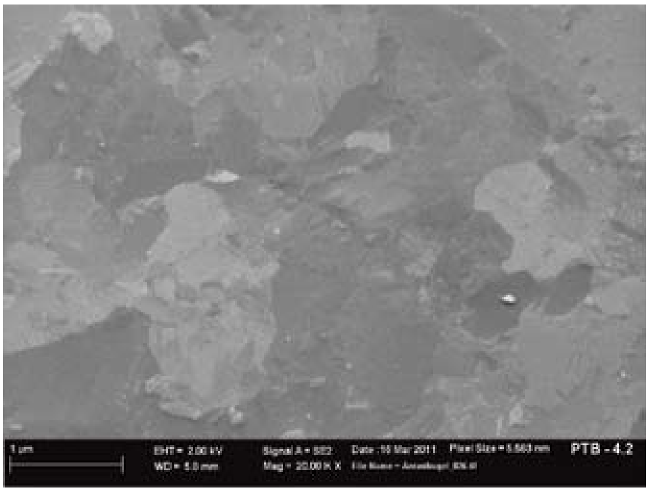


Figure 4. Polished diamond-coated probe surface; 20,000x magnification.

Diamond-coated measuring probes offer some major advantages compared to sapphire and Si_3N_4 measuring probes:

1. Hardness 10 (Mohs scale) like natural diamond.
2. No wear whatsoever, so ball diameter and accuracy no longer change.
3. Lowest friction coefficient of all materials, which is of particular interest when measuring Zerodur.
4. No aluminum adhesion onto the ball, as is the case when using sapphire.
5. G10 to G5 quality.
6. Increased smoothness, better than sapphire and Si_3N_4, R_a < 0.8 nm.
7. Diameters as low as 0.2 mm are possible (see Figure 5).

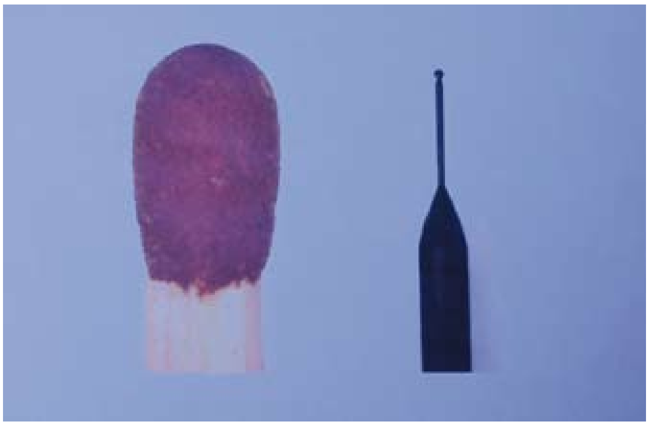


Figure 5. Smallest diamond-coated & polished probe in the world, with 0.2 mm diameter and a form accuracy better than G5.

Figure 6. 3-mm diamond-coated & polished probe with M5 insert for use on a measuring machine.

8. Ball and shank from one piece of tungsten carbide, so no risk of the ball falling off.
9. Very attractive price/quality ratio.

The probes can fit all existing CMM measuring machines. Users just have to specify insert and thread, and then the right insert can be glued or brazed onto the end of the shank (see Figure 6). Every possible shank design can be made.

Earlier this year, diamond-coated & polished probes with a diameter of 0.2 mm and 0.3 mm were launched to the market's great excitement. TNO is using the probe for the end measurement of aluminium parts, with accuracies < 50 nm peak-to-valley over 90 degrees. Nowadays, there are more and more micro-CMM measuring machines with measuring accuracies of ~0,1 micron. It could be very interesting for these CMMs to have measuring probes that do not wear, where the sphere does not fall off and that offer the lowest possible friction coefficient with the best output signal.

Other capabilities and products

- Diamond product development for customers.
- Diamond prototype processing; single pieces and small series.
- Processing of free-standing CVDD, natural diamond and diamond coatings to any shape and specification.
- Diamond-coated SiC rings with a diameter of up to 100 mm, radius of curvature ~10,000 meters and circular waviness < 100 nm after polishing (see Figure 7).
- Processing of diamond-coated SiC mechanical seal faces; diameters of up to 200 mm, circular waviness < 150 nm, roughness R_a < 5 nm.
- Diamond-coated Si_3N_4 full spheres; diameters between 2-12 mm (see Figure 8).
- Gliding surfaces in general.
- Diamond-coated & polished contact surfaces; no debris.

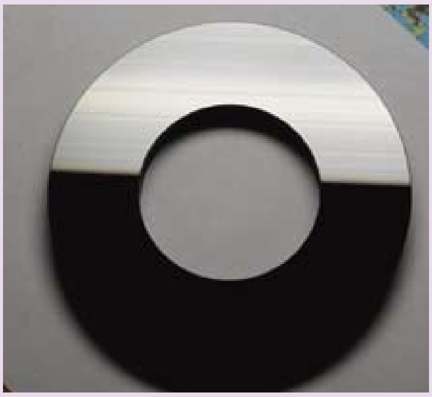


Figure 7. 100-mm diameter diamond-coated & polished ring (< 1 fringe); underlying material of SiC.

Figure 8. 12.7-mm diamond-coated & polished full sphere; Si_3N_4 material (in development).

Measuring mirrors

As part of the armoury of hardware used in steering and focusing high-energy beams in today's synchrotrons, precision mirrors are becoming increasingly important as energy levels continue to rise. This article sets out to explain some of the challenges in designing and building a metrology system to precisely map the surface of these large mirrors, for use at the new National Synchrotron Light Source II site at Brookhaven National Laboratory, Long Island, New York (USA).

In simple terms, a synchrotron consists of a large storage ring where electrons circulate at high energy levels under the control of strong magnetic fields. Each time the electrons are turned by the magnets, they emit radiation which can be directed down one of the tangential beamlines, where the collimated beams are used for a wide variety of experiments. To accurately focus and shape the beam, a series of optical components are used, including long mirrors with both plane and curved surfaces. The requirements on these mirror surfaces are extreme and, with the low incidence angles employed, the surface profiles must be precisely measured. To characterise such surfaces, the Long Trace Profilometer (LTP) was developed; see Figure 1. It's function is to scan the reflecting surface of mirrors up to 1,500 mm long, measuring their slopes to better than 0.1 microrad.

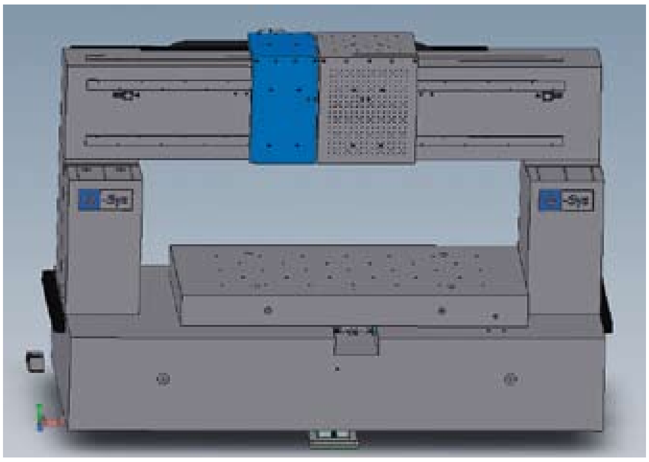


Figure 1. Design of the LTP.

Scanning options

The techniques for scanning these reflective surfaces have been developed and refined over recent years and one method involves exploring the surface with a pair of laser beams and recording the surface slope. These beams must be scanned over the entire mirror surface, generally in a raster-scan type pattern. Directed down through a pentaprism to aim them directly onto the mirror surface, the beams are moved along a straight scan path, either in step-by-step mode or in a constant speed traverse. The mirror is then indexed sideways, perpendicular to the scan path and the next line scan is performed. This is repeated across the entire area of interest and the returning data is used to create a complete computer model of the mirror surface.

Editor's note

This article was contributed by Q-Sys, based in Helmond, Netherlands. Q-Sys designs and builds precision motion and positioning systems for various markets.

www.q-sys.eu

to the max

Step-by-step scanning means the motion system must be able to acquire a new target position and settle to a 'quiet' state in a reasonable time, while constant-speed sampling requires a very steady, vibration-free movement to enable good data capture on-the-fly. Generally speaking, motion systems are optimised for one or other of these two types of motion – this system, however, must be capable of excelling at both. Also, with the laser source and measuring equipment being mounted in fixed positions, the resulting optical path is very long, potentially 3 m or more. The effect of this is that an angular error of just 5 microrad can introduce an uncertainty in position of up to 15 microns. As a result the angular performances of the motion stages – particularly repeatability and stability – are of paramount importance.

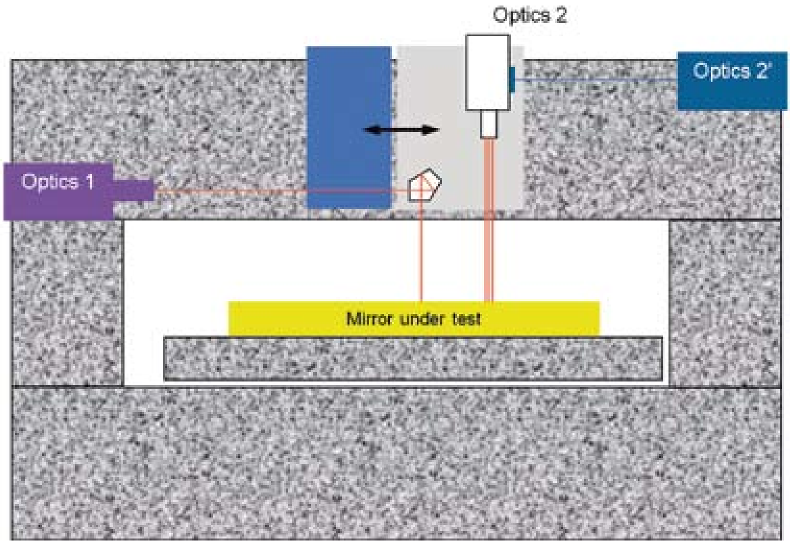


Figure 2. Set-up for scanning a mirror surface, with the lower axis carrying the mirror and the upper axis carrying the optics.

