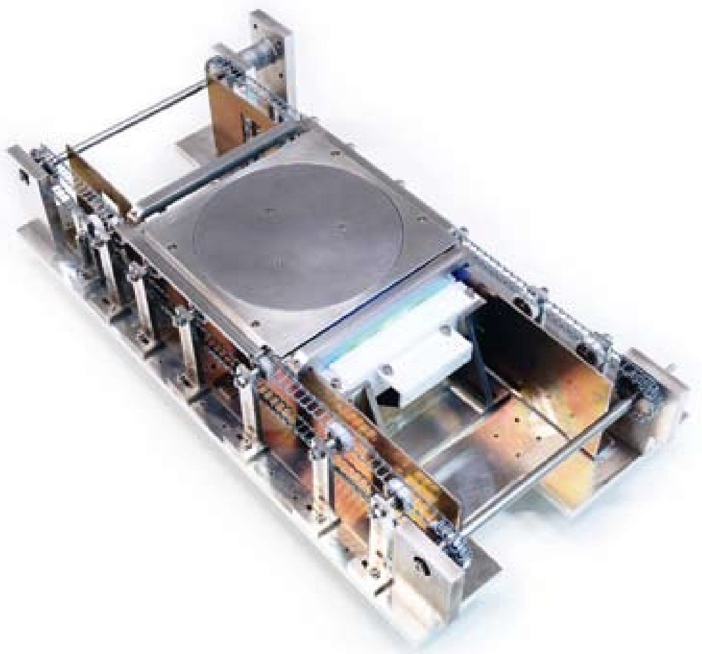
Mikroniek

PROFESSIONAL JOURNAL ON PRECISION ENGINEERING 2011 (VOL. 51) – ISSUE 5

Creating artificial laser guide stars using Optical Tube Assemblies
LUXeXceL's printoptical technology for stacking droplets-on-demand
Micromanufacturing in glass-ceramics • PiezoMotor takes nanometer steps
Holland Instrumentation Delta • Twin-head fiber alignment

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

THE DEVIL IS IN THE DETAILS



TNO innovation for life

CLEAN, CLEANER, CLEANEST

Chipmakers strive constantly to make smaller and cheaper products. To keep up with this trend the structures on a chip are getting ever smaller and the wafers ever bigger.

On these increasingly smaller chip structures even smaller particles (in the order of 50 nanometer) are producing defects that may cause the chip to stop functioning. So it is essential for the manufacturing processes to be extremely clean and for any contamination like dust particles to be entirely removed. TNO develops future-proof solutions like plasma, cleaning rolls and electrical fields for cleaning wafers. Rapid, efficient and affordable innovation for industrial application.

TNO.NL

5

Mikroniek - 2011

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, The Netherlands
+31 (0)40 - 296 99 15 / 26 (tel/fax)
info@dspe.nl, www.dspe.nl

Editorial board
Ir. Herman Soemers (chairman, Philips Innovation Services), ir.ing. Bert Brals (CCM), ir. Jos Gunsing (NTS Mechatronics, Avans), ir. Bart Dirkx (TMC), ir. Rob van Haendel (Philips Innovation Services), ir. Huub Janssen (Janssen Precision Engineering), ir. Henk Kiela (Opteq, Fontys), ir. Casper Kruijer, MBI (FEI), ing. Ronald Lamers, M.Sc. (MI-Partners), ir. Piet van Rens (Settels Savenije van Amelsfoort), ir. Ad Vermeer (SoLayTec, Adinsyde)

Editor
Hans van Eerden
hans.vaneerden@dspe.nl

Advertising canvasser
Sales & Services
PO Box 2317, 1620 EH Hoorn (NL)
+31 (0)229 - 211 211 (tel), sns@wxs.nl

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

Subscription costs
The Netherlands € 70.00 (excl. VAT) per year
Abroad € 80.00 (excl. VAT) per year

Mikroniek appears six times a year.

© Nothing from this publication may be reproduced or copied without the express permission of the publisher.

ISSN 0026-3699

The cover photo (completed Optical Tube Assembly) is courtesy TNO/F. Kamphues.

editorial

Intelligent Community welcomes Certification Program

The Eindhoven region, also dubbed Brainport, has been declared Intelligent Community of the Year 2011. Over 400 regions around the world were in the running. After an initial ranking, the Intelligent Community Forum jury travelled to the city to form a well-founded opinion, resulting in us now joining an exclusive list of previous winners such as New York, Taipei, Singapore, Stockholm and Seoul. I'm very proud of this fact. Fifteen years ago, the picture here was very different: truck manufacturer DAF had gone bankrupt and the head office of electronics firm Philips, the heart of industry in our region since time immemorial, had disappeared. And now the region has shot to the top, thanks to the successful collaboration between authorities, knowledge institutes and the business community. This so-called triple helix has laid down its vision in the Brainport 2020 document.

Part of the reason we won the prize is because of the precision machines that are developed and built here by OEMs like ASML, Philips and FEI, in collaboration with dozens of first-tier and hundreds of second-tier suppliers.

That said, even in the most intelligent region we still have problems. For example, there is a lack of public investment in R&D, which we may come to regret in the future. Moreover, the accessibility of our country to international knowledge workers, even for short stays, is problematic. However, my main concern is the fact that, every day, we lose out on 12 people from the core of our region: technology. This is why I visit secondary and primary schools to tell kids about the options for technology, so that we will be able to tackle future societal challenges in the fields of food, water, ICT, energy, etc.

Compared to countries like Germany and France, the Netherlands is far behind in terms of efforts in the field of life-long learning. That's our weakest link when it comes to education and training, which is why I really appreciate the fact that DSPE has launched a Certification Program for Precision Engineers with the support of the Point-One innovation programme. This is really essential, because with fewer people we will need more knowledge and skills to fight the competition. We have to be quicker at applying knowledge, so we need to invest more energy into updating it. As such, I'd like to wish DSPE and Brainport Eindhoven every success with this Certification Program.

Rob van Gijzel
Mayor of Eindhoven and Chairman of Brainport Foundation

Creating artificial stars

Atmospheric turbulence reduces the image quality of ground-based astronomical telescopes. Adaptive optics is increasingly applied to correct for this. A wavefront sensor measures the distorted wavefront coming from the star, a computer calculates the required correction, and a deformable mirror rapidly deforms such that the wavefront is flat after reflection on this mirror. There are however insufficient bright stars to serve as a reference for the wavefront measurement. Astronomers therefore now create their own stars. TNO has developed the Optical Tube Assemblies for the ESO Very Large Telescopes, which is a projection system for generating these artificial laser guide stars.

• ***Rens Henselmans, David Nijkerk, Martin Lemmen, Niek Rijnveld and Fred Kamphues*** •

ESO (European Southern Observatory) operates the Very Large Telescopes (VLT, see Figure 1). These 8.2 meter telescopes are located in the Atacama Desert in Chile, at 2,635 m altitude, because it is one of the driest places on earth with virtually no cloud cover year round. There is almost no light pollution from civilisation, and there is less air to see through because of the high altitude.

ESO is now equipping one of these telescopes with a new Adaptive Optics Facility (AOF, [5]). This system will correct for atmospheric turbulence, to further improve the telescope's performance. Adaptive Optics is a key technology for the future European Extremely Large Telescope (E-ELT), and the VLT AOF will serve as a

Authors' note

This article is based on papers presented at SPIE Optics & Photonics 2011 [1, 2, 3] and the Symposium on Integrated Modeling of Complex Optomechanical Systems 2011 [4]. Rens Henselmans, Martin Lemmen and Niek Rijnveld work for the TNO Optomechatronics department as system engineer, thermal analyst and mechatronic designer, respectively. David Nijkerk is an optical designer for the TNO Optics department, and Fred Kamphues is a project manager at the TNO Space department. They are all based in Delft, the Netherlands.

www.tno.nl/vtl4lgsf

Figure 1. ESO Very Large Telescope observatory with current laser guide star in operation. (Photo courtesy ESO)

technology demonstrator for the E-ELT. With the new AOF, the VLT images will be as sharp as those made by the Hubble Space Telescope.

Laser guide stars

The faintest objects in the sky are usually the most interesting ones, because they are the furthest away and therefore the oldest. The few photons coming from these objects are insufficient for the wavefront measurement. Therefore, a bright natural star nearby the faint object under study is normally used as a reference. As there are insufficient bright stars, this approach limits sky coverage to only 1%. To overcome this problem, astronomers create their own artificial laser guide stars.

At 90 km altitude in the atmosphere there is a layer of sodium atoms, coming from burned meteorites. By pointing a powerful 589 nm laser (sodium wavelength, e.g. streetlights) to the sky, these sodium atoms can be excited such that they start emitting light, thereby creating the artificial laser guide star.

ESO currently has one laser guide star in operation (Figure 1), but will replace this with four units that are more compact and more powerful and will cover the complete field of view of the telescope. This system is called the Four Laser Guide Star Facility (4LGSF, see Figure 2). Each system consists of a laser, a beam conditioning unit and a beam expander. The latter is called the Optical Tube Assembly (OTA). TNO recently successfully delivered the first of four OTAs to ESO.

Optical design

The OTAs are 20x Galilean beam expanders; see Figure 2, right. This optical system expands a ∅15 mm input beam to a ∅300 mm output beam, and operates at a wavelength of 589 nm with 25 W of continuous laser power. The outer dimensions of the system are about ∅450 mm x 1.3 m. The OTA consists of:

- a ∅25 mm quarter-wave plate (QWP, not shown), for turning the linearly polarised input beam into a circularly polarised output;
- a ∅25 mm double-concave Fused Silica entrance lens L1;
- a ∅100 mm multi-layer coated Zerodur 45° mirror (Field Selector Mirror, FSM), which can be actuated in tip and tilt for precise pointing;
- a ∅380 mm conical aspherical NBK7 exit lens L2; this lens has to be aspherical to achieve the required wavefront quality over the entire pointing range of the FSM.

Requirements

The main requirements are shown in Table 1, together with the achieved results. The three most challenging requirements are:

1. The output wavefront quality, which requires a highly aspherical exit lens with nanometer level form accuracy.
2. The thermally induced defocus, which requires an athermal design that also includes thermal effects on the refractive index of the large exit lens.
3. The pointing accuracy, which is equal to steps of 45 mm at 90 km distance.

Table 1. OTA main requirements and achieved results.

Requirement	Value	Achieved
Transmitted wavefront error (excl. focus and tilt)	< 50 nm rms	17-23 nm rms
Thermally induced defocus	< 0.2 waves PV* (= 118 nm)	~ 0.15 waves PV (= 88 nm)
Pointing accuracy on-sky	< 0.3" (3σ)	0.07" (3σ)
Polarisation extinction ratio (PER)	> 97%	99.7%
Throughput	**> 95%**	**97.7%**

* PV = Peak to Valley

The OTA must achieve this performance under operational conditions. The operational temperature is 0 - 15 °C with

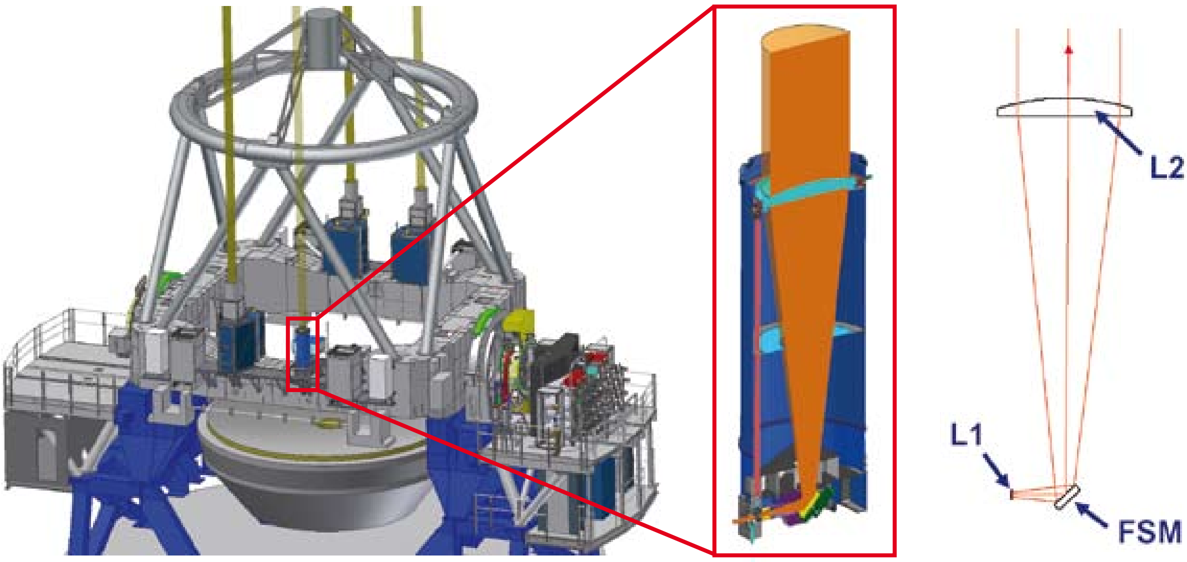


Figure 2. The VLT 4LGSF system, with the location of the OTA and the optical design. (Pictures courtesy ESO)

10 °C average, with a maximum gradient of –0.7 °C/hr for 8 hours. The gravity vector can vary between 0 - 60° zenith angle. The air pressure differs between the locations at which the OTA is aligned, tested and used: 1,013 mbar in Delft, the Netherlands (TNO), 960 mbar in Garching, Germany (ESO) and 750 mbar in Paranal, Chile (VLT). Extensive testing is required to verify the performance under operational conditions.

