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Veldhoven, the Netherlands
2 and 3 December 2009

DSPE mikrocentrum IOP

Coriolis mass flow rate meter • Summer school: optics, mechatronics, fun
Ultra-precision, high-volume CMM • Simulating photonic integrated circuits
'Medical' laser machining • Cryogenic mechatronics • Nano-fabrication
Biomechanical engineering • 6-DOFs manipulator • Official fair catalogue

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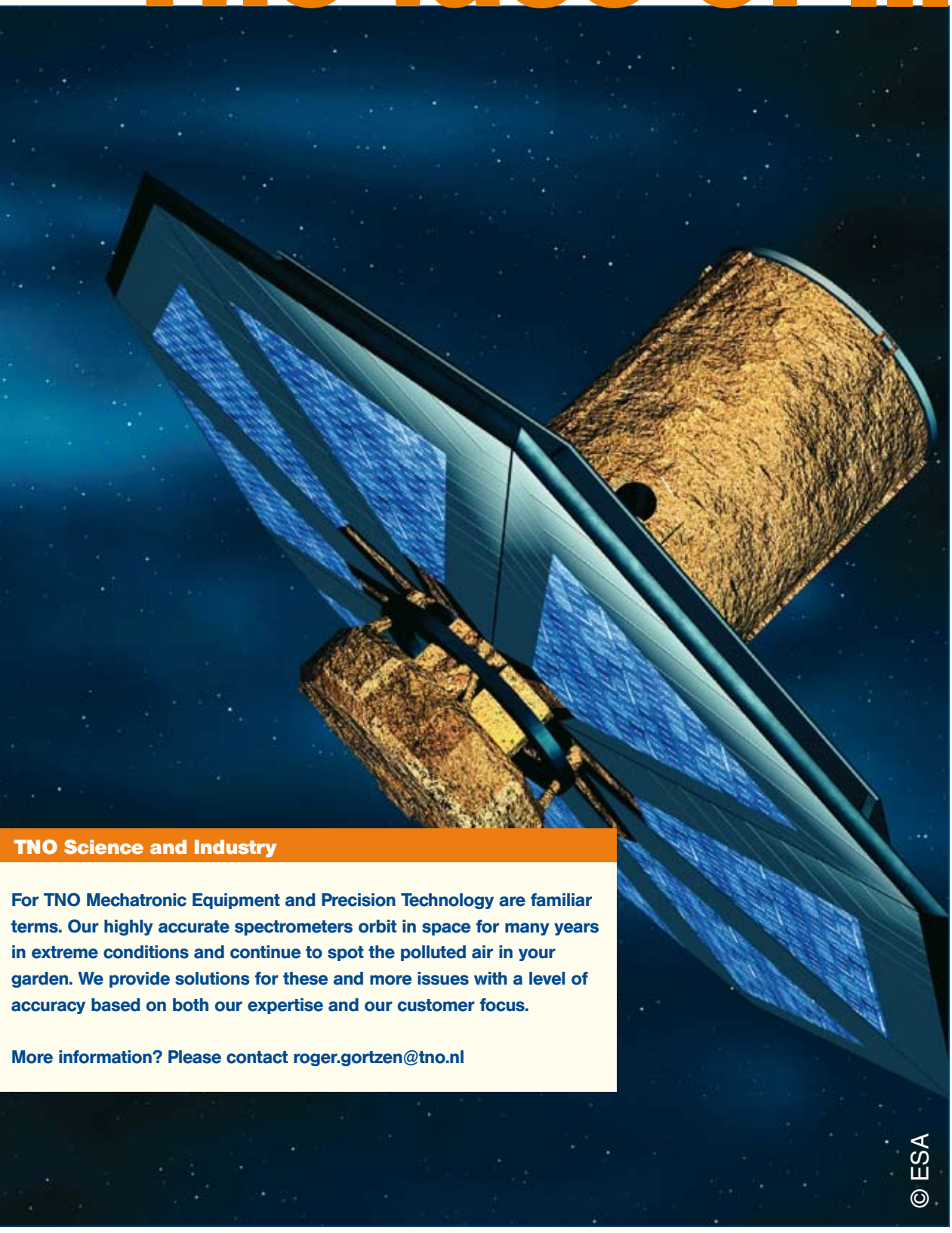

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In this issue

Publication information

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Professional journal on precision engineering and the official organ of the 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.
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The cover photo (part of a multi-axis manipulator) is courtesy Boers & Co.

editorial

Dutch Precision Engineering goes international

As the industry for high-tech industrial systems and high-tech consumer products is becoming ever more international, the Nederlandse Vereniging voor Precisie Technologie (NVPT) has decided to change its name to the Dutch Society for Precision Engineering, or DSPE. In a global market, more and more of our colleagues are from different countries and feel more comfortable communicating in English. Consequently, DSPE will gradually start to announce and conduct its activities in English to ensure the best possible communication between all professionals.

For example, the international Summer school on Opto-mechatronics has proven to be a great success, offering a solid platform of education for enthusiastic international participants. Every year, forty students follow the week-long summer courses held in a pleasant atmosphere.

Mikroniek is transforming itself into an English-language magazine. It is now distributed throughout Europe and has subscriptions from as far afield as the United States. Yet despite this transformation, we have decided not to change the name. Mikroniek, like the Swedish cracker knåckebrod, is now an internationally accepted term.

Although it will be a huge effort, we will steadily transform our website www.dspe.nl into English as well. The website is already frequently visited by professionals seeking to expand their knowledge (an average of 7,000 unique users per month over the last three years).

For post-academic education, DSPE has launched a certification programme for precision engineering education, comprising a high-quality range of courses, offered by professional institutes and Dutch universities. For each course, a sub-certificate is granted, and when students achieve nine sub-certificates, they will be assigned the title of Certified Precision Engineer (CPE), acknowledged by DSPE.

Now in its ninth year, the Precision Fair 2009 in Veldhoven, organised by Mikrocentrum, once again shows that precision engineering is an important economic activity in this part of Western Europe, offering interesting jobs, extensive challenges and great opportunities for both industry and individuals.

We hope that you enjoy your visit to the Precision Fair 2009, meet many interesting people and pick up new ideas to use in your professional work.

Hans Krikhaar
President of DSPE

Design and construction of a novel Coriolis mass flow rate meter

The Coriolis principle for measuring flow rates has great advantages compared to other flow measurement principles, the most important being that mass flow is measured directly. Up to now the measurement of low flow rates posed a great challenge. In a joint research project, the University of Twente and mechatronics company DEMCON worked on the mechatronic design and construction of a novel Coriolis mass flow meter for low flow rates. Innovations included shape and fixation of the meter tube, contactless (pure torque) actuation of the tube oscillation and contactless sensing of Coriolis force-induced displacements. As a result, the accuracy of the mini Coriolis is ten times better than that of existing, commercially available Coriolis mass flow rate meters. The resulting instrument is being produced and sold via Bronkhorst Cori-Tech.

• *Aditya Mehendale, Rini Zwikker and Wybren Jouwsma* •

The accurate and quick measurement of small mass flow rates (~ 1-10 mg/s) of fluids is considered an 'enabling technology' in the semiconductor, fine-chemical, and food & drugs industries. Flowmeters based on the Coriolis effect offer the most direct sensing of the mass flow rate. For this reason, they do not need complicated translation or linearization tables to compensate for the effects of other physical parameters (e.g. density, state, temperature, heat capacity or viscosity) of the medium that they measure, as is for example the case with the well-known thermal flow rate meter principle. It also makes Coriolis meters versatile – the same instrument can, without need for factory calibration, measure diverse fluid media, liquids as well as gases. Additionally, Coriolis meters have a quick response, and can principally offer an all-metal fluid interface with no wearing parts.

The Coriolis effect

A Coriolis force is a pseudo force that is generated when a mass is forced to travel along a straight path in a rotating system. This is apparent in a hurricane on the earth (a rotating system): when air flows towards a low-pressure region from surrounding areas, instead of following a straight path, it 'swirls', in a 'towards + sideways' motion. The sideways motion component of the swirl may be attributed to the Coriolis (pseudo) force. To harness this force for the purpose of measurement, a rotating tube may be used. The measurand (mass flow rate) is forced through this tube. The Coriolis force will then be observed as a sideways force (counteracting the swirl) acting upon this tube in presence of mass flow; see the box for an elaboration on the Coriolis meter principle.

The need for innovation

Based on the principle described in the box, Coriolis meters have been constructed for over fifty years, up till now mostly for medium to high flow rates; see Figure 2. This is because Coriolis meters scale poorly. Generally speaking, their performance degrades as the overall size decreases. From a constructional viewpoint, the Coriolis force is generated in an oscillating (rather than a continuously rotating) meter tube that carries the measurand fluid. In such a system, besides the Coriolis force, there are also inertial, dissipative and spring forces that act upon the meter tube. As the instrument is scaled down, these other forces become significantly larger than the generated Coriolis force. Several 'tricks' can be implemented to isolate these constructional forces from the Coriolis force, based on orthogonality – in the time

The Coriolis meter principle

In the construction of Figure 1, fluidic mass flow is introduced into a so-called 'active tube length' by means of two slip couplings and (compliant) bellows. The inlet and outlet are fixed, while the tube construction in between is driven to rotate by means of an external engine, such as an electric motor. A stiff frame couples the feeding sections of the pipe so that the inlet and outlet 'elbows', together with the frame, form a stiff rotating construction. A (stiff) force sensor is positioned between the rigid frame and the central straight piece of 'sensor' tube between the two bellows (constituting the active tube length).

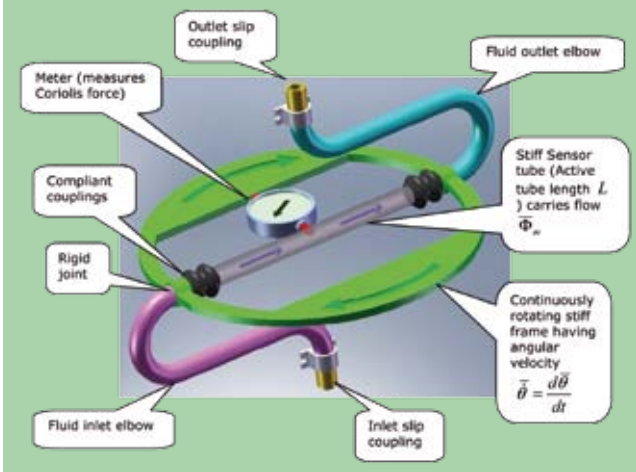

Figure 1. An illustrative rotating-tube Coriolis mass flow rate meter.

The resulting construction is rigid (meaning that the Coriolis force does not distort the tube geometry). As the construction rotates, and a mass flow is forced through it, all rotating parts of the tube (including the elbows) will experience a Coriolis force. This force will be restrained by the stiff construction – i.e. bearings around the slip couplings, and the rigid frame. The (sideways) Coriolis force in the middle section of the tube will also be restrained, but via the (stiff) force sensor. The reading on this sensor will thus indicate the net Coriolis force acting on the central rotating tube section, pushing against the rigid frame. It can be derived [1] that the Coriolis force amounts to:

$$F_{Coriolis} = -2l \cdot \left(\dot{\bar{\vartheta}} \times \bar{\Phi}\right)$$

So, a displacement due to the Coriolis force is orthogonal to the flow as well as to the rotation direction. The Coriolis mass flow meter tube may thus be viewed as a 'modulator', which has as an output (Coriolis force) that is proportional to the product of the angular velocity of the tube $\left(\dot{\bar{\vartheta}}\right)$ and the measurand $\bar{\Phi}$ (mass flow rate). It increases with active tube length *l*.

Figure 2. Large omega-shaped twin tube Coriolis meter for petrochemical applications (Rheonik RHM160).

domain, in eigenmodes and in terms of position (unobservable and uncontrollable modes, symmetry, etc.).

As with all flowmeters, it is desirable to make an instrument with high repeatability and small offset-drift. To avoid the need for characterization, linearity is also desirable. Due to the unwanted forces of relatively large magnitudes interfering with the Coriolis force, a large drift can arise in the meter's reading. Designing a meter (for a small flow rate) with an acceptably small drift is the most challenging task.
In defining the requirements for the new Coriolis meter, functional (flow rate range, accuracy, zero stability, pressure drop, medium density determination, response speed) as well as technical (small dimensions, eigenfrequency range versus mains frequencies) aspects were taken into account. The subsystems that were considered in the design process, included the tube, the actuator, the sensor system, data processing and finally the housing, which has to act as a stiff basis for the other subsystems. See the box for typical requirements.

Mechatronics

The design of a Coriolis flow meter involved multidisciplinary elements: fluid dynamics, precision engineering construction principles, mechanical design of the oscillating tube and surroundings, sensor and actuator design, electronics for driving, sensing and processing, and

Typical requirements

- Dynamic measurement range 1 g/h - 1 kg/h.
- Zero stability ≤ 0.1% of full scale.
- Accuracy ≤ 0.2% of reading + zero-stability.
- Settling time (98%) ≤ 1 sec for a setpoint change (i.e., deviation of actual flow rate from the setpoint being less than 2% of full scale).
- Pressure drop (water) ≤ 1 bar at full scale.
- Operating pressure ≤ 200 bar.
- Accuracy for medium density ≤ 10 kg/m^3

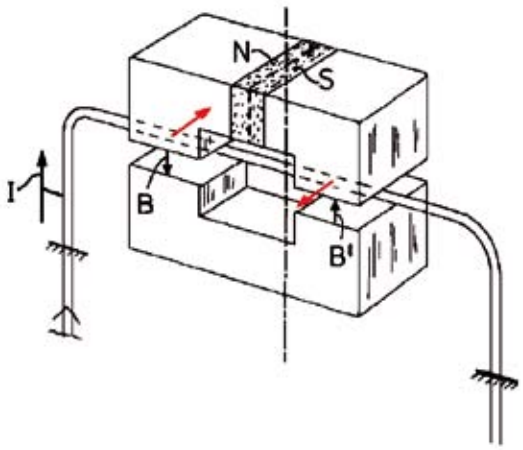

Figure 3. Schematic of a pure torque actuator; the Coriolis tube carries an alternating current.

software for data manipulation and control. This called for a mechatronics design approach, including a statically determined construction, orthogonality of modes, constructional symmetries, strategic sensor and actuator placement and separation in the frequency domain. Processing (compensation for higher-order physical effects) was also required in order to reduce sensitivity errors. This was done by means of purely time-domain measurements, correction using multiple position sensors, and (sensitivity) correction for medium density and temperature. The principal innovations that were realised in the course of the project, included the shape and fixation of the measurement tube, the contactless excitation of the tube, and the contactless sensing of Coriolis force-induced displacements.

Excitation

It is advantageous to have contactless actuation to drive the Coriolis tube into oscillatory motion. This avoids potential interference caused by actuator parts attached to the tube. Therefore, Lorentz force actuation was selected; see Figure 3. The tube, itself acting as the (alternating) current carrier, is exposed in two (oppositely oriented) magnetic gaps, which carry flux lines in anti-parallel directions. As the two gaps are in 'series', the flux densities in the gaps are (nearly) identical, and the Lorentz forces generated in the gaps will be equal-and-opposite – in fact constituting an almost ideal torque. Being a torque actuator, its position (in the horizontal direction in Figure 3) does not significantly affect the nature of the actuation. The frequency of the oscillation is chosen so as to correspond with a tube eigenfrequency. This minimizes the actuator effort needed to drive the tube.

Tube shape

A crucial 'trick' in Coriolis meter design is selecting the optimal tube shape. Already, numerous unique tube shapes have been patented, which suggests that it may be

impossible to arrive at “the one best tube shape”. In this project, the following aspects were considered:

- Attachment
  The way in which the tube is attached to the fixed world should not affect its properties and motion. This suggests the use of a statically determined, vibration-free foundation. If the inlet and outlet of the tube can be placed close to each other, thermal stresses in the foundation are less likely to distort the shape of the tube.
- Independent modes
  The Coriolis force is generated in a direction perpendicular to the mass flow, as well as to the rotation. Given that oscillation at one eigenfrequency in a particular eigenmode is the source of said rotational motion, this implies that the Coriolis force will act on a different eigenmode of the tube. In case this (very small) force is to be sensed indirectly (i.e. by observing deflection in the tube), the tube deflection mode (the response) should have a well-defined characteristic (transfer function gain) at the oscillation frequency. This suggests, that the eigenfrequency of the response mode should be away from the oscillation frequency. (This is contrary to the intuition to place the response mode’s eigenfrequency close to the excitation eigenfrequency to maximize gain, because in that case the gain and the phase change a lot with minor property changes). Furthermore, the unused oscillation modes of the tube should be designed far away from the excitation and response modes, to prevent parasitic interactions.
- Maximizing the response
  To generate a large Coriolis force, the rotating tube segment should be as large as possible. The tube should be either compliant or light in the response mode, depending on whether stiffness or mass determines the response. The moment arm of the Coriolis force upon the response mode should be as large as possible. This increases the achieved mechanical deflection (caused by a small Coriolis force).
- A mechanically ‘closed’ form
  To minimize the effect of unavoidable asymmetries, the energy storage elements (elastic element, and centre of mass) of the oscillatory system should be close to the axis of rotation. For the same reason, it is advantageous to have the possibility to place the oscillation actuator near the rotation axis of the response mode.

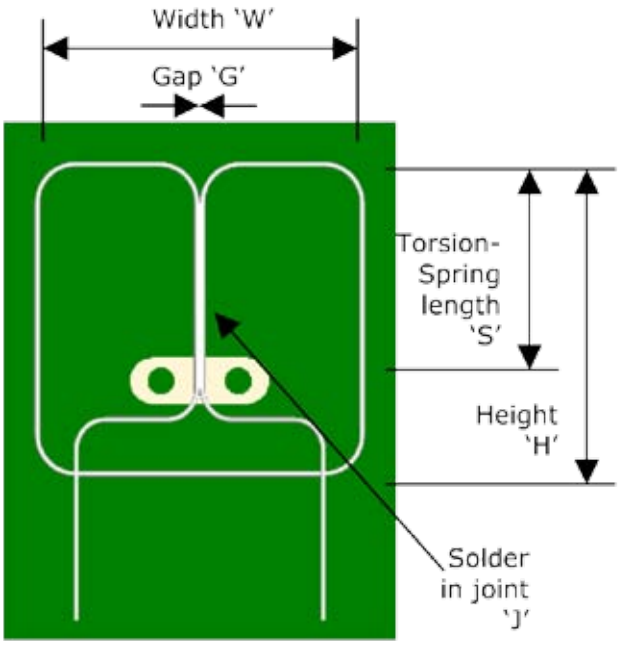

Figure 4. The ‘window’-shaped Coriolis tube, shown with the relevant dimensions.

Based upon these considerations, the ‘window’ shape was designed; see Figure 4. To be able to obtain an accurate tube shape, a dedicated bending tool was constructed by DEMCON.

Mode analysis

Following the discussion on independent modes, finite element simulations were performed to gain insight in the eigenfrequencies of the tube, as determined by the tube dimensions; Figure 5 shows a typical example. Here, the frequency of the mode that can be associated with the Coriolis response (‘swing’) lies below the eigenfrequency (used for the excitation). From detailed considerations it was concluded that this is to be preferred above the reverse situation, $f_{Coriolis} > f_{eigen}$. A complicating factor in this respect is that the mains frequency and its odd harmonics have to be avoided, to prevent interference.

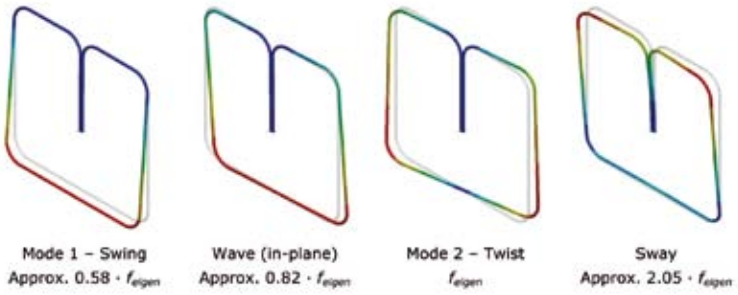

Figure 5. Tube eigenfrequencies determined by finite element simulations, after optimisation of the dimensions.

Measurement

For contactless measurement of the Coriolis force, optical transmissive (interruption-based) position sensing was selected. An aligned pair consisting of an optical emitter (typically a LED) and an optical detector (typically a phototransistor) forms a basic sensing entity. Light from the emitter traverses a gap and is incident upon the detector. By placing an occluding element in this gap, the amount of light reaching the detector may be modulated, thus proportionally modulating the photocurrent that is generated; see Figure 6. This photocurrent may be converted to an analog signal suitable to be digitized and interpreted by a digital signal processor (DSP). A vane placed on the Coriolis tube may act as the occluding element.