Motion platform

The LTP bench designed by Q-Sys consists of a split-axes XY motion platform, with the main structure constructed from precision granite pieces; see Figures 1 and 2. The mirrors to be measured are anything up to 1,500 mm long, with a mass of up to 150 kg in their holding supports. The lower axis of the platform is used to position the mirror and hold it precisely in position during the measurement process. It needs to be stable to better than 0.15 micron during the scan and is also used to step the mirror position beneath the flying optics. The upper axis carries these optics over a travel of 1,500 mm and must have minimal angular errors over this travel range, combined with the capability to deliver point-to-point and constant speed movement profiles. A further complication is that the optics payload and associated components may be anything up to 20 kg. Mounted to the front face of the carriage, this constitutes a cantilevered load introducing unwanted angular forces that must be restrained by the bearing arrangements.

Lower axis carriage

The final design for the system employs air-bearings for lift and guidance on both axes. The lower axis carriage consists of a single granite block with four air-bearing pucks for lift; see Figure 3. These in turn bear on prepared surfaces on the main granite base plate. A gully in the base plate accommodates the linear motor and optical encoder components, together with additional air-bearing pucks that restrain and guide the carriage along a straight path. The combination of the location of the linear motor and the precision of the walls of the gully ensures the motion of the lower carriage has minimal straightness and yaw errors. As the carriage is never moving during the scanning process,

Figure 3. The underside of the lower axis carriage, with guidance air-bearing pucks mounted.

the principal requirements on its performance are for accuracy and repeatability of positioning. This of course is not true for the upper carriage.

Upper axis carriage

The motion requirements for the optics axis are particularly demanding. Not only must the linear positioning of the carriage be precisely known, but – as mentioned above – its angular stability is crucial and it must also be able to move with near-zero velocity ripple. Linear motors, in common with rotary servo motors, exhibit cogging as part of their characteristics. While the use of ironless motors reduces this, the effect is still noticeable, particularly at these levels.
While specifications for speed control are often defined in terms of velocity stability, in practice this is a very difficult parameter to define. Since velocity is a time-based variable, a measurement of variations will also be time based. However, very short or long variations in actual velocity can result in quite different results depending on the time period of averaging. In reality, a time period can always be chosen to portray the error in the manner desired, be it good or bad. Such manipulation must devalue the final answer.
For this reason, it was decided that the only meaningful definition for velocity variation is to measure the instantaneous position error at any point. Position error can be measured at any time and represents the difference between actual position and commanded or expected position. Clearly this is valid for both position control and velocity control, provided the bandwidth of the sampling is high enough to show cyclic variations. In this way, velocity ripple can be displayed and analysed to gauge its effect on the overall system.

With the optics carriage being an L-shaped construction, it is impossible to locate the centre of force from the motor in line with the centre of mass. The Q-Sys design has the motor mounted in the upper section of the carriage while the user mass, made up from various optical components in different configurations, will generally be lower down. This means the motor can introduce torques to the carriage, which are clearly undesirable for such an error-sensitive part of the system.
For this and other reasons, the moving part of the upper axis is actually designed as a split-carriage. One section carries the linear motor, velocity feedback encoder, electrical and air connections etc., while the second section is a free-running carriage with solely the guidance and lift air-bearings and their respective supply pipes. This second carriage will carry the user optics, in whatever configuration appropriate for the measurements being made. It is connected to the motor carriage by a carefully designed flexure link, which is stiff in the axis of motion but flexes under the effect of any other linear or axial forces. This link enables the two parts of the carriage to move along the axis as one but isolates the optics carriage from as many undesirable disturbances as possible. The optics carriage is fitted with its own encoder readhead, so the point of measurement is as close to the point of interest as possible.

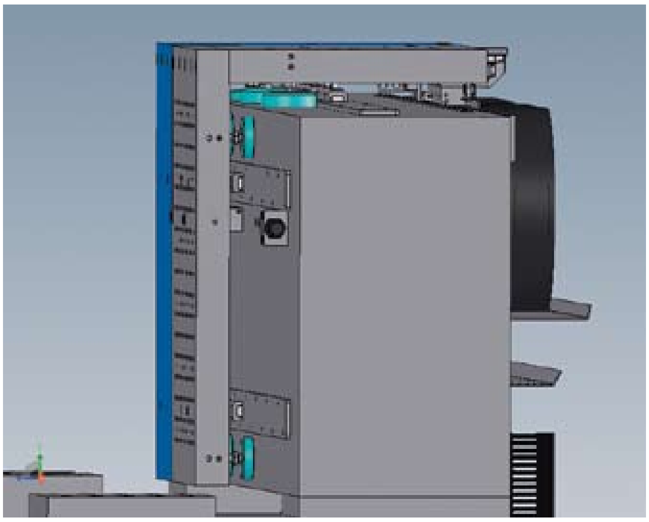


Figure 4. Sideview of the upper axis carriage, showing the guidance air-bearing pucks.

Both parts of the upper axis carriage are supported and guided by air-bearing pucks, with the lapped granite beam providing the flat bearing surfaces; see Figure 4. These bearings use magnetic pre-load to maintain them at the correct flying height. Pre-loading the bearings in this way provides a high stiffness support that introduces no cyclic disturbances as the carriage moves – which is essential. This is further complemented by the use of linear amplifiers to drive the system axes, ensuring no undesirable harmonics are injected into the system.

Result

The final result, see Figure 5, is an excellent demonstration of the benefits of custom system design and build – a bench capable of positioning a large, 150kg payload precisely beneath a set of flying optics and completing high-accuracy measurements reliably and repeatably. Previous systems in this family have yielded measurements of slope error down to 50 nanorad with a noise level of just 15 nanorad – this latest bench is expected to at least reproduce this level of performance.

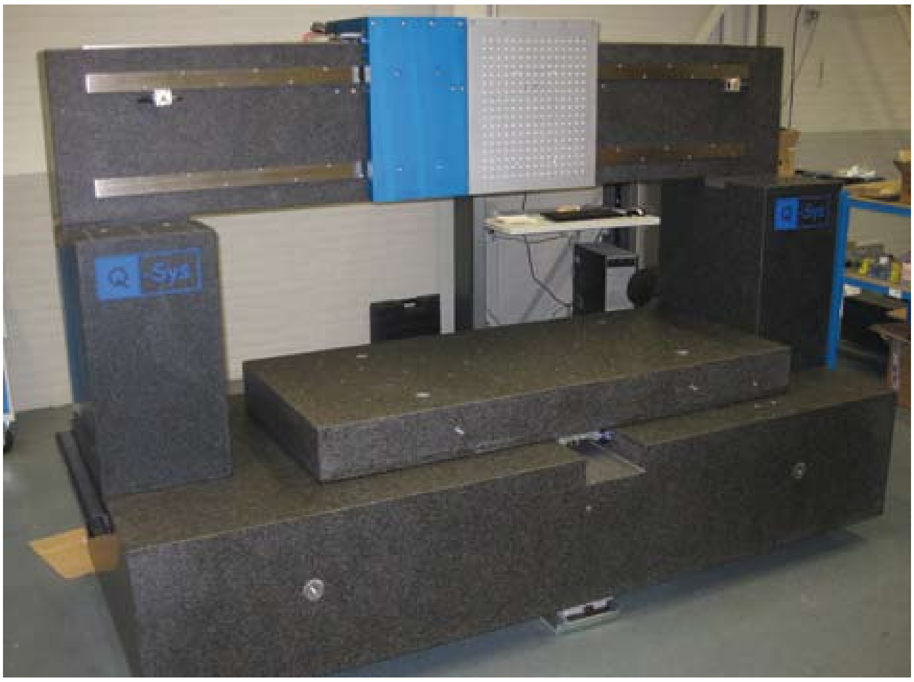


Figure 5. The optical bench nearing completion.

Robotics is

Speaking or writing in exclamation marks is something you can leave up to Stefano Stramigioli, professor of Advanced Robotics at the University of Twente and champion of service robotics in the Netherlands. As chairman of the RoboNED platform, he presented the Dutch Robotics Strategic Agenda at the RoboNED Conference 2012, which was held on 5 and 6 June in conjunction with the Vision & Robotics 2012 trade fair in Veldhoven. His main message to the Netherlands: don't miss the robotics train!

"How can we tackle the challenges in society we will be facing in the coming years? How can we create real value for our economy and provide real services to our society?" Stefano Stramigioli has good reason to believe that robotic technology can address these crucial and fundamental questions at least partially. "RoboNED is aiming at a better understanding of how robotics in the Netherlands could be shaped in order to yield an ecosystem that is capable of addressing the goals underlying these questions."

Potential

RoboNED was launched in 2010 with the aim of delivering a Strategic Agenda with an analysis and concrete suggestions on how to achieve these goals. Robotics is a large multidisciplinary field that encompasses many key technologies and has a very broad field of application. The analysis in the Agenda was based on the perspective of the market and the application fields, and a number of key markets were identified and studied. A SWOT analysis was made to arrive at an objective and unbiased overview of the potential for the Netherlands.

At the RoboNED Conference 2012, the first copies of the Dutch Robotics Strategic Agenda were received by Chris Buijink, Secretary General of the Ministry of Economic Affairs, Agriculture and Innovation, Eppo Bruins, Executive Director of Technology Foundation STW, and

Figure 1. Chris Buijink (left), Secretary General of the Ministry of Economic Affairs, Agriculture and Innovation, received one of the first copies of the Dutch Robotics Strategic Agenda from RoboNED chairman Stefano Stramigioli.

booming!