Athermal design

The defocus of the system due to thermal effects is determined by four components: L1, L2, the internal air and the distance between L1 and L2. For the lenses this is caused by the temperature dependency of the refractive index (d*n*/d*T*), the coefficient of thermal expansion (*CTE*), the bulk temperature and the temperature distribution. For the air, the refractive index is a function of pressure (d*n*/d*P*), temperature (d*n*/d*T*) and humidity (d*n*/d*RH*). For the structure, thermal effects are governed by the *CTE*, the average temperature and the temperature distribution. The sensitivity of each component was determined using the optical design program CodeV; see Table 2. To make the system passively athermalised, the structure between L1 and L2 must induce a defocus of +0.04283 waves/K, which corresponds to a *CTE* of 3.2 μm/m/K. Note that 1 wave is equal to 589 nm.

Table 2. Defocus sensitivities.

Component	Sensitivity (waves/K)	Relative (%)
L1	–0.01356	–20
L2	–0.05731	–80
Internal air	+0.02804	+40
Structure	**+0.04283**	**+60 (goal)**

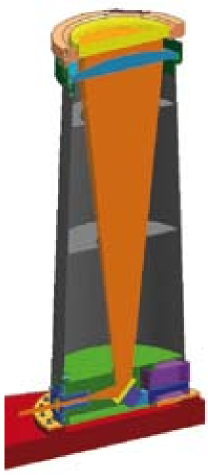
Two concepts were evaluated; see Figure 3. In the first, a carbon tube with a tuned *CTE* is used to determine the spacing between L1 and L2. This tube also constrains the L2 in lateral direction. This design is light and stiff, but has a relatively high uncertainty for the *CTE*. It has a low thermal time constant, making the tube (and the internal air) much faster than L2. This creates defocus during thermal transients. The carbon design is relatively difficult and costly to manufacture.

The second concept creates the desired *CTE* by combining 0.2 m stainless steel with 1 m Invar. The Invar is implemented as three rods constraining piston, tip and tilt of the L2. A steel tube with three tangential plate springs constrains the L2 in lateral direction. This design has similar stiffness as the carbon design, but with higher mass. The uncertainty on the expansion coefficient is smaller, and the time constant is much larger. This slows down the internal air, keeping the defocus-determining components better in pace during thermal transients. It is also expected to be easier and less costly to manufacture.

A lumped-mass model was made of both concepts, with which the defocus performance was simulated. In the steel and invar concept, the time constants are better matched, resulting in less defocus. By making some components heavier than necessary from a stiffness point of view, the thermal matching was optimised. Figure 4 shows the final expected behaviour (temperature difference from external temperature shown), with up to –0.013 waves defocus after six hours. FEM analysis was also performed to calculate the defocus from thermal gradients in the lenses. All combined, a nominal defocus of nearly zero was expected, with a model uncertainty of 0.122 waves PV.

Carbon tube with tuned α *(CTE)*
- Carbon tube does 6 DOFs of L2
- Tuned to 3.2 µm/m/K

Trade-off:
+ Light, stiff
– α uncertain (~0.5 µm/m/K)
– Small thermal time constant
– Difficult to manufacture
– Higher cost (interfaces)



Steel tube with Invar struts
- 3 Invar struts do piston & tilt of L2
- Steel tube does lateral DOFs
- 1 m Invar + 0.2 m steel ≈ 3.2 µm/m/K

Trade-off:
+ Function separation
+ α less uncertain
+ Larger thermal time constant
+ Easier to manufacture
+ Lower cost
– Larger mass

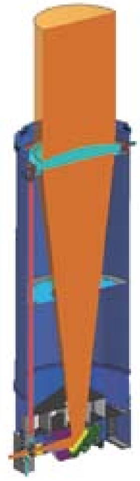


Figure 3. Concept trade-off.

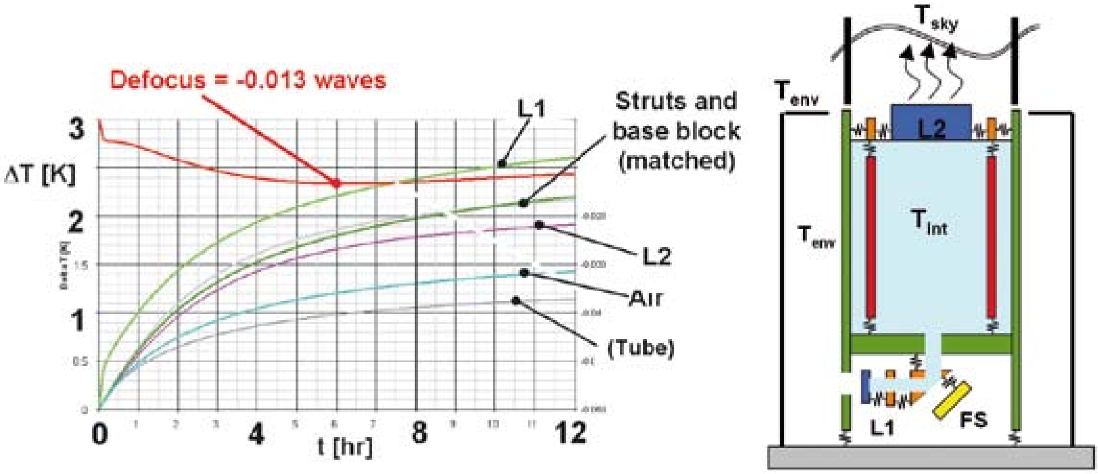


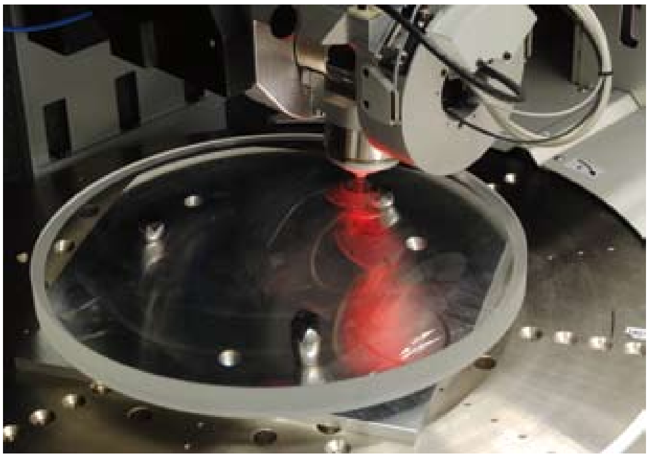
Figure 4. Lumped-mass model defocus simulation.

Field selector mechanism

The FSM must provide a pointing accuracy of 0.3” (3σ) on-sky, which is equivalent to 45 mm steps at 90 km distance. The FSM design and testing is described in more detail in [2], a summary is given here. To achieve a 4.8 arcmin radius field of view on-sky, the FSM has to tilt up to ±6.1 mrad, in combination with a better than 1.5 µrad rms absolute accuracy. The maximum settling time for a 1 arcsec step on-sky is 0.2 sec, which translates to about 20 µrad mirror rotation.

Figure 5. Field Selector Mechanism. (Photo: TNO/F. Kamphues)

The FSM design (Figure 5) consists of a Zerodur mirror, bonded to a membrane spring and strut combination to allow only tip and tilt. Since the range is too large for piezos, two (self-locking) spindle drives actuate the mirror, using a stiffness-based transmission to increase resolution. Absolute accuracy is achieved with two differential inductive sensor pairs. The FSM electronics were developed by Eltromat.
Friction in the spindle drive is overcome by creating a local velocity control loop between the spindle drives and the shaft encoders. Accuracy is achieved by using a cascaded low-bandwidth control loop with feedback from the inductive sensors. Eventually, a pointing jitter < 0.07” (3σ) on-sky was achieved.



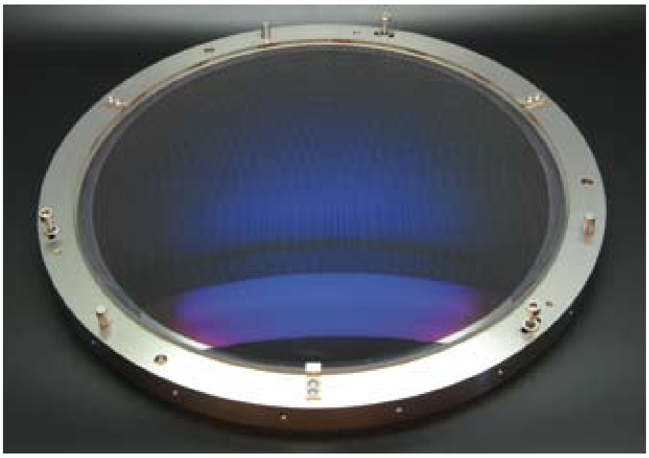


Figure 6. L2 asphere metrology on NANOMEFOS (left) and final result. (Photos: TNO/F. Kamphues)

L2 fabrication

The fabrication of L2 is described in more detail in [3], a summary is given here. The aspherical L2 lenses were manufactured using TNO's unique manufacturing facilities for aspherical and freeform optics. The process was hereto optimized for minimal mid-spatial content and low roughness (1 nm *Rq* achieved). The asphere was polished from 5 µm PV to 24 nm rms form error in six deterministic corrective polishing runs. If the lens were the size of the Netherlands, 24 nm would translate to a bump of about 20 mm.

Figure 6 shows the surface being measured with the NANOMEFOS measurement machine [6]. This non-contact measurement machine typically obtains 2k x 2k points in about 15 minutes, giving interferometric resolution with nm level accuracy. The resulting form error after polishing is about 24 nm rms, of which 14 nm rms is mid-spatial content. This contributes about 7 nm rms to the wavefront error. A custom-hardened anti-reflection coating was applied with less than 0.2% reflectivity.

Figure 7. Completed OTA. (Photo: TNO/F. Kamphues)

Testing and model update

The completed OTA is shown in Figure 7. The OTA wavefront quality was tested first by placing a reference flat mirror on top of the OTA and measuring the transmitted wavefront quality with a Fisba interferometer. The result is 17 - 23 nm rms, depending on the field of view. Other parameters such as tilt dependency, pointing hysteresis and placement repeatability were also tested. All requirements were met.

The thermal behaviour was first assessed in a few preliminary transient tests at TNO, before shipping the instrument to ESO for controlled testing in their climatic chamber. During the tests at TNO, defocus appeared to be within the requirements but larger than expected. Figure 8 shows a typical test result that clearly demonstrates this. In this test the temperature was increased to 24 °C, and subsequently kept constant for about a day. In the right figure, a defocus during warm-up can be seen, which disappears when the temperature becomes uniform again. The athermalisation as described earlier therefore works for uniform temperature changes. During the warm-up and cool-down however, the defocus is larger than expected. After further testing and modeling, it appeared that the thermal coupling of the L2 to its mount was larger than initially anticipated, resulting in a radial thermal gradient causing defocus. After including the L2 radial gradient in an updated thermal lumped-mass model, it matches the measured behaviour very well. The modeling and the update is further described in [4].

After the cool-down from 24 °C back to 21 °C the temperature was kept constant during several days. Some defocus was observed that could not be explained from temperature variation. After taking the atmospheric air pressure sensitivity (6 nm/mbar) into account, the behaviour was fully explained. This model now enables

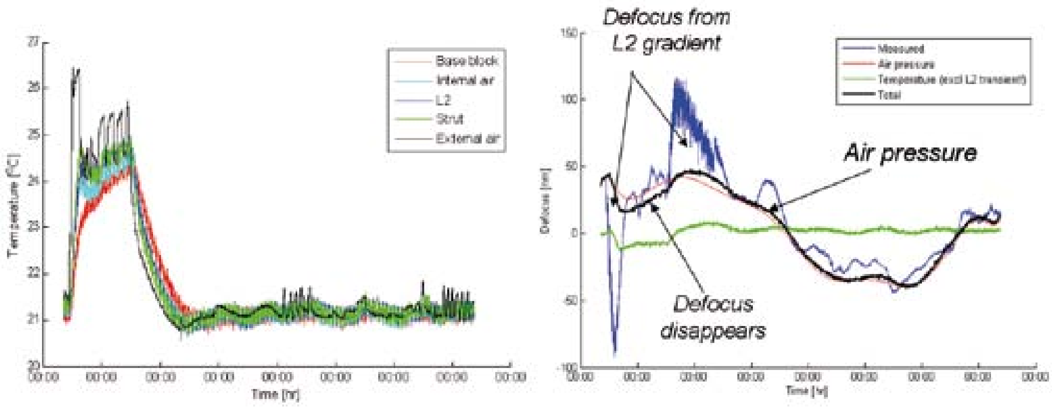


Figure 8. TNO preliminary (uncontrolled) thermal transient test result.

ESO to feedforward the defocus, to further improve the OTA defocus performance.

High-power testing

Next, controlled thermal testing in combination with the high-power laser was performed in the ESO climate chamber; see Figure 9. No surprises were found here, and the system meets the requirements. The main results are shown in Table 1.

Figure 9. High-power thermal testing in ESO climate chamber. (Photo: TNO/F. Kamphues)

Conclusion

Artificial laser guide stars serve as a reference for correcting disturbances from atmospheric turbulence. TNO recently successfully delivered the first of four Optical Tube Assemblies for the ESO VLT. It is a passively athermalised design, made by optimising the *CTE* and time constants of the system's components. A custom Field Selector Mechanism was developed, and TNO's freeform polishing and metrology facilities were employed for fabricating the L2. Thermal transient testing showed unexpected defocus behaviour, albeit within specification, coming from a larger L2 gradient than expected. A model update now accurately describes the transient behaviour of the L2 lens. After final testing in the ESO climate chamber, the OTA meets all its requirements. TNO will now proceed with the assembly of OTA copies 2 to 4.

Acknowledgement

TNO would like to thank ESO for awarding the contract for the realisation of the Optical Tube Assemblies for the Very Large Telescope. TNO also acknowledges the many suppliers contributing to this project. The L2 blanks and other optical components were supplied by Schott, Qioptiq, RMI and Laser Components. The complex steel tube assembly was supplied by Vernooy Vacuum Engineering, and the other mechanical components by GL Precision, Vacutech and Rovasta. Hittech MPP applied the black coating. The compact FSM electronics were developed by Eltromat, the motors and sensors were supplied by maxon motor benelux and Air-Parts, respectively. The transport container was developed by IPS Technology.