The excitation motion of the active portion of the tube needs to be a rotation, in order to generate a Coriolis force. For a periodic excitation, the motion resulting from a Coriolis force is a periodic translation. For any given point on the tube these rotation and translation motions are orthogonal, i.e. appear as a superposition. These two motions ('excitation' and 'response') should be separated in order to isolate the response motion (which represents the Coriolis force). Two factors can be used to aid this separation:

1. As the excitation motion is a rotation, it has an axis. At this axis, the position change of the tube due to rotation is zero; here, the motion is purely due to translation. Alternatively, if two position sensors observe the tube symmetrically around the rotation axis, the common-mode signal (mean of the two) corresponds to the translation, while the difference corresponds to the excitation (rotation) motion.

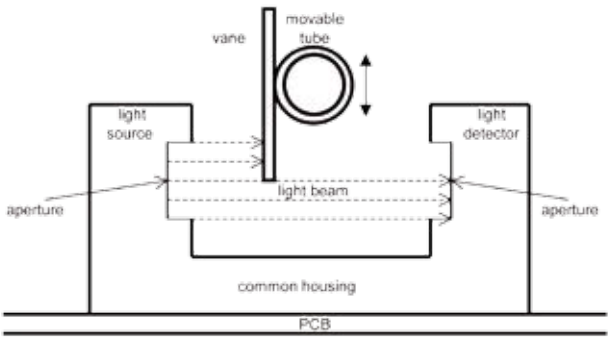

Figure 6. Occlusion-based optical position sensing.

2. The Coriolis force is by definition in phase with the angular excitation velocity of the active tube section, which is excited in a simple harmonic (sinusoidal) motion. This means that the Coriolis force is 90° phase-shifted from the excitation motion. The Coriolis force is generated at the frequency of the excitation motion, not at the eigenfrequency of the Coriolis mode. The Coriolis motion is therefore either in phase or in opposite phase with the Coriolis force. Knowing the exact phase of one of the two – the excitation or the response – can enable the isolation of the response motion.

As a result from this – and essential for the measurement – is that the Coriolis motion for any point on the tube is not only orthogonal (resulting in superposition) but also 90° phase-shifted from the excitation motion. This allows a measurement of the Coriolis force to be done in terms of phasor-angle differences only, i.e. entirely in the time domain.
Consider two sensors placed symmetrically around the excitation rotation axis. Each simultaneously measures the superposition of amplitudes of a point on the tube caused by rotation (excitation) and translation (Coriolis). The excitation motion can be considered a phasor arrow, its length corresponding to the amplitude of excitation as seen by the sensor, and its direction to the phase. As the position sensors are placed on two sides of the rotation axis, the excitation phasors are 180° out-of-phase – thus represented by anti-parallel arrows; see Figure 7. The Coriolis translation of the tube can be represented as two in-phase phasors for both sensors. As explained above the Coriolis phasors are 90° phase-shifted from the excitation phasors.

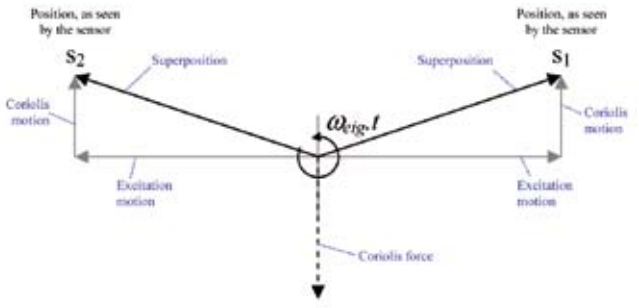

Figure 7. Phase diagram of the Coriolis tube's displacement. The two position sensors 'see' anti-parallel excitation phasors and parallel response phasors.

The superposition of the excitation sine and the Coriolis cosine results in a phase shift of both sensor signals relative to the excitation. This phase shift on each of the two position sensors is in opposite direction, causing a change of the relative phase angle between both phasors. This phase shift is a direct measure for the mass flow rate through the tube.
The advantage of this time domain approach is that it is ratiometric: the phase shift is only determined by the ratio between Coriolis and excitation amplitudes, not by their absolute values. It is therefore insensitive to excitation amplitude and sensor sensitivity, and any drift thereof. This makes the gain and offset calibration of (position) sensors unnecessary.

To maximize the position sensor ratio gain, the two sensors are placed close to the rotation axis, thus detecting relatively small rotation-induced displacements, wheras measuring the full Coriolis-induced displacement. A third position sensor, lying in one line with the other two sensors, is added to allow for correction of a rotation axis shift; see Figure 8. Using the fact that all three sensors measure the same Coriolis-induced displacment, a shift of the rotation axis can be calculated.

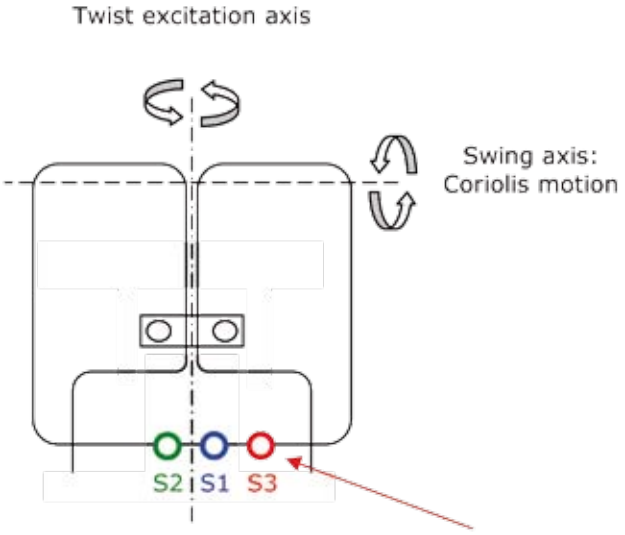

Figure 8. Position sensors S1 and S2 are placed near the rotation axis. A third position sensor S3 is added to allow for correction of a rotation axis shift.

Phase detection

Various phase detection schemes are available for accurately measuring a phase difference between two signals. A dual zero-crossing detector may be the simplest option. However, a so-called dual quadrature detection scheme was selected, because it offers several advantages, such as lower measurement noise, the possibility of rejecting of harmonics, and ease of implementation on inexpensive commercial DSPs. This detection method uses phase-locked loop algorithms to observe the complete waveform, not just the zero-crossing instants, to extract phase information.

Performance

In conclusion of the research project, from the subsystems described above a Coriolis flowmeter prototype with an all-steel fluid interface was constructed, having a specified full-scale (“FS”) mass flow rate of 200 g/h (~55 mg/s) of water. This instrument was shown to have a long-term zero-stability better than 0.1% FS and sensitivity stability better than 0.1%, density independence of sensitivity (within 0.2% for liquids), negligible temperature effect on drift and sensitivity, and a settling time of less than 0.1 seconds. For higher and/or negative pressure drops, the instrument was seen to operate from –50xFS to +50xFS (i.e., from –10 kg/h to +10 kg/h) without performance degradation – particularly important in order to tolerate flow pulsations in dosing applications.
Subsequently, instruments for various flow rate ranges were built and studied. Figure 9 gives an indication of the high accuracy that is associated with measuring flow using these instruments. The relative measurement errors of several instruments were compared to a ‘conventional true value’, measured by a reference instrument. The results in Figure 9 for water show that the relative error is within 0.2% over a large part of the flow rate range. From this it may be concluded that this novel type of Coriolis mass flow rate meter has an accuracy that is ten times better than that of existing, commercially available instruments for this low flow range.

Commercial instrument

Based upon this research outcome, a commercial instrument was developed, that is now available in a compact housing (130 x 60 x 30 mm) in three versions, each having a different measuring range: 100 g/h, 1 kg/h and 10 kg/h, respectively. Up to now, over six patent

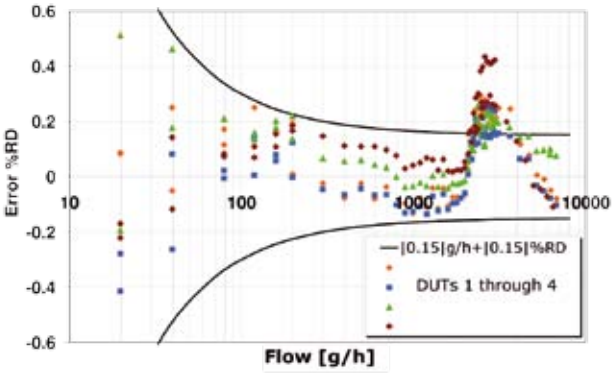

Figure 9. Relative measurement errors for various instruments (DUTs 1 through 4). The rise in error observed for flow rates above 2,000 g/h is ascribed to the laminar-turbulent flow transition of the medium (water). The 'trumpet curve' shown corresponds to a boundary beyond which the error is larger than acceptable; here, the boundary is expressed as a combination of relative (0.15% of reading) and absolute (0.15% of full scale) error.

applications have been filed. Since April 2008, the instruments, named mini CORI-FLOW, are being produced and sold by Bronkhorst Cori-Tech; see Figure 10. At the 'Het Instrument' trade fair in 2008, the mini CORI-FLOW was awarded the Novelty Award.

Authors' note

Aditya Mehendale received his Bachelor's Degree in Electronics Engineering from the University of Pune, India, and his Master's Degree in Mechatronics from the University of Twente, Enschede, the Netherlands. He worked as a Ph.D. student in the Measurement and Instrumentation group at the same university, on the design and construction of the Coriolis meter decribed in this article, in close collaboration with mechatronics company DEMCON. In 2008 he received his Ph.D. Now, he works as a researcher stationed at DEMCON for the university's Mechanical Automation and Mechatronics group, in the field of MEMS-based Coriolis devices.
Rini Zwikker is senior mechatronic systems engineer and project leader at DEMCON in Oldenzaal, the Netherlands. He was in charge of the Coriolis meter project.
Wybren Jouwsma is technical director of Bronkhorst Cori-Tech.

Reference

A. Mehendale, "Coriolis Mass Flow Rate Meters for Low Flows", Ph.D. thesis, University of Twente, 2008, ISBN 978-90-365-2727-9.

Figure 10. The mini CORI-FLOW, housing a novel Coriolis meter for low mass flow rates.

Information

www.bronkhorst-cori-tech.com
www.ce.utwente.nl
www.demcon.nl

Optics, mecha

This summer, the Dutch Society for Precision Engineering (DSPE) organised the second Opto-mechatronics Summer school. Held from 29 June to 3 July, the event was hosted by TNO Science and Industry in Eindhoven and, with some forty participants, was fully booked. While most participants came from companies, universities and research institutes in the Netherlands, others came from as far afield as France. Once again, the Summer school proved to be a successful event, offering a combination of lectures on high-tech engineering, ample networking opportunities and enjoyable social activities.

• *Jeroen Theeuwes* •

Summer school Precision Technology Opto-Mechatronics

The first day started with a word of welcome from Hans Krikhaar, president of DSPE, who stressed the importance of mechatronics, especially in the Netherlands, and clarified DSPE's vision. He told the participants that DSPE is currently in discussions with various HR departments at major technology companies in the Netherlands regarding an official and acknowledged certificate for the participants of the summer and winter schools (on optics and opto-mechanics) organised by DSPE. This should make it easier for engineers to enrol in the courses.

Systems engineering

Then the main topic of the first day was introduced, namely systems engineering. Flip Zijdemans from Dutch Space and Friso Klinkhamer from TNO presented the concept of systems engineering, which was followed by a discussion on budget and system breakdown analyses. Next up was the V-model, which is often used in systems engineering to break down the total process into a number of steps, from functional specification to system integration and testing.

The entire course had something of central theme – an optical delay line for the Very Large Telescope Interferometer (VLTI) of the European Southern

Figure 1. With some forty participants, the second DSPE Summer school was once again fully booked.

tronics and fun

Figure 2. The optical delay line of ESO's Very Large Telescope Interferometer on Mount Cerro Paranal in Chile. (Photo: Fred Kamphues)

Observatory (ESO). The VLTI comprises four optical telescopes, operated in an array configuration. The optical delay line (see Figure 2) is created with a 'cat's eye', i.e. light is deflected back in the direction from which it came. After Flip Zijdemans and Friso Klinkhamer had introduced the case and discussed the specifications, small groups of participants practised using system budgets to analyse the design of a delay line.

After a delicious meal, Frank de Lange, a systems engineer at ASML, presented his view of systems engineering at the company. While agreeing with the methods proposed earlier in the day, he noted that time constraints usually prevent ASML from actually following the whole systems engineering approach. Frank had some amusing examples of what can go wrong if you do not follow these procedures.

Optics

The second day focused on optics, the day's lecturers being Stefan Baumer from Philips and Eddy van Brug from TNO. Given that the optical delay line consists of several optical parts, knowledge of optics is essential for the design of the cat's eye. After an explanation of optical metrology, aberrations in optical systems and Zernike polynomials, the participants were asked to work in groups to calculate the different lenses in the cat's eye – an assignment that turned out to be quite a challenge. After dinner, Frederic Derie from ESO gave a presentation about the optical delay line in Chile. In addition, he talked about other uses for this telescope and ESO's future plans, such as the OverWhelmingly Large Telescope (OWL), which will be completed around 2021.

Control engineering

The theme of the third day was control engineering, the lecturers being Professor Maarten Steinbuch from Eindhoven University of Technology and Rufus Fraanje from TNO. Steinbuch stressed the importance of control in mechatronics and how control engineering helped in many innovative products, such as the Compact Disc. In addition, the Laplace transform, Bode diagrams, Nyquist plots and

Figure 3. Besides lectures, the participants were given practical exercises.

Figure 4. A social activity with lots of K'NEX and lots of fun.

SISO (single input, single output) and MIMO (multiple input, multiple output) were also discussed. Practical exercises during the afternoon session enabled the participants to familiarise themselves a little more with control engineering under the supervision of Raymond Knaapen and Niek Rijnveld from TNO. Using Matlab, everybody had to design a controller for a mass-spring set-up, which had to exhibit a specified settling time and steady-state behaviour.

Lots of fun

A social activity was planned for Wednesday evening; see Figure 4. The participants were split up into eight groups and each group was given a K'NEX construction set, some tape and paper. The assignment was to build something consisting of at least 10 K'NEX parts, that would stay airborne for as long as possible on being launched from the third floor of the TNO building. Extra points could be earned for originality, for the total number of components used and for a creation that was still intact on landing. Some of the creations behaved like a helicopter, while others behaved more like a brick… The winners all went home with a box of K'NEX.

Opto-mechanical design

Thursday, the fourth day, focused on opto-mechanical design. Lecturer of the day Jan Nijenhuis from TNO started with some examples of what can go wrong with optical components when they are improperly mounted. Issues such as temperature and stress can cause the optical system to degrade and even break down. Jan explained what should have been done in these examples to prevent the errors and then went on to focus on the opto-mechatronic design of the cat's eye of the optical delay line. Throughout the presentations, Jan stressed that elastic mechanisms guarantee the best possible performance and that temperature changes can have a serious impact on the performance of an instrument.

Opto-mechatronics

On Friday – the fifth and final day – the focus shifted to opto-mechatronics. This subject was addressed by Professor Rob Munnig Schmidt from Delft University of Technology. He discussed precision positioning of optics, control of vibration, skyhooks and position metrology, and provided various examples of how these techniques can be used in the optical delay line. Significant attention was paid to encoders and how to increase their precision with the Vernier principle. This session also looked at interferometers.

Closure

To conclude the week, the participants were divided into groups. Each group had to use the knowledge they had gathered throughout the course to design an optical delay line for use in the Antarctic. The groups had to make an inventory of problems that might occur when a delay line is operated at 220 K as well as thinking about maintenance issues. They also had to indicate key problems and possible solutions before presenting their findings to Munnig Schmidt, who then provided them with feedback.

After the presentations, the participants were joined by all the lecturers, who received their feedback. The participants were also able to provide feedback on the Summer school, the general feeling being that the week had been a great success.

Author's note

Jeroen Theeuwes works at TNO Science and Industry in Eindhoven. He would like to thank DSPE and all the speakers for the great learning experience, and TNO Science and Industry for the exemplary way in which they organised the Summer school.

Information

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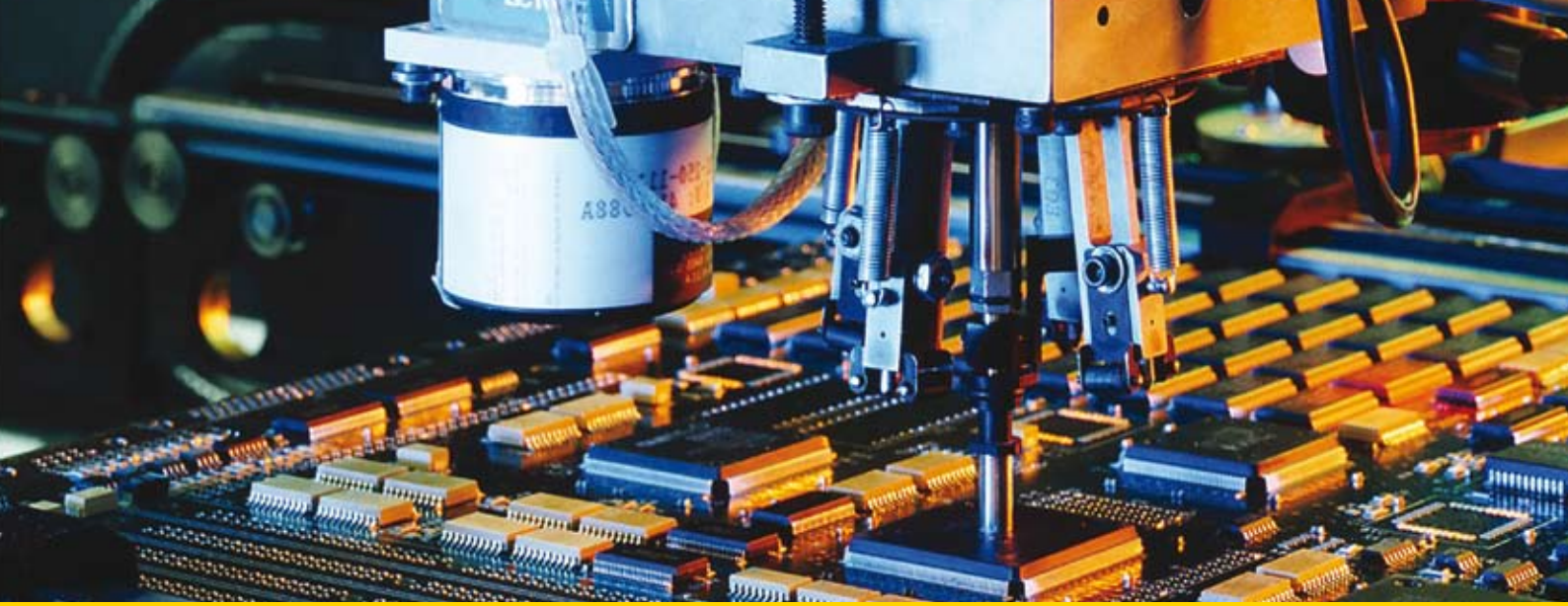

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Isara 400 features

In various fields of manufacturing and research, a growing demand for ultra-precise 3D measurement of large products exists. To fulfil this demand, IBS Precision Engineering is developing a new ultra-precision coordinate measuring machine (CMM) with an unprecedented ratio of measurement volume vs. measurement accuracy. This article presents the design concept, various design details and the realization of the Isara 400 CMM.

• *Rilpho Donker, Ivo Widdershoven and Henny Spaan* •

In collaboration with Philips Applied Technologies, IBS PE previously developed the Isara CMM, an ultra-precision 3D coordinate measuring machine (CMM), based on the design by Ruijl [1], with a measuring volume of 100 x 100 x 40 mm and a 1D measuring uncertainty of 15 nm; see Figure 1. Similarly, other ultra-precision measuring machines [2] [3] have been developed, which also typically feature measuring ranges ≤ 100 mm. In response to the demand for 3D measurement of larger products with features that require nanometer measuring uncertainty, the new Isara 400 ultra-precision CMM is being developed.

Figure 1. The first Isara CMM.

‘mega volume’ vs ‘nano accuracy’

Isara 400 concept

The new Isara 400 CMM features a measurement volume of 400 x 400 x 100 mm. Three plane-mirror laser interferometers are applied as measuring systems for the machine axes. The interferometers each measure against the sides of a mirror table, on which the work piece is mounted. These interferometers are mounted in a single-body metrology frame, which also holds the probe system; see Figure 2.
The laser beams are aligned to the probe tip and their mutual alignment does not change during movement of the axes, thus fulfilling the Abbe principle [4] in 3D within the complete measuring volume. As a result, straightness errors and rotations of the three translation stages will have no first order influence on the measurement result. The influence of flatness and squareness errors of the three mirrors is eliminated by means of a series of on-machine calibration measurements.