Robert van der Drift, Head of Computer Science at the Dutch Research Council (NWO). See Figure 1.

Market survey

Although most perspectives are overly optimistic, as the Agenda summarises, it is clear that the global robotics market will grow by around 7% over the 2012-2025 period. Professional and domestic service robots will comprise the largest part of this growth, while industrial robotics will grow slowly in line with economic recovery. There are significant opportunities, particularly in health/medical areas and in field robots. Asia has the largest robotics market, both in industrial and service robotics. By 2013, Europe will be experiencing major growth in the general robotics market and will rise to second place. This will be due mainly to the growth in sales of professional service robots. The Netherlands is, for example, world leader in milking robots (Lely).

High-tech components

However, the Netherlands has just a few original robot designers and suppliers. The majority of Dutch robotics companies are engineering firms making special components that deliver high-tech products to the original robot designers and suppliers. These engineering firms are not always taken into account in market results. This may explain the impression that the Netherlands is not at the forefront of the robotics industry. However, a closer inspection reveals that the Netherlands has a strong position in robotics, focusing on high-tech special components.

Joining forces

To conclude, the Agenda recommends that Dutch entrepreneurs take advantage of this position by joining forces to develop more Dutch original robot design suppliers by integrating the robotic components into one robot. This will encourage already established engineering firms that produce special components. Promising applications can be found in professional service robotics. In addition, Dutch companies could focus on compatibility of their separate components, and advise end users on how to compose their robot with the components most suitable for their particular application.

See the Agenda's executive summary in the box on page 32.

Vision & Robotics 2012

The RoboNED Conference 2012, where the Agenda was presented, was held in conjunction with Vision & Robotics 2012. This knowledge and business network event, organised by Mikrocentrum, focuses on innovations and solutions for vision systems, robotics, motion control, sensors and machine automation. The eleventh edition of this trade fair attracted 1,100 visitors and 60 exhibitors, both representing an increase of 30% as compared to the 2011 edition. The fair featured the RoboNED plaza, with knowledge institutes and companies showing what they have to offer, supported by live demos; see Figure 2.

At the trade fair, see Figure 3 for impressions, various exhibitors showed their product innovations. For example,

RoboNED

As one of the Dutch ICT Innovation platforms, RoboNED has been coordinating robotics activities in the Netherlands since April 2010. It aims to stimulate the synergy between the various robotics fields and to formulate a focus. RoboNED's goal is threefold: bringing the fields and disciplines involved in robotics together, stimulating the Dutch innovation ecosystem by uniting stakeholders from research, education, industry and society, and stimulating the social acceptance of robotics in the Netherlands.

The RoboNED Steering Board, chaired by Twente professor Stefano Stramigioli, comprises representatives from academia (Eindhoven professor Maarten Steinbuch on behalf of 3TU, the three Dutch universities of technology), major industry (Barry Goeree, Philips Consumer Lifestyle), SMEs (Dennis Schipper, Demcon), and trends exploration (Hans van der Veen, STT Netherlands Study Centre for Technology Trends).

Last year, RoboNed developed a database for producing a clear survey of Dutch robotics to which each party can add its own activities. Also, an inventory was made of the RoboNED community and the Dutch Robotics Strategic Agenda was presented this month.

www.roboned.nl
www.robodb.org

Figure 2. One the robots featured at the RoboNED plaza was the KUKA youBot. This robot was developed by German industrial robotics manufacturer KUKA Robotics as a mobile manipulator for education and research.

Focal Machine Vision & Optical Systems launched its IVI-SYS machine vision platform for highly demanding industrial vision inspection applications. Pilz demonstrated SafetyEYE, the first safe camera system for 3D zone monitoring, combining intelligent sensor technology with effective control. And Stäubli Robotics introduced the new TP80 Fast Picker, an ultrafast four-axis robot for standard pick & place applications, featuring more than 200 picks per minute.

Executive Summary

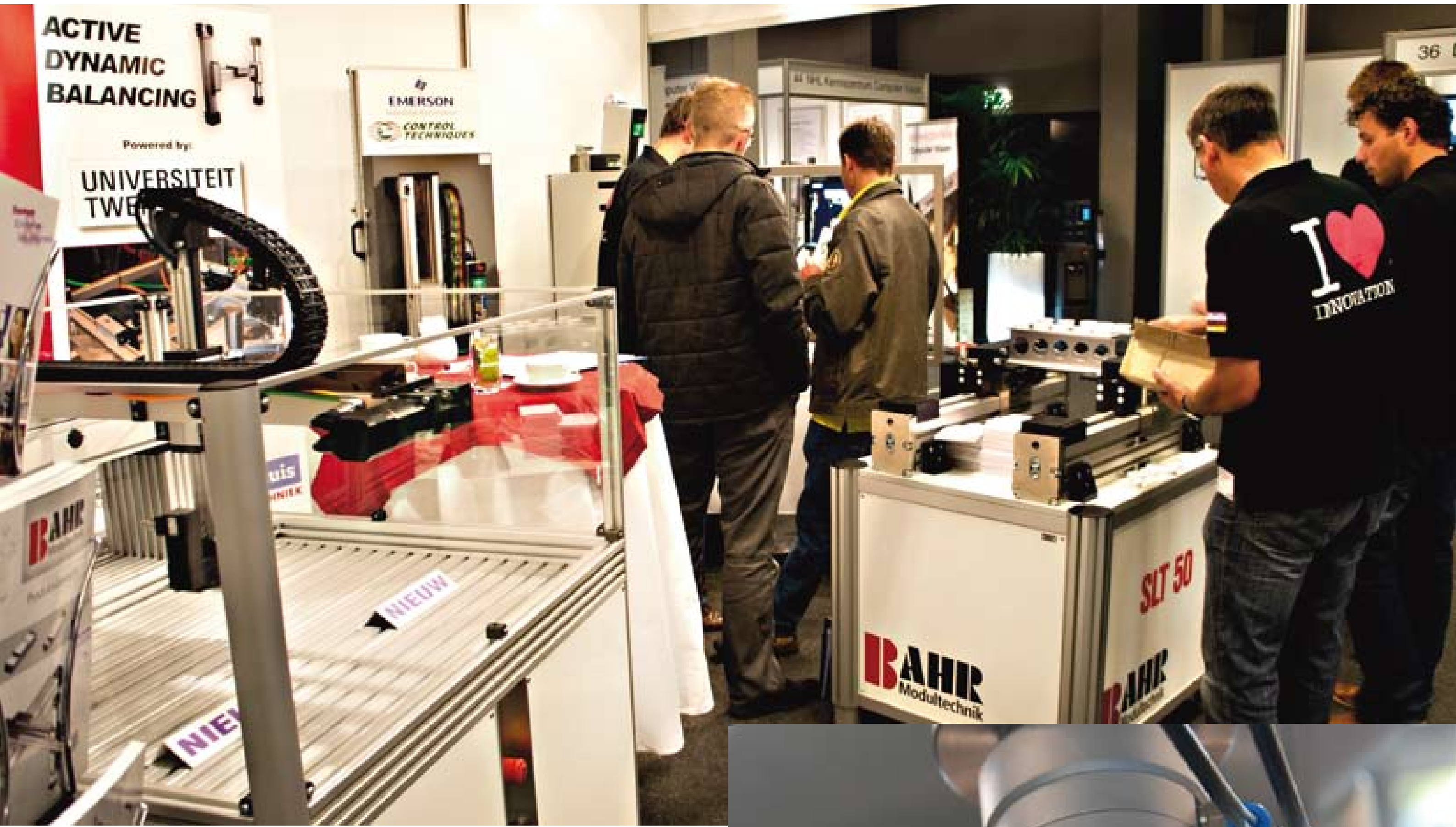
Robotics is booming! The Netherlands: don't miss the train!
- Global perspectives for robotics are optimistic.
- Huge opportunities for the Netherlands to become an important global player in robotics.

Strengths and Opportunities
- Great social need for robotics, e.g. in healthcare due to the aging population and in agriculture due to labour shortages.
- Dutch universities occupy top positions in high-tech research and development and already have access to a large part of the technology they need.
- The Netherlands has a lot of innovative high-tech mechatronic engineering companies supplying components for the robotics industry.
- The Netherlands has a globally leading position in milking robots.
- The Netherlands has a positive innovation climate, with direct links between companies and knowledge institutes.

Weaknesses and Threats
- There are not enough engineers in the Netherlands.
- There are not enough investors in robotics in the Netherlands.
- Society is sceptical about robotics. Social acceptance of robots is an issue.

How to seize the opportunity (the shift from traditional industrial robots towards service robots)?
- More commercialisation driven by valorisation.
- Improved technology, focusing on the interaction of humans with robots.
- Technological breakthroughs in the field of 3D perception, motion/task programming, soft/compliant actuation, and cognitive learning algorithms.
- Actions on safety, standardisation, public awareness, and human capital.
- More exchange of knowledge and collaboration within the robotics field, both between disciplines and between application fields.

Required actions
- Government: become launching customer of robots. Invest in start-up and spin-off companies and invest in robotics research & development as well as in coordination actions.
- Social institutions: stimulate the acceptance of robots, e.g. in public debates and 'free zones'.
- Knowledge institutes: achieve technological breakthroughs, perform research into social practices and relations, and develop a safety framework for service robots.
- Educational institutes: deliver more and better-educated students in robotics.
- Companies: invest in care, cure, agro&food and professional service robotics; join forces in the whole value chain of suppliers, robot producers and engineering firms; create business cases.
- Community (RoboNED): stimulate knowledge exchange and collaboration.