References

[1] Henselmans, R., D. Nijkerk, M. Lemmen, N. Rijnveld, F. Kamphues, "Athermal design of the Optical Tube Assemblies for the ESO VLT Four Laser Guidestar Facility", SPIE Optics & Photonics, 2011.

[2] Rijnveld, N., R. Henselmans, B. Nijland, "A tip/tilt mirror with large dynamic range for the ESO VLT Four Laser Guide Star Facility", SPIE Optics & Photonics, 2011.

[3] Gubbels, G., R. Henselmans, C. van Drunen, "Flexible manufacturing of large aspheres for VLT's Optical Tube Assemblies", SPIE Optics & Photonics, 2011.

[4] Henselmans, R., D. Nijkerk, M. Lemmen, F. Kamphues, "Athermal design of the Optical Tube Assemblies for the ESO VLT Four Laser Guidestar Facility", Symposium on Integrated Modeling of Complex Optomechanical Systems, Kiruna, Sweden, 2011.

[5] www.eso.org/sci/facilities/develop/ao/images/AOF_Booklet.pdf.

[6] Henselmans, R., "Non-contact Measurement Machine for Freeform Optics", Ph.D. thesis, Eindhoven University of Technology, the Netherlands, ISBN 978-90-386-1607-0, 2009.

mikrocentrum
opleiden • ontmoeten • ondernemen

Precision Fair 2011

"Fast and accurate"

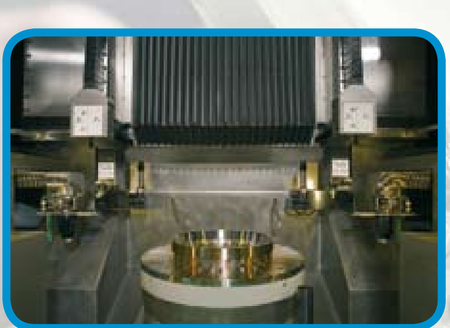
- New technologies, solutions and products
- Exhibition of 200 specialized companies and knowledge institutions
- Participation congress programme included

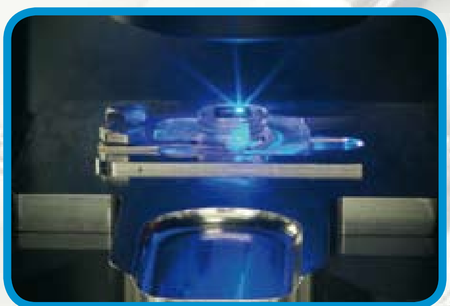
TECHNOLOGY HOTSPOT
Powered by IOP Precisietechnologie

11th edition • Free entrance
www.precisiebeurs.nl

Trade fair & Conference

30 November and 1 December 2011
NH Conference Centre Koningshof, Veldhoven, Netherlands





With the support of:

NL Agency
Ministry of Economic Affairs, Agriculture and Innovation

DSPE

Stacking drop

Creating tools for producing optical components used to be very time-consuming. This irritated Richard de Vrie and Kurt Blessing enormously when they were launching LED armatures onto the market. Their obsession with solving the problem of reducing the time-to-market for components like lenses and prisms inspired their innovation: building optical parts from transparent droplets on demand (DODs). To do this, they wanted to use a professional printer, but were confronted with many problems, including the inadequate accuracy of droplet deposition. So their newly established firm LUXeXceL concentrated on modifying a printer and developing an innovative process called 'printoptical technology'. This term and the basic technology are now copyrighted, as are the many inventions required to make the new technology really work.

• *Frans Zuurveen* •

Richard de Vrie of LUXeXceL, based in Goes, the Netherlands, illustrates the time and cost advantages of printoptical technology using the manufacture of a plastic lens with a focal distance of 50 mm as an example. When conventional injection moulding is used to manufacture this optical part, the tools required cost about € 30,000 and there is a four- to eight-month delivery time. LUXeXceL's new printoptical technology only requires about € 1,000 in preliminary costs with a one- to two-week delivery time, primarily required to create the CAM software program.

Author's note

Frans Zuurveen is a freelance text writer who lives in Vlissingen, the Netherlands.

But, back to the professional printer. When people hear the brand name Roland, most of them think about the company's well-known digital pianos. Roland is, however, also a leading manufacturer of large professional printers, mainly used in the graphic design industry. LUXeXceL decided to use Roland printers as the basic tools for its

lets-on-demand

Figure 1. Roland professional printers with working widths of up to 1,400 mm.

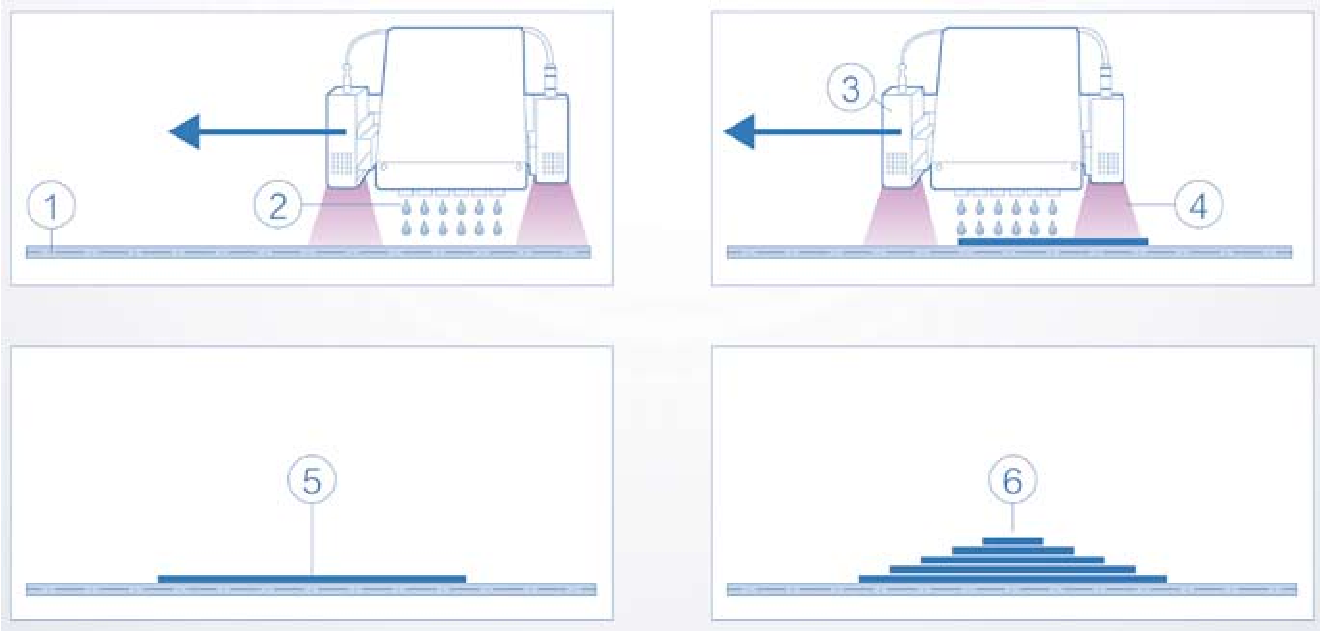
Figure 2. A Roland printer modified by LUXeXceL.

printoptical technology (see Figure 1), seeing as modifications were unavoidable. As a result, the modified Roland printer proudly bears the maxim “LUXeXceL inside” (see Figure 2).

Improving stacking accuracy

Using a Roland printer for more than one layer of deposited ink is not new, as special effects can be created for graphic design by using additional glossy layers. In this case, accuracy requirements are not extremely high; instead it is reproducibility that is more important. Roland specifies an absolute distance accuracy of ±0.3 mm or a relative one of ±0.3%, whichever value is greater. For a printing width of 1,400 mm, as used by LUXeXceL, this means a completely inadequate accuracy of about ±4 mm.

Figure 3 provides a schematic representation of the stacking of dots of UV-curable polymer in printoptical technology. A printer head ejects tiny dots and deposits them on a substrate, which is made of glass, foil or PMMA (commonly called Perspex or Plexiglas). UV light is then used to cure the dots, the process for which will be explained later on.



1. Substrate.
2. Spraying dots of UV-curable polymer.
3. UV-LED source.
4. UV beam.
5. First layer of polymerised bubbles.
6. Stacked layers of bubbles.

Figure 3. Schematic representation of the four stages in printoptical technology.

When stacking multiple layers of dots for producing optical components, including lenses, prisms and gratings, accuracy requirements are much higher than in graphic applications. Fortunately, adjusting successive layers by using markings – a standard practice in IC manufacturing – is not required in printoptical technology, because products are made in a single working cycle with no repositioning; see Figure 4. Nevertheless, an optical product generally has to meet stringent dimensional requirements (see Figure 5) and for the droplet stacking process to be successful, the reproducibility of droplet deposition is of utmost importance.

LUXeXceL partner Screen Products in Badhoevedorp, the Netherlands, is responsible for modifying standard Roland printers for the printoptical process. The details of the modifications that this Roland printer wholesaler carries out are a trade secret. Nonetheless, an optical measuring scale – most likely from Renishaw – could be seen measuring the transversal movements of the printhead across the substrate. The displacement in longitudinal direction caused by driving rollers is controlled by a stepping motor with an accurate angular encoder.

Another modification concerns the maximum flat substrate length. Roland printers are mostly used for sheets on rolls, but the modified LUXeXceL Roland printer is able to handle flat sheet material with a length of up to 5 m.

Droplets on demand

The most essential component for printoptical technology is the printhead. This is a piezoelectric controllable printhead with so-called Micro Piezo Technology from Seiko Epson. In a Roland printer with "LUXeXceL inside", this provides a resolution of 1,440 dpi, which equates to a dot size of 18 μm and an approximate volume of one droplet of 7 pl (picolitre). The maximum droplet volume is 40 pl. The variation in droplet volume is due to the variation in voltage applied to the piezoelectric elements in the printhead, which generate the ink bubbles. It is not unrealistic to expect a higher accuracy in the near future thanks to an improvement in the resolution of probably up to 2,880 dpi.

As said, LUXeXceL uses UV-curable polymer in the manufacture of optical components. UV light radiating LEDs take care of the radical polymerisation process for building repeated layers of dots, resulting in transparent geometrical shapes. This type of polymerisation utilises free-radical building blocks for coupling monomer molecules, resulting in much larger polyacrylate molecules. A relatively high refractive index of 1.5 can be achieved.

Figure 4. Making optical products with printoptical technology on a modified Roland printer. The yellow rollers are for guiding the substrate.

Figure 5. Checking the dimensions of a LUXeXceL optical product.

Given the discrete elementary dots, you might think that the process described would generate an uneven, bubble-like structure. However, LUXeXceL has a little trick for smoothing out this structure, thereby improving the surface quality and decreasing roughness. The secret of this technique is delaying the time between ejecting a bubble and applying UV light. This delay gives the monomer the opportunity to flow, so that the bubble loses its spherical form. Part of LUXeXceL's innovative work is mastering this smoothing-out technique.

After the dots have been deposited and polymerised, the products have to be cut out of the much larger substrate of glass, PMMA or other transparent material. To do so, a laser has to outline a controlled movement around the contour of each single product. At present, a separate laser cutting machine is used, but, in the future, integrating the laser into the printer would be a better idea. The laser could then be mounted onto the slide for the printhead. To control the laser movements, the current software for printhead control is used, which does not require the substrate to be repositioned.

Another problem that LUXeXceL had to solve was the imperfect perpendicular direction of the bubble speed when hitting the substrate, which is caused by the speed of the printhead: the speed vector of one bubble is the result of the vertical bubble ejection speed and the printhead speed. An additional complicating factor was the changing sign of this effect when the printhead returns at the end of one stroke. Software compensation provided the solution for this problem.

In addition to transparent polymer, LUXeXceL uses printheads with orifices for resins with the usual colours, i.e. cyan, magenta, yellow, black and white, mainly required for graphic design. All resins are UV-curable.

Optical products

LUXeXceL does not intend to produce optical and other components itself. The company's objective is to establish licensing agreements with third parties to use the printoptical technology. As such, LUXeXceL has acquired ample patents covering the secrets of the technological details. Nevertheless, test products have been made in Goes, which are outlined below.

Printing optical structures on foils is an important application area; see Figure 6. Such foils can be fitted to windows to enhance daylight and light distribution in offices, for example. They can also be used to increase the output of photovoltaic cells for converting solar radiation into electrical energy.

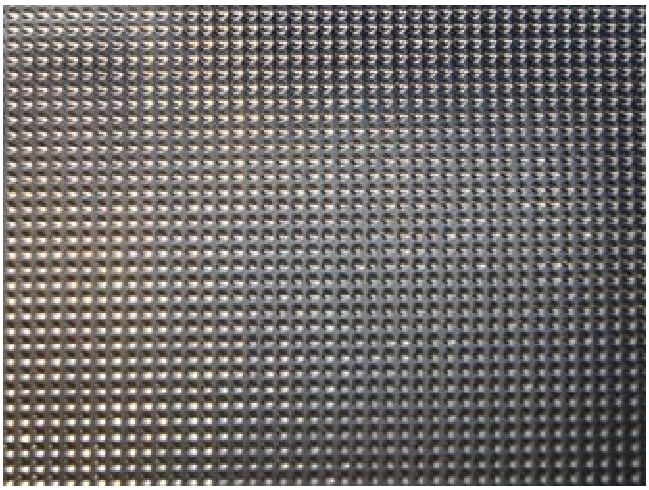


Figure 6. An optical structure printed on foil.