In the configuration of the translation axes, a machine concept was chosen in which the variable product mass does not need to be moved vertically; see Figure 3. The product is mounted on the mirror table, which moves only in X- and Y-direction over a granite plate, guided by air bearings. The complete metrology frame moves in Z-direction, with guiding provided by air bearings against a vertical granite surface. This metrology frame contains the three laser interferometers and the probe, thus maintaining the Abbe alignment.
The Isara 400 CMM features several design principles that are required for precision measurement machines [5]. The design of several key components is described in the next sections.

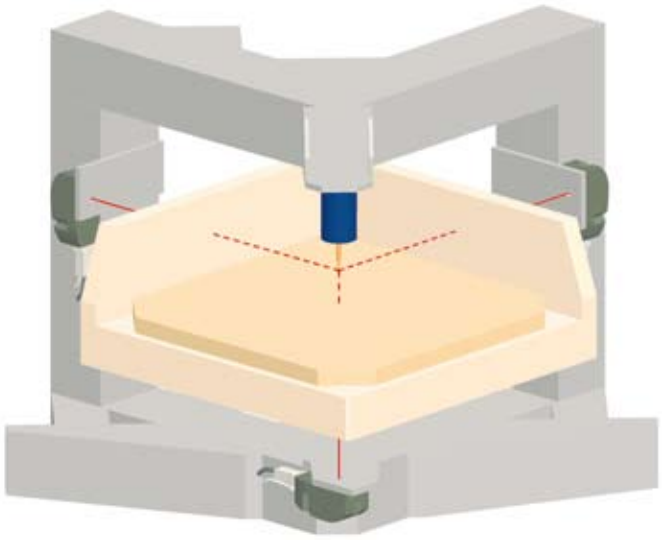


Figure 2. The 3D Abbe principle of the Isara 400 CMM.

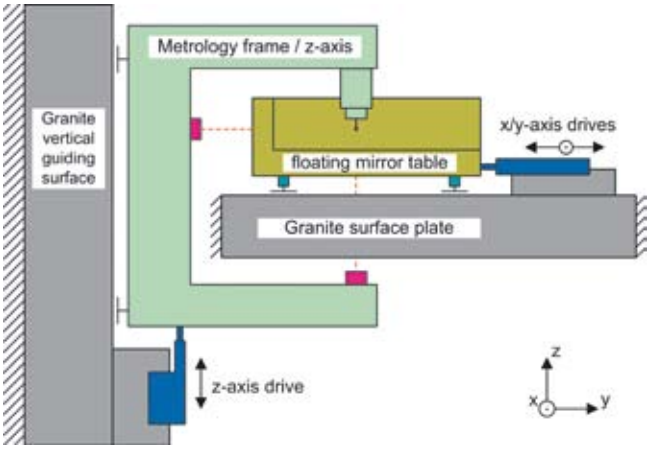


Figure 3. Concept of the Isara 400 CMM.

Mirror table

The mirror table of the Isara 400 is a monolithic Zerodur part with three reflective sides; see Figure 4. An additional product table is used as an interface between product and mirror table. This Silicon Carbide (SiC) product table was designed to be both light and stiff. The three supports of the product table are placed directly above the three supports of the mirror table, so that the weight of the product and product table does not cause additional deformation of the mirrors. The mirror table is supported by three flat air bearings, whose preload is provided by the weight of the mirror table assembly with product.
The coupling between the floating mirror table and the X-carriage, see Figure 4, must define three degrees of freedom (X, Y and Rz) and allow for differences in thermal expansion. As the coupling is directly connected to the

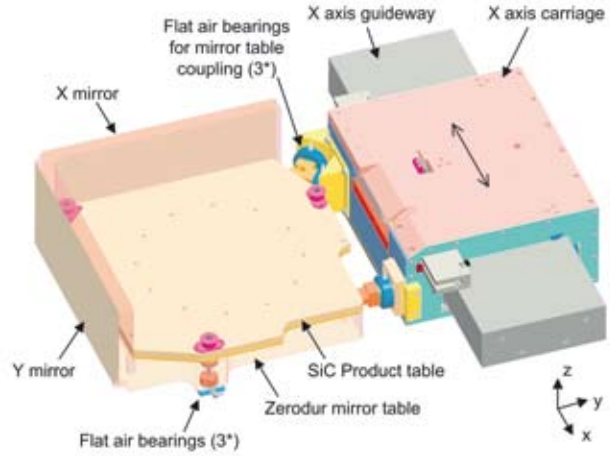


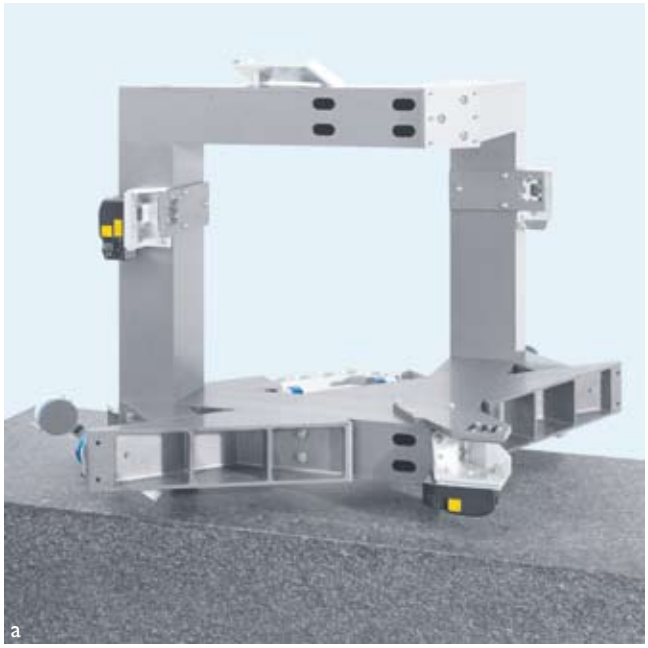
Figure 4. Floating mirror table and X-axis drive.

mirror table, it must be very compliant for parasitic motions between the mirror table and the X-carriage (Z, Rx and Ry); such parasitic motions should not cause deformations of the mirrors. Especially the flatness of the Z-mirror is sensitive to forces exerted by the coupling due to such motions. Parasitic motions may result from non-flatness and non-parallelism of the X-Y guideways and sagging of the guideways because of the moving parts. Furthermore, the coupling must deal with different fly heights of the floating table resulting from different product loads.

The selected coupling concept consists of three air bearings which are mounted onto the side of the mirror table. One bearing is placed normal to the X-axis carriage, while the other two are placed under a 45° angle, thus fixing the X, Y and Rz degrees of freedom. Influences from vertical motions and also thermal effects will not lead to forces acting on the mirrors, because the frictionless coupling of the bearings cannot transmit any forces in Z direction. The parasitic Ry motions will only act on the two bearings at the back side, Rx motions will act on all three bearings. An error budget was made of all possible parasitic rotations and the worst case situation was used as input for a finite element method analysis. With this design, the effect on the flatness of the three mirrors was found to be < 1 nm. As the three bearings are only required to move over a few micrometers, the preloading can be achieved by adding extension springs directly to the bearings. These compliant springs will cause a force-closed preload for the bearings. The influence of those springs on the mirrors was also calculated and found to be negligible.

Metrology frame

The metrology frame, shown in Figure 5a, has to maintain the mutual position and alignment of the probe and the three laser interferometers with high stability. This means that it should be very stiff, so that deformations due to acceleration forces are small, but also that its thermal



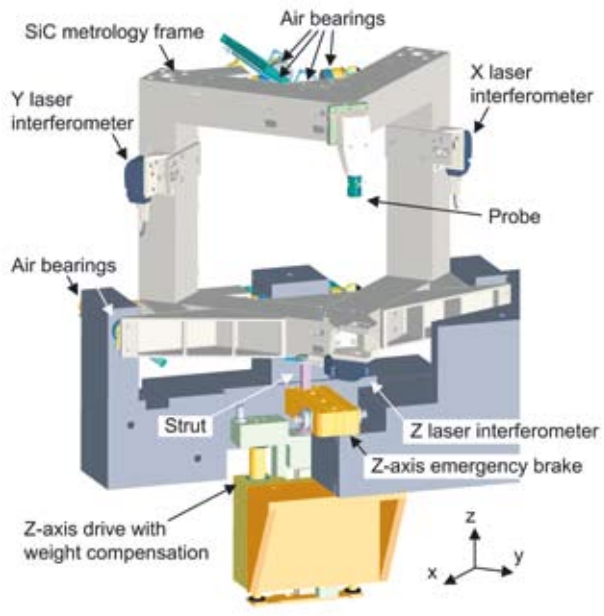


Figure 5. The metrology frame.
(a) Actual construction.
(b) Schematic, also showing the Z-axis drive. Granite guiding surfaces are shown only partially.

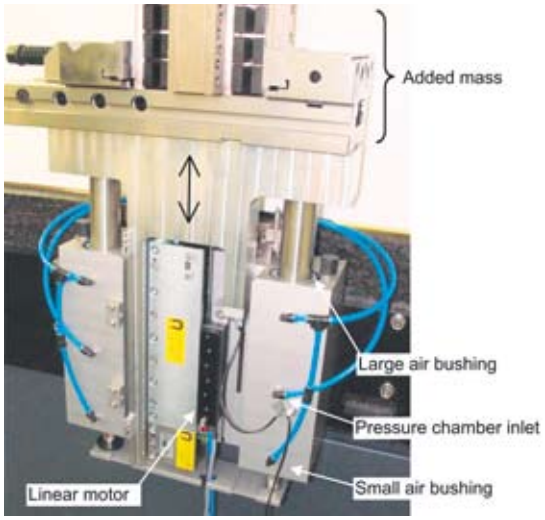


Figure 6. The Z-axis drive with weight compensation system.

expansion needs to be very low. In addition, as the metrology frame in this design is translated vertically, it is preferable that its mass be as low as possible. The metrology frame is an assembly of SiC beams. Although this material has a larger thermal expansion than for example Invar, it has a much better specific stiffness (ratio of elasticity modulus vs density) and better thermal conductivity. The metrology frame is statically determined in six degrees of freedom by means of five flat air bearings and a strut joint to the Z-drive. All bearings are preloaded with flat air bearings on the opposite side. As the machine is a multi- probe machine, it contains a kinematic probe mount for a quick and reproducible exchange of probes. The Z-drive moves the metrology frame in the vertical direction. It is placed below the metrology frame and connects with a strut directly through the centre of mass. Around the coupling strut an emergency brake is placed which can hold the metrology frame in place by clamping the strut, for example when no electric or pneumatic supply is present, see Figure 5b.

The Z-drive contains an air bearing guide for the linear motor, with an integrated weight compensation system, see Figure 6. This bearing system consists of two shafts; each shaft is guided in two cylindrical air bearings (bushings) with different diameters. The space inbetween is sealed by the two bushings, thus serving as a pressure chamber. By supplying exactly the right air pressure, the weight of the metrology frame can be compensated and equilibrium is achieved. As a result, the required force from the linear motor to hold the metrology frame in place is minimized. The heat generation of this drive is therefore very low. The Z-drive shown in Figure 6 is currently being tested.

Ultra-precision probe

Conventional touch probes are generally not suitable for ultra-precision coordinate metrology, due to their relatively high measuring uncertainty and large probing forces, and

Figure 7. Triskelion ultra-precision probe.

their ability to measure small features is limited, due to the relatively large probe tips that are applied. Several different ultra-precision touch probes developed over the past years [6] [7] [8] [9] share a common design feature: the stylus is elastically suspended, allowing deflection of the probe tip and thus reducing probing forces. This deflection is measured by means of an integrated measurement system within the probe. Building on these previous efforts in the development of ultra-precision touch probes, the new Triskelion probe system was developed; see Figure 7.

The stylus, which consists of a stiff tungsten carbide shaft with a small ruby sphere (Ø 0.5 mm) at the end, is elastically suspended, thus allowing deflection of the tip during probing measurements. The flexure part is a monolithic foil. Three targets for the capacitive probes are integrated in the leaf-spring design. The displacements of these targets are measured with capacitive sensors and can be used to determine the X, Y and Z deflections of the probe tip. Except for the sensors, the stylus and the probe tip, the complete probe is made from invar to ensure good thermal stability.

The sensitivity calibration of this probe system is performed on an ultra-precision CMM. The probe is placed in contact with a flat work piece surface, which is located on the product table. The table is then displaced and the output signals of the probe are measured simultaneously with the table displacement, which is measured by laser interferometer systems. By repeating this measurement for multiple probing directions, a full 3D calibration model of the sensitivity is obtained. This sensitivity calibration is validated by performing additional probing measurements. For all measurements, the absolute measurement errors are < 10 nm per axis of the coordinate system and < 15 nm in 3D. Several product measurements have been performed, using the new probe system integrated into an ultra-precision CMM. Figure 8 shows the measurement of an aspherical mould insert and the corresponding form error of the profile measurement across the center, which is obtained after subtraction of the theoretical asphere.

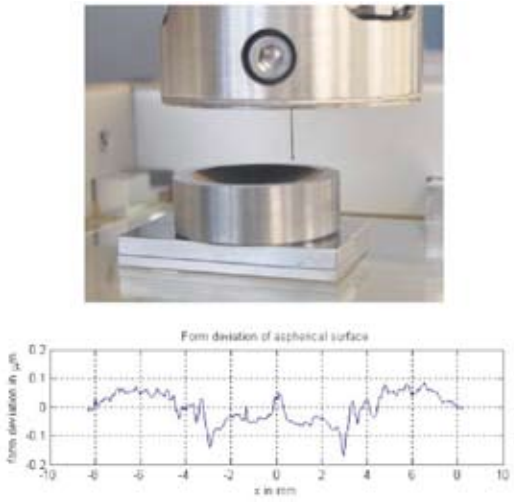


Figure 8. Aspheric mould measurement using the Triskelion probe.

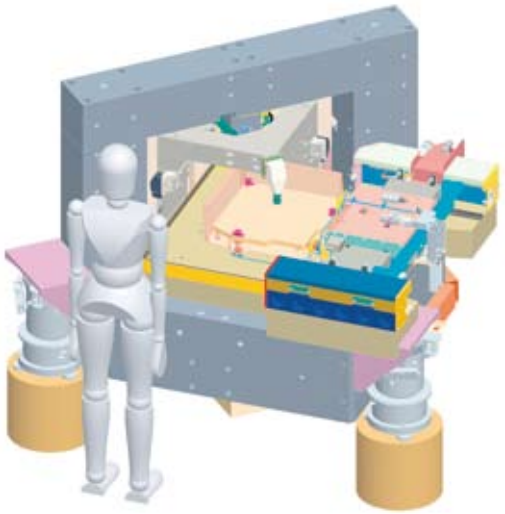


Figure 9. Overview of the Isara 400 CMM.

Measuring uncertainty

An extensive uncertainty analysis was performed to make an accurate estimation of the expected measuring uncertainty of the Isara 400 CMM. Some of the most important contributing factors are the uncertainty of the laser interferometers, the calibration uncertainty of the mirror table (flatness and perpendicularity), the stability of the metrology frame and the measurement uncertainty of the probe. For all axes, the expected 1D measuring uncertainty is 45 nm (2σ), whereas the full-stroke 3D measuring uncertainty totals 100 nm (2σ). Both values include contributions from the described probe system and are valid within the complete measuring volume of the machine.

Conclusion

The new Isara 400 CMM is the latest development of IBS Precision Engineering for coordinate metrology of large, complex parts with nanometer level measuring uncertainty. The expected 3D measuring uncertainty is 100 nm within the complete measuring volume of 400 x 400 x 100 mm. Tactile probes, such as the presented Triskelion ultra-precision touch probe, as well as other possible (optical) probe systems can be used to perform scanning or point measurements. The machine, see Figure 9, provides a technology basis which can be adapted and optimized for specific user requirements. It will be operational by the end of 2009.

Authors' note

The authors work at IBS Precision Engineering, headquartered in Eindhoven, the Netherlands, Rilpho Donker as a senior mechanical designer, Ivo Widdershoven as a metrology expert, and Henny Spaan is the managing director.

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Information

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Smart algorithms and smart design tools

Even though James Clerk Maxwell derived his famous set of equations around the year 1865, solving them to accurately predict the behaviour of light remains a challenge. In the design of photonic integrated circuits, which are used as chemical or biological sensors and as chips for fiber-optic communication systems, simulation of light on a micro-scale is of utmost importance. However, the complexity of modern devices is such that full, direct simulation is impossible – hence there is a need for smart algorithms and smart design tools.

• *Remco Stoffer, Alyona Ivanova and Twan Korthorst* •

In photonic integrated circuits, or PICs, functionality is created by manipulating light on a micro- or nanoscale. Light can be guided in small dielectric or semiconductor waveguides, much like in optical fibers. Light from a laser or from an optical fiber can be taken across the surface of an optical chip. This guidance and the interaction between waveguides provide passive functionality, and furthermore, the guides may be used to transport the light to parts of the chip where interaction with the outside world may take place. The two main areas of PIC application are sensors and telecommunications.

Since the interaction of light with substances on the surface of the optical chip is limited to a layer very close to the surface, minute quantities or very small concentrations of chemicals or biological antibodies can be accurately sensed by integrated optical sensors. Commercially available [1] sensors can measure down to a refractive index change of about 10^{-8}, which corresponds, for example, to a sugar concentration of only about 0.7 mg in a liter of water.

Data communication bandwidth needs are ever increasing, and ultra-high-bandwidth fiber-optic links are used in the backbone of the internet; moreover, more and more private homes get access to direct optical fiber links, the so-called ‘Fiber to the Home’ initiatives. PICs are employed at the transmitter and receiver end of these optical fibers. Traditionally, a PIC would be used to modulate the signal data, as supplied by an electronic circuit, onto the optical carrier. The potential data rate that a fiber-optic cable can transmit, however, is far higher than electronics can reach. The functionality of communication PICs has therefore been expanded to multiplex many different electronic signals into one optical signal – for example, by

modulating each electronic signal at a different optical wavelength – and to include lasers and detectors. For examples of such PICs, see Figures 1 and 2.

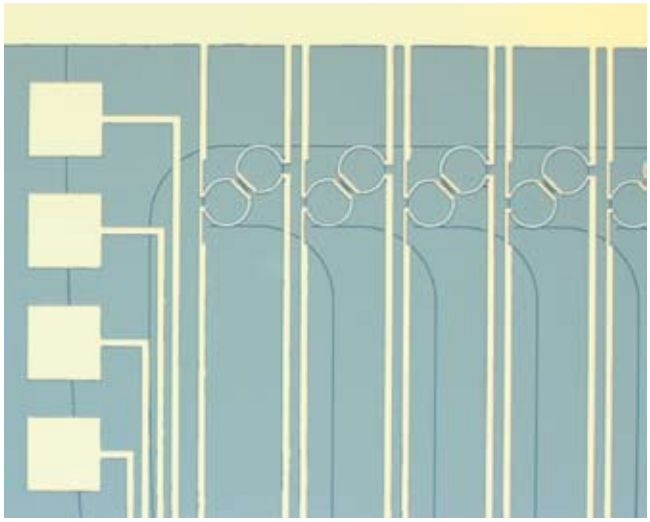

Figure 1. A photonic integrated circuit that dynamically routes signals at different wavelengths to different customers. Waveguide widths are typically in the order of 2 µm [2].

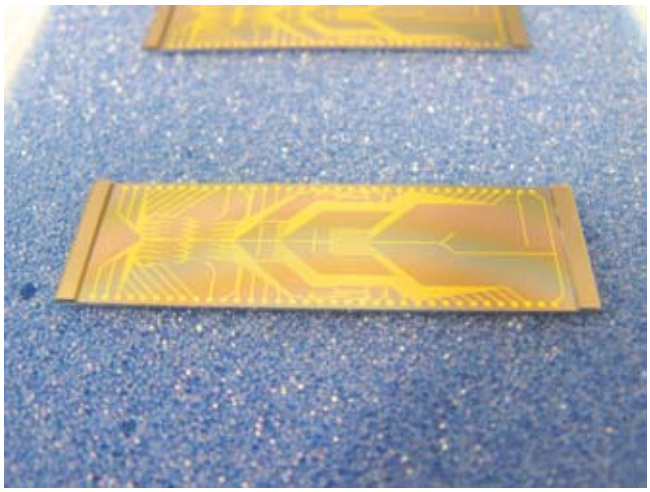

Figure 2. Athena, an integrated chip combining filters, splitters and switches [2] [3].

PIC Design

As the industry is maturing, the specifications of devices get tighter and tighter. Because of this, it becomes ever more important to have good control over and knowledge about the fabrication processes of the chips. Process flows and measured data are stored in databases, such as PhoeniX Software's manufacturing execution system, the 'Living Database' [4]. From such a system, fabrication variations can be obtained; for the various steps in a process, the standard deviations of the results become known.