Alongside the RoboNED Conference, Vision & Robotics also featured a lecture programme. Henrik Christensen, full professor at Georgia Institute of Technology (USA), delivered one of the plenary keynotes, “Robotics – From vision to reality”. He talked about his experience as Founding Chairman of the European Robotics Research Network (EURON) and Chairman of the US Robotics Roadmap Committee. Another international contribution, at the conference, came from Geoff Pegmann, Managing Director of R.U. Robots (UK) and Jon Agirre Ibarbia, Project Manager / Senior Researcher at Tecnalia (Spain). They talked about encouraging entrepreneurship in European robotics. Herman Bruyninckx, Professor at K.U.Leuven University (Belgium), discussed the software challenges for future robotic systems. Other conference lectures covered navigation and motion planning, sensing, perception and cognition for service robots, interaction with robotic systems, and learning and adaptive systems.

Finally, an encouraging message was issued by Paul Mencke of Govers Accountants/Adviseurs to the large audience that attended his plenary lecture. Based on the analysis of financial results and business models of industrial companies, he said that robotics and production automation could play an important role in mastering the challenges posed by the current economic crisis.

Figure 3. Impressions of Vision & Robotics 2012. (Photos courtesy of Purple Vision)

More information

www.vision-robotics.nl

Remote care with robots:

At the “Zorg op Afstand met Robots” [Remote Care with Robots] symposium in Eindhoven on 21 May, healthcare managers and healthcare professionals got a taster of how robots could be used in the healthcare sector. This symposium was the closing event of a project subsidised by the Ministry of Economic Affairs, Agriculture and Innovation and the Province of Noord-Brabant, as part of which Eindhoven University of Technology and the Eindhoven-based care provider ZuidZorg collaborated with eight other partners to develop a robot for the healthcare sector for at-home care. The result is Robot Rose (Remotely Operated SErvice robot).

In addition to presenting three robots (Amigo: autonomous, Rose: tele-operated, and MobiServ: intelligent support), other key focus areas were the financing for this form of remote care and introducing projects in this field. Major investments and effective collaboration with the sector are essential to reduce development times and to accelerate implementation.

Shortage of staff

New applications should be developed in due course to be able to continue providing care, as healthcare demand and costs increase and there is (already) a shortage of healthcare staff. Joep de Groot from CbusineZ, part of health insurance company CZ, outlined this alarming future perspective during the symposium. It’s a given that robots will be introduced, but right now it’s a question of developing these in collaboration with the sector itself to create a standardised and functional robot quickly. CZ wants to assume its responsibility in this and participate in these developments. There are also national government and EU programmes and subsidy opportunities relating to the further development of robots.

Unpredictability

Although robots are already being widely used in the industrial sector, aeronautics, the army and in surgery, it’s quite a different story in healthcare, says Prof. Kees van Hee, who

Robot Rose in operation. (Photo courtesy of Inroads)

development has to accelerate

initiated the project. The industrial environments in which robots are widely used are predictable and can be effectively standardised, plus robots can easily carry out the actions. The healthcare sector and real life, however, are massively unpredictable, which increases the development challenges exponentially. That said, robots have a lot of advantages compared with people: they're stronger, move faster over a greater distance, can multi-task and can work where people cannot or do not want to work.

Robot Rose

Service robots like Robot Rose should be capable of performing daily healthcare duties for clients at home, either controlled – remotely or by the client themselves – or working autonomously. ZuidZorg clients were involved in the development of Robot Rose, says project leader Michiel van Osch. For the time being, Rose will have to carry out simple housekeeping duties, but there are no fundamental limits to her functional possibilities. One basic principle is that a human being is always in control of the robot; safety, reliability and user-friendliness are key. During the symposium, Rose gave her operator a rose, she opened a microwave door, grabbed a carton of milk, was able to pick up a tray and wipe a table clean with a cloth.

Consortium

Pilot projects are on the agenda for Rose's further development. When these will start and on what scale they will be set up depends on the financing and subsidy options, says Henk Zeegers from Inroads, the agency that co-developed and managed the Robot Rose project. A consortium of interested parties across the entire chain is ready and waiting, including Sioux Embedded Systems, NTS-Group, Exact Dynamics and Tegema Group. The idea is to use Rose and the experience gained with other robots, such as Amigo, Car-o-Bot, PR2, Mobiserv, etc., to build up practical experience in different healthcare environments. The aim of these pilot projects, which will last some three years, is to learn to work with service robots in the healthcare sector, to evaluate their performance and to increase their functionality.

www.robot-rose.nl

ASML expert Erik as "tenacious and

The first Martin van den Brink Award was presented to Erik Loopstra, ASML program system engineer, at the Conference Centre on the High Tech Campus Eindhoven on 30 May. Martin van den Brink is ASML's current chief product & technology officer in Veldhoven. Since ASML was founded in 1984, he has played a key role in the continued growth of the company, which has been the world market leader in lithography machines for years. The award named after him reflects the importance of system architecture in the development of high-tech machines, in which the Netherlands is world leader.

The biennial Martin van den Brink Award is an initiative of DSPE (Dutch Society for Precision Engineering) in collaboration with TNO, Brainport Industries, High Tech Systems Platform, Point-One and the High Tech Campus Eindhoven. The award aims to underline the importance of system architecture to the success of the Dutch high-tech systems industry and to show that our country plays a leading role in this field. The prime example of this is the Veldhoven-based company ASML, which originated from Philips in 1984 and has since grown into the current global market leader for lithography machines. Lithography is the crucial step in the production process for chips that determines their performance. It is in part thanks to ASML machines that we now all have tablets, smartphones and countless other high-tech electronic products.

Smartest region

At the symposium at the Conference Centre of the High Tech Campus Eindhoven on 30 May, a number of former ASML employees shared their memories of working with Martin van den Brink during the company's first turbulent years. Eindhoven mayor Rob van Gijzel ascribed a key role to the high-tech systems industry in the region when it was voted the 'smartest region in the world'. That title was awarded to the Eindhoven Brainport region last year by the Intelligent Community Forum.

System architecture

Martin van den Brink himself contributed to the symposium – although he was not particularly happy with "his glorification" – to ensure that the importance of system architecture was showcased properly. He once again stressed the importance of the environment – the good people at his own firm and the qualified suppliers in the region and beyond – to the success of ASML. When designing a lithography machine, it's up to ASML to safeguard the system architecture and to connect all modules to each other. This is the job of the system architect, who has a total overview of the system and can decide whether something should be implemented in hardware, electronics or software. They also have a good overview of all of the modules and all of the interfaces between the modules in the system. Moreover, they keep future developments in mind, so that when there's a new design, most of the modules can be used again very easily.

Loopstra honoured

sharp” system architect

Tenacious

Alongside Van den Brink, Erik Loopstra has been fulfilling this crucial role of system architect at ASML for more than 20 years. The role he has played in ASML’s development processes was described during the symposium by Henri Werij, Director of Research Technical Sciences at TNO. He described Loopstra as sharp, as someone who is open to unconventional solutions and ready to go places where others think the limit has been reached. He also looks at whether something can really work in practice. It’s thanks to his tenacity that he was able to contribute to the development of the successful ASML machine concepts such as Twinscan, immersion and EUV (still in development), all of which prompted the initiators to present the first award to Erik Loopstra. The award he received from name giver Martin van den Brink was an original multicolour lithograph by Belgian graphic designer Hedwig Pauwels. His design was printed on an authentic lithography press in the Dutch Museum of Lithography in Valkenswaard. Pauwels artistically depicted how a lithograph is produced. As is known, there is a remarkable relationship between the photographic lithograph from the late 19th century and the modern microchip.

Erik Loopstra received the award from name giver Martin van den Brink (right). (Photo courtesy of Techwatch)

Materials analysis business

As one of the first tenants, MATinspired recently moved into the new multiple-occupancy building 'Catalyst' in Eindhoven, the Netherlands. From its base here, MATinspired can further expand its services in the field of high-tech materials analysis for the industry, thanks to its own lab space. The Catalyst Technology & Business Incubator is one of Brainport Development's business centres.

At Catalyst, MATinspired has office and lab space with high-tech measuring equipment; see Figure 1. Because Catalyst is based on the Eindhoven University of Technology (TU/e) campus, MATinspired – previously housed at TU/e's department of Applied Physics – can go on using TU/e's high-tech measuring and other equipment and know-how.
MATinspired helps businesses develop and improve products with the help of measurements and customised research in the field of materials science and nanophysics. The fledgling company was established in 2008 by Niels Kuijpers, who has a Ph.D. in materials science. MATinspired works for such sectors as the automotive industry, the aerospace sector and the biomedical industry. MATinspired helps customers gain greater insight into their materials in order to improve the quality of their products. Research can also be geared to improving production, such as preventing fractures, deformations, inclusions, stain formation, or coating and welding problems.

Figure 1. Director Niels Kuijpers in MATinspired's lab. (Photo: Bart van Overbeeke)

Editor's note

This article is based on a MATinspired press release.

www.matinspired.nl

in new Catalyst centre

Characterising coatings

An example of the services provided is the characterising of applied coatings, to either determine or check quality. Various techniques are available for characterising a divergent array of layers: from extremely thin coatings with thicknesses in the order of nanometers up to layers of hundreds of micrometers thick.
Examples of layers for characterising are:

- vapour-deposited layers (titanium nitride, silicium nitride, indium tin oxide, silicon carbide, etc.);
- oxide layers (iron oxide, titanium oxide, aluminium oxide, zinc oxide, etc.);
- various semiconductor materials (II-V materials, photoresist layers, solar cell layers, etc.);
- plated layers (gold, copper, chrome, zinc, etc.);
- paint layers;
- organic layers.

Ellipsometry

The layer thicknesses of applied coatings can be determined with nanometer accuracy using the recently acquired Horiba Uvisel Ellipsometer; see Figure 2. Figure 3 shows schematically how the ellipsometer works. In most cases, thinly applied coatings are partially transparent. Ellipsometry uses polarised light that falls onto the sample at a specified angle. Part of this light is reflected directly by the surface, but part of it passes through the coating and is reflected by the substrate (e.g. metal). This impacts the intensity of the total outgoing light. The polarisation direction of the outgoing light is also different. The intensity and polarisation of the outgoing light are measured at various wavelengths. Then, with the help of a computer model, the thickness of the layer is determined to a high degree of accuracy. The advantage of ellipsometry is that measurements are done rapidly and that there is no need to prepare a sample. Measurements can be conducted directly on the sample itself (non-destructive).