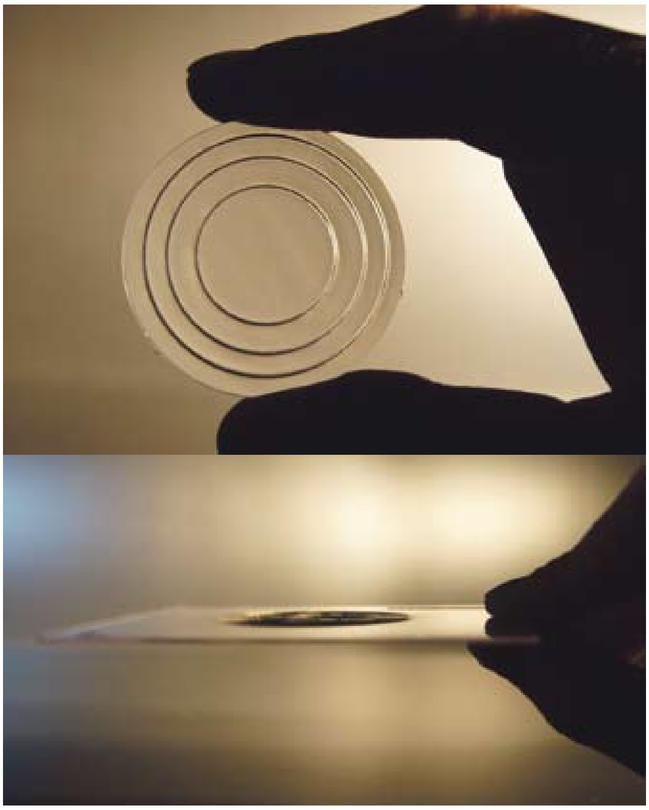


Figure 7. A Fresnel lens manufactured using printoptical technology. The Fresnel type stands out because of its thinness.

What might be of more interest to the readers of Mikroniek is the manufacture of discrete optical components. In the case of lenses, the Fresnel type is often the preferred option (see Figure 7), as it saves on time, material and costs because of its thinness. Figure 8 shows more examples of (Fresnel type) lenses.

These examples also clearly show that it is quite easy to modify prototypes optically, because only graphic design software modifications are required, as opposed to complex tool modifications in the conventional production of optics. Producing aspherics or freeform optics is relatively easy – if the geometrical CAD description is available, of course. The same applies to complex bifocal or trifocal optical components. Printoptical technology also makes optical experiments easy, because modifying components does not require much time.

Possibilities

It is very easy to let your imagination run wild and think about where else LUXeXceL's printoptical technology could be used. Mikroniek recently featured an article on the capability of Anteryon in Eindhoven, the Netherlands, to produce optics for mobile phones (see Figure 9) in huge quantities and with excellent precision [1]. It is probably not unrealistic to think that printoptical technology could be used for such miniature optical systems.

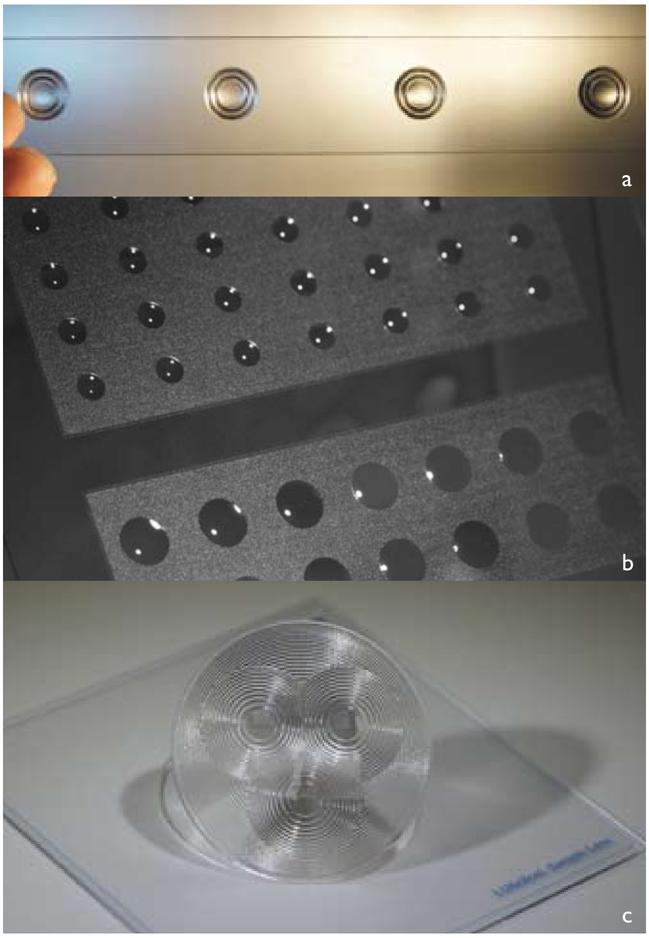


Figure 8 Examples of discrete optical components manufactured using printoptical technology.
(a) An array of Fresnel lenses.
(b) An assembly of printoptical lenses.
(c) A complex Fresnel structure.

Up to now, the production of multifocal glasses was a cumbersome affair of grinding and polishing (see Figure 10), and this may also be a fruitful area of application. In theory,

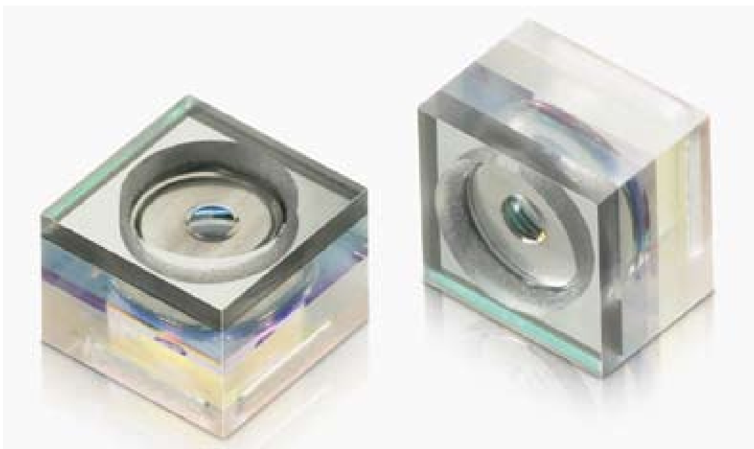


Figure 9. Objectives for mobile phones, produced by Anteryon in Eindhoven. (Photo courtesy Anteryon)

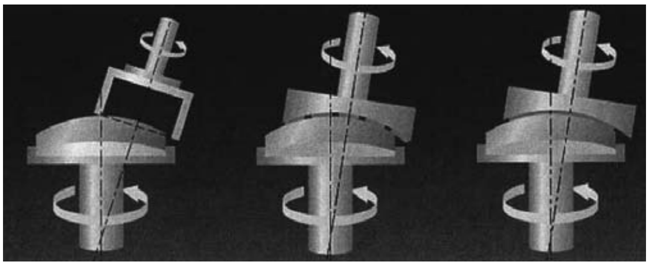


Figure 10. Conventional polishing and grinding of multifocal glasses.

providing the geometrics of such glasses in digital form would be sufficient to build them from transparent dots in printoptical technology. Moreover, hard and probably even soft contact lenses could be made in a comparable fashion.

Going one step further and looking at a medical application area, implant lenses for cataract disease could also be made using printoptical technology. Naturally, the high sterility requirements would have to be met. An additional complication would be creating the two protruding flexible legs for centring within the lens pocket of the eye; see Figure 11 [2].

Dreams

When thinking about the future of printoptical technology, other deposition techniques could be imagined than the one described with UV-curable polymer. When heating a printhead, it might be possible to spray dots of molten plastic. Such dots would harden when deposited on the relatively cold substrate. Such a technique could also be applied to deposit electrically conductive plastics on the substrate for manufacturing conductors in electrical circuits. Spraying doped plastic might also make it possible to integrate active components such as OLEDs and optical switches.

Another conceivable technique would be to use two printheads, each of which sprays a composing liquid for a two-component resin, e.g. the hardening agent and basic resin for making polyester. After being deposited, the two differently composed dots would react together to form a thermoset or thermoplastic.

A further conceivable idea would be to combine printoptical technology with, for instance, surface mounting technology in hybrid circuitry. Then, active elements like LEDs and optical switches could be mounted on a substrate that already has optical elements thanks to printoptical technology.

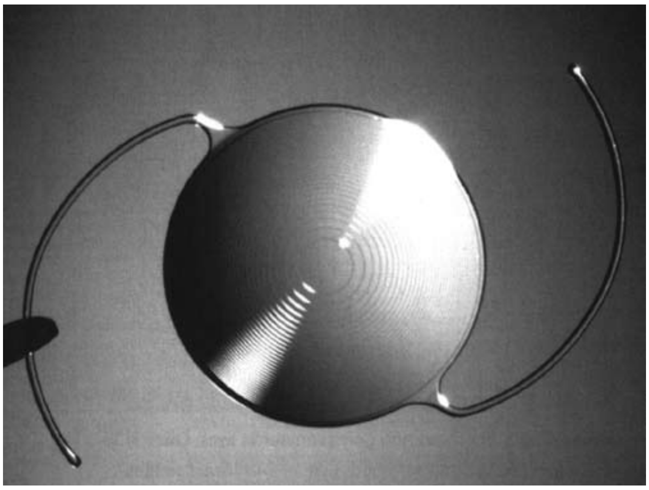


Figure 11. A bi-focus Fresnel implantation lens for treating both presbyopia and cataracts. (Photo: Pharmacia 2002).

As a result, relatively cheap photonic integrated circuits could be made. And going even further, you could imagine optical displays based on printoptical technology with surface-mounted or directly deposited transistors and LEDs.

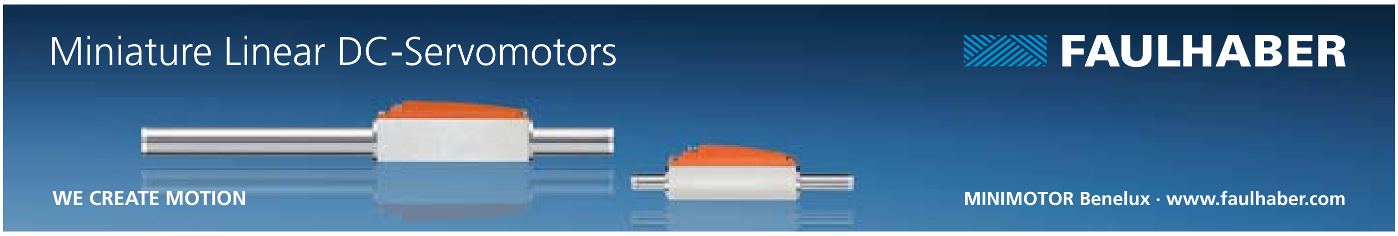
In the near future, creative minds will most definitely understand the advantages of printoptical technology for straightforward optical component production. Meanwhile, one last little tip: don't hesitate to jump on board this fast-moving technological train.

References

[1] F. Zuurveen, "Millions of stacked lenses a week", *Mikroniek*, Vol. 50 (2010) no. 2, pp. 24-27, 2010.
[2] F. Zuurveen, "Precisietechnologie helpt staarlijders", *Jaarboek Precisietechnologie*, 2003, pp. 96-106.

Information

www.luxexcel.com



Micromanufacturing

Photo-Sensitive-Glass-Ceramic (PSGC) is a very important tool in the toolbox for the production of a wide variety of microbiological, -mechanical and -electrical systems. High-aspect-ratio microstructures can be produced relatively quickly without masks, photo-resist, DRIE (Deep Reactive Ion Etching) or substantial upfront costs. Because PSGC can be attached to metals, ceramics and other glasses, at room temperature, without the use of adhesives, high-aspect-ratio structures can be easily achieved in complete electrical/mechanical or biological functionalised systems without damaging the activated surfaces. Such microsystems are chemically inert and very robust in high-temperature environments. Finally, for the purpose of production, PSGC can be processed in high volume using masks, however, without the use of photo resist, making PSGC a 'green material'.

• ***Raymond Karam and Richard Bijlard*** •

In microsystems technology, glass and glass-ceramic components are required with well-defined shapes and strict tolerances. Often, conventional machining methods used in the manufacturing of glass can not fulfil these requirements. Subsequent mechanical operations such as drilling, milling, sandblasting, etc. add cost and are limited in precision and the types of structures that can be made. A solution to this problem is offered by glass from the basic Li_2O/SiO_2 family, containing traces of noble metals. After exposure to UV light and subsequent heat treatment, this material will partially crystallise. The meta-crystalline phase is lithium silicate, which is much more soluble in hydrofluoric acid than the surrounding unexposed amorphous glass. This makes the production of complicated and high-precision structures/components possible via an etching process. During the last ten years, a broad range of micro-structured components have been manufactured commercially by

Authors' note

Ray Karam is President and CEO of the Invenios group, based in Santa Barbara, USA and Mainz, Germany (subsidiary mikroglas chemtech). Invenios is a quick-turn 3D microfabrication foundry services company serving a broad range of traditional and emerging micro-manufacturing applications. Richard Bijlard is the owner of Technogation, representing Invenios and mikroglas chemtech in the Benelux. Technogation actively sells, promotes and develops new solutions in mechatronics, microfluidics and biochemical segments.

www.invenios.com
www.mikroglas.com
www.technogation.com

in glass-ceramics

Invenios/mikroglas, a US/German-based group of companies, using a PSGC, called FOTURAN®.

The process in detail

Exposure
The exposure process can be described by the following chemical reactions.
During the glass melting process Ce^{3+} ions are formed. They are stabilised by Sb_2O_3 or other reducing agents:

$$2\ Ce^{3+} + Sb^{5+} \Leftrightarrow 2\ Ce^{4+} + Sb^{3+}$$

When the glass is exposed, the Ce^{3+}, working as a sensitiser, absorbs photons and strips one electron to go into the stable Ce^{4+} state:

$$Ce^{3+} + h\nu \Rightarrow Ce^{4+} + e^{-}$$

The electron is absorbed by silver ions which are now reduced to silver atoms:

$$Ag^{+} + e^{-} \Rightarrow Ag$$

After this process, an invisible image is created in the glass.

Baking
During a heat treatment the exposed substrates are heated slowly up to approximately 500 °C and nucleation takes place. Silver atoms that are formed during the exposure with UV light agglomerate to form bigger nuclei. When the temperature is increased to approximately 600 °C, the glass crystallises around the silver nuclei, forming lithium-metasilicate Li_2SiO_3. These crystals have other physical properties (density, thermal expansion) than the glass itself, enabling localised etching.