In the design of photonic devices, simulation of the behaviour of light is of crucial importance. Over time, many different calculation methods have been created, starting from mode solvers of one-dimensional planar waveguides and two-dimension unidirectional beam propagation methods (BPM, see Figure 3) and culminating in advanced full 3D vectorial calculation methods like 2D mode solvers [4] (see Figure 4), 3D BPM [4] or Finite Difference Time Domain (FDTD) [5].

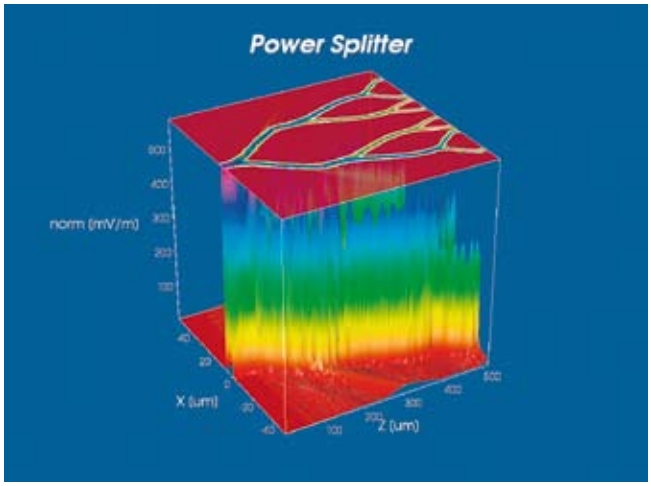

Figure 3. 2D BPM simulation of a 1×4 power splitter.

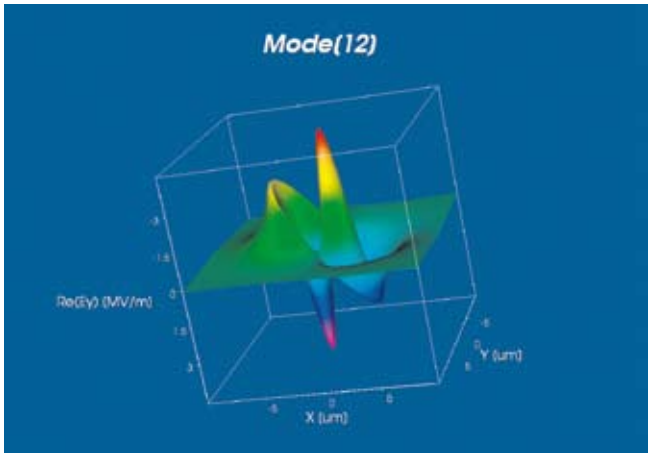

Figure 4. Simulation of an optical fiber mode.

However, unfortunately, the amount of calculation that needs to be performed to design a device has gone up faster than the increase in computer processor speeds can handle. This is in part due to the increased complexity of the devices, in part due to the more advanced simulators, and in part due to the fact that fabrication data is at hand – and thus the effects of fabrication variations on the yield of a device should be calculated. In fact, most actual devices are far too large – with small feature sizes – to simulate even one design at once on a personal computer; one would require supercomputers. So, both the designer and his tools need to become smarter in order to be able to properly design a photonic device. Two examples of how to do this will be discussed briefly: first, by separating the device into building blocks, each of which is manageable, and performing Design of Experiment-like simulations on them, and second, by using an advanced numerical tool.

Building blocks

As an example of the designer using his tools in a smarter way, the widely used Arrayed Waveguide Grating may serve. It was shown in the article by Meint Smit in the June edition of this magazine [6]; see also Figure 5. This methodology to simulate the structures was developed within the European project Apache [7]. These devices are used to separate or combine light of different wavelengths. They come in many shapes and sizes, depending on the technology platform they are created on. Their size can be several centimeters, while the individual waveguides are just a few micrometers wide. These devices are such that the third dimension can be neglected by choosing the parameters of the 2D simulation correctly, and moreover, reflections inside the structure are usually neglected. Even with those approximations, however, the device is too large to simulate in its entirety.

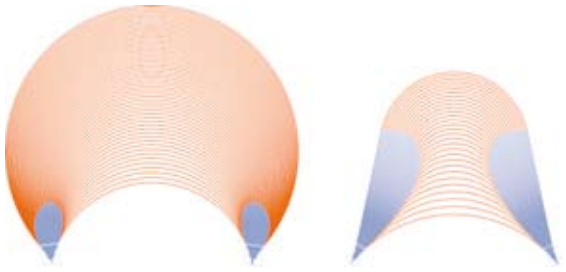

Figure 5. Examples of Arrayed Waveguide Grating layouts.

The first thing that one can do is to identify those parts of the structure that need detailed analysis, and those that can be approximated by simpler models. In this case, the large array of waveguides consists of guides that are completely decoupled – meaning that they do not influence each other. One may thus simulate the input section of the AWG using a 2D BPM method, take the amplitudes of the modes of the array waveguides and simply transfer them with the correct phase to the start of the output section of the AWG, and simulate that section using BPM again. By applying this procedure for each wavelength, the spectrum can be obtained, from which the relevant performance parameters may be obtained. However, this still is a lengthy procedure – each wavelength point may take several minutes.

Another significant speed-up may be gained by using the physical law of reciprocity; the transfer from one port (input mode) of an optical system to another port is the same as from that other port to the first one. This allows one to set up the scattering matrix of the parts of the device with only a few simulation runs, and by proper interpolation between wavelengths the whole spectrum (see Figure 6) can be generated in just a few minutes, and the relevant performance parameters may be obtained in a couple of seconds. Furthermore, the responses of the building blocks vary smoothly with the technological variations (like waveguide width and height and the refractive index of the materials), so one may use Design of Experiment techniques to set up a model for these responses, essentially applying interpolations in the space of technological parameters.

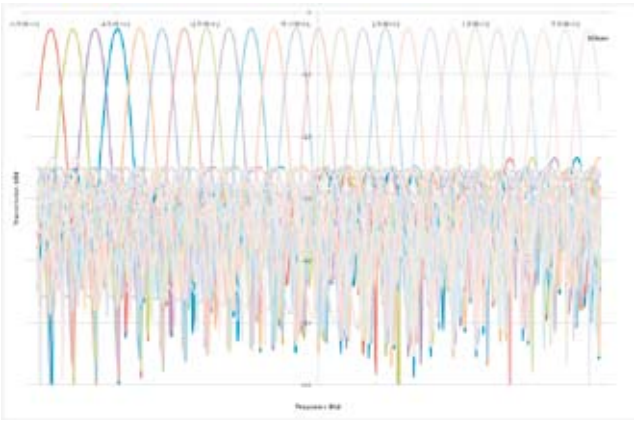

Figure 6. Spectrum of an AWG; the plot shows the response of all 25 output channels.

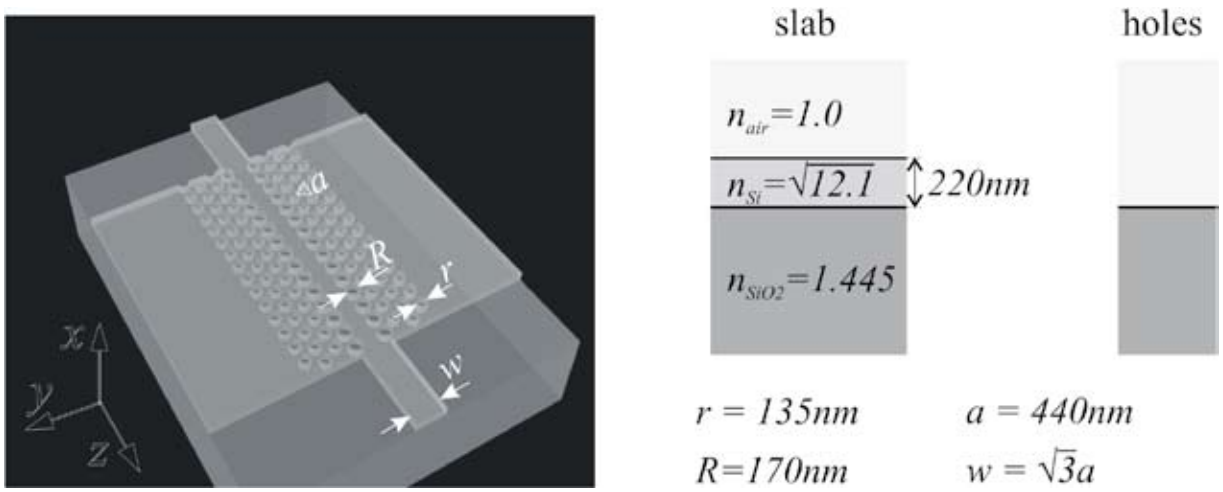

Figure 7. Photonic crystal slab waveguide structure. As denoted in the figure, all critical dimensions are below 1 µm.

Reducing dimensionality of simulations

In other devices, the third dimension is very relevant. As an example of simulation tools becoming more intelligent, we will look at a photonic crystal waveguide. A photonic crystal is a periodic variation of the refractive index in such a way that light propagation is forbidden in a certain wavelength range. One can use two slabs of such a crystal to guide light. The structure in Figure 7 shows an example. It turns out that there is a wavelength region in which this waveguide does not transmit any light, which could be used for sensing applications.

Simulations should be able to predict the location of this so-called bandgap accurately. Fully-vectorial 3D FDTD can be used; it produces accurate results, but it takes a large amount of computer time and memory – on the order of 10 hours and 4 GB on a state-of-the-art personal computer. Traditionally, photonics designers would try to reduce the dimension of the system from 3D to 2D by means of the Effective Index Method – taking a 1D mode of the vertical cross-section at each 2D location. However, for this structure, these 1D modes do not exist in the hole regions, forcing the designer to guess an effective index. He can choose either the index of the substrate or of the air surrounding the structure, but Figure 8 shows that neither predict the location of the bandgap or other features in the spectrum very well. A new method, the Variation Effective Index Method (VEIM) [8], developed at the University of Twente, overcomes this problem, allowing a unique definition of the effective index everywhere, as well as a proper continuous field representation in the whole space. As can be seen in the spectrum graph of Figure 8, the spectral features are much more faithfully reproduced. Figure 9 show a 3D representation of the fields at wavelengths outside and inside the bandgap.

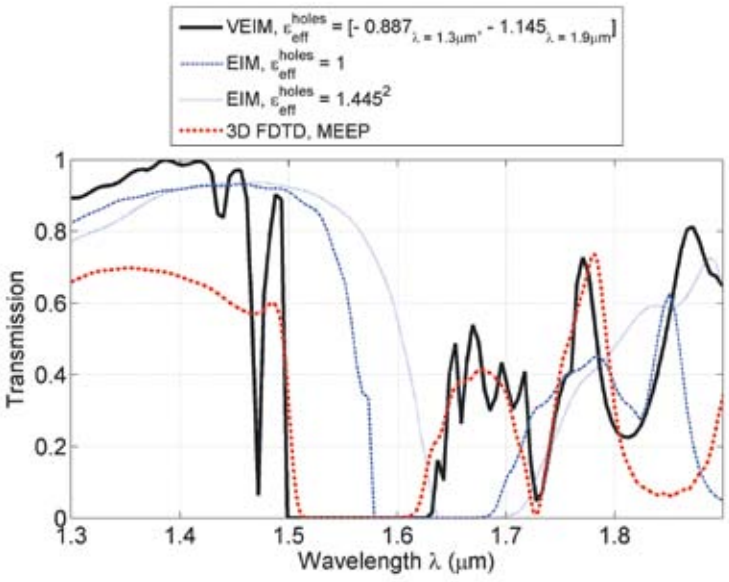

Figure 8. Spectrum of the waveguide of Figure 7. 3D FDTD [5] is more or less accurate, but the calculation is slow; the other calculation methods all have the same (higher) speed, but the VEIM [8] curve is much closer to the FDTD than the more traditional effective index methods.

The way forward

As described in [6], it is expected that foundry-based approaches to PIC design and manufacturing will become a standard in Europe. This approach ties in well with the simulation ideas described here; a foundry can provide its customers with basic building blocks of photonic components, fully characterized including fabrication variations, which designers can combine into an integrated circuit having the properties they desire. Depending on the degree of openness of the foundry, simulations on the building blocks can either be done by the foundry itself (meaning that the foundry does not disclose its real technology and variations, but generates a model of the building blocks including all tolerances) or by the designer, if the foundry discloses the actual processing steps and variations. In either case, smarter simulation algorithms

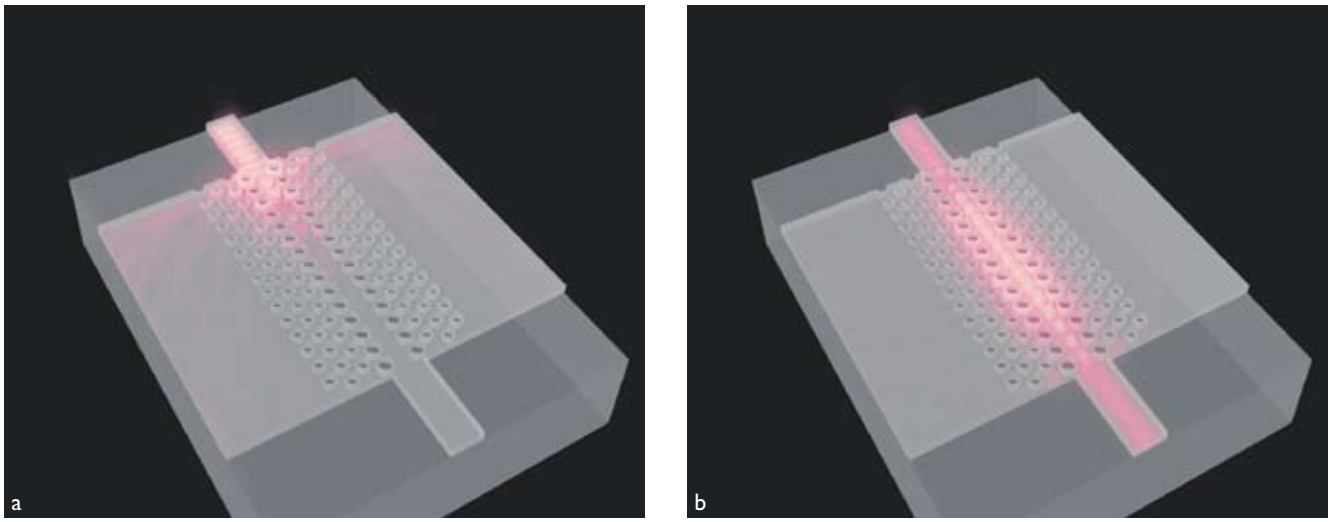

Figure 9. 3D VEIM field of the structure of Figure 7.
(a) At 1568 nm, inside the bandgap.
(b) At 1498 nm, outside the bandgap.

make a designer's life easier and get products into the market faster.

Authors' note

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PhoeniX Software

PhoeniX Software supports more than 120 companies and institutes worldwide to improve quality, reduce time to market, enhance research and automate micro- and nanotechnology fabrication by offering a fully integrated mask layout, process flow design and simulation environment and the only dedicated Manufacturing Execution System and Technology Knowledge Base for the industry, The Living Database. PhoeniX Software is a privately held company, based in Enschede, the Netherlands. Founded in 2003, it has achieved significant presence in the photonics industry as supplier and developer of state-of-the-art photonic simulation tools at the physical and sub-system layer.

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Submicron

Today's technological advancements usually fall into one or more of three categories: more features, faster, and/or smaller. Medical devices are not immune to rapid technological change and, in fact, are pushing the envelope, as it has become extremely important to improve time to market, throughput, and tolerances. An interesting example is the manufacture of stents, where manufacturing tolerances have actually reached the submicron level. In addition, because these devices will be inserted into human arteries, they must be free of grooves and burrs and also must be completely hygienic.

• *Ken Hetrick* •

To review typical manufacturing requirements of stents:

- They are usually manufactured from stainless steel, nitinol, or a cobalt-based alloy.
- The design is usually a mesh structure or a coil; see Figure 1.
- The materials can be as thin as 25 µm.
- Typical diameters are from 2 to 5 mm.
- Complex geometries require accuracies and cutting tolerances of +/- 2.5 µm.

Just to put some of these numbers into perspective, the diameter of a human hair is approximately 100 µm, so the entire wall thickness of the material in a stent is 25% the thickness of a human hair. By reviewing these numbers, it is easy to understand the difficulties of ensuring quality manufacturing. But what is the best method of production to meet these tight tolerances?

Figure 1. A typical stent.

Laser processing

Due to its unique capabilities, laser processing has become the predominant method of cutting, ablating, and welding materials for stent manufacturing. Compared to other cutting methods, laser processing produces very smooth

accuracy in stent manufacturing

edges that substantially reduce the finishing process. Another laser processing benefit is the ability to make intricate design cuts with extreme precision and accuracy. These factors allow the system to be more cost-effective as well as to improve throughput.
The ideal laser-machining center will produce the highest quality, be highly repeatable, and will optimize the entire process. When designing the laser-machining center there are several factors to consider: the laser, motion equipment, the controller, and the base structure.

Laser

Factors to consider when selecting the laser include: laser power, bandwidth, wavelength, operating frequency, spot size, pulse duration, and beam quality. The choice of laser, which is usually YAG or fiber, will depend on the type of material being cut, the wall thickness of the tube, and the type and cutting detail that is required.

Mechanical equipment

In general, a stent-cutting machine requires a rotary and a linear axis. In its simplest form, this can be accomplished by bolting individual components together. It is then necessary to add some material handling capability. However, due to the inherent errors in the individual components themselves and the bolting of the axes together, and the addition of a material handling system, it is not possible to assemble a truly optimized system.

Improved design

With the push for tighter tolerances and higher throughput, an optimal design that integrates the rotary and linear axes, as well as the collet (material handling) mechanism, provides a better solution. An example of an optimized, integrated system (VascuLathe® series) was developed and patented by Aerotech; see Figure 2. The rotary axis has been designed to integrate directly onto the linear axis so that it is in-line with the linear motor and bearings. This design improves overall system stiffness and increases the resonant frequency. The rotary axis also has an integral pneumatic-activated collet mechanism, effectively reducing system complexity and minimizing the total system moving mass. The system also has an optional wet-cutting configuration for applications that utilize fluid to minimize the heat-affected zone, backwall damage, and to assist in the evacuation of waste material.

The cumulative effect of the VascuLathe's optimized design results in throughput improvements from 200% to 500% when compared to traditional component-level manufacturing approaches, while still maintaining submicron tolerances on tight part geometries. When comparing the VascuLathe to component-based systems, the following error was reduced from roughly 3.25 microns to 0.75 microns.

Controller

In addition to selecting the proper mechanical stages, it is equally important to choose an appropriate multi-axis motion controller. An example of a feature-rich multi-axis controller that is very good for medical device

Figure 2. Aerotech's VascuLathe integrated, optimized stent-manufacturing platform.

manufacturing, Aerotech presents Automation 3200, a software-based controller that offers up to 32 axes of synchronous motion. Key A3200 features used in medical stent manufacturing include contoured motion, PSO laser triggering, circumferential units, and multi-block look-ahead.

One feature that is extremely useful is the ability to program in circumferential units. By specifying the diameter of the cylindrical part, a program can be written as if it were in XY space. The program then translates the XY coordinates onto the cylindrical part and cuts accordingly.

Another feature that is essential for cutting small circles or arcs on a cylindrical part is contoured motion. This refers to motion in which multiple axes are required to work in conjunction with each other. The A3200 is not only capable of providing contoured motion, but also utilizes an advanced feature called 'multi-block look-ahead' to optimize cutting velocity as a function of part geometry; see Figure 3. While executing a program, the multi-block look-ahead function is constantly reviewing lines of code that execute later in the program. Accelerations induced by arcs and circles in the part are calculated by the look-ahead function and compared to a threshold acceleration value defined by the user. If the acceleration in an arc is above the allowable threshold, the controller will slow the cutting speed before the part feature is processed to ensure that the acceleration limit is not exceeded. Once the feature has been processed the programmed cutting velocity resumes. By adjusting the acceleration limit in the program, it is possible to directly control the part accuracy and system throughput. Reducing the acceleration limit results in lower position errors and longer processing times. Higher acceleration settings result in increased position error and increased system throughput.

Another key feature is the A3200's ability to trigger and control the laser based on position. PSO (Position Synchronized Output) uses a combination of hardware and software to allow laser triggering to be based on the actual position of the axes. When used in combination with multi-block look-ahead the PSO function will ensure consistent laser beam spot overlap as the cutting velocity changes, resulting in improved edge quality and reduced heat-affected zone.