Figure 2. The ellipsometer in the MATinspired lab can accurately determine the thickness of thin coatings.

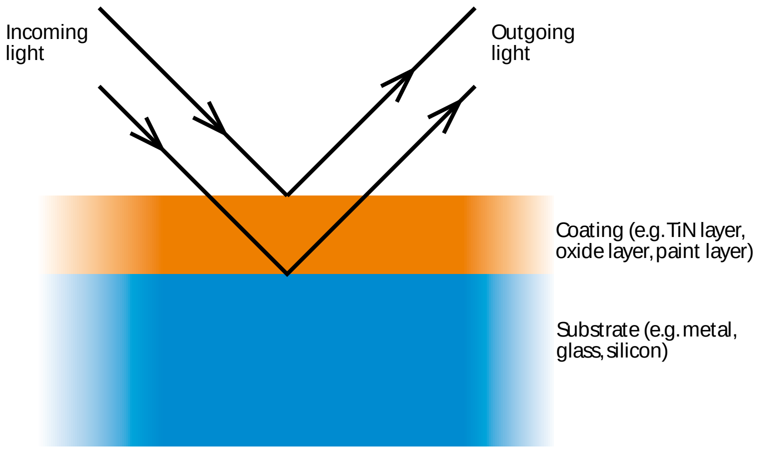


Figure 3. Highly simplified diagram of the working of an ellipsometric measurement of a thin coating.

Catalyst and Brainport Development

The Catalyst Technology & Business Incubator is one of Brainport Development's special business centres in the Eindhoven region, which was voted the smartest region in the world last year by the Intelligent Community Forum. Catalyst, a breeding ground for knowledge and innovation, is aimed at techno-starters whose activities focus on the development and marketing of technologically innovative products, processes and/or services.

www.brainportdevelopment.nl

1-6 July 2012, Amsterdam (NL)
SPIE Astronomical Telescopes + Instrumentation 2012

SPIE, the international society for optics and photonics, presents this event as a "fantastic showcase of the world's ideas and technologies for enabling astronomical research". There will be more than 2,200 technical presentations complemented by a program of professional development courses and an exhibition with over 80 companies.

spie.org

12-15 August 2012, Chicago, Ill. (USA)
ASME IDETC & CIE 2012

The ASME 2012 International Design Engineering Technical Conferences (IDETC) and Computers and Information in Engineering Conference (CIE) is the "flagship international meeting for Design Engineering" and comprises a number conferences, including the 1st Biennial International Conference on Dynamics for Design and the 36th Mechanisms and Robotics Conference.

www.asmeconferences.org/idetc2012

4-5 September 2012, Deurne (NL)
DSPE Conference

DSPE and Brainport Industries organise this first conference on precision mechatronics. The target group includes technologists, designers and architects in precision mechatronics, who (through their respective organisations) are connected to DSPE, Brainport Industries, the mechatronics contact groups MCG/MSKE or selected companies or educational institutes. See also page 42.

www.dspe-conference.nl

25-28 September 2012, Besançon (FR)
Micronora 2012

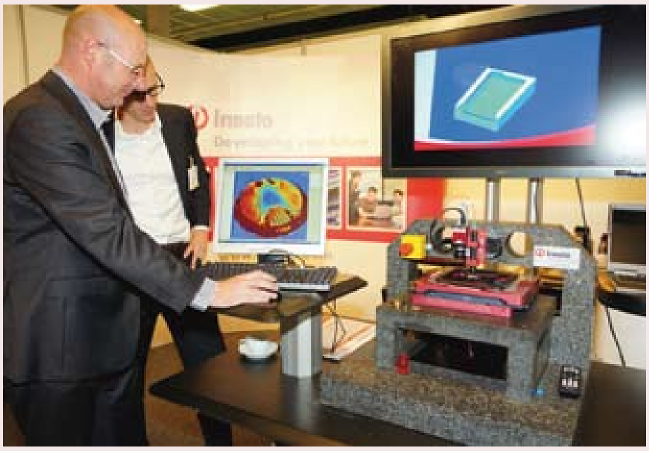
The biennial microtechnology and precision trade fair features multiple activities – from assembly, engineering and machining to metrology and nanotechnology – for markets with high technological value, including aerospace, (bio)medical, microelectronics and telecommunications. The event includes conferences and a European technology brokerage event on micro- and nanotechnology. Micronora 2010 attracted over 14,000 visitors and 565 direct exhibitors (200 from abroad), with a further 300 firms or brands represented.

www.micronora.com

25-28 September 2012, Amsterdam (NL)
HET Instrument 2012

Technology trade show, covering industrial electronics, industrial automation and laboratory technology, organised by FHI, Federation of Technology Branches. The previous edition, in 2010, attracted over 450 exhibitors and 17,000 visitors.

www.hetinstrument.nl



Impression of the Precision Fair 2011.
(Photo courtesy of Jan Pasman, Mikrocentrum)

8 November 2012, Den Bosch (NL)
Bits&Chips 2012 Embedded Systemen

Eleventh edition of the conference on embedded systems and software. Last November, the event celebrated its tenth anniversary with over 600 participants and some fifty high-tech companies and organisations presenting themselves at the conference venue.

www.embedded-systemen.nl

28-29 November 2012, Veldhoven (NL)
Precision Fair 2012

Twelfth edition of the Benelux premier trade fair on precision engineering. Some 250 specialised companies and knowledge institutions will be exhibiting in a wide array of fields, including optics, photonics, calibration, linear technology, materials, measuring equipment, micro-assembly, micro-connection, motion control, surface treatment, packaging, piezo technology, precision tools, precision processing, sensor technology, software and vision systems. The Precision Fair is organised by Mikrocentrum, with the support of DSPE, NL Agency, the Dutch Precision Technology association, and Dutch HTS, the gateway to the Dutch High Tech Systems industry.

www.precisiebeurs.nl

5-6 December 2012, Teddington (UK)
Topical Meeting: Structured and Freeform Surfaces

This meeting of the euspen Special Interest Group Structured and Freeform Surfaces will focus on the technology, needs and design of engineered surfaces. This is the fourth in the series of topical meetings on the manufacturing and metrology issues that modern manufacturing industry faces.

www.euspen.eu

10-11 December 2012, Ede (NL)
Netherlands MicroNanoConference ’12

Conference on academic and industrial collaboration in research and application of microsystems and nanotechnology. The eighth edition of this conference is organised by NanoNext.NL and MinacNed. Previous editions enjoyed attendance levels of approximately 450 academics and industrialists, visiting both the exhibition and the conference.

www.micronanoconference.nl

Programme of the

The first DSPE conference on precision mechatronics, an initiative of DSPE and Brainport Industries, will be held at the inspiring conference location of Willibrordhaeghe in Deurne, the Netherlands, on 4-5 September 2012. The target group includes technologists, designers and architects in precision mechatronics, who, through their respective organisations, are connected to DSPE, Brainport Industries, the mechatronics contact groups MCG and MSKE, or selected companies and research/educational institutes.

In addition to demos and paper and poster presentations, the conference will provide the ideal setting for networking, technical discussion and sharing the enthusiasm of working in this challenging field. The theme this year is ‘Systems Thinking’.

info@dspe-conference.nl
www.dspe-conference.nl
www.brainportindustries.com

The DSPE Conference is organised by DSPE and Brainport Industries, the association of leading tier-one, tier-two and tier-three high-tech suppliers in the Eindhoven region.

Programme

Tuesday 4 September 2012

Morning

- Harry Borggreve (Senior Vice President ASML), *Opening session*
- Prof. Paul Shore (Head of the Cranfield University Precision Engineering Institute), *Systems thinking in advancing productivity of ultra precision machines*

Afternoon

Session 1 Precision Technology I

- Hans Vermeulen, R. van Lieshout, H. Butler, M. van de Wal, W. Aangenent, H. Heintze, R. Beerens, S. Donders (ASML), *450 mm lithography challenges*
- Eelco van Hoeven, J. van Koppen, P. Kappelhof (Hittech Multin), *Design of a 2 DOF scan stage with nanometer accuracy in an electron microscope*
- Dick Laro, E. Boots, J. van Eijk, L. Sanders (MI-Partners), *Novel through-wall 450 mm vacuum compatible wafer stage*

Session 2 Motion Control I

- Edwin Verschueren, M. Lagrange (FEI Electron Optics), *UHR-Stage Motion Control Tuning*
- Eric Smeets (Philips Healthcare), *Motion control challenges in a medical environment*
- Sjirk Koekebakker, R. Blom, P. van den Bosch (Océ Technologies), Bas Lemmen, Okko Bosgra (TU Eindhoven), *How to get 50% more speed out of an existing print platform*

Session 3 System Engineering and Design I

- Johan Bosman (ECN Solliance), Hans Kooter (ECN EEE), *Back end laser scribing and inkjet for thin film solar R2R production tool*
- Raymond Knaapen, P. Poodt, R. Olieslagers, A. Lankhorst, M. van den Boer, D. van den Berg, A. van Asten (TNO), F. Roozeboom (TNO/TU Eindhoven), *Atmospheric Spatial Atomic Layer Deposition in Roll-to-Roll Processes*
- Philippus Feenstra, N. den Haak (SKF), *Load Sensing and Condition Monitoring for a Subsea-multiphase pump*

first DSPE conference

Programme

Wednesday 5 September
Morning
Session 4 Business/System Architecture

- Henk Tappel (Frencken Europe), *Mechatronics as a money maker*
- David Rijlaarsdam, E. Hezemans (NTS System Development), *Extending Boundaries in System Thinking*
- Hans Kuppens (CCM), *System Architecture in Medical Application for Pathology*