Etching
The etching is performed in a conventional etching bath with ultrasonic support or a spray etcher at room temperature. The main compound in the material is SiO_2, which can be etched with a solution of 10% hydrofluoric acid (HF):

$$SiO_2 + 6\ HF \Rightarrow SiF_6^{2-} + 2\ H_2O + 2\ H^{+}$$

The process

Glass has an amorphous structure; therefore, it does not have an ordered crystalline structure. Because of this, it etches isotropically, i.e., uniformly in all directions. Isotropy by definition limits etched glass to an etch ratio of 1:1, that is, a 10 µm wide structure will render a 10 µm deep V-shaped structure with a rounded bottom. *Photosensitive* glass (PSGC) like FOTURAN makes it possible to induce an anisotropic behaviour. This is done by exposing the glass to a collimated UV light/laser with the appropriate energy and geometry, subsequently heat-treating it, then etching the meta-silicate using HF; such structures can have up to a 30:1 aspect ratio; see Figure 1. Post etching, the substrates can be functionalised, then bonded together with other structures to form closed active micro-electrical-biological devices; see Figure 2.

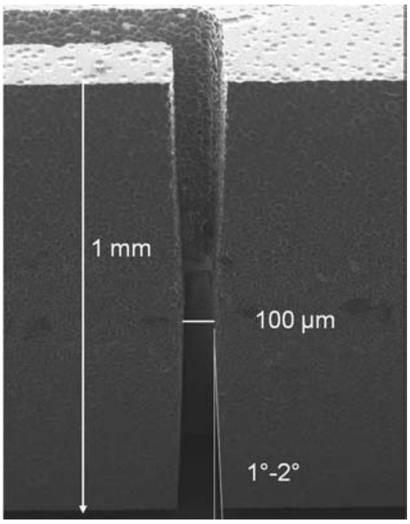


Figure 1. Cross-section of a channel etched into FOTURAN.

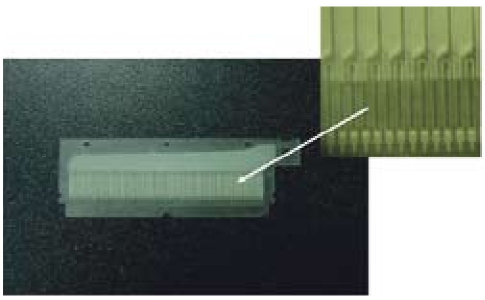


Figure 2. 128 Nozzles (each with 35 x 35 µm² cross-section) with integrated sonic chambers and backstop valves. (Bonded without adhesive, 100 pl output)

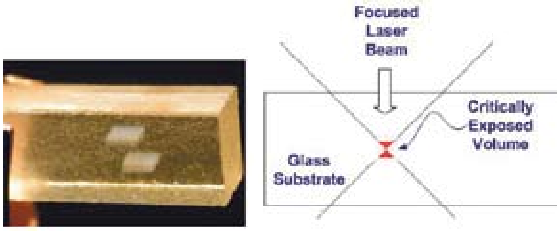


Figure 3. Direct 3D writing in PSGC (FOTURAN) with a laser.

Direct 3D writing

By using a laser with the required wavelength (patented), it is common to directly write into the photosensitive glass and create 3D structures, entirely eliminating the use of masks; see Figure 3. The density of nanocrystals is directly proportional to the fluence within the critically exposed volume. By controlling the depth of focus and numerical aperture of the UV laser optics, sub-10-micron features can be created. In order to critically expose a larger volume (e.g., a large diameter hole), optics with a larger depth of focus are used. By means of a computer-controlled multi-axis positioning system, a path of laser pulses can be written into the glass and by linking such paths, complex 3D volumes of exposed material can be created; see Figure 4.

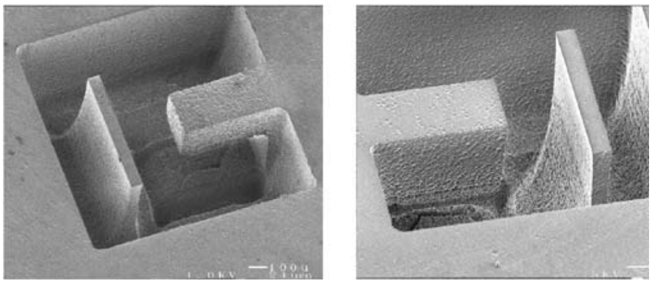


Figure 4. High-aspect-ratio 3D structures (with 300 μm undercut and arbitrary 3D figures), written by laser in FOTURAN.

Figure 5. Embedded diffraction grating with 10 μm pitch.

Applications

The process outlined in the above sections can be used to create a broad range of microsystem applications: optical masks and gratings (see Figure 5), 3D microstructures (see Figure 6), micromoulds (for microreplication or micro-injection moulding, see Figure 7), inkjet printheads (Figure 8) and microfluidics chips (Figure 9).

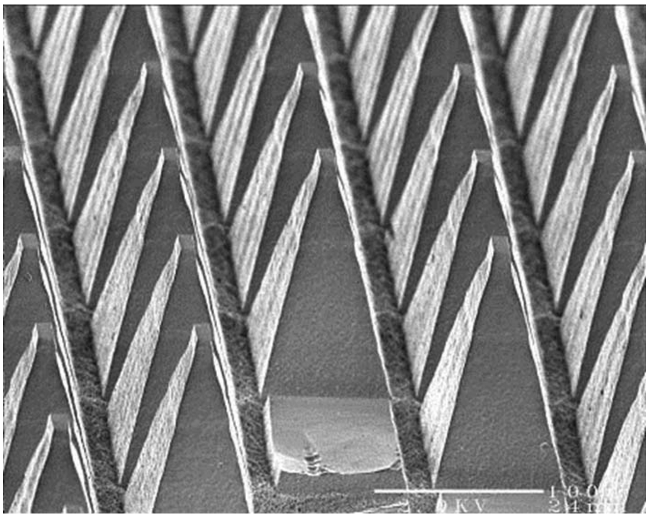
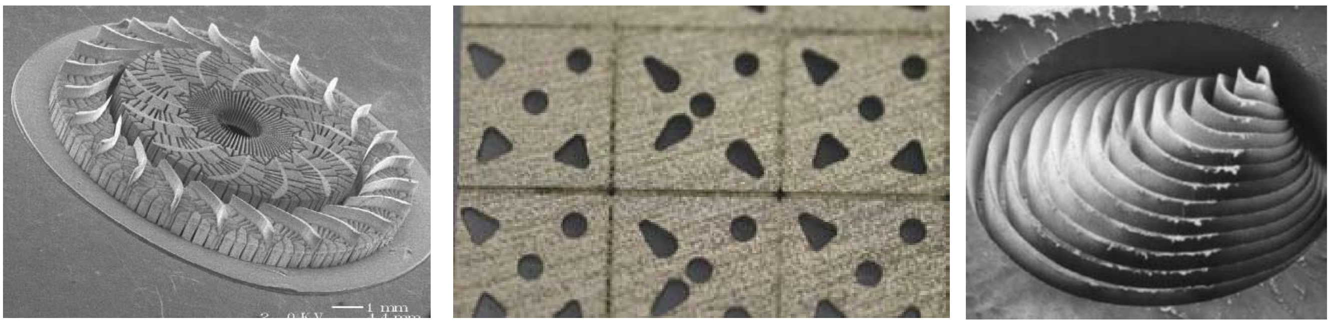


Figure 7. High-aspect-ratio periodic structure for use as a microreplication mould.



a b c

Figure 6. Examples of 3D microstructures.
(a) Miniature Multi-vane Centrifigual Pump Rotor.
(b) A 5mm² chip (750 μm thick) with different wall angles (7° and 14° (round holes) in the same part), metallised.
(c) High-aspect-ratio structure (75μm kerfs, 2 mm x 2 mm).

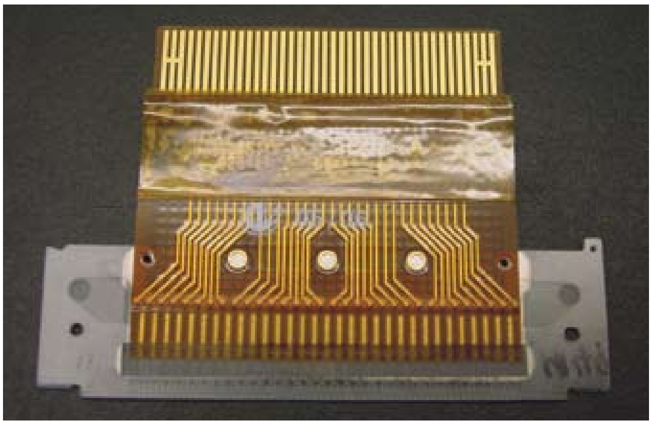


Figure 8. Adhesive-free bonded 64-nozzle Invenios-patented printhead with fully imbedded and centred nozzles (each with 100 x 100 μm^2 cross-section).

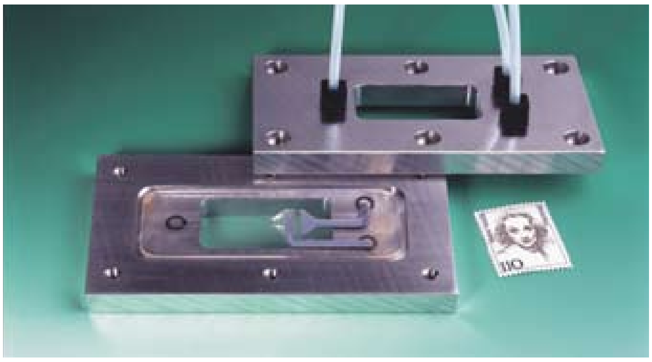


Figure 9. Microfluidics chip made out of FOTURAN (in stainless steel holder).

Conclusion

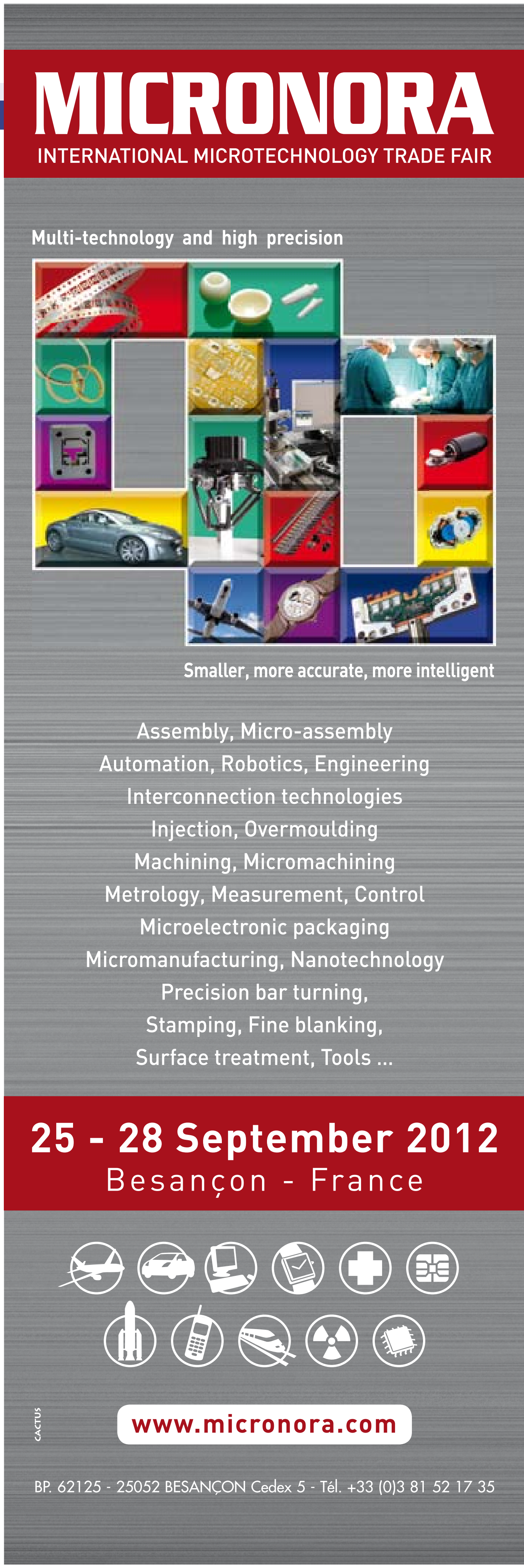
Photo-structural glass (PSGC) is a very suitable material for micromanufacturing. It combines the unique properties of glass with the possibility to obtain very fine structures with high aspect ratios. FOTURAN PSGC can be processed by means of masks (series production) as well as by a UV laser in a true 3D direct-write manner, enabling low-to-medium-volume production of components in a relatively quick manner at a low barrier to entry. Finally, it works well as a component in a structure made from a host of different materials.

References

[1] R.M. Karam, R.J. Casler, "A new 3D, direct-write, sub-micron microfabrication process that achieves true optical, mechatronic and packaging integration on glass-ceramic substrates", *Sensors Magazine*, 2003.

[2] Th.R. Dietrich, A. Freitag, R. Scholz, "Production and Characteristics of Microreactors Made from Glass", *Chem. Eng. Technol.* Vol. 28 (2005), No. 4.

[3] Th.R. Dietrich, W. Ehrfeld, M. Lacher, M. Krämer, B. Speit, "Fabrication technologies for microsystems utilizing foto-etchable glass", *Microelectr. Eng.* Vol. 30 (1996), pp. 497-504.



PiezoMotor takes

High-speed, high-power, high-torque: all words that are often used to describe the performance of drives. But how often are we interested in the slowest speed that a linear motor can reach? Facial hair grows at a 'speed' of about 5 nanometers per second. A PiezoLegs linear motor from Faulhaber can reach an even slower speed of only a few nanometers per second! In precision-technological applications such unusually low speeds may be an important factor. Also interesting to note is the relatively high stationary holding force of such a linear piezoelectric drive, exerted without any energy being consumed. To ease the mind of the sceptics, the maximum speed of a PiezoLegs motor comes to 20 mm/s.