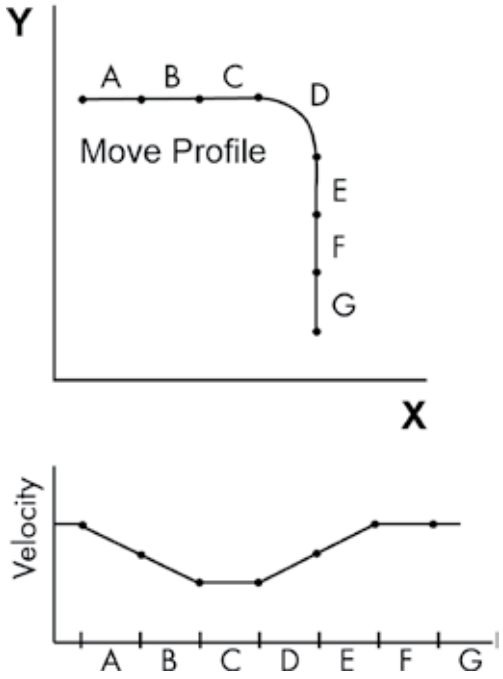

Figure 3. Contoured motion is facilitated by the multi-block look-ahead feature, which allows the controller to anticipate sharp corners and small radius arcs and automatically accelerate and decelerate as needed.

Base structure

The base structure includes the machine base, system base plate, and the support for the laser optics. If the system is not optimized for stability, significant errors can occur that will affect the quality of the parts produced. Errors are introduced into the process from high system dynamics transferring energy into the system and thus affecting the system stability and position tracking error during the process. As the axes move, reactive forces are generated within the system. In order to minimize the effects of system dynamics, a stable base structure design is recommended, which may include components such as a granite base plate, elastomeric isolation, and a steel machine base.

The other area of concern is the error that can be created in the differential motion between the part and the laser head. This error is not observable within the control system and thus cannot be corrected through the control loop. The best method for reducing this error is to optimize the stiffness of the structure holding the laser and optics. One recommended method is to provide a solid granite bridge structure to mount the optics and to minimize the length of the unsupported laser head. This design not only provides the necessary support to compensate for the moving axes, but also can support the optics, resulting in improved part quality.

Figure 4. The VascuLathe DS version, which allows simultaneous laser machining for two stents.

Productivity

To increase productivity, a version was designed that allows simultaneous laser machining for two stents. The precision built into the axes and the 'electronic gearing' between the two rotary axes enables two identical stents to be produced. This is particularly advantageous for polymer stents, which require ablating rather than cutting (which is done on metals). The ablation process takes more time than cutting and the time saved to produce two stents makes a considerable difference in production throughput. The cost of adding the second rotary axis turns out to be well worthwhile for polymer stent manufacture.

Author's note

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Information

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Cryogenic tip-tilt an astronomical

The development of astronomical instruments has always been a field where precision engineering and optical design meet. Latest developments also involve the implementation of precision engineering and mechatronic control in cryogenic environments. With almost twenty years of experience in precision engineering, in both ambient and vacuum environments, Janssen Precision Engineering has over the years expanded its working field to the cryogenic environment. A recent activity is the development of a cryogenic tip-tilt mechanism for a future astronomical instrument.

• *Maurice Teuwen, Har Craenen and Huub Janssen* •

The European Southern Observatory (ESO) has planned a new instrument to be installed on the existing VLTI (Very Large Telescope Interferometer), which is located on the mountain Cerro Paranal in Chile. This new instrument is called MATISSE, which stands for Multi-AperTure mid-Infrared SpectroScopic Experiment. It will combine images of up to four separate VLTI telescopes and thereby improve the capabilities of the interferometer and open a new scientific prospective.
MATISSE is being developed by a European consortium of several institutes and universities. The optical and infrared instrumentation division of the Netherlands Research School for Astronomy NOVA (located at the facilities of ASTRON, the Netherlands Institute for Radio Astronomy) is a lead player within this consortium. NOVA has engaged Janssen Precision Engineering (JPE) to develop and test one of the key modules of the future instrument.

Giant interferometer

The VLTI is the flagship facility for European ground-based astronomy at the beginning of the third millennium; see Figure 1. It is the world's most advanced optical instrument, consisting of four unit telescopes with main mirrors of 8.2 m diameter, and four movable 1.8 m diameter auxiliary telescopes. The telescopes can work together to form a giant 'interferometer', allowing astronomers to see details up to 25 times finer than with the individual telescopes. The light beams are combined in the VLTI using a complex system of mirrors in underground tunnels where the light paths must be kept equal within 1 µm over a hundred metres. With this kind of precision the VLTI can reconstruct images with an angular resolution of milli-arcseconds, equivalent to distinguishing the two headlights of a car on the moon.

mechanism for instrument

Figure 1. ESO site on Cerro Paranal. The VLTI is formed by four unit telescopes with main mirrors of 8.2 m diameter (large buildings) and four movable 1.8 m diameter auxiliary telescopes (small domed buildings). (Picture: ESO)

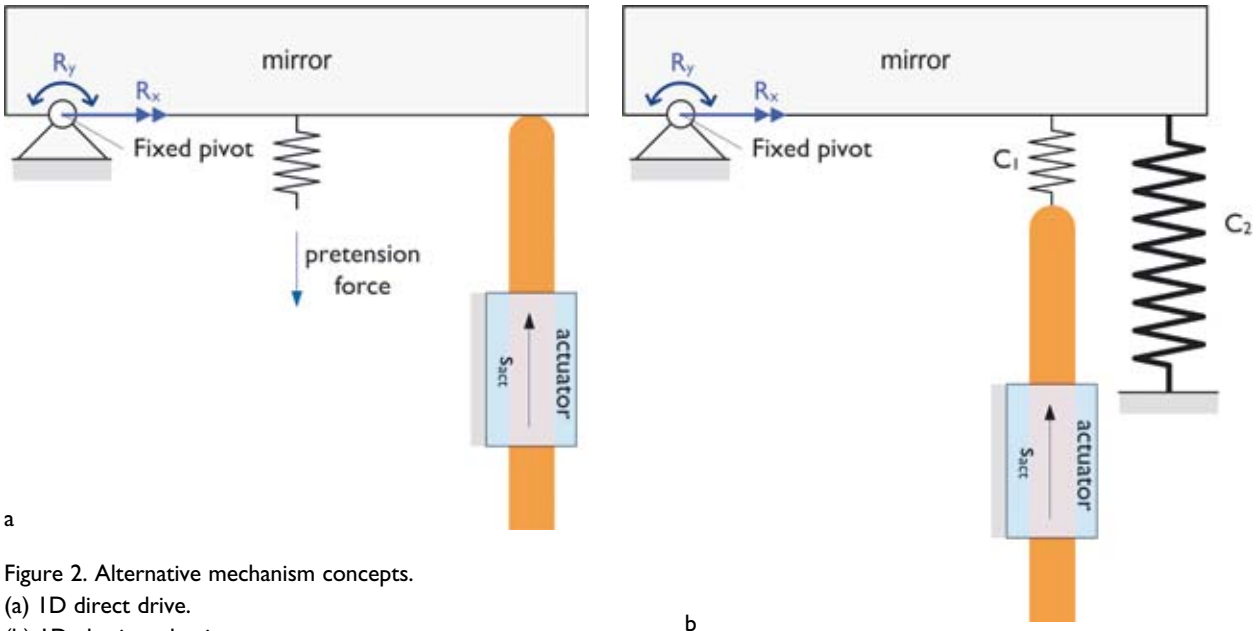
MATISSE

MATISSE is designed to be a mid-infrared spectro-interferometer combining the beams of up to four different source telescopes of the VLTI. With this new instrument, the scientific area of long-baseline optical interferometry will benefit from two major breakthroughs. Firstly, the wavelength range is extended with observed wavelengths from 3 to 15 µm, opening a new window to the universe. Secondly, MATISSE will measure closure phase relations and thus offer an efficient capability for image reconstruction. It will for the very first time allow image reconstruction of small-scale regions in the mid-infrared wavelength domain and thus allow an investigation of these structures.

In order to achieve its performance the optical beams in MATISSE are split various times. Firstly, for every telescope the low wavelengths are separated from the high wavelengths. Later, every single beam is split into three in order to create beam pairs with the beams of the other three telescopes. Finally the beams are duplicated in a special way creating a spectrum with both a positive and a negative interference pattern. Image reconstruction is done from these interference patterns, 24 in total. Alignment is crucial, because the interfering beams have to overlap exactly on the detector pixels. Since infrared radiation is created by heat, the MATISSE instrument must be cooled to cryogenic temperatures down to 8 Kelvin. These temperatures can only be achieved in a high-vacuum environment.
From investigations it has been concluded that the required angular accuracies of all the mirrors that are used for alignment of all individual beams cannot be guaranteed at low working temperatures using fixed mountings with accurate tolerance budgeting. A motorized tip-tilt mirror alignment mechanism that can operate in this cryogenic environment is therefore required as an enabling technology for the development of the MATISSE instrument. Based on this importance for the instrument as a whole, it was decided by NOVA to demonstrate the feasibility of the tip-tilt mechanism (TTM) at an early stage by means of a prototype. This demonstration project has been performed by Janssen Precision Engineering. Within a limited timeframe of only four months, a TTM concept was developed, built and successfully tested.

Specifications

The TTM basically consists of a nearly rectangular mirror with a typical dimension of 33 mm, and a baseline thickness of about 8 mm. Tip and tilt of the mirror should be manipulated with microrad resolution within a range of + and - several millirad's. Operation should be possible in both the ambient and the cryogenic (30-100 K) environment, though final use will be in the cryogenic environment at 40 K.



a

b

Figure 2. Alternative mechanism concepts.
(a) 1D direct drive.
(b) 1D elastic reduction.

Specifications include:

- Mirror dimension (square) ≈ 33 mm (X-Y)
- Tilt range > ±5.24 mrad
- Tilt resolution < 1.22 μrad
- Tip-tilt crosstalk < 10%
- Short-term stability < 0.70 μrad/hr
- Long-term stability (typically 10 yrs) < 1.30 μrad
- Mirror flatness < 63 nm (pk-pk)
- Parasitic mirror displacement – in plane < 0.2 mm
- Parasitic mirror displacement – perpendicular < 100 μm
- Operational temperature 40 K
- Design envelope 75 mm (X) x 75 mm (Z) x 35 mm (Y)

Actuator baseline

Within NOVA's optical and infrared instrumentation division, an extensive inventory was performed on commercially available actuators that can be used in cryogenic applications. In general it can be said that piezo actuators are suitable for this environment, though it should be noted that movement efficiency is affected by the low temperature.
For this particular mechanism, it was decided to use the PiezoLEG™ actuator from the Swedish company PiezoMotor Uppsala AB as a baseline. The actuator has only a small envelope (22 mm x 11 mm x 20 mm). The output motion is via a ceramic bar, which is claimed to have a movement resolution in the nanometer range. To compensate (as far as possible) for the actuator's efficiency loss in cryogenic temperatures, a custom amplifier stage was built by NOVA that supplies a higher output voltage to the PiezoMotor.

TTM concepts

With the above mentioned input, JPE started the evaluation of possible mechanism concepts. The first major issue in the conception of a feasible concept was whether or not to use a 'direct drive' principle. In the direct drive, the actuator is directly connected to the mirror without any further reduction. A simplified 1-dimensional representation of this concept is shown in Figure 2a. By implementing a second actuator in an orthogonal location with respect to the fixed pivot, the mechanism can be extended to a full 2-dimensional tip-tilt mechanism.

Although the concept is very attractive due to its simple nature, with some basic analyses it was soon proven that this concept is not a match for the given specifications. The required angular resolution requires a stepping resolution which cannot be met by the actuator even in ambient conditions. Moreover, the limited actuation force has to cope directly with the angular stiffness of the fixed mirror pivot which cannot be made sufficiently weak within practical dimensioning. Taking into account the performance loss – both in resolution and force – of the actuator in cryogenic conditions, this concept was soon eliminated.

The alternative to a direct-drive mechanism is to implement a reduction between the actuator's input movement and the mirror's output movement. This can be realised by an elastic reduction mechanism, as conceptually visualised in Figure 2b. By tuning the stiffness ratio between C_1 and C_2, a reduction between actuator movement and mirror output movement can be realised. Although there is a discrepancy between optimisation for a low drive force on one hand and a high natural angular frequency on the other hand, this can yield a feasible design as far as resolution and force are concerned. The reason why this

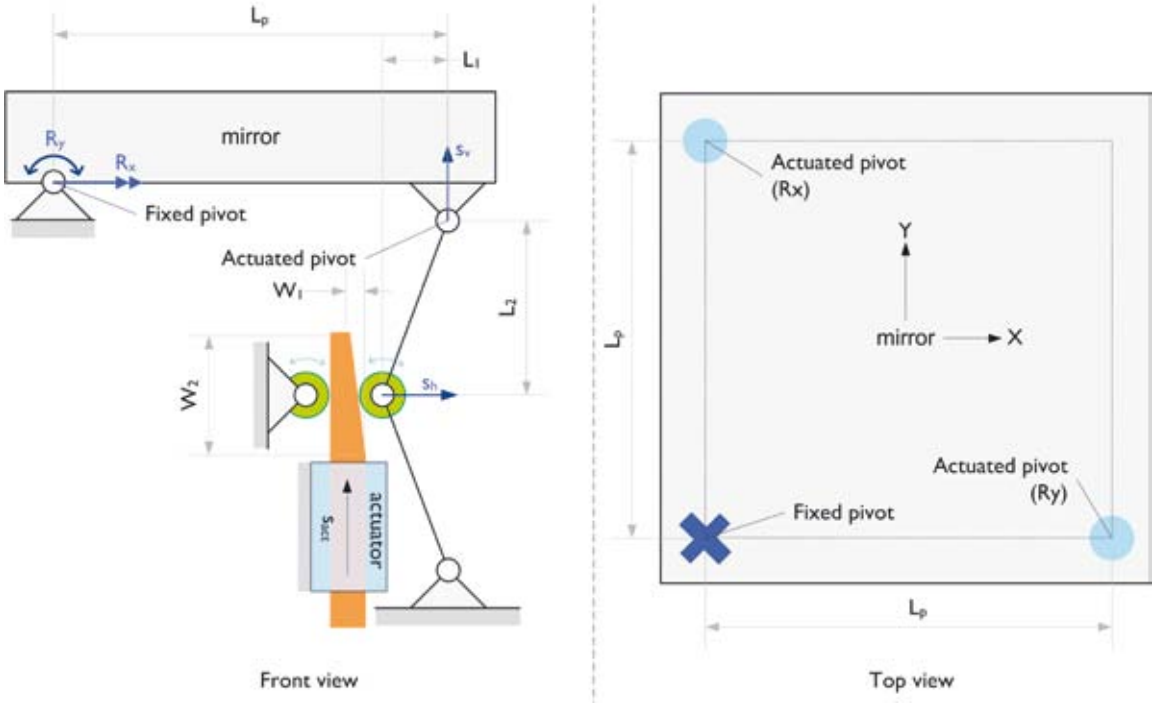


Figure 3. Tip-tilt mechanism concept.

concept was finally discarded is the uncertain stability behaviour of the springs and thereby the mechanism.
In this case, a better option for realising the reduction is to use a linkage mechanism which is based on a geometrical reduction of the movement. After weighing several alternatives, the toggle mechanism in Figure 3 was chosen the concept to be used for the TTM.
The mirror body is supported on three pivots. The base pivot directly connects the mirror body to the base. The two other pivots are connected to the base by a toggle mechanism. It is operated by the piezo actuator via a wedge on the ceramic bar of the actuator.

The positive distinctive characteristics of the concept are:

- This concept accommodates two serial reductions. Firstly, there is a wedged shape on the actuator output bar, which transfers the actuator motion only fractionally into the mechanism. Secondly, there is the toggle mechanism which transfers the horizontal input motion only fractionally to a vertical output motion. Thereby the concept enables to implement a large reduction between actuator input movement and mirror output movement. This enables less demanding use of the actuator with respect to actuation force, displacement resolution and position stability.
- Tip and tilt actuation are separate though integral parts of the design; there is no stacked layout where the tip-mechanism is mounted on top of a tilt mechanism. This benefits the stiffness of the mechanism, and it enables a monolithic manufacturing approach which is beneficial for stability behavior.
- Tip and tilt actuation are fully orthogonal; each actuator is directly linked to a single output rotation without disturbing the other output rotation.

Input-output relation

In order to obtain the relation between the actuator input and the mirror output movement, the following three movement transformations are combined:

1. Actuator bar movement S_{act} to toggle mechanism 'knee' displacement S_h:

$$S_h = \frac{W_1}{W_2} \cdot S_{act}$$

2. Toggle mechanism 'knee' displacement S_h to mirror support Z displacement S_v:

$$S_v = 2\frac{L_1}{L_2} \cdot S_h$$

3. Mirror support S_v to mirror angular displacement tip/tilt:

$$R_{xy} = \frac{S_v}{L_p}$$

Combining the equations yields the following input-output relation:

$$R_{xy} = \frac{2}{L_p} \cdot \frac{L_1}{L_2} \cdot \frac{W_1}{W_2} \cdot S_h$$

With realistic dimensions the transformation between linear input actuator motion and angular mirror output movement is then 0.81 μrad/μm. The pure linear movement reduction ratio between the linear output motion on the mirror (S_v) and the linear input actuator motion (S_{act}) is then 0.022 μm/μm (ratio 1 : 46). In other words, the specified

Figure 4. Two views of the realised tip-tilt mechanism.

angular tip/tilt resolution of 1.22 μrad equals a displacement resolution of the actuator bar of 1.51 μm. And the specified angular tip/tilt range of +/- 5.24 mrad equals a displacement resolution of the actuator bar of +/- 6.47 mm. These are feasible requirements for the actuator.

Actual design

The actual design is depicted in Figure 4. The mechanism was realised as a monolithic body machined (milling) from Aluminum T6061-T6. Milling and polishing have been performed in the mechanical workshop of ASTRON. The two toggle mechanisms are point-symmetrically implemented in the mechanism. The mirror is an integral part of the mechanism and is polished as a final step in the manufacturing process.

The pivots are realized as elastic hinges. The two lower hinges of the toggle mechanism have a single pivot axis (line pivot), the upper hinge (to the mirror) has two orthogonal pivot axes (point pivot) to accommodate rotations introduced by the other actuator. An integral end-of-stroke protection is implemented per toggle mechanism, in order to prevent damage to the hinges.
A bearing is situated at the level of the 'knee' of the toggle mechanism. This bearing is pushed against the wedge shape of the ceramic actuator bar by a tension spring. As the actuator bar is not constrained in this direction by the actuator guiding itself, a support bearing is implemented directly opposite to the toggle mechanism bearing. In this way the actuator bar is able to self-align within the mechanism. The bearings are currently of the same type as the actuator bearings, though the use of commercially available hybrid bearings is also possible.

For the dimensioning of the elastic pivots, the cryogenic material properties were accounted for. The American National Institute of Standards and Technology (NIST) presents an extensive database on its website (cryogenics.nist.gov) with cryogenic properties for typical construction materials.
The data on E-modulus and yield/shear strength for Aluminum T6061-T6 that are listed on this site are represented in Figure 5. Although it might seem quite logical that the E-modulus is higher at lower temperatures, it might be counter-intuitive to see that the yield and tensile stress levels also are higher at lower temperatures!

Mirror flatness

Mirror flatness is an important specification for the TTM. Therefore finite-element analysis (FEA) calculations were performed to optimize the performance of the design with respect to this feature. As design parameters to optimise the flatness performance it was decided to use:

- the dimension of the base pivot.
  By reducing the thickness of the base pivot, the pivot becomes weaker. Less force is involved when moving the mirror to a certain tip/tilt orientation. As this force is propagated as a bending moment through the mirror body, this will decrease the deformation of the mirror.
- the diameter of a saw cut groove in the mirror body, parallel to the mirror surface.
  The underlying idea is that the bending moments through the body are contained within the lower part, which becomes isolated from the mirror surface, in the upper part of the body.

Both parameters seem to have a more or less linear effect on the flatness; reduction of the input parameter by a factor 2 improves flatness behaviour also by roughly a factor 2. It was decided to use the effect of both parameters to limit the mirror deformation. The expected deformation of the mirror at full tip/tilt stroke is then expected to be 27 nm (peak-peak value), which is well below the design target.