Session 5 New Business

- Ad Vermeer (Adinsyde), *System and Business Architecture of Spatial ALD Equipment for Solar Cell Production from SoLayTec*
- Edwin Bos, A.J.M. Moers, M.C.J.M. van Riel (Xpress Precision Engineering), *Design aspects of the TriNano ultra precision CMM*
- Henk Jan Zwiers (MuTracx), *Revolutionizing the PCB industry with an industrial inkjet printing solution*

Session 6 Motion Control II

- Dennis Bruijnen, N. van Dijk, S. Jia (Philips Innovation Services), *A practical comparison of feedforward control design techniques for high-precision motion systems*
- Thiemo van Engelen (NXP ITEC), *NXP ITEC implements advanced control in high speed wire bonder*
- Rob Hoogendijk, R. van de Molengraft, M. Steinbuch (Eindhoven University of Technology), *Data-based control design methods for lightweight high-precision motion systems*

Afternoon
Session 7 Precision Technology II

- Henk Mol (SKF Engineering and Research Centre), *Angle Sensing Bearings*
- Jack van der Sanden, P. Philips (Philips Innovation Services), *FEM model based POD reduction to obtain optimal sensor locations*
- Nima Tolou, P. Pluimers, J. Herder (Delft University of Technology), B. Jensen, S. Magleby, L. Howell (Brigham Young University), *Carbon-Nanotube-Based Constant Force Mechanisms*

Session 8 System Engineering and Design II

- Bram Krijnen, D.M. Brouwer (Demcon Advanced Mechatronics / University of Twente), *A closed-loop large range of motion positioning system in MEMS*
- Gerrit van der Straaten (Settels Savenije van Amelsvoort), *"Systems thinking" to meet contradicting system requirements*
- Rob de Jongh (ASML), *Mechatronic challenges for control of mirrors*

New international Holland High-Tech Systems conference

Brainport Industries, DSPE, Syntens/Enterprise Europe Network and Techwatch (publisher of Bits&Chips and Mechatronica) have taken the initiative to organise a high-tech event with an international flair in the southern part of the Netherlands.

The event builds on Hightech Mechatronica, the trade fair and conference that Techwatch has been organising since 2007. The name of the revamped event is Holland High-Tech Systems, subtitled International Conference and Exhibition on Mechatronics and Precision Technology. The collaborating partners are aiming for a three-day event, during which international delegations and guests will be offered a programme involving company visits and matchmaking on Tuesday, and a conference and exhibition organised by Techwatch on Wednesday and Thursday.

The conference meets the need for an international branding of Holland High-Tech as part of the top sector for High-Tech Systems and Materials. HTSM is one of the top sectors designated by the Dutch government to spearhead its economic policy. The sector is aiming to double exports of 32 billion euros in 2009 to 77 billion euros by 2020.

The initiators will be organising a conference and a trade fair in March/April 2013 that will attract three thousand top-notch visitors, a quarter of whom from neighbouring countries. The idea is to use the Netherlands' unique high-tech formula to attract these international visitors. The top-quality knowledge in the field of mechatronics and precision technology has helped the Netherlands rise to a leading position in the global ranking of key technology regions.

As with Hightech Mechatronica, an independent lecture committee will assess proposals for presentations at the Holland High-Tech Systems conference. A sounding board comprising people from industry, government and the academic world will be formed to advise on subject matter and direction at this new international high-tech event.

Impression of Hightech Mechatronica 2012, the event on which the new Holland High-Tech Systems is to build. (Photo courtesy of Techwatch)

Precision Fair expanding

Mikrocentrum has been organising the Precision Fair at the NH Conference Centre Koningshof in Veldhoven, the Netherlands, for a number of years. This trade fair attracts large numbers of visitors and exhibitors, and was in fact fully booked with exhibitors in recent years.

Mikrocentrum therefore decided to look at alternative venues or to explore the possibility of expanding at the existing venue. Based on feedback from the exhibitors and visitors, there is a strong preference to stay at the existing venue, partly on account of the conference facilities, hotel accommodation, excellent accessibility, ample and free parking, and the wish to keep organising the exhibitors' buffet in the evening. Furthermore, after so many years, Veldhoven has become synonymous with the Precision Fair.

Expansion at the current venue was difficult but was successfully done thanks to the concerted efforts of Koningshof and Mikrocentrum. Koningshof is investing in modifications to the infrastructure and Mikrocentrum is investing in a new, semi-permanent hall that will provide space for approximately 40 further exhibitors. For these additional stands, priority will be given to companies that have previously shown an interest.

The twelfth edition of the Benelux premier trade fair on precision engineering will be held on 28 and 29 November 2012 at Koningshof. Some 250 specialised companies and knowledge institutions will be exhibiting in a wide array of fields, including optics, photonics, calibration, linear technology, materials, measuring equipment, micro-assembly, micro-connection, motion control, surface treatment, packaging, piezo technology, precision tools, precision processing, sensor technology, software and vision systems.

www.precisiebeurs.nl

Benelux Laser Event 2012

The laser world is not resting on its laurels and new developments (products, processes and services) are contributing to a more sustainable manufacturing industry. The one-day Benelux Laser Event will highlight the impact that laser technology can have on companies and the role a knowledge partner can play in it. The focus is on developments in the field of high-capacity laser applications, such as cutting, welding, cladding and additive manufacturing, and their contribution to sustainability.

Organised by Mikrocentrum in association with VITO (the Flemish Institute for Technological Research), the event will be held on 25 September 2012 at VITO in Mol (Belgium). The latest developments can be viewed live in VITO's laser lab. The Benelux Laser Event will also highlight a number of initiatives for knowledge transfer to companies, including laser cutting using modern fibre and disc lasers, and the certification of laser processes.

www.mikrocentrum.nl

Impression of the previous edition of the Precision Fair at a crowded Koningshof. (Photo courtesy of Jan Pasman, Mikrocentrum)

Jan van Eijk receives euspen 2012 Lifetime Achievement Award

Early June, at the euspen Conference in Stockholm, Jan van Eijk was awarded the euspen 2012 Lifetime Achievement Award. According to euspen, Prof.Dr.Ing. Jan van Eijk is, without doubt, a world leading authority in the field of high-precision mechatronics. Today, he provides consultancy expertise to world-renowned precision equipment manufacturers through his own company MICE, not only on technical concepts and designs for systems but also on how to develop key competences necessary for the successful growth of advanced technology organisations.

His unique skills and expertise have arisen from the knowledge and experience gained from working at Philips, Eindhoven, the Netherlands, where he became Chief Technical Officer of Mechatronics, and also from his 12 years' experience as part-time professor at Delft University of Technology.

Jan van Eijk gained his Ph.D. at Delft in 1985, after which he was invited to join the Philips Centre for Manufacturing Technology. The invitation came from a leading specialist of that time, Prof. Wim van der Hoek, who was nearing the end of his career. Over a 30-year period, Van der Hoek had been a leader in establishing a large community of technical specialists chiefly responsible for the success of Philips's industrial activities from 1955 to 1985. Jan van Eijk found this strong technical community based on the open exchange of knowledge and continuous learning to be fertile ground for his own development.

During his years at Philips, Jan van Eijk was himself driven by two guiding principles. The first was the need to always thoroughly understand technical issues in every detail. He compelled his staff to translate complex science to simple descriptions, thereby permitting broader groups of individuals to contribute to the development of engineering solutions. One example is the representation of Modal Decomposition that has helped many engineers improve the critical interaction of machine dynamics and control.

His second principle was the need to protect and grow the existing community and network of technical specialists. He is convinced that such a network of world-renowned mechatronics and precision engineering specialists continues to form the basis of the highly competitive industrial activities in the Eindhoven region. He points to a 12-day intensive industrial mechatronics training course which has trained more than 1,000 engineers in the interactive skills needed for effective mechatronics systems development. Other training activities and conferences have also contributed strongly to this.

During his time at Philips he contributed extensively to the conceptual design of a multitude of advanced technical systems, one of which was the Compact Disc modules using actively controlled motion systems to achieve micrometer accuracy. Arguably the most important contribution made by Jan van Eijk and many colleagues was the architecture of the mechatronic elements of ASML's world leading lithography tools. Here, nanometer performance at accelerations of up to 100 m/s^2 had to be achieved together with extreme attention to fully integral system optimisation.

Jan van Eijk has made outstanding contributions to national and international societies in mechatronics and high-precision engineering. He has served on the Council of euspen and the Board of ASPE for several years. He has made huge contributions to the enrichment, development and growth of the euspen society, by applying his second guiding principle to building its international network and running leading tutorials in precision mechatronics. It is therefore, that euspen decided to award this outstanding engineer, Jan van Eijk, the euspen 2012 Lifetime Achievement Award.

www.euspen.eu

Distance measurement with thousands of lasers simultaneously

A laser is frequently applied as a tool for accurate measurement of distance, with the laser wavelength serving as a 'ruler'. The Dutch national metrology institute VSL and Delft University of Technology have developed a new technique to exploit the thousands of wavelengths that are present in the spectrum of a femtosecond laser for distance measurement. The wavelengths of such a 'frequency comb' are locked to an atomic clock for direct traceability to the SI second. Using a spectrometer with an unprecedented resolution, the closely spaced wavelengths are individually resolved.

A wealth of information is obtained when measuring a distance with all wavelengths simultaneously. This allows for direct measurement of absolute distances with a measurement uncertainty on the level of tens of nanometers. In this scheme it is not necessary to generate a displacement and measure incrementally, which is an important advantage compared to the single-wavelength scheme. The new method may find applications in set-ups that require accurate absolute distance measurement that cannot be determined incrementally, like the determination of distances between satellites.