• *Frans Zuurveen* •

Figure 1. A Faulhaber PiezoMotor PiezoLegs 6N linear motor. The piezo elements are enclosed in steel. Above two ball bearings for guiding the ceramic driving rod. Holding force 7 N, resolution < 1 nm, maximum speed 20 mm/s.

About 60 years ago, Fritz Faulhaber invented an electric motor with an ironless self-supporting rotor with a skew-wound coil. The very low inertial moment of the rotor made the motor an excellent servo drive. In 1962, his invention led to the Swiss company Minimotor being founded. The Faulhaber Group was eventually established after several acquisitions in the small motor industry, and it now has sites in France, Switzerland, Germany, China and Sweden. It was in Sweden in 2007 that the Faulhaber Group invested in PiezoMotor in Uppsala, adding their products to the Faulhaber range. PiezoMotor developed the PiezoLegs (see Figure 1) and PiezoWave linear motors, which this article is about.

Author's note

Frans Zuurveen is a freelance text writer who lives in Vlissingen, the Netherlands.

nanometer steps

Piezo-effect stepping

In 1880, brothers Pierre and Jacques Curie discovered the piezoelectric effect in Rochelle salt, potassium sodium tartrate, i.e. that mechanical tension produces an electrical voltage and vice versa. Older readers may remember that Rochelle salt was used in acoustic pick-up elements, but its moisture sensitivity posed a major disadvantage. Fortunately, modern piezoelectric ceramics – mostly titanates or niobates – are not susceptible to water degradation.

Limited piezoelectric expansion makes it nearly impossible to reach considerable displacements in the direction of applied voltage. However, by making so-called bimorphs – two electrically separated ceramic strips bonded together – higher deviations can be accomplished by bending. Applying a relatively high voltage – typically 42 V – to one of the strips stretches this strip, whereas the other one stays stationary. This results in a considerable deviation at the top opposite the clamped end. Applying this voltage to both strips expands the complete bimorph; zero voltage contracts it again.

Figure 2 shows a four-leg piezoelectric element used in a PiezoLegs linear motor. Each of the legs consists of two electrically isolated piezoelectric strips, which can be separately provided with a voltage. By applying synchronised electronic signals to the eight strips, a stepping action of the complete piezoelectric element can be achieved; see Figure 3. Figure 3a shows the start from the rest position; leg 1 and leg 3 are going to move to the right. After that, leg 2 and leg 4 contract as shown in Figure 3b. These legs expand again, as shown in Figure 3c, thereby creating a step. In Figure 3d legs 1 and 3 prepare for the next step.

Figure 2. A piezoelectric four-leg element for a PiezoLegs linear motor.

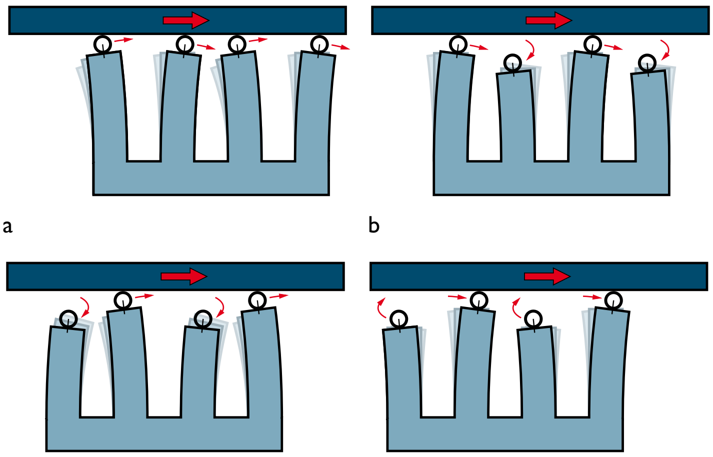


Figure 3. Four stages in the piezoelectric cycle for two successive steps in a PiezoLegs motor (see text for explanation).

The same wave form is applied to the separate strips, but 90° phase-shifted between each leg's strip and 180° between each pair of legs. Varying the amplitude and frequency of this feed signal influences the step speed and step size, and, therefore, the driving speed and force. Thus, the PiezoLegs motor can move in full steps, shorter steps or partial steps. In the latter case, which is called the micro-stepping mode, a motor establishes a positioning accuracy in the nanometer range. The exact size of one step, however, is a function of the load and the quality of the control signal. Therefore, a closed-loop control with nanometer sensor is required to accurately acquire constant steps. Faulhaber proposes using an incremental linear encoder from Nanos Instruments. The highest resolution requires a capacitive sensor at a limited stroke of a few millimeters. PiezoMotor itself supplies a rather wide range of drivers and controllers.

Two PiezoLegs motors can work together as a PiezoLegs 20N Linear Twin; see Figure 4. Two four-leg elements then exert force on opposing sides of one driving rod. Special non-vacuum contaminating and non-magnetic versions are also available. Rotating piezoelectric motors can also be supplied, and in this case four-leg elements exert force on a disc, instead of a rod.

Figure 4. A PiezoLegs 20N linear twin motor with two four-leg elements.

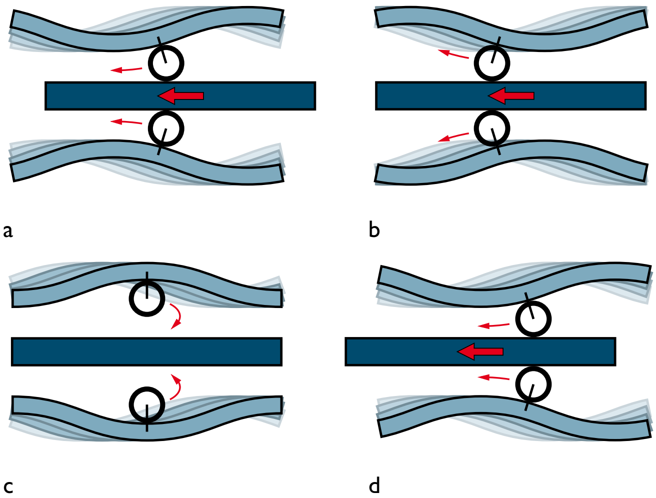


Figure 6. Four stages in the piezoelectric cycle for one step in a PiezoWave motor (see text for partial explanation).

Another stepping principle

PiezoWave motors (see Figure 5) from the PiezoMotor product range work in a different way. Figure 6 shows the operating principle. Piezoelectric elements vibrate on both sides of the driving rod in the form of a standing wave. Again, each element is a piezoelectric bimorph. The left and right halves of each bimorph are being controlled separately to reach the target waveform. For instance, in the upper element of Figure 6a, upper left contracts, lower left expands, upper right expands, lower right contracts, etc.

As a stepping device, PiezoWave motors are not as accurate as the PiezoLegs linear motors. Moreover, they have a lower stationary holding force. Therefore, PiezoWave motors are better suited to powering hand-held consumer electronic devices, such as mobile phones. They are also being integrated into other applications, including medical technology, electromechanical door locks and cameras. Typical motor characteristics are a non-load speed of 150 mm/s, at 0.1N load a speed of 50 mm/s, a holding force of 0.3 N and a stroke of 8 mm. Just like the PiezoLegs motors, various control units are available.

Applications

Figure 7 shows a precision stage powered with two PiezoLegs 10N motors. The stage is a Feinmess Dresden product. PM Bearings in Dedemsvaart, the Netherlands, has a range of PiezoMotor-powered XYZ stages (see Figure 8) with sensors from Renishaw and strokes of 10-100 mm. A special version for use in a vacuum is also shown.

Figure 9 illustrates the use of a PiezoWave motor. Two motors drive a shutter for a FLIR (forward looking infrared) camera. In this design, the speed and size of the PiezoWave motor were the most important selection criteria.

Figure 10 is a medical application developed by Swedish BioResonator. A linear moving probe with a PiezoWave motor is used to measure the pressure in the vitreous body of the eye. Carefully controlled speed and driving force

Figure 5. A PiezoWave 0.1N linear motor: dynamic force 0.1 N, holding force 0.3 N, maximum speed 100 mm/s.

Figure 7. A precision XY stage from Feinmess Dresden powered with two PiezoLegs 10N motors.

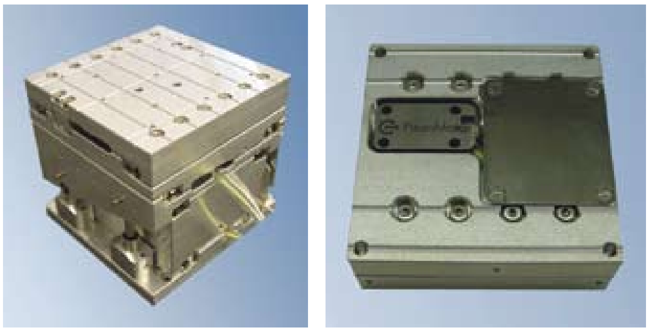


Figure 8. XYZ stages from PM Bearings with PiezoLegs drives and Renishaw sensors. On the right, a special contamination-free version for use in a vacuum.

were the design criteria. This intraocular pressure device is based on patented resonance technology and is considerably more flexible to use than conventional intraocular pressure measuring systems.

To conclude

It goes without saying that those working in the field of precision technology are well aware of Faulhaber's life-long experience in the design and manufacture of miniature motors. However, what is not as widely known is their commercial joint venture with PiezoMotor to market piezoelectric drives. Nonetheless, this co-operation will undoubtedly be very productive in the field of precision technology.

Information

www.faulhaber.com
www.piezomotor.se

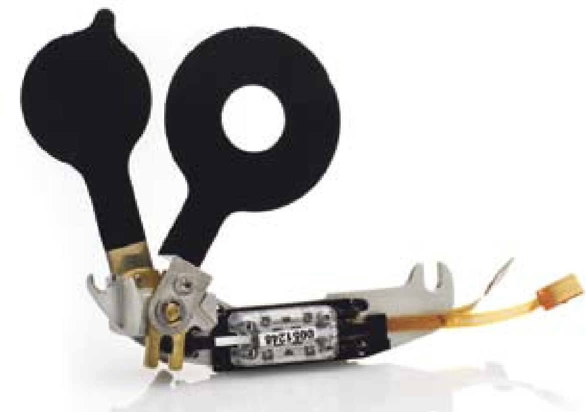


Figure 9. Two PiezoWave motors drive a shutter for an infrared camera.

Figure 10. A PiezoWave motor used for measuring the pressure in the vitreous body of an eye.

Seminar on Micro and Precision Manufacturing

Mikrocentrum and Fraunhofer IPT (Institute for Production Technology) will be holding a seminar on micro and precision manufacturing in Aachen, Germany, on Wednesday, 22 November. The day includes a guided factory tour at Fraunhofer IPT.

Micro system technology (MST) and nanotechnology are the key drivers behind the seminar on micro and precision manufacturing. Micro systems are miniature products whose technical functionality is achieved by components with very high accuracy. The importance of MST and nanotechnology is increasing for many products, such as personal computers, mobile phones, printheads, etc. New developments are not only expected in ICT but also in control technology, biotechnology, sensor technology, LED technology, robotics and telecommunications.

The 'everyday' use of nanotechnology in such things as cars, household appliances and cosmetics is also on the increase. This, in turn, increases the importance and demands on the entire manufacturing industry. Manufacturers of micro and precision components must have the machines, tools and technology to be able to produce these small and accurate products and/or components, which, in turn, creates new challenges for the manufacturing industry, knowledge institutes and technical universities.

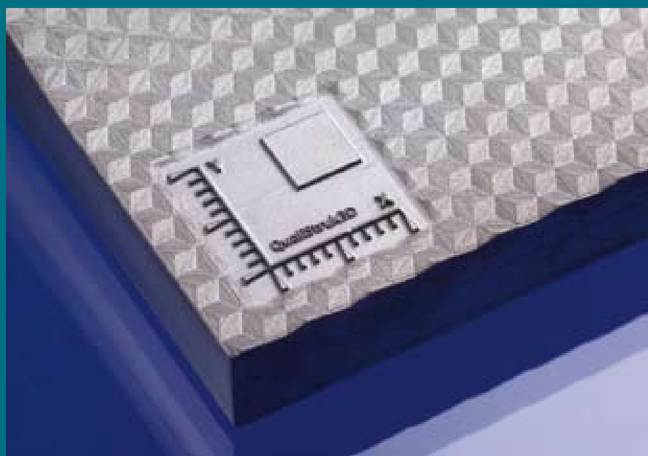
This seminar on micro and precision technologies aims to examine the state of the art of real micro and precision manufacturing for the benefit of all sectors involved in this manufacturing area. The seminar will be held at Fraunhofer IPT in Aachen, as they have a lot of know-how and practical experience to share.

(Photos courtesy of Fraunhofer IPT)

The seminar covers such industrial sectors as tool and mould making, medical, aerospace, micro-electronics, automotive, rapid prototyping and LED. The target group includes:

- engineers and other qualified technicians in research and development, production, work preparation, design engineers, technicians and purchasers;
- managers in production and development, and technologists;
- general managers who want to increase their knowledge of micro and precision manufacturing.

www.mikrocentrum.nl



Systems engineering course

The next Engenia systems engineering course will start in Utrecht, the Netherlands, on November 28. This course provides insight into the ins and outs of systems engineering and instruction on how to use its main elements. Participants will learn to assess the results of project parts in conjunction with systems engineering tools. This should eventually lead to improved cooperation within a project between participants and customers. The 3-day course has a strong interactive element because the material presented will be immediately tested in short exercises.

www.engenia.nl

How do you reposition a wafer, nanometer accurate, every 50 µs?

Join ASML as a Software Engineer and help to push the boundaries of what's possible.

At ASML we bring together the most creative minds in physics, electronics, mechatronics, computer science, software and precision engineering to develop lithography machines that are key to producing cheaper, faster, more energy-efficient microchips. Our machines need to image billions of structures in a few seconds with an accuracy of a few silicon atoms.