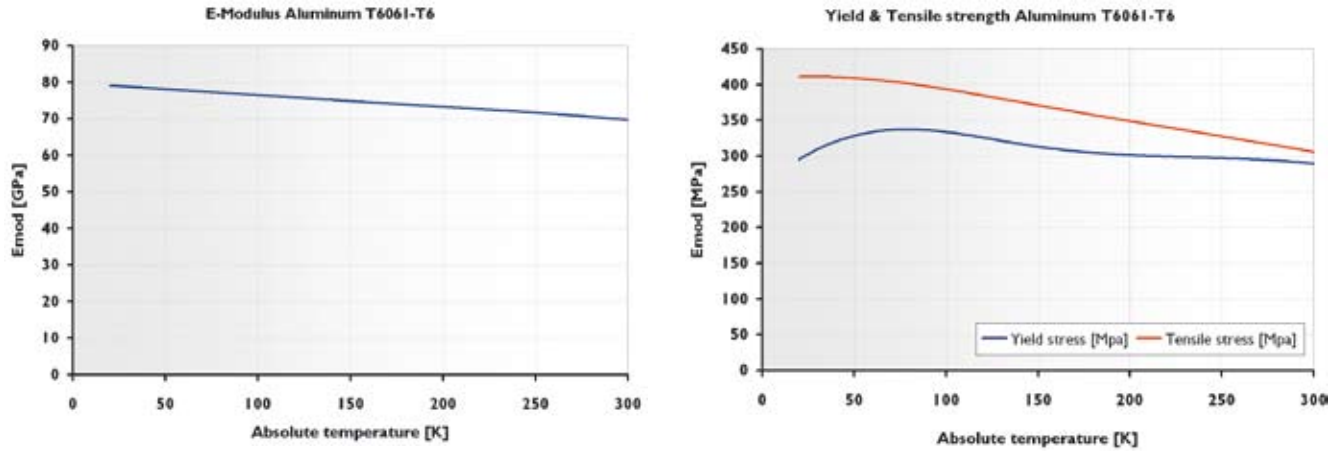


Figure 5. Aluminum T6061-T6 properties (E-modulus and yield/shear strength) against temperature.

Resonance frequencies

As a design verification, the resonance frequency of the TTM was calculated. No specific requirement had been set for this parameter, though common engineering sense dictates that a resonance frequency of >> 100 Hz is preferred, so that the mechanism will not be affected by system dynamics.
By FEA it was determined that the first resonance mode is a Rz mode of the mirror body at approximately 355 Hz, where the two toggle mechanisms allow a tangential movement of the mirror around the base pivot; see Figure 6. The second mode is a combined tip/tilt movement at approximately1,590 Hz, as a result of a local Z movement of the mirror body at the output of the two toggle mechanisms and with the base pivot as a center of rotation.

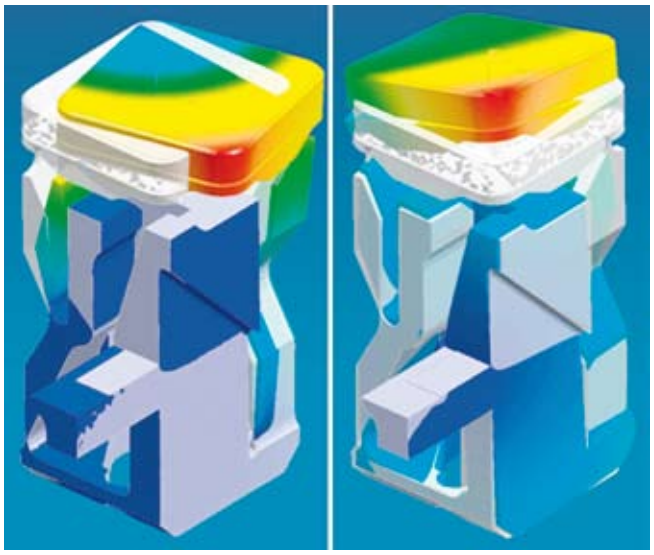


Figure 6. On the left the first resonant mode (355 Hz), on the right the second one (1,590 Hz).

Test results

The realised mechanism was tested first in ambient conditions as a design validation. The measurements indicated that the behaviour of the mechanism was in quite perfect resemblance with the theoretical models which were made to predict the performance of the system.
After that, the mechanism was installed in a cryostat at ASTRON facilities. The cryostat was evacuated and cooled down to 20 K by a closed-cycle cooler. Flatness of the mirror surface was measured by an interferometer through a window of the cryostat. Also the tip/tilt measurement was achieved from outside the cryostat by using an autocollimator with an angular resolution of 0.1 arcsecond (0.49 μrad).
Key performance results at cryogenic temperature:

- Operational temperature during test: 30-40 K
- Tip/tilt resolution < 0.2 arcsec (= 1.0 μrad)
- Tip/tilt crosstalk < 7 %
- Mirror flatness (in extreme tip/tilt orientation) < 0.15 λ P-V @ 633nm (= 90 nm peak-valley (P-V))

Authors' note

The authors work at Janssen Precision Engingeering (JPE) in Maastricht, the Netherlands, Maurice Teuwen as a system engineer, Har Craenen as a senior mechanical engineer, and Huub Janssen is the managing director.
The project described in this article was executed by JPE in cooperation with the optical and infrared instrumentation division of NOVA located at ASTRON facilities. The authors would like to thank the NOVA/ASTRON organisation, and in particular Ramon Navarro, Niels Tromp and Eddy Elswijk for their professional expertise in the realisation of this joint project, and NOVA director Wilfried Boland for initiating the project.

Information

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A novel below-knee prosthesis for snowboarding

Snowboarding with a below-knee prosthesis is compromised by the limited rotation capabilities of the existing below-knee prostheses, which are designed for use in normal walking. Based on snowboarding range of motion analyses, a novel below-knee prosthesis was designed with the aim of allowing a disabled snowboarder to achieve a similar range of motions as able-bodied colleagues.

• *Sander Minnoye and Dick Plettenburg* •

A prosthesis can support physically challenged people in their daily activities. The two most important factors for someone with a lower limb defect using a prosthesis are mobility and comfort in diverse daily activities. This is different for other activities like sports, because often it is not possible to practice sports at all or while practicing sports the mobility is limited by the prosthesis. A prosthesis specially designed for snowboarding can improve comfort and mobility on the slope for people already snowboarding with a leg prosthesis. For other people it can be an encouragement to see the possibilities of performing sports with a physical challenge. Such a prosthesis can also be employed in similar sports, like wakeboarding or kitesurfing. In future, the prosthesis may be used for skiing or wave surfing after adjustment of some parts of the prosthesis.

During snowboarding the head, arms and upper body are mainly used to initiate and end a turn, whereas the lower body is active during the entire turn, requiring rotations of the foot, ankle, knee, and hip joints. Because of the absence of a foot and an ankle, someone with a below-knee amputation is limited in performing these motions, making snowboarding more difficult. Unfortunately, existing prosthetic components do not provide the required passive and/or active rotation possibilities, as most of the prostheses are set with a fixed alignment. As a result, three major sub-problems can be identified:

- Due to the fixed alignment of a traditional below-knee prosthesis, the up-right posture of a person with a transtibial amputation on a snowboard differs considerably from a person without an amputation [1], making snowboarding more challenging.
- Further, a certain amount of passive rotation ability within the ankle joint is important. Such a rotation is normally used by snowboarders in adapting to the different types of terrain, in landing jumps and when leaning into turns. The rotations at the ankle used in

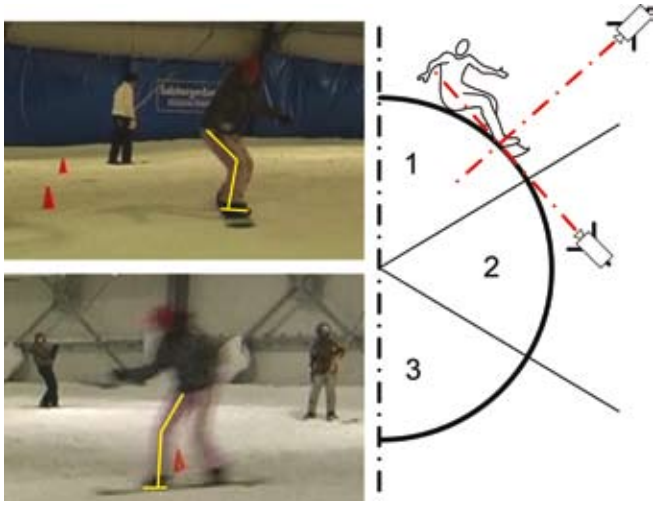


Figure 1. The use of the ankle joint was measured with the help of two HD video cameras. Marker strips were placed on the leg to have a clear vision on rotation of the leg, as shown on the left. One video camera was placed in line with the subject, the other perpendicular to the subject.

snowboarding are plantarflexion/dorsiflexion (movement of the foot downwards/upwards), inversion/eversion (twisting movement of the foot inward/outward), and abduction/adduction (movement of the foot away from/towards the center line of the body) [1] [2] [3]. Traditional below-knee prostheses do not, or only to a limited amount, provide such rotations.

- The majority of below-knee prostheses are passive, meaning that the amputee is not able to exert control over the ankle joint. However, 'voluntary control' of the plantarflexion/dorsiflexion in a small range of motion would enable the snowboarder to correct the angle of the snowboard with respect to the slope, thus modulating its grip when turning.

Based on these limitations, it was decided to design and construct a new below-knee prosthesis for snowboarding that would allow "near-normal" interaction between person and board.

Methods

The new design is intended to approximate able-bodied ankle movement during snowboarding. Motion and force analysis were performed to understand snowboarding biomechanics and kinetics required for the design. The following were considered important design criteria:
(a) foot angles, (b) passive degrees of freedom, and
(c) possibility to 'voluntarily' control the ankle in order to adapt to different slope angles during turning. A literature survey was used to determine the required angles. With the criteria found, a new design was conceived, inspired by the anatomy and functionality of the normal human ankle.

A prototype of the newly designed prosthesis was manufactured and subsequently tested.
In the laboratory, the actual passive and active rotation angles achievable were measured and compared to the design criteria. For field tests the usual 3D motion analysis systems could not be used due to the reflection of infrared light on the slope. Therefore, two normal HD video cameras were used instead; see Figure 1.Video recording was performed on the three phases of a turn: the launch, the turn and the release, for both a front- and a backside turn, i.e. facing down- and uphill, respectively. The motions with the new prosthesis were analysed and compared to the motions made with a traditional below-knee prosthesis, and those of an able-bodied snowboarder. The measurements were performed for an able-bodied subject, a subject with a traditional below-knee prosthesis, which is a carbon fibre reinforced shell, shaped as a mirrored copy of the sound leg, and the same subject with the new below-knee prosthesis discussed here. This subject was a highly professional snowboarder and a candidate for the Olympic Winter Games before her amputation. Prior to their participation, the subjects were informed about the aims of the study and they provided consent.

Results

Biomechanical analysis

From the literature, the angles for the foot in initial stance, for the passive rotations and for the active 'voluntary' control were derived, see Figure 2.

Bio-inspired design

The human ankle was used as inspiration for the design. The passive rotation of the below-knee prosthesis can be related to the plantarflexion and dorsiflexion in the human ankle joint [4]. The active control by using supination/pronation (an outward/inward roll of the foot, actually a combination of inversion, plantarflexion and adduction, or eversion, dorsiflexion and abduction, respectively [3]) can be related to the rotation of the subtalar joint of the human ankle, where a combination of plantarflexion/dorsiflexion and inversion/eversion resembles the motion required for the active control [4].
By using an outward rotation of the knees and hip, the abduction/adduction and inversion/eversion of the newly designed subtalar joint can be controlled. This joint is

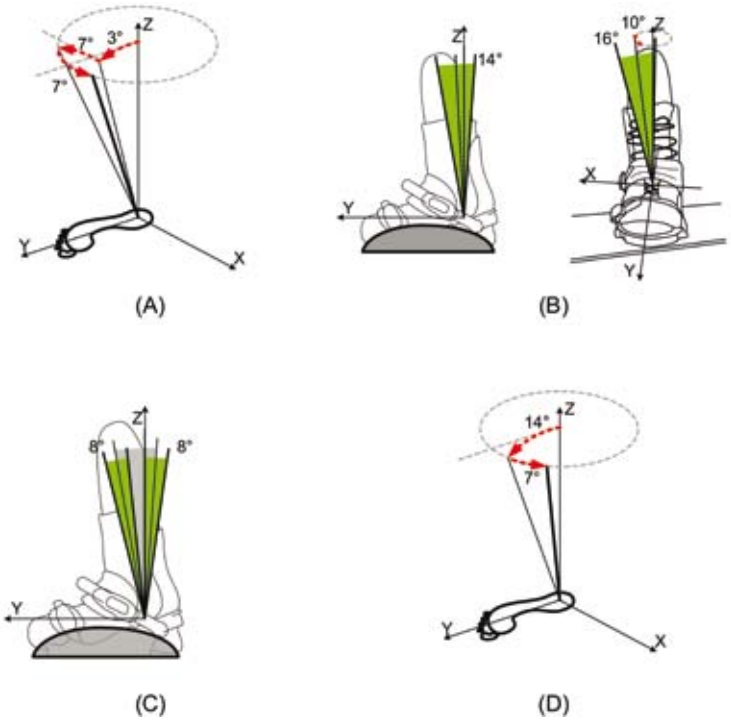


Figure 2. Results from biomechanical analysis.

(A) Initial set-up of the ankle joint for snowboarding of the front leg. The Z-axis represents the lower leg for normal prostheses. The rotations are shown to reach the set-up used for the prosthesis for snowboarding, +3° dorsiflexion, +7° eversion and +7° adduction.

(B) Passive rotational freedom within the ankle joint for snowboarding.
On the left, the passive rotation around the ankle joint, leading to plantarflexion/dorsiflexion, is shown. A 14° range of motion is required, which is evenly divided around the initial set-up of the ankle indicated by the dotted line.
On the right, the passive rotation around the subtalar joint, leading to adduction/abduction and inversion/eversion. A 16° range of motion is required for the inversion/eversion, which is evenly divided around the initial set-up of the ankle indicated by the dotted line. A 10° range of motion is required for the abduction/adduction, which is evenly divided around the initial set-up of the ankle indicated by the dotted line.

(C) Active control of the plantarflexion and dorsiflexion in the ankle joint. An 8° range of motion is required, which is evenly divided around the end of the passive range of motion discussed in the previous part. This active range of motion is used at the end of the passive range of motion in the frontside as well as the backside turn.

(D) Initial set-up of the ankle joint for snowboarding of the rear leg. The Z-axis represents the lower leg for normal prostheses. The rotations are shown to reach the set-up used for the prosthesis for snowboarding, +14° dorsiflexion and +7° adduction.

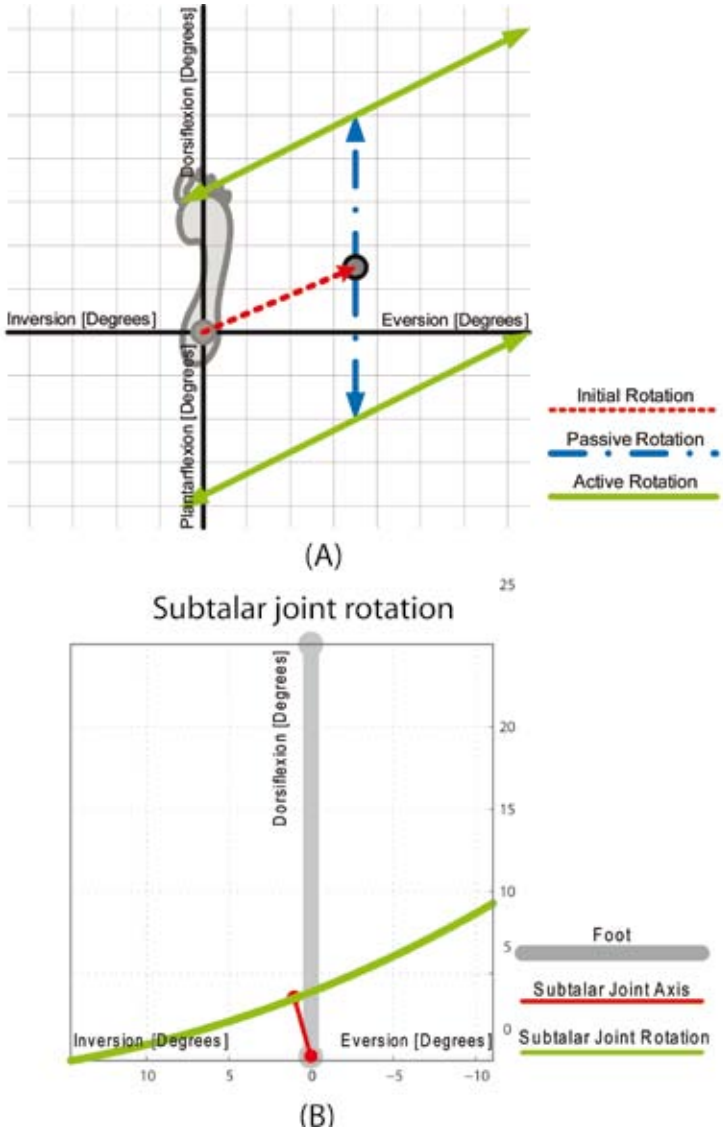


Figure 3. Rotations in the bio-inspired design.

(A) Superior view of the foot. The orientation of the lower leg with respect to the foot is shown in degrees. Within this figure the summation of the movement of the ankle joint in the prosthesis is shown. The red line indicates the transfer from a normal stance of the ankle to the initial stance for snowboarding, where the +3° dorsiflexion and +7° eversion is implemented. The blue line indicates the passive rotation around the ankle joint, which was discussed earlier, +7° plantarflexion and +7° dorsiflexion around the initial stance. The green lines indicate the rotations of the active control at the end of the passive rotation. Here the combination of the 8° plantarflexion/dorsiflexion, the desired active motion, is combined with the +16° inversion/eversion, the passive motion required.

(B) The rotation around the subtalar joint axis, shown in superior view. The bold grey line indicates the foot, the red line the subtalar joint axis and the green line the rotation of the leg around this axis.

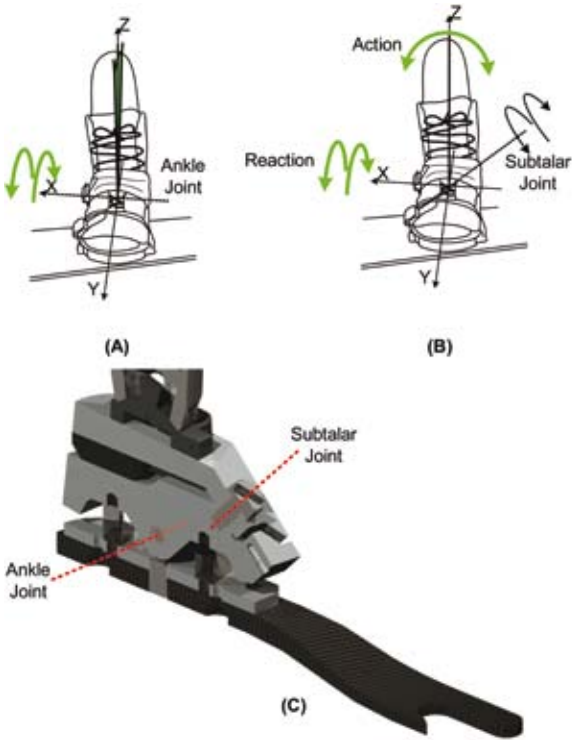


Figure 4. The design of the new prosthesis.

(A) The green shaded area in the XZ-plane indicates the passive plantarflexion/dorsiflexion option.
(B) Active plantarflexion/dorsiflexion is made possible by the incorporation of a 'subtalar joint'. This joint is a normal hinge joint that has its axis of rotation pointing into the negative X-, the positive Y- and the positive Z-direction. Voluntary lateral or medial rotation of the upper leg and knee (the action) initiates a rotation around the 'subtalar joint', which subsequently results in plantarflexion/dorsiflexion of the ankle.
(C) Cross-sectional drawing of the ankle. The axes for the ankle joint and the subtalar joint are clearly visible.

shaped in such a way that the abduction/adduction and inversion/eversion of the foot is coupled to plantarflexion/dorsiflexion of the foot. Thus a lateral rotation (away from the center line of the body) of the upper leg and knee will result in dorsiflexion of the ankle and vice versa a medial rotation (towards the center line of the body) of the upper leg and knee will lead to plantarflexion [5]. This method is used by able-bodied snowboarders to actively control the difference between a drifting and a carving turn.
The orientation of the lower leg with respect to the foot can be analysed in the transverse plane, see Figure 3A. Using Euler rotation matrices to calculate the rotation of the lower leg around the subtalar joint for a human ankle, Figure 3B, leads to approximately the same orientation of the oblique solid black lines in Figure 3A, representing the active rotation of the below-knee prosthesis and the subtalar joint rotation in the human ankle, respectively.