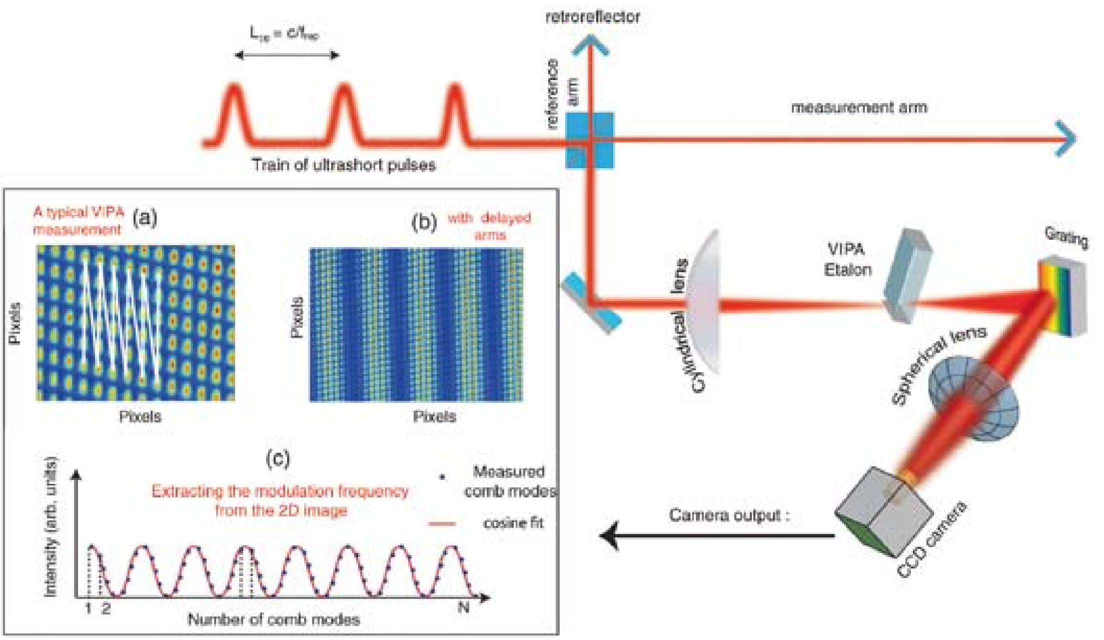
S.A. van den Berg, S.T. Persijn, G.J.P. Kok, M.G. Zeitouny and N. Bhattacharya, "Many-Wavelength Interferometry with Thousands of Lasers for Absolute Distance Measurement". *Phys. Rev. Lett.*, Vol. 108, 183901, 2012.

www.vsl.nl

New micro & nano newsletter

This spring, the first newsletter of the Micro- & Nanotechnologies sector group of the Enterprise Europe Network was issued. The aim of the sector group is to support (clusters of) SMEs, multinationals, universities and research institutes in the micro & nano field, in finding innovative technological solutions to complement their product development, as well as in finding clients and co-operation partners for their products and processes. In addition, the sector group can arrange visits of trade fairs and companies, and it provides information on European policies, programmes and regulations.

portal.enterprise-europe-network.ec.europa.eu/about/sector-groups/nano-microtechnologies



Schematic overview of the set-up for unraveling the output of a Michelson interferometer into distinct modes. In the inset (a) a small fraction of a typical CCD image is shown, as obtained with the measurement path blocked. Inset (b) shows a part of the CCD image when interference between the two arms occurs. The mode-resolved signal is mapped on a frequency axis by stitching together vertical lines, as schematically indicated by the white arrows (in reality one vertical line consists of about 50 dots). The result is shown in (c).

6D nano-precision

ALIO Industries has developed a hexapod 6-axis motion system through the integration of its Tripod with two nano-precision XY stages and a rotary stage. According to ALIO, this motion system covering six degrees of freedom can achieve True Nano^{TM} precision. Test results indicate a repeatability in X, Y and Z of +/– 63, 81 and 35 nm, respectively, and a repeatability in pitch, roll and yaw of +/– 0.3, 0.4 and 0.3 arcsec, respectively

Due to its basic physics, the platform can outperform other hexapod systems while increasing the work envelope and significantly increasing the stiffness of the structure, making this platform ideal for nano-machining and thermal bonding applications where reactive forces are common. The ALIO product family of Linear Servo Tripods can be packaged from three axes to more than six axes while still maintaining the ALIO forward and inverse kinematic equations allowing for G-Code programming as in traditional machine tools.

ALIO products are available in the Netherlands through Groneman.

www.alioindustries.com
www.groneman.nl

Assembléon welcomes new CEO

Jeroen de Groot, the new CEO of Assembléon.

One year after the privatisation from Royal Philips, the management of Assembléon has been transferred to a new CEO and management team, fully composed of people with a long experience with Assembléon, its customers and technology. The new management team is lead by Jeroen de Groot, formerly responsible for Marketing and Innovation of Assembléon.

Assembléon, a global supplier of Surface Mount Technology (SMT) Pick & Place solutions for the electronics manufacturing industry, with headquarters in Eindhoven, the Netherlands, became an independent company in April 2011. Since that time Assembléon has made substantial progress, according to a press release. It has been able to turn itself around into a profitable company, realised a worldwide very successful introduction of its new pick & place platform iFlex and expanded its business, products and customer relations in the back-end, embedded and module market.

www.assembleon.com

Holland High Tech website launched

This spring, the English-language website www.hollandhightech.nl was launched. The website provides information on the Dutch high-tech sector, including facts & figures, presentations, images and case stories on innovative developments that substantiate the “Holland High Tech” claim. The website, powered by FME, the Dutch organisation representing employers and businesses in the technological industry, and the Ministry of Economic Affairs, Agriculture and Innovation, features “High Tech Solutions for Global Challenges”.

www.hollandhightech.nl

New miniature goniometer positioning stages

Complementing and completing Nanomotion’s range of ceramic motor driven miniature positioning stages, the new FBG series goniometer is available in four stack sizes that combine to provide a common pivoting point for a two-axis tip/tilt angular motion set-up with a positioning resolution as low as 1 arcsec. Available from UK-based Heason Technology, the low-profile stages provide pivot axis radii of 71, 96, 102 and 137 mm.

The new FBG goniometer features Nanomotion’s HR series high-force ceramic motors with non-contact optical encoders and precision cross-roller bearings. With the encoders and bearings in a precise curved design that follows the travel profile, according to a press release, the goniometer stage provides a wide dynamic speed range with very high acceleration characteristics, exceptional smoothness with high stiffness, zero backlash, and an excellent load carrying capacity. The entire Nanomotion stage range can be assembled to provide multi-axis automated micropositioning covering all six degrees of freedom and prepared for standard, vacuum and UHV environments.

www.heason.com
www.nanomotion.com

Course	CPE points	Provider	Starting date (location, if not Eindhoven)
Basic			
Mechatronic System Design (parts 1 + 2)	10	HTI	1 October 2012 (part 1) 5 November 2012 (part 2)
Construction Principles	3	MC	30 October 2012 (Utrecht)
System Architecting	5	HTI	29 October 2012
Design Principles Basic	5	HTI	14 November 2012
Motion Control Tuning	6	HTI	20 November 2012
Deepening			
Metrology & Calibration of Mechatronic Systems	2	HTI	to be planned
Actuators for Mechatronic Systems	3	HTI	8 October 2012
Thermal Effects in Mechatronic Systems	2	HTI	to be planned
Summer school Optomechatronics	5	DSPE	25 June 2012
Dynamics & Modelling	3	HTI	3 December 2012
Specific			
Applied Optics	6.5 6.5	MC HTI	13 September 2012 30 October 2012
Machine Vision for Mechatronic Systems	2	HTI	27 September 2012
Electronics for Non-Electronic Engineers	10	HTI	8 January 2013
Modern Optics for Optical Designers	10	HTI	25 January 2013
Tribology	4	MC	30 October 2012 (Utrecht) 27 November 2012
Introduction in Ultra High & Ultra Clean Vacuum	4	HTI	29 October 2012
Experimental Techniques in Mechatronic Systems	3	HTI	to be planned
Design for Ultra High & Ultra Clean Vacuum	4	HTI	26 November 2012
Advanced Motion Control	5	HTI	8 October 2012

DSPE Certification Program

Precision engineers with a Bachelor's or Master's degree and with 2-10 years of work experience can earn certification points by following selected courses. Once participants have earned a total of 45 points (one point per course day) within a period of five years they will be certified. The CPE certificate (Certified Precision Engineer) is an industrial standard for professional recognition and acknowledgement of precision engineering-related knowledge and skills.
The certificate holder's details will be entered into the international Register of Certified Precision Engineers.

www.dsperegistration.nl/list-of-certified-courses

Course providers

- The High Tech Institute (HTI)
  www.hightechinstitute.nl
- Mikrocentrum (MC)
  www.mikrocentrum.nl
- Dutch Society for Precision Engineering (DSPE)
  www.dspe.nl

Mikroniek guide

Bearing and Linear Technology

Schaeffler Nederland B.V.

Schaeffler Nederland B.V.
Gildeweg 31
3771 NB Barneveld
T +31 (0)342 - 40 30 00
F +31 (0)342 - 40 32 80
E info.nl@schaeffler.com
W www.schaeffler.nl

Schaeffler Group - LuK, INA and FAG - is a world wide leading company in developing, manufacturing and supplying of rolling bearings, linear systems, direct drives and maintenance products. Applications: automotive, industrial and aerospace.