The speed and precision of our machines are critical to help our customers meet their production targets. As a result, our software-controlled lithography machines have to reposition silicon wafers to nanometer accuracy in all three axes every 50 microseconds. It's a complex piece of choreography that requires multi-disciplinary skills and real teamwork.

If you're a team-oriented software engineer who is challenged by complex technical problems, expert in programming and modeling for critical real-time applications and capable of working to demanding deadlines, you'll find working at ASML as a Software Engineer a highly rewarding experience. Per employee we're Europe's largest private investor in R&D, giving you freedom to experiment and a culture to get things done.

www.asml.com/careers

ASML

For engineers who think ahead

Holland Instru actions speak

This summer, Holland Instrumentation Delta in Delft gained momentum as several companies, universities and TNO joined forces in the Dutch province of Zuid-Holland. A knowledge transfer project was initiated and an event on sensor technology and innovation is in preparation. The aim is to bring together regional excellence in the high-tech instrument community to improve knowledge transfer, cooperation with universities and expert institutes, and to leverage contacts with the government.

• *Anton Duisterwinkel* •

Holland Instrumentation Delta was set up by Pieter Kappelhof (Hittech Multin), Rob Munnig Schmidt (Delft University of Technology) and Egbert-Jan Sol (TNO). They realised that the Dutch province of Zuid-Holland is underutilising its potential. This region has a very significant instrumentation industry, three highly respected universities in Delft, Rotterdam and Leiden and several renowned expert institutes such as TNO. Modules for satellites are produced, such as the OMI sensor for measuring ozone and other atmospheric contaminants. Also, this region manufactures world-class instruments for eye surgery, analytical chemistry and printing, while the semicon industry is also based here. Produced in small series, these highly complex products are precisely the type of products whose design, production, testing and calibration requires creative, highly skilled and highly motivated staff.

In addition to these directly recognisable instruments, it is also clear that heavier industries, which were originally not

Author's note

Anton Duisterwinkel is portfolio manager Semicon at TNO in Delft, the Netherlands.

anton.duisterwinkel@tno.nl
www.tno.nl

mentation Delta: louder than words

associated with high-tech instrumentation, have gradually evolved into true high-tech industries applying precisely controlled processes with sophisticated sensors, actuation and control. A good example is robotics, which is used in the offshore and agricultural industries.

Furthermore, TU Delft and TNO have an outstanding knowledge position in optics and mechatronics in terms of fundamental knowledge and how it is translated into applications used in space, optical modules, medical instruments and metrology. Erasmus University Rotterdam and Leiden University have excellent positions in medical applications. The Leiden Instrument Makers School is unique in its kind. Both Medical Delta and the Kennisalliantie Zuid-Holland offer excellent liaison services in medical and economic sectors. However, cooperation and knowledge transfer is not yet optimal in this region. Local and regional authorities do not appear to fully appreciate the value of the industry and need to strengthen their support. Improved cooperation is also needed to apply for grants and tenders in the EU as well as in the High Tech top sector recently identified by the Minister for Economic Affairs, Agriculture & Innovation.

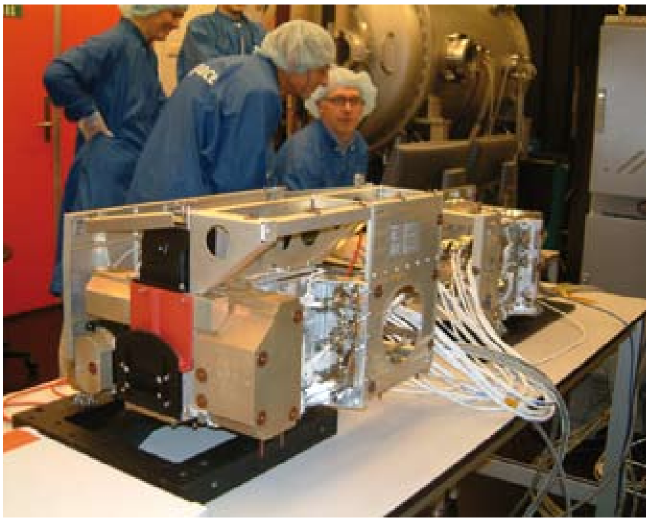
Sensor technology

Although still in preparation, Holland Instrumentation Delta has already launched two activities, as demanded by the local culture's can-do mentality reflected in the saying "actions speak louder than words". The first activity is a 'Technology Cluster' aimed at the transfer of knowledge on sensor technology between SMEs and TNO. This subject was selected because rapid, robust, repeatable and reliable sensors form the core of the instruments and are key to their commercial success. Also, TNO has a unique position in several sensor types, including spectroscopy, fibre and nano-optical sensors, acoustic sensors and radar technology. This technology cluster comprises Da Vinci Europe (Rotterdam), HedoN electronic developments (Delft), Hittech Multin (Delft), Lely Industries (Maassluis), Lencon (Koudekerk aan den Rijn) and VIRO engineering (Schiedam). The cluster is sponsored by the Ministry of Economic Affairs, Agriculture & Innovation.

Instrumentation event

Secondly, preparations have started for the ZIE, the Zuid-Holland Instrumentation Event, which is to take place in Delft on 29 November 2011. The focus will again be on sensor technology innovation. TNO and employers organisation for the technological industry, FME, are cooperating and sponsoring the programme, and other parties are or will also be invited. The programme will have a keynote speaker on the High Tech top sector, sessions on sensor technology in practical applications and on innovation management and funding, an information market where participants can present their products and expertise, and a meet-the-expert session.

Holland Instrumentation Delta hopes to launch even more initiatives and in this way attract more regional manufacturers, authorities, institutes and individuals that want to support the regional instrument industry and technology. In turn, these can and will generate new ideas on cooperation and coordination in this interesting, intelligent and intricate instrumentation industry.



The Ozone Monitoring Instrument (OMI) before shipment. OMI, built by a consortium in Zuid-Holland, measures ozone and other pollutants in earth's atmosphere from space. It is the first instrument ever for globally monitoring atmospheric ozone concentrations on a daily basis.

Twin-head

In silicon photonics, light can be manipulated on a very small scale on silicon chips. Silicon not only makes it possible to confine light into very tight waveguides, but by harnessing the silicon processing technologies used for electronics, very complex optical circuits are now becoming a reality. In Belgium, IMEC and Ghent University are among the pioneers of this field, and have developed a process portfolio for silicon photonic components for applications in optical communication (datacom/ telecom) as well as sensors, medical diagnostics and signal processing.

• *Sander Slagter* •

One of the issues with complex circuitry is that it needs reliable testing, preferably at wafer level. Such tests need to be fast and accurate. At the same time, research in silicon photonics requires an immense amount of optical measurements, often under varying conditions. Newport and the photonics research group at Ghent University-IMEC worked out a solution which could address both requirements: efficient wafer-scale measurements, as well as flexibility.

Solution

The set-up consists of two parts: a bottom translation stage which can manipulate the small samples and/or large 200mm wafers. The top twin fiber alignment heads accurately position fibers and keep them stable to enable longer-time measurements. Single fibers, as well as gratings, couple the light into the optical chips. The fibers are positioned above the wafer and the light from the fiber is then coupled to, e.g., the on-chip waveguide through a diffraction grating. While in many applications these gratings are fixed, the fibers in this set-up can also be tilted arbitrarily to optimise the coupling for custom gratings or wavelengths.

The set-up

The set-up, see Figure 1, was conceived with flexibility in mind: single fiber heads can be easily replaced by fiber arrays. The top and bottom stage assemblies are decoupled for many reasons, one big advantage is that the same fiber set-up can be applied onto commercial wafer testers as well. The system also enables thermal control to avoid any position drift and a provision has been made for electrical testing as well. Figure 2, as an example, shows the standard

Author's note

Sander Slagter is regional sales manager Benelux at Newport Corporation, a premier supplier of micropositioning and nanopositioning motion products to various industries. Contact for queries is Beda Espinoza, senior manager for motion product marketing.

beda.espinoza@newport.com
www.newport.com

fiber alignment

Newport rotary stage URS100BPP that was used for the TZ-sample axis.

Figure 1. Overview of the set-up, including:
- three standard linear stages for the X-, Y- and Z-sample axis, respectively;
- a standard rotary stage for the TZ-sample axis;
- two standard linear stages for the two XYZ-Fibers;
- two goniometric cradles for the two TY-Fibers;
- two XPS motion controllers for the wafer stack and the two fiber stacks.

Figure 2. The standard rotary stage URS100BPP used for the TZ-sample axis.

Description of the solution

The system is built up into three groups; see Figure 3. The first group at the centre (X-Y-Z-TZ-sample) supports the sample. This stack is to enable loading/unloading and a coarse adjustment of the sample. The second group (X-Y-Z-TY-Left) supports the first fiber, for its fine adjustment. The third group (X-Y-Z-TY-Right) supports the second fiber, delivering its fine adjustment.

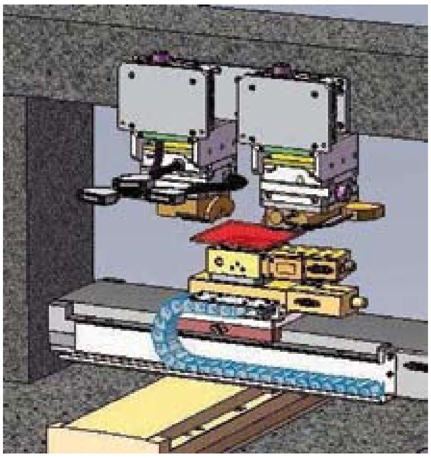


Figure 3. Close-up of the system, comprising the three stage groups.

One of the two last groups must be fitted with a 180° carrousel in order to allow an easy change of the heads; see Figure 4. The linear stage is mounted upside-down and uses a spring for counter balancing the weight.

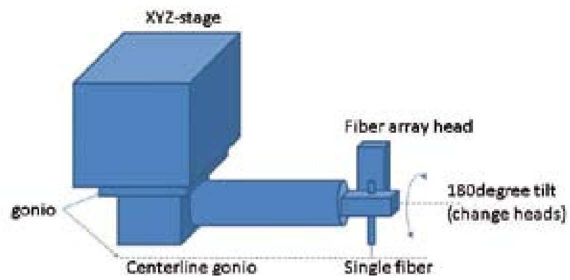


Figure 4. The group fitted with a 180° carrousel allowing an easy change of the heads.

Another challenge was that the fibers had to be close to each other (for small chips) and needed the flexibility of being able to have a 10° movement freedom with the gonio stages. So the fibers were cantilevered in such a way that they were close to each other. On the bridge, between the linear stages, there was a camera mounted to have visibility of the fibers and chips.

Demcon acquires minority interest in Imotec

High-end technology supplier Demcon has acquired a minority interest in Imotec, a company that focuses on analysing and designing mechatronic systems and innovation products. This transaction gives Imotec (Hengelo, the Netherlands) the means to grow further. For Demcon, the cooperation signifies a reinforcement of the Twente mechatronic ecosystem in which the company from Oldenzaal (the Netherlands) has become a prominent player.

Imotec has been active in the field of mechatronics at a high level for almost ten years. The company employs a staff of eight and will continue to operate independently, says director Jan Peters. “By cooperating with Demcon we can boost our professionalisation and sharpen our profile. Our focus will be on the control of mechatronic systems for which we devise concepts, make designs, write software and can also realise hardware. In addition, we can also select or develop the right sensors and actuators.”

In the field of intelligent & distributed control Imotec is in close contact with knowledge suppliers such as University of Twente (UT) and the KU Leuven University in Belgium (in the Open Robot Control Software (Orocos) project). Co-founder Theo de Vries is, among other things, associate professor of Mechatronics in the UT’s Control Engineering department.

www.demcon.nl
www.imotec.nl

Mecal receives American high-tech award

High-tech company Mecal received the ‘Supplier Excellence Award’ from American company Cymer at the end of August. It was presented with this award for a mechatronic farm-out project, says Jim Barnhart, Cymer’s Vice President Global Operations. Cymer selected Mecal last year on account of its knowledge of the semiconductor industry and its skills in the field of mechanic construction, optics and vibration insulation. For the project, which was conducted on a farm-out basis, Mecal engineers carried out inspections at a chip factory in the Far East, after which they took care of the full development, production and installation of a vibration-insulated mirror unit for positioning a high-capacity laser beam.

A clear trend towards farm-out has become visible among OEMs in recent years. Suppliers take on full responsibility for the development and production of a subsystem and for safeguarding knowledge and skills throughout the lifecycle. According to Johan van Seggelen, who was responsible for the project as business development manager, the fact that Mecal received recognition for a farm-out project is especially valuable: “Not just as a compliment for our company but I also see it as a statement about what the Dutch high-tech systems industry is capable of.”

www.mecal.eu

Johan van Seggelen of Mecal (left) and Jim Barnhart of Cymer during the award ceremony. (Photo: Mecal)

High power density

Maxon motor has fitted 170 Watts of power in the Ø40 x 80 mm, palm-sized housing of its new brushless direct-current motor EC 40. The motor features a neodymium permanent magnet, stainless steel housing and welded flanges. Technical data include very flat speed/torque gradient (about 3.7 rpm/mNm), mechanical time constant 2.1 ms, permissible speed 18,000 rpm, and efficiency 89%. The ironless winding offers extra quiet running and high stall torque.

www.maxonmotor.com

Roundness/cylindricity, flatness and straightness measurement

Mitutoyo recenly introduced the new ROUNDTEST® RA-1600 roundness/cylindricity measurement instrument at the Control Messe 2011 in Stuttgart, Germany. The instrument offers high-end precision plus data analysis software in a compact footprint. The high rotational accuracy of the unit's turntable (radial [0.02+6*H*/10,000] µm, axial [0.02+6*X*/10,000] µm) enables measurement of flatness in addition to roundness/cylindricity. A high-precision, power-driven Z-axis column enables evaluation of straightness as well as cylindricity. A detector is included to prevent damaging collisions in the Z-Axis.

www.mitutoyo.nl

PI acquires a majority of shares in miCos

The Karlsruhe-based company PI has recently become co-owner of miCos in Eschebach, Germany. This allows PI to supplement its extensive micro- and nanopositioning portfolio with a specialist in the field of vacuum applications and system integration. PI thereby expands its range of fast, high-precision system solutions, especially in the area of micropositioning, with air bearing technology and linear motors, for example.