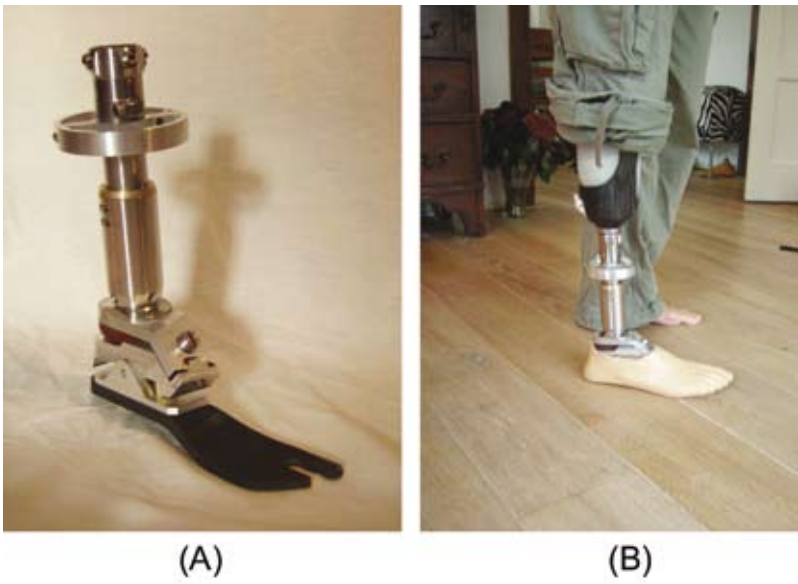


Figure 5. Final prototype.
(A) After construction and assembly.
(B) Connected to the socket and residual limb.

Prototype

The bio-inspired concept was transformed into a prototype design using standard modular prosthetic components where possible: a Trulife, adjustable clamp adapter (titanium, SCA225) was used for the connection of the prototype to the socket. A slight modification was made to a standard keel of a Seattle carbon lightfoot (SCF, Trulife) to enable its connection to the remainder of the design. Materials for the design-specific parts were aluminium, stainless steel and bronze, selected because of their price, specific strengths and machining properties.

In Figure 4A the passive rotation of the design is shown, a rotation around the 'ankle joint' reacting to external forces only. The 'voluntary' rotation, shown in Figure 4B, is a rotation around the newly created subtalar joint. Voluntary lateral or medial rotation of the upper leg and knee initiates this rotation.

The main challenge in the design was the oblique angle of the subtalar joint. As a consequence, many different adjourning parts have faces which are not perpendicular to one another. The overall design and construction of the prosthesis was straight forward. No very high precision and tolerances were needed; the main bearings of the ankle axis and the subtalar axis were with an h7/H7 fit the tightest in tolerance.
Figure 5 shows the final prototype after construction. The total mass of the foot in combination with the socket is 1.5 kg.

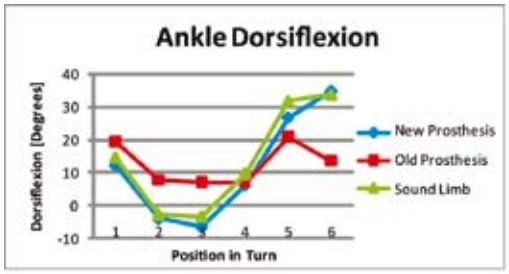
Test results

The laboratory tests showed the rotations defined in the design criteria were met in the prototype. A field test with a single subject was performed to obtain a first impression of the qualities of the new design. The measured angles are plotted in a graph, see Figure 6 (the standard deviation is left out for readability). The new prosthesis achieved similar angles for ankle dorsiflexion and ankle eversion as those seen for an able-bodied person, see Figure 6A. The test subject with the below-knee defect was very pleased with the new prosthesis design, as it enabled improved control over the board: “Snowboarding with the new prosthesis is like it was before the amputation.”

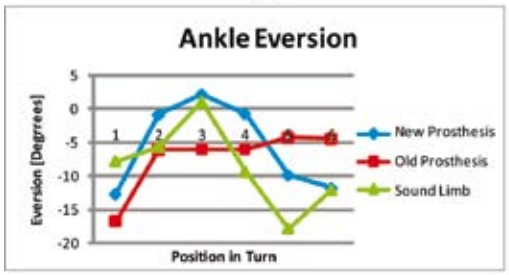
Discussion

In the prostheses currently used for snowboarding the ankle plantarflexion/dorsiflexion has a smaller range of motion than the one achieved with the new design. A smaller range of motion will lead to an asymmetrical turning behaviour, thus reducing controllability. The increased plantarflexion/dorsiflexion of the new design indicates the extended use of passive rotation.

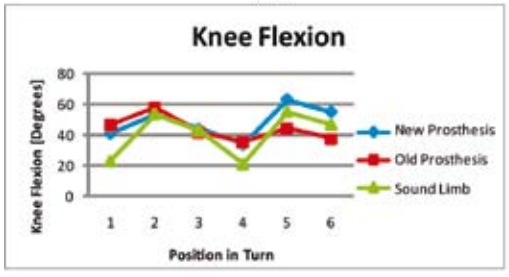
Lateral rotation of the upper leg and knee will result in pronation of the subtalar joint (used for backside turns), and the medial rotation of the upper leg and knee will result in supination of the subtalar joint (used for frontside turns). The inversion/eversion of the ankle joint during snowboarding indicates the use of the active rotation of the subtalar joint, see Figure 6B. The able-bodied subject and the subject with the new prosthesis show an increased



(A)



(B)



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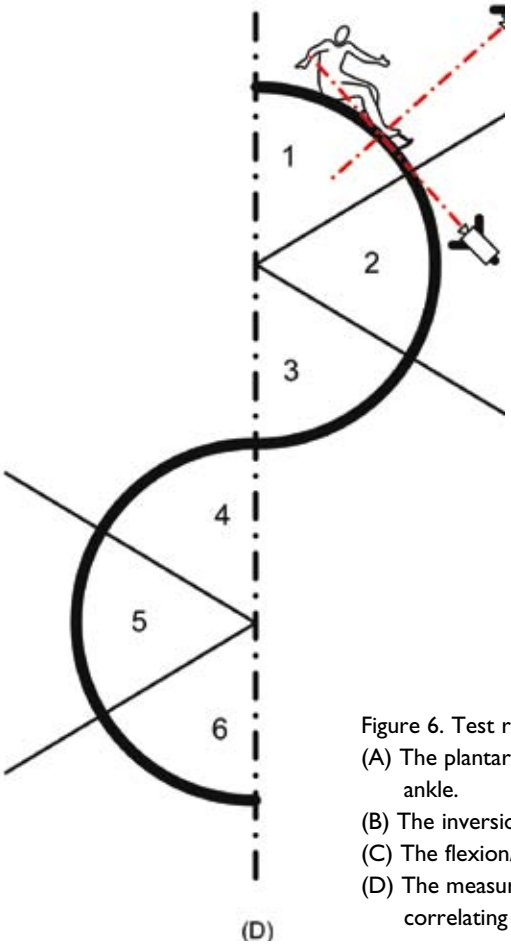

(D)

Figure 6. Test results.
(A) The plantarflexion/dorsiflexion of the ankle.
(B) The inversion/eversion of the ankle.
(C) The flexion/extension of the knee.
(D) The measurement positions in the turn, correlating to the graphs.

similarity in active dorsiflexion/plantarflexion indicating that they may use similar techniques to achieve this rotation.
All subjects have a correlated knee flexion/extension, see Figure 6C. However, the range of knee flexion/extension of the subject with the new prosthesis is larger than that of the subject with the currently used below-knee prosthesis and shows more resemblance with that of the able-bodied subject.
It must be noted that measurement of joint angles with video cameras has limited accuracy, but can be used, however, for comparison purposes, as was done in this study. Because of this limitation, and given the single-subject trial, it is difficult to generalise the findings.

Concluding remarks

The overall goal of this R&D project was to improve mobility and control when snowboarding with a below-knee prosthesis. The orientation of the lower leg with respect to the foot resulted in a standing posture which was symmetrical, taking the sagittal plane as reference. The ability to dorsiflex, evert and abduct the new prosthetic design leads to a stance that is natural for snowboarding. Added passive rotation in the ankle joint shows a clear change in the plantarflexion/dorsiflexion rotation during the turns for the subject with the new prosthesis, which is comparable to the range of motion used by the able-bodied subject.
The 'voluntary' rotation of the new subtalar joint enabled additional control of the supination/pronation angle and resulted in a drifting or carving turn. Its design was derived from the use of the subtalar joint for able-bodied snowboarders. The test subject had been snowboarding before the amputation, which made it possible to retrieve this technique during the first descents. The measurements of the inversion/eversion of the lower leg with respect to the foot show an increasing use of this rotation for the subject with the new below-knee prosthesis when compared to the subject with the traditional below-knee prosthesis. This finding gives an indication for the use of this new additional joint.
On a subjective basis, it was noted that the subject was very enthusiastic about the additional rotation possibilities, allowing the ankle to adjust to turns. In particular, the ability to control the subtalar joint and thus to increase the pressure on the snowboard while turning seems to make snowboarding like it used to be.

Authors' note

This article is an abbreviated version of the article "Design, fabrication, and preliminary results of a novel below-knee prosthesis for snowboarding: A case report", as published in *Prosthetics and Orthotics International*, September 2009, 33(3): 272-283, doi: 10.1080/03093640903089576.
The work described here was performed within the BioMechanical Engineering Group at Delft University of Technology (DUT), Delft, the Netherlands. The group focuses on human-machine interaction, as approached from many different angles, such as rehabilitation aids (upper-limb prosthetics) and, more recently, prosthetics in sports.
Sander Minnoye received his MSc degree in Mechanical Engineering and in Industrial Design Engineering from DUT. He is now a part-time tutor at DUT's Industrial Design Engineering Department and works in his own company DIDID, on product development of sports products for able-bodied and physically challenged people.
Dick Plettenburg received his PhD degree in Mechanical Engineering Design from DUT. He is currently an assistant professor, heading the Delft Institute of Prosthetics and Orthotics.

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Information

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Scale-up for

Manipulators with guidance constructions based on elastic mechanisms are of interest for the increasing number of precision vacuum applications. Previously, the design of an elastic MEMS-based 6-DOFs manipulator was presented. Characterization in six degrees of freedom (DOFs) of a manipulator the size of several square millimeters, however, is difficult. Therefore, a scaled-up version of the manipulator was built. This 'macro' version serves as a research platform for the verification of the flexible multi-body model including control that was set up using the SPACAR toolbox for Matlab.

• *Martijn Huijts, Dannis Brouwer and Johannes van Dijk* •

For sample manipulation inside a confined space a Micro Electro-Mechanical Systems (MEMS)-based multi-DOFs manipulation stage is being researched [1]. The purpose of the manipulator is to position small samples (10 x 20 x 0.2 μm^3) in, for example, a Transmission Electron Microscope (TEM). MEMS offers the opportunity for downscaling, because of the confined space inside a TEM. Such a small in-situ manipulator would be of great advantage, because of the absence of having a distance (TEM typically 100 mm) between the sample and the manipulator, with all the jeopardized positional stability due to vibrations and heat influences involved. The time needed to create stable images would therefore be reduced seriously, which implies an improved operational time of the TEM.

Amongst others, the main criteria given for this manipulator are manipulation with a range of motion in three DOFs translations of tens of microns and three DOFs rotations of up to five degrees. The lowest vibration mode frequency should be higher than 1 kHz, taking into account the (very small) sample load. To obtain a good positioning repeatability, the mechanism design is based on exact constraint design [2] and the motion is realised by deformation of elastic parts, such as leaf-springs [3]. Real hinges would introduce backlash and friction, which would negatively influence accurate positioning and obstruct the repeatability of manipulator positioning.

Due to the small size and the 6-DOFs motion of this system a model is difficult to validate with experiments. Therefore, a scaled-up version, which was magnified roughly 100 times, was fabricated. The purpose of this set-up is the validation of a model-based control system design which will later also be applied for the MEMS manipulator. This set-up should resemble the behaviour of the MEMS-based manipulator. To this end, the characteristics of this manipulator, with the restrictions resulting from MEMS fabrication methods, were preserved, such as the parallel kinematic elastic mechanism with all the actuators in one (horizontal) plane and the asymmetric layout of the leaf-springs at the end-effector, which originates from the crystallographic orientation of single crystal silicon. Furthermore, a typical MEMS-based aspect ratio was used for the leaf-springs. The width/length ratio of the in-plane leaf-springs for example is approximately 1/10. More details about these ratios can be found in [1].

model verification

Design

The scaled-up configuration consists of only five elastic parts, which are clamped together at points indicated by dashed circles in the centre of Figure 1. All five parts were wire spark eroded out of one piece, to reduce the effects of internal stress [4] and to minimize hysteresis.

This manipulator mechanism was based on a proper choice of actuated and released DOFs as is pointed out in Figure 2. This was done by a combination of stiffnesses and masses such that there is a discrepancy between the low-frequency first six actuation-related modes and the seventh and higher high-frequency deformation modes.

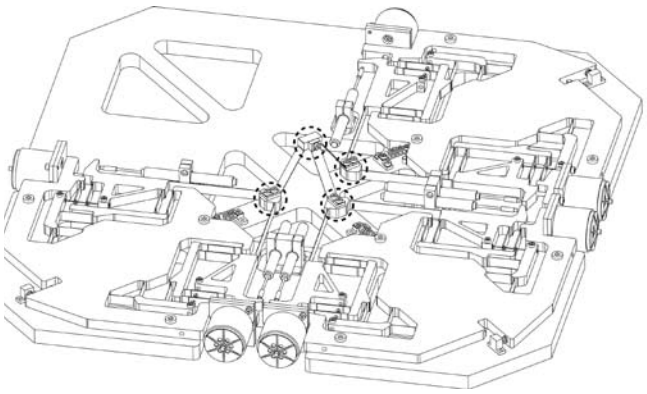
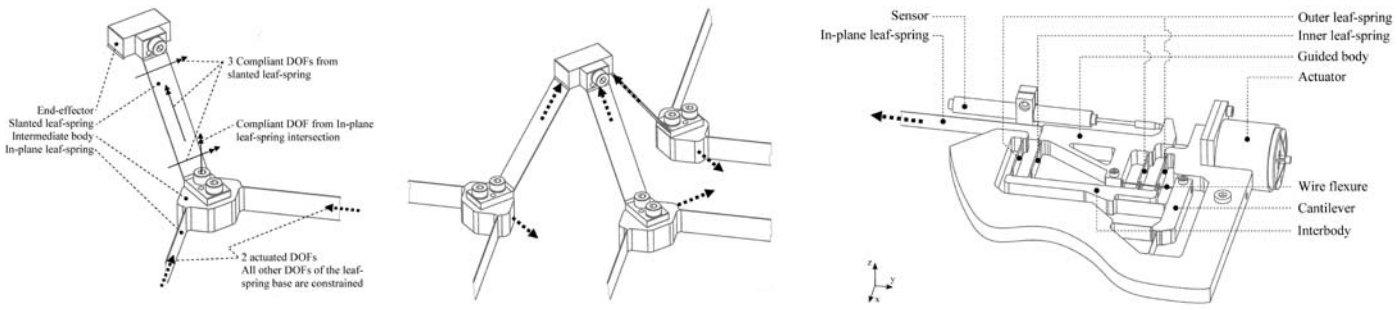


Figure 1. Scaled-up configuration with clamped points indicated by dashed circles.

As can be seen in Figure 2a, each intermediate body is connected by two perpendicularly placed in-plane leaf-springs. They ensure one compliant degree of freedom of the intermediate body, namely the rotation around the global z-axis (out-of-plane direction). The in-plane leaf-springs are actuated in the longitudinal direction resulting in two DOFs at the intermediate body. The remaining three DOFs are constrained by the high stiffness of the leaf-springs. Each slanted leaf-spring releases another three DOFs at the end-effector. One intermediate body together with a slanted leaf-spring will now ensure an actuation of the end-effector in two DOFs, while the other four DOFs are compliant. In total three of these intermediate bodies are connected to the end-effector by slanted leaf-springs, as shown in Figure 2b. In total this allows actuation in all six DOFs of the end-effector.

At the actuator part, shown in Figure 2c, the in-plane leaf-springs are connected to a straight guidance, which is actuated by a voice-coil actuator. This straight guidance leaves only the actuated direction free, while the other five DOFs are suppressed. Besides the thickened and therefore reinforced leaf-springs, the cantilever is added to improve the stiffness in the x-direction [1]. This cantilever pivots around an elastic hinge created by two leaf-springs. A wire flexure through the thickened part of one of the inner and one of the outer leaf-springs makes this lever mechanism complete.



a b c

Figure 2. DOF selection for the manipulator mechanism.
(a) The four compliant DOFs and two actuated DOFs of the end-effector realized by one slanted leaf-spring connection.
(b) Two actuated DOFs per slanted leaf-spring resulting in six actuated DOFs of the end-effector.
(c) The actuator with guidance.

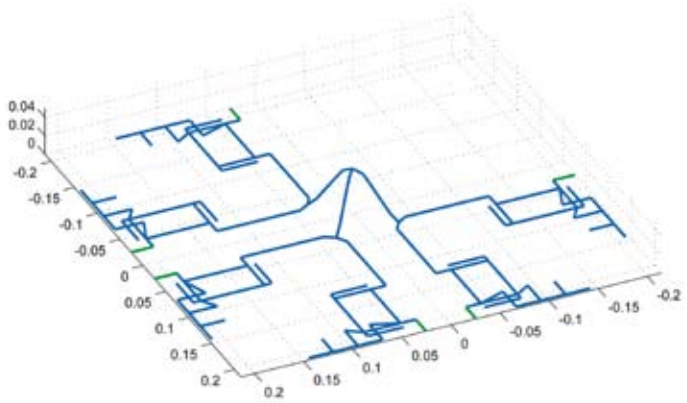


Figure 3. SPACAR model.

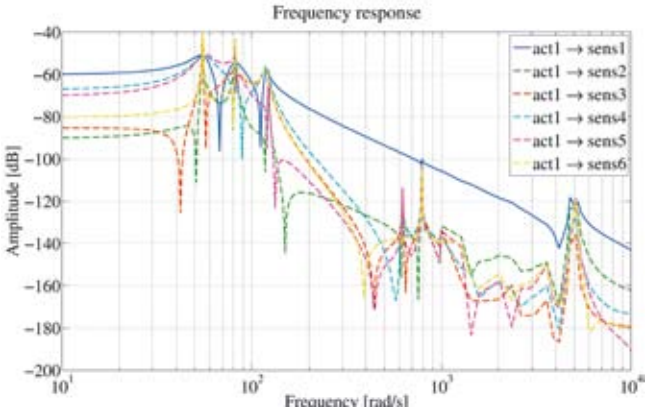


Figure 4. Transfers between actuator force and displacement as obtained by SPACAR.

Modeling in SPACAR

The displacements of the elastic elements are relatively large, and because there is no sensor that measures the movements of the end-effector itself in six DOFs, an accurate modeling method is required, that describes the non-linear kinematic relations between the actuator and end-effector movements. This model, shown in Figure 3, was built using a multibody systems approach that is implemented in the SPACAR toolbox for Matlab [5]. This toolbox is based on a non-linear finite element description of flexible multibody systems [6].

With this model, the dynamics were analyzed. As can be seen in Table 1, the first six eigenfrequencies, hereafter called actuation-related modes, can be found in the region 50-125 rad/s. The next three eigenfrequencies are located in the region of 650-1,000 rad/s and the higher frequencies are just above 1,000 rad/s. Ideally the actuation-related modes have low frequencies due to high compliance, whereas the deformation modes should have high frequencies.

Table 1. Modeled eigenfrequencies with associated vibration modes.

Mode	Frequency (rad/s)	Vibration motion*
1	54.6	end-effector translation in y'-direction
2	55.2	end-effector translation in x'-direction
3	81.1	end-effector rotation around z-axis
4	83.3	end-effector translation in z-direction
5	119	end-effector rotation around y'-axis
6	122	end-effector rotation around x'-axis
7	624	z-bending of in-plane leaf-springs
8	787	z-bending of in-plane leaf-springs
9	836	z-bending of in-plane leaf-springs
10	≥944	other (internal) modes of leaf-springs

* The x'-y' axis system is rotated 45 degrees, with respect to the x-y axis system, around the z-axis.

Control strategy

To obtain insight into the dynamical behavior of the mechanism, the transfers between actuator force and sensor displacement can be analyzed with help of the model; see Figure 4. Although the system is non-linear, for control purposes the system is linearized around the equilibrium configuration. The dominant character of the direct transfers between actuator force and sensor displacement, which was shown in analyses with the model, allows the use of a relatively simple single-input single-output (SiSo) control on every actuator-sensor pair separately. This results in a 6xSiSo controller for the whole system.

Each nominal SiSo model of the dominant transfer, with voltage as input and displacement as output, can be described by:

$$G_{nom_j} = \frac{\frac{k_m}{R}}{m_j s^2 + \frac{k_m k_v}{R} s + k_j}, \qquad (1.1)$$

where k_m is the motor constant, k_v the velocity constant, R the coil resistance and m_j and k_j are the nominal mass and nominal stiffness per actuated direction respectively, and j = 1...6. These nominal models will be used for a controller design. As feedback controller type a PID-controller was chosen. Advantages of this type of controller are a good stability margin because of the D-action and a small setpoint error because of the I-action. The basic form of PID-control is:

$$G_{FB_j} = k_{p_j} \frac{R}{k_m} \frac{(s\tau_z + 1)(s\tau_i + 1)}{(s\tau_p + 1)s\tau_i}, \qquad (1.2)$$

with the design parameters given in Equation (1.3) based on loop-shaping [7] (where j stands for the j^{th} controller and hence actuator).