Development

TNO
Postbus 6235
5600 HE Eindhoven
T + 31 (0)88-866 50 00
E wegwijzer@tno.nl
W www.tno.nl

member DSPE

Development and Engineering

ACE ingenieurs- & adviesbureau werktuigbouwkunde en elektrotechniek BV
Dr. Holtroplaan 25
5652 XR Eindhoven
T +31 (0)40 - 2578300
F +31 (0)40 - 2578397
E info@ace.eu
W www.ace.eu

ACE has developed into a leading engineering and consultancy firm with a strong focus on mechanics and mechatronics. Services include conceptualization, development, engineering and prototyping.

member DSPE

Education

top opleidingen voor professionals

Engenia
High Tech campus 9
ß Building
Room 3.27
5656 AC Eindhoven

T +31 (0)40-7513921
M +31 (0)6-51626976
E ad.brouwers@engenia.nl
W www.engenia.nl

Leidse instrumentmakers School

Leiden school for Instrumentmakers (LiS)
Einsteinweg 61
2333 CC Leiden
The Netherlands
T +31 (0)71-5581168
F +31 (0)71-5681160
E info@lis-mbo.nl
W www.lis-mbo.nl

The LiS is founded in 1901 by the famous scientist prof. Kamerlingh Onnes. Nowadays the LiS is a modern school for vocational training on level 4 MBO-BOL. The school encourages establishing projects in close cooperation with contractors and scientific institutes, allowing for high level “real life” work.

member DSPE

opleiden • ontmoeten • ondernemen

Mikrocentrum
Kruisstraat 74
5612 CJ Eindhoven
Postbus 359
5600 AJ Eindhoven
T +31 (0)40 296 99 11
F +31 (0)40 296 99 10
E info@mikrocentrum.nl
W www.mikrocentrum.nl

member DSPE

PAO Techniek
Stevinweg 1, 2628 CN Delft
Postbus 5048, 2600 GA Delft
T +31 (0)15 27 88 350
F +31 (0)15 27 84 619
E info@paotechniek.nl
W www.cursus.paotechniek.nl

Laser Systems

Applied Laser Technology
De Dintel 2
5684 PS Best
T +31 (0)499 375375
F +31 (0)499 375373
E techsupport@alt.nl
W www.alt.nl

member DSPE

TRUMPF Nederland B.V.
Oude Boekeloseweg 31
7553 DS Hengelo
Postbus 837
7550 AV Hengelo
T +31 (0)74 2498498
F +31 (0)74 2432006
E info@nl.trumpf.com
W www.nl.trumpf.com

member DSPE

Linear Technology

The Mark of Linear Motion

LM Systems BV
Kruisboog 2
3905 TG Veenendaal
T +31 (0)318-554615
F +31 (0)318-550842
E info@thk.nl
W www.thk.nl

THK/LM Systems is your partner for all Linear Motion products.
Our creative ideas and unique technology made us pioneers in the development of the Linear Motion (LM) Guide mechanism.

member DSPE

3D Measurement Services

Mitutoyo Nederland B.V.
Storkstraat 40
3905 KX Veenendaal

T +31 (0)318-534911
F +31 (0)318-534811
E info@mitutoyo.nl
W www.mitutoyo.nl

We make it visible.

Carl Zeiss
Industrial Metrology
Trapezium 300
3364 DL Sliedrecht
T +31 (0)184 433 551
F +31 (0)184 433 500
E m.trupia@zeiss.nl
W http://www.zeiss.nl

Carl Zeiss Industrial Metrology is the world’s leader in CNC coordinate measuring machines and complete solutions for multidimensional metrology in the metrology lab and production environment. We also provide contract programming and contract measuring in our newly founded Measuring House near Eindhoven (NL).

Mikroniek guide

Mechatronics Development

centre for concepts in mechatronics

CCM Centre for Concepts in Mechatronics
De Pinckart 24
5674 CC Nuenen
T +31 (0)40 2635000
F +31 (0)40 2635555
E info@ccm.nl
W www.ccm.nl

CCM translates technology into technique.
Commitment, motivation, education and skills of our employees are the solid basis for our business approach.

member DSPE

Metal Precision Parts

ETCHFORM metal precision parts

Etchform BV
Arendstraat 51
1223 RE Hilversum
T +31 (0)35 685 51 94
E info@etchform.com
W www.etchform.com

Etchform is a production and service company for etched and electroformed metal precision parts.

member DSPE

Micro Drive Systems

MINIMOTOR Benelux Miniature Drive Systems FAULHABER

Minimotor Benelux

Belgium
Dikberd 14/6c
B-2200 Herentals
T +32 (0)14-21 13 20
F +32 (0)14-21 64 95
E info@minimotor.be

The Netherlands
Postbus 49
NL-1540 Koog a/d Zaan
T +31 (0)75-614 86 35
F +31 (0)75-614 86 36
E info@minimotor.nl
W www.faulhaber.com

Faulhaber is a leading manufacturer of miniature drive systems based on ironless micromotors with the highest power-to-volume ratio.

member DSPE

Micromachining

REITH LASER

Reith Laser bv
Bijsterhuizen 24-29
6604 LK Wijchen
The Netherlands
T +31 (0)24 3787564
F +31 (0)24 3787586
E info@reithlaser.nl
W www.reithlaser.nl

For more than 22 years Reith Laser bv is the leading supplier of laserprocessed products in Europe.
We can offer you a great diversity of lasermaterialprocessing activities:

- Laser- (micro-) cutting
- Laser drilling
- Laser welding
- Laser micromachining

Reith Laser is active in precision industry, medical industry, aerospace, semiconductor- and automotive industry.

Motion Control Systems

AEROTECH

Aerotech LTD
Jupiter House, Calleva Park
Aldermaston
Berkshire
RG7 8NN England
T +44 (0)118 9409400
F +44 (0)118 9409401
E sales@aerotech.co.uk
W www.aerotech.co.uk

ALT

Applied Laser Technology
De Dintel 2
5684 PS Best
T +31 (0)499 375375
F +31 (0)499 375373
E techsupport@alt.nl
W www.alt.nl

member DSPE

IBS Precision Engineering

IBS Precision Engineering
Esp 201
5633 AD Eindhoven
T +31 (0)40 2901270
F +31 (0)40 2901279
E info@ibspe.com
W www.ibspe.com

IBS Precision Engineering is an innovator in high-grade precision engineering and involved in special machines, machine tool calibration & inspection, noncontact precision sensors, air bearings and laser interferometer systems.

member DSPE

Newport Experience | Solutions

Newport Spectra-Physics B.V.
Vechtensteinlaan 12 - 16
3555 XS Utrecht
T +31 (0)30 6592111
E netherlands@newport.com
W www.newport.com

Newport Spectra-Physics BV, a subsidiary of Newport Corp., is a worldwide leader in nano and micro-positioning technologies.

member DSPE

Reliance Precision Mechatronics LLP

Reliance Precision Mechatronics LLP
Florijnstraat 20
4879 AH Etten-Leur
The Netherlands
T +31 (0)76 5040790
F +31 (0)76 5040791
E sales@rpmechatronics.co.uk
W www.rpmechatronics.co.uk

- Positioning systems
- Drives
- Standard components
- Mechatronic assemblies

Manufacturer of among others: gears, rack, couplings and linear systems

Motion Control Systems

Rotero Holland bv
Pompmolenlaan 21
3447 GK Woerden
Postbus 126
3440 AC Woerden
T +31 (0)348 495150
F +31 (0)348 495171
E info@rotero.com
W www.rotero.com

Rotero is specialized in small electrical motors and mechanical drives. Products: AC-, DC-, stepper- and servo motors up to 1,5 kW, actuators and small leadscrews.

Optical Components

Applied Laser Technology
De Dintel 2
5684 PS Best
T +31 (0)499 375375
F +31 (0)499 375373
E techsupport@alt.nl
W www.alt.nl

member DSPE

Molenaar Optics
Gerolaan 63A
3707 SH Zeist
Postbus 2
3700 AA Zeist
T +31 (0)30 6951038
F +31 (0)30 6961348
E info@molenaar-optics.nl
W www.molenaar-optics.eu

member DSPE

Piezo Systems

Applied Laser Technology
De Dintel 2
5684 PS Best
T +31 (0)499 375375
F +31 (0)499 375373
E techsupport@alt.nl
W www.alt.nl

member DSPE

Heinmade B.V.
High Tech Campus 9
5656 AE Eindhoven
T +31 (0)40 8512180
F +31 (0)40 7440033
E info@heinmade.com
W www.heinmade.com

HEINMADE develops and supplies piezo system solutions for positioning and vibration damping. HEINMADE cooperates with and is distributor of Nanomotion, Noliac and Piezomechanik.

Technical Ceramics

Ceratec Technical Ceramics BV
Poppenbouwing 35
4191 NZ Geldermalsen
T +31 (0)345 580101
F +31 (0)345 577215
E ceratec@ceratec.nl
W www.ceratec.nl

Ceratec has specialized in industrial components constructed from technical ceramics since 1983. Ceratec`s strength lies in the total formula of problem analysis, development, prototyping and production. Ceratec has modern production facilities for processing technical ceramics.

member DSPE

Your company profile in this guide?

Please contact:
Sales & Services
Gerrit Kulsdom
+31 (0)229 211 211
gerrit@salesandservices.nl

ADVERTISERS INDEX

25 – 28 SEPT. AMSTERDAM RAI
HET
INSTRUMENT
2012
X-PLORE
ELECTRONICS
INDUSTRIAL ELECTRONICS
INDUSTRIAL AUTOMATION
LABORATORY TECHNOLOGY
www.hetinstrument.nl


HEIDENHAIN
Hitting a hole in one across town?
Imagine standing on the golf course teeing off, and playing well. The ball flies and flies—and lands in the hole. A classic hole in one! Now imagine that the hole were about 17 kilometers away on the other side of town. And you tee off countless times and score a hole in one each time. Hard to imagine? For any golfer in this world, yes. But not for the LC sealed absolute linear encoders from HEIDENHAIN! Positioning over a one meter path of traverse to an accuracy of ± 3 µm—at 17 km that's half the diameter of the hole. Reliability, flexibility, resilience and its high integration density of electronic components make the LC the unbeatable champion on any course.
HEIDENHAIN NEDERLAND B.V., Postbus 92, 6710 BB Ede, Tel.: (0318) 581800, Fax: (0318) 581870, http://www.heidenhain.nl, e-mail: verkoop@heidenhain.nl
Absolute
linear encoders LC
angle encoders + **linear encoders** + contouring controls + digital readouts + length gauges + rotary encoders