In the future, PI-miCos will function as a subsidiary of PI. Lucius Amelung, Managing Director of miCos, comments: "Cooperation with the technological leader in nanopositioning technology and piezoelectric drives opens up new possibilities for us to develop high-quality, innovative products."

(Source: www.alt.nl)

www.micos-online.com
www.physikinstrumente.com

13-18 November 2011, Denver (US)
2011 American Society for Precision Engineering Annual Meeting

A forum for presentation and discussion of the latest technical information and achievements in precision engineering. The meeting will introduce new concepts, processes, equipment and products while highlighting recent advances in precision measurement, design, control and fabrication.

www.aspe.net

15-16 November 2011, Ede (NL)
Netherlands MicroNanoConference '11

An overview of the latest developments in micro- and nanotechnology, both from the academic and industrial point of view.

www.micronanoconference.nl

Networking at the Netherlands MicroNanoConference '10.

18 November 2011, Eindhoven (NL)
Bits&Chips 2011 Embedded Systemen

Conference on embedded systems and software; keynote speaker will be the ASML CEO, Eric Meurice.

www.embedded-systemen.nl

29 November 2011, Delft (NL)
Zuid-Holland Instrumentation Event

The focus of the event will be on sensor technology innovation. See also the article on Holland Instrumentation Delta in this Mikroniek issue.

www.tno.nl

30 November - 1 December 2011, Veldhoven (NL)
Precision Fair 2011

Eleventh edition of the Benelux premier trade fair on precision engineering. Some 200 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 and media partner Mikroniek.

Precision Fair 2011

www.precisiebeurs.nl

30 November - 1 December 2011, Bremen (DE)
Lamdamap 10th International Conference and Exhibition

Event focused on laser metrology, machine tool, CMM and robotic performance.

www.lamdamap.com

25-26 January 2012, Veldhoven (NL)
RapidPro 2012

The annual event for the total additive manufacturing, rapid prototyping and rapid tooling chain.

www.rapidpro.nl

4-7 June 2012, Stockholm (SE)
euspen 12th International Conference and Exhibition

Conference topics will include:

- Precision Engineering of Plastic based Electronics and Optronics
- Scandinavian Precision Engineering and Nanotechnology
- Nano & Micro Metrology
- Ultra Precision Machines & Control
- High Precision Mechatronics
- Ultra Precision Manufacturing & Assembly Processes
- Important/Novel Advances in Precision Engineering & Nano Technologies

www.stockholm2012.euspen.eu

Impression of the euspen 11th International Conference and Exhibition, May 2011 in Italy. (Photo courtesy euspen)

Miniature Drive Systems for Medical and Laboratory

FAULHABER

- DC-Micromotors
- Brushless DC-Motors
- Stepper Motors
- Linear DC-Servomotors
- Precision Gearheads
- Encoders
- Motion Control

WE CREATE MOTION

MINIMOTOR Benelux · www.faulhaber.com

Kick-off Certifi

At the end of August, mayor Rob van Gijzel of Eindhoven, the Netherlands, gave the go-ahead for the DSPE (Dutch Society for Precision Engineering) Certification program. The aim of the program is to raise the entire range of post-academic training courses for the Dutch high-tech industry to a higher level by certifying training courses for precision engineers. DSPE received funds from Agentschap NL to set up a Certified Precision Engineers (CPEs) register, within the framework of the efforts of the Point-One innovation programme for developing the Dutch high-tech ecosystem.

Two years ago, DSPE initiated the certification program to give the Dutch high-tech ecosystem a much-needed new boost. The fact was that as a result of the decline in the field of post-graduate training – the end of which was marked by the closing down of the Philips Centre for Technical Training in late 2009 – the available training programs were in danger of falling apart or even disappearing altogether. The high-tech sector in the Netherlands and especially the smartest region in the world (as Brainport was termed this summer) simply can't afford that, a fact also underlined by mayor Rob van Gijzel on 31 August in Best, the Netherlands, which you can read in his editorial in this Mikroniek issue.

Fortunately, new training suppliers for precision technology, mechatronics and related fields emerged. DSPE decided to review the courses on offer for both potential candidates and their employers and to monitor course quality by setting up a certification program. Having collated extensive amounts of information and armed with recommendations from prominent Dutch professors and major course users on the ground, training courses can now be certified. The common thread in the program of previously certified training courses is the multidisciplinary system thinking that has taken the Dutch high-tech systems industry to such great heights. The ultimate aim of these certification efforts is to hold on to and expand the industry's top position.

The kick-off was attended by over sixty representatives of the Dutch high-tech systems industry.

cation Program

Outline

The target group of the DSPE Certification Program includes precision engineers with a Bachelor's or Master's degree and with 2-10 years of work experience. They can earn certification points by following selected courses, and 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 certificate is an industrial standard for professional recognition and acknowledgement of precision engineering-related knowledge and skills, which allows the holder to use the title of Certified Precision Engineer (CPE). The certificate holder's details will be entered into the international Register of Certified Precision Engineers. In the (near) future, DSPE will outline a lifelong learning program, which is a prerequisite for maintaining CPE accreditation. A program committee supported by renowned Dutch professors will ensure quality control by constantly monitoring and evaluating the courses.

What's in it for precision engineers?
- Quality-assured high-end courses.
- A one-stop shop for education planning.
- Professional improvement and satisfaction.
- Greater networking opportunities.
- Management and peer recognition.

What's in it for companies?
- Quality-assured employee education.
- Efficient, straightforward high-potential development.
- More efficient product development, fewer design errors.
- Improved reputation with customers.
- Improved attractiveness as an employer.

Overview of certified courses
(some are still under construction)

Basic skills
- Mechatronic System Design
- System Architecting
- Motion Control Tuning
- Design Principles Basics/Construction Principles

Deepening skills
- Dynamics & Modelling
- Summer school Opto-mechatronics
- Actuators for Mechatronic Systems
- Metrology & Calibration of Mechatronic Systems
- Thermal Effects in Mechatronic Systems

Specific skills
- Applied Optics
- Modern Optics for Optical Designers
- Machine Vision for Mechatronic Systems
- Introduction in Ultra High & Ultra Clean Vacuum
- Design for Ultra High & Ultra Clean Vacuum
- Finite Element Method
- Advanced Motion Control
- Tribology
- Experimental Techniques in Mechatronic Systems
- Electronics for Non-Electronic Engineers
- Opto-mechanics

The courses are offered by established training institutes (The High Tech Institute, Engenia, Mikrocentrum, PAO-Techniek), the three universities of technology, and DSPE itself (Summer school Opto-mechatronics).

www.dsperegistration.nl

During the kick-off, Brainport Industries chair Marc Hendriks stressed the importance of collaborating. “Here we are, so many smart people, in the smartest region in the world, but it will only work if we collaborate across the entire chain.” Machteld de Kroon, Director of Research at TNO Technical Sciences, talked of the added value of training programs for the profession of precision engineer, emphasising the importance of explicit knowledge transfer on the one hand and the sharing of experiences (implicit knowledge) on the other. She was inspired by the feedback from participants in the annual Opto-mechatronics summer school organised jointly by DSPE and TNO. There is evidently great appreciation for the multidisciplinarity, the link between theory and practice, the instructors’ practice-based input with their do’s & don’ts, and the broad-based knowledge that is transferred in record time and at low cost. Moreover, it emerged from the final report of the knowledge workers regulation (set up by the Dutch government during the recent crisis to hold on to knowledge workers in the high-tech industry by incorporating them temporarily in knowledge institutes) that the knowledge exchange between businesses and knowledge institutes was highly valuable, De Kroon reported.

Finally, Joannes Collette, lector in Industrial Automation at Avans Hogeschool University of Applied Sciences and supervisor of the Certification Program, sketched the outline of the program aimed at helping precision engineers to obtain their ‘MBA degree’; see the box.

Introducing DSPE board members: Marty van de Ven

From the moment I started my career, I’ve had a strong link with fine mechanics. That started at Philips NatLab. The research done there is mainly for internal rather than external Philips customers. The combination of technology and application has always fascinated me – that was ingrained in the applied physics I studied – and when I was working at NatLab, I was contact for internal Philips customers.

I subsequently worked at TNO which is where I recognised the link between technology and business. Many businesses visit TNO to see what TNO has to offer. There I found very clearly that however beautiful technology is, there’s little you can do with it if it’s not applied. The role of making sure that technology finds application was the driving force behind setting up The House of Technology. My job there is to link technical experts to innovative companies so that these experts’ expertise is applied in a product, machine, process or wherever.
Basically, this is also one of DSPE’s roles: mutual contact, cross pollination and cooperation. When I started up The House of Technology, it was logical to join this network. So many people working towards the same goal: applying precision engineering. At DSPE, I’m now looking into ways of making technology more transparent and visible, which we do for DSPE members with the Precision-in-Business days I help Robert Swinckels to organise. I also want to get involved in the Brainport initiative towards creating more transparency for technology throughout the entire Brainport community.
In this way, I want to contribute towards strengthening DSPE and use mutual contacts to take businesses and their technology one step further.

www.thehouseoftechnology.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 precision mechanics and mechatronics. Services include conceptualization, development, engineering and prototyping.

member DSPE

Education

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

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

Argon Measuring Solutions bvba
Technologielaan 9
3001 Heverlee
Belgium
T +32 (0)16 380830
E info@argon-ms.be
W www.argon-ms.be

- Dimensional Quality Control
- Process Maintenance
- 3D Scanning / Reverse Engineering

3D measurement services range from ad-hoc interventions to turn-key metrology projects

Carl Zeiss B.V.
Industriële Meettechniek
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

MECAL

Engineering for a small planet

MECAL offers services for concept development; engineering and realization of mechatronic systems for OEM companies in the high-tech systems industry.

Mecal Applied Mechanics
De Witbogt 17
5652 AG Eindhoven
T +31 (0)40 2302700
F +31 (0)40 2302770
E mechatronics@mecal.eu
W www.mecal.eu

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

MARTEK

MARTEK BVBA
René Comhairelaan 82
1082 Brussel
Belgium
T +32 2 4670040
F +32 2 4670049
E info@martek.be
I www.martek.be

MARTEK is the BeNeLux specialist importer company for precision sensors, linear and angular encoders, inspection instrumentation, digital readouts and probing systems for machine tools.

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 micropositioning technologies.

member DSPE

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

ROTERO
ELECTRICAL MOTION & CONTROL

Rotero Holland bv
Pompmolenlaan 21
3447 GK Woerden
Postbus 126
3440 AC Woerden
T +31 (0)348 491150
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

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
supplier piezo ceramic solutions

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

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

Technical Innovation Services

PHILIPS
sense and simplicity

Philips Innovation Services
High Tech Campus 7
5656 AE Eindhoven
T +31 (0)40 27 48060
E SBO.innovationservices@philips.com
W www.innovationservices.philips.com

Philips Innovation Services draws upon a huge range of resources and know-how to support our customers in bringing their innovations to market, as fast and as efficiently possible. Our support covers the entire innovation process, from front-end innovation to mass production.

Your company profile in this guide?

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

DSPE Dutch Society for Precision Engineering

Your button or banner on the website www.DSPE.nl?

The DSPE website is the meeting place for all who work in precision engineering.

The Dutch Society for Precision Engineering (DSPE) is a professional community for precision engineers: from scientists to craftsmen, employed from laboratories to workshops, from multinationals to small companies and universities.

If you are interested in a button or banner on the website www.dspe.nl, please contact Sales & Services.

T: 00 31(0)229-211 211 ■ E: sns@wxs.nl

ADVERTISERS INDEX

DSPE

mikrocentrum
opleiden • ontmoeten • ondernemen

Precision Fair 2011

With the support of DSPE, Mikrocentrum organizes the 11th edition of the Precision Fair on 30 November and 1 December

Precision Fair 2011

- New technologies, solutions and products
- Exhibition of 200 specialized companies and knowledge institutions
- Participation congress programme included

TECHNOLOGY HOTSPOT

Mikroniek

The only official fair catalogue appears on the 25th of November

Book your ad and contact:

Sales & Services Gerrit Kulsdom
Tel. 0229-211 211 E-mail: gerrit@salesandservices.nl


Altering the world
The world of today is a world of progress, with advances coming at the speed of light. Things that seem impossible today are all but routine by tomorrow. Applied laser technology plays a key part in these expanding horizons and has become indispensable in a wide range of fields.
ALT has been a supplier of lasers and light sources for 25 years. Specialising in applications for microscopy, material and surface treatments, sorting and CARS, and working with leading suppliers, we can always deliver the latest in technology. Today and tomorrow. Day by day, we're working to develop our world.
ALT
PUTS
YOU IN
POSITION
www.alt.nl

HEIDENHAIN

How large is a critical difference?

Those like HEIDENHAIN who manufacture micrometer-precise measurement technology know: it's the details that make the vital difference. This applies to our products—and to our company. HEIDENHAIN has been engaged in metrology since 1889. We find this unparalleled performance to be worth investment: more than 10 percent of our revenue is allocated to research and development. The human side is also an important distinguishing feature. Mutual respect, fairness and trust are important to us—particularly when dealing with our customers. These "inherited traits" make our products that decisive tad better, and make HEIDENHAIN the world's preferred partner in measurement technology. HEIDENHAIN NEDERLAND B.V., Postbus 92, 6710 BB Ede, Telefoon: (03 18) 58 18 00, Fax: (03 18) 58 18 70, www.heidenhain.nl, e-mail: verkoop@heidenhain.nl

angle encoders + linear encoders + contouring controls + digital readouts + length gauges + rotary encoders