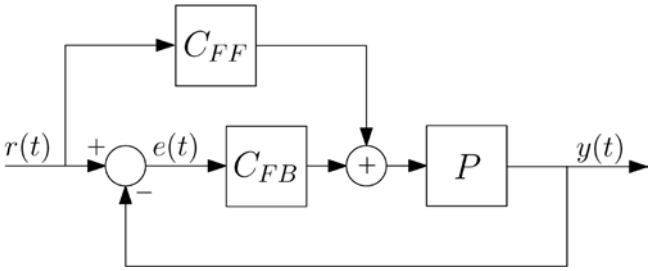


Figure 5. Closed loop with feedforward and feedback.

$$\begin{aligned} \tau_z &= \frac{\sqrt{1/\alpha}}{\omega_c} \\ \tau_i &= 2\cdot\tau_z \\ \tau_p &= \frac{1}{\sqrt{1/\alpha}\cdot\omega_c} \\ k_{p_j} &= \frac{m_j\cdot\omega_c^2}{\sqrt{1/\alpha}} \end{aligned} \tag{1.3}$$

where ω_c is the desired cross-over frequency of the open-loop, α a parameter between 0.1 and 0.2, namely the factor for the desired phase margin [7], k_{p_j} the proportional gain of the controller, τ_i the corner point to stop integral action, τ_z the corner point to start derivative action and τ_p the corner point to stop derivative action – the corner point being the point in the Bode magnitude plot of a transfer function where the asymptote is turning into a line with a different angle.

However, using only feedback control will require a high cross-over frequency/bandwidth to reach the desired performance. Therefore, the reference signal is fed forward, filtered and added to the signal calculated by the feedback controller. In this way the feedback control is used for stability and disturbance rejection and the feedforward control is used to increase performance. The control structure is shown in Figure 5.

The optimal filter in the feedforward is equal to the inverse of the open-loop system model, which in this case leads to the following feedforward filter:

$$C_{FF_{jj}} = G_{nom_j}^{-1} = \frac{R}{k_m}\cdot\left(m_{jj}s^2 + \frac{k_m k_v}{R}s + k_{jj}\right) \tag{1.4}$$

where the left part, R/k_m, is the multiplication factor between voltage and force. Since using the model allows analysis of the non-dominant transfers as well, the elements outside the main diagonal of the feedforward filter matrix can be filled with stiffness parameters. This is valid, as the elements on the diagonal are dominant and represent the dynamics. The off-diagonal parameters are only used for static compensation. This leads to a feedforward filter matrix given in Equation (1.5), where k_{ij} is the modeled nominal stiffness between actuator i and j.

$$C_{FF_{jj}} = \begin{bmatrix} C_{FF_{11}} & \frac{-R}{k_m}\frac{k_{22}^2}{k_{12}} & \cdots & \frac{-R}{k_m}\frac{k_{66}^2}{k_{16}} \\ \frac{-R}{k_m}\frac{k_{11}^2}{k_{21}} & C_{FF_{22}} & \cdots & \frac{-R}{k_m}\frac{k_{66}^2}{k_{26}} \\ & \vdots & & \\ \frac{-R}{k_m}\frac{k_{11}^2}{k_{61}} & \frac{-R}{k_m}\frac{k_{22}^2}{k_{62}} & \cdots & C_{FF_{66}} \end{bmatrix} \tag{1.5}$$

To quantify the controller behavior, a measure for the tracking error was formulated, based on a skew sine as reference signal:

$$e_{tracking} = \frac{4\omega_r^2(1-\gamma)}{\alpha\omega_c^3}\frac{h_m}{t_m}, \tag{1.6}$$

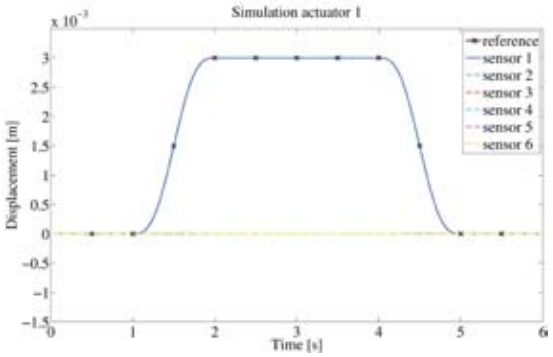
in which ω_r is the resonance frequency, ω_c the required cross-over frequency, α a factor for the desired phase margin, γ a factor for the expected model (un)certainty, h_m the step size and t_m the set-up time of the step of the reference. In case of a maximum tracking error according to the specifications (4 µm) this leads, combined with the parameters given in Table 2, to the requirement of ω_c = 323 rad/s.

Table 2. Control parameters.

Parameter	Value	Unit
$e_{tracking}$	≤ $4\cdot10^{-6}$	m
α	0.1	-
ω_r	75	rad/s
r	0.9	-
k_{p_j}	$8\cdot10^3$ – $9.1\cdot10^3$	-
m_j	0.243-0.276	kg
h_m	$6\cdot10^{-3}$	m
t_m	1	s

Simulations

Simulink was used to simulate the closed-loop system in order to check the calculations. As a reference signal a skew sine with a step size of 3 mm with a set-up time of 1 second was used. The simulation results are shown in Figure 6. As can be seen the maximum tracking error is larger than in the calculations, where only one SiSo case was accounted for. This shows there is some amount of crosstalk which cannot be ignored, but which is small enough to make 6xSiSo control possible.



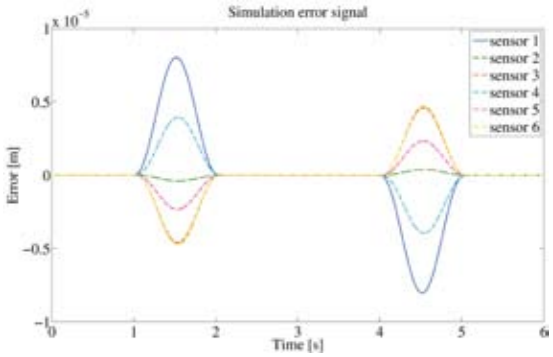


Figure 6. Simulation of the complete system.
(a) One actuator was being fed a non-zero reference signal. (b) Tracking errors.

Furthermore, these simulations show that the maximum tracking error occurs at the actuator with the non-zero reference signal. This is because the feedforward is designed in SiMo mode, where the reference signal of one actuator is forwarded to all actuators through the modeled stiffness of the mechanism.

Experimental validation

To validate the calculations and simulations a functional set-up, Figure 7, was built. In this set-up voice-coil actuators were used. Besides these actuators, linear variable differential transducer (LVDT) sensors were used. These actuators and sensors are connected to their amplifiers and signal conditioning electronics, respectively, which are each connected to a dSpace 1103 interface board. At this interface board six digital-to-analog and six analog-to-digital ports were used.

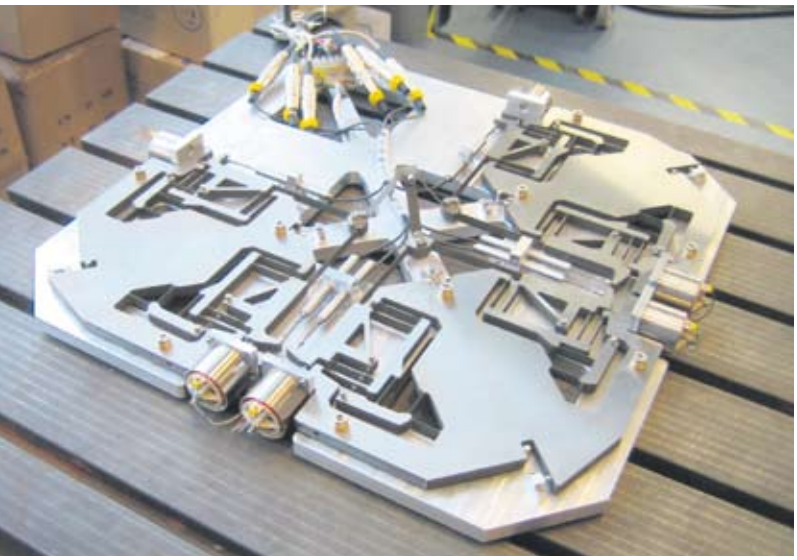


Figure 7. Experimental set-up.

Identification

Figure 8 shows the experimentally determined frequency responses between actuator 1 and all sensors. As can be seen at first glance, the transfers resemble the transfers predicted by SPACAR (Figure 4).

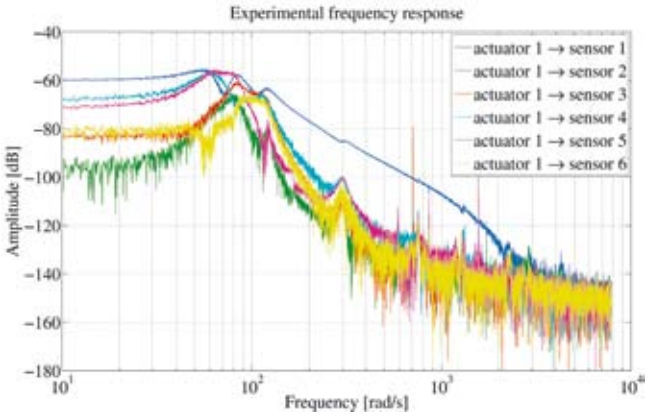
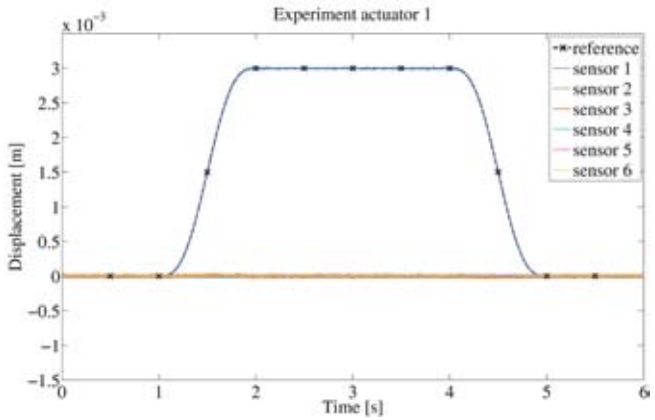


Figure 8. Experimentally determined frequency responses.

A closer inspection leads to the frequencies given in Table 3, completed with the relative errors between the values from experiment and model. As can be seen the relative error of the seventh to ninth frequency is larger than that of the lower frequencies. This can be explained by fabrication tolerances. The difference is probably caused by the non-uniform dimensions of the wire spark eroded leaf-springs, which are slightly different compared to the specification. The other peaks visible are introduced by the electronics used. The first highly damped peak at 314 rad/s (≈50 Hz) is caused by the AC power which is used by all electronics.

Table 3. Experimentally determined eigenfrequencies with their relative error.

Mode	Eigenfrequency		Error (%)
	Model (rad/s)	Exp. (rad/s)	
1	54.6	55.8	2.2
2	55.2	57.0	3.3
3	81.1	80.2	1.1
4	83.3	85.2	2.3
5	119	118	1.2
6	122	-	-
7	624	589	5.9
8	787	753	4.5
9	836	800	4.5



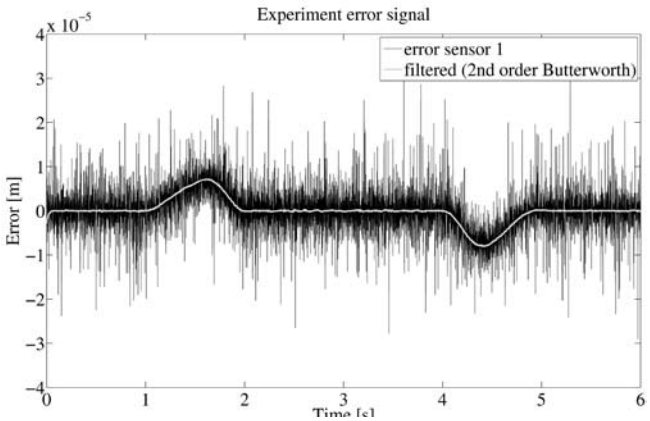


Figure 9. Experimental results of the complete system.
(a) One actuator was being fed a non-zero reference signal.

(b) Error signal.

Closed-loop experiments

Once the frequency responses of the prototype are known, the designed controller can be tested in practice. From comparing the modeled transfers (Figure 4) to the estimated frequency responses (Figure 8) it can be concluded that the model seems to resemble the prototype very well. Therefore, the frequency responses modeled by SPACAR are assumed to be valid. This has the advantage that the previously designed controllers do not have to be modified and can be integrated directly.

In the experiments again one actuator was given a skew sine reference signal, and the other actuators were given a zero reference signal. The result of an experiment with a step size of 3 mm is shown in Figure 9a (positive displacement is outward). This figure shows that the system behaves as expected. However, a large signal variance is observed for the actuators which are kept at zero displacement. This is mainly due to the noise generated by the sensors.

When the error of actuator 1 is inspected in detail (Figure 9b) it can be seen that the tracking error is in accordance with previous simulations. The other error signals show a behavior comparable to the simulations performed; hence, they are not given.

Conclusions

In this article the design, modeling and control of a scaled-up elastic parallel kinematic 6-DOFs manipulator has been discussed. The model created with the SPACAR toolbox showed a great resemblance with the prototype. Identification experiments showed an error between prototype and linearized model of the first six eigenfrequencies below 3.5% and the error of the seventh to ninth just below 6%. This difference can be caused by dimensions of the wire spark eroded leaf-springs that are slightly different compared to specification, due to fabrication tolerances.

Furthermore, simulations performed with the model were validated with experiments at the prototype. This comparison showed the model is relatively accurate. Therefore, the SPACAR model is assumed to be adequate and applicable for model-based controller design.

Authors' note

Martijn Huijts is a mechanical designer at MI-Partners in Eindhoven, the Netherlands. The work described in this article was part of his Master's thesis at the University of Twente. Dannis Brouwer and Johannes van Dijk are assistant professors in the department of Mechanical Engineering at the University of Twente, Enschede, the Netherlands. Dannis Brouwer is also project manager with DEMCON in Oldenzaal, the Netherlands.

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Nano-fabrication

Nano-science has generated a lot of new knowledge about phenomena in the small world. It is expected that these phenomena contribute to mastering current and future industrial and societal challenges. One of the scenarios how this shall be implemented involves microfabricated instruments and tools for sensing and production. In both cases throughput considerations impose parallel operations of large amounts of instruments. In turn, this requires innovations in the field of micro-actuation, systems architecture and control, and micro-assembly. This article presents the case of the scanning force microscope that was developed for the Phoenix mission to Mars, addresses the challenges of up-scaling nano-manufacturing, and presents current and future research in Delft.

• *Urs Staufer* •

Urs Staufer, PhD, is professor of Micro and Nano Engineering at Delft University of Technology, the Netherlands. Before becoming a professor in Delft, he obtained his PhD at the University of Basel, Switzerland, and worked as a postdoc with IBM in Yorktown Heights, USA, as a researcher in Basel and at IBM Rüschlikon, Switserland, and finally as an associate professor at the Institute of Microtechnology, University of Neuchâtel, Switzerland. This article was based on his inaugural lecture [1], which he delivered in Delft on November 13, 2009.

On May 25, 2008, the Phoenix Mission landed on Mars. On board was a scanning force microscope opening a new era, the microscopic investigation of the solar system. This original nano-scientific instrument, developed by a Swiss consortium which I led, enabled an unprecedented view on Martian soil and dust, and contributed to the understanding of the history of 'Water on Mars'. The challenges on the instrument were formidable and its successful operation was an important milestone for micro electro-mechanical systems (MEMS) in space. This example shows how scientific instrumentation enables new basic scientific research; and it also stands for what engineering research receives from science: exciting, stimulating first applications and knowledge for innovative building blocks for future technologies.

and -manufacturing

Life

Mars has played an important role in the history of science, the development of scientific knowledge and the search for extraterrestrial life. Liquid water is considered the single most important factor for the development of life. The presence of liquid water leaves traces, which (on earth) can be detected in the geomorphology of a landscape and in the structure of the soil. Hence, one way to assess whether liquid water has been present is to investigate the soil, its particle size distribution and particle texture. This requires microscopic experiments, for which the most recent Mars exploration, the Phoenix mission, had a special scientific instrument on board, the Microscopy and Electrochemistry and Conductivity Analyzer. MECA comprised an optical microscope and a scanning force microscope (SFM). The SFM was designed as a 'technology demonstrator' but turned out to provide 'real' results. Space applications are among the most demanding environments for any instrument. Therefore, the development of the Phoenix SFM may serve as an example for the fascinating engineering field of scientific instrumentation.

The Mars SFM

The Swiss consortium led by the University of Neuchâtel designed the Mars SFM to measure the size, size distribution, texture and hardness of dust and soil particles on Mars. It was originally conceived as part of the Mars Surveyor 2001 mission, which was cancelled, to explore hazards for future human explorers of the red planet. These threats include dust and soil particles, which were to be inspected by optical microscopy followed by SFM. Later, the SFM was included in the Phoenix mission [2], which was launched in 2007; see Figure 1. Now, the main objective was to investigate the structure of the soil and look for traces of liquid water.

Figure 1. Artist impression of Phoenix landed on Mars. (Picture: NASA/JPL-Caltech/Univ. of Arizona)

SFM basics

The SFM, often called atomic force microscope (AFM) [3], extended the abilities of the scanning tunneling microscope (STM) [4] to image also insulating material at atomic resolution. Both the SFM and the STM have a small sharp probing tip scanning very closely across the sample's surface. The distance between the tip and the sample surface is so small, that atomic range forces act between them, hence the name AFM. The tip is attached to the end of a cantilever spring in order to measure these forces. The force acting on the tip can then be determined by detecting the deflection of this cantilever, by means of either a laser beam deflection system, or a piezo-resistive strain gauge located on the cantilever, as implemented in the Mars SFM. During operation, the tip is raster scanned across the sample and the cantilever bending kept constant by means of controller electronics, which moves the sample closer to or further away from the tip to compensate for changes in the force. The servo signal is recorded and when plotted against the tip position, it represents an iso-interaction force contour, which closely represents the topography.

In order to reduce unwanted lateral sample-tip interactions, the SFM can be operated in the so-called dynamic mode, where the cantilever is set to vibrate at its resonance frequency. Any force gradient that the tip experiences detunes this resonance, which can be used as a signal for controlling the time-averaged separation between the sample and the tip. There are several variants to this principle, the Mars SFM employing the frequency modulation technique. In this implementation, the phase difference between the cantilever excitation and its vibration frequency is locked by a phase-locked loop. The control signal is used to approach or withdraw the sample, hence, suppressing the modulation of the frequency. Again, the servo signal represents the sample topography; see Figure 2.

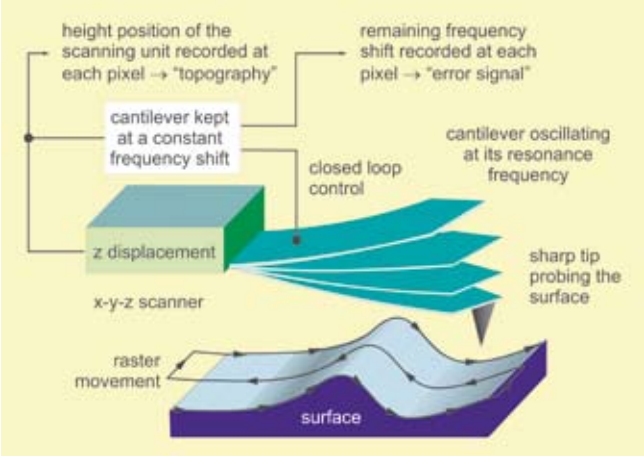


Figure 2. SFM working principle described for the dynamic mode with closed loop for constant force gradient imaging.

Instrument design

The requirements for the Mars SFM differ in many aspects from those for a normal laboratory version. The obvious demands are low mass (sending one gram of payload to Mars costs about 10,000 US$) and structural robustness, required by the rough conditions during journey, where shocks of up to 2,500 g, and strong vibrations (~ 0.1 g^2/Hz, from about 80 to 800 Hz) occur. These specifications can at least partially be addressed by reducing the size, because the relevant physical properties scale favorably. The second obvious condition was that there is no operator on Mars. Broken or contaminated tips must be exchanged by remote operations. The time delay of a few minutes for radio signals traveling from Mars to Earth, and the fact that satellite communication with the lander was restricted to only two or three times a day, required complete autonomy of the instrument. The tip exchange was implemented by an array of eight cantilevers, which can be cleaved off if no longer usable; see Figure 3. Additional design challenges were posed by the low atmospheric pressure on Mars and the nearly 100% absence of magnetic and atmospheric shielding of cosmic radiation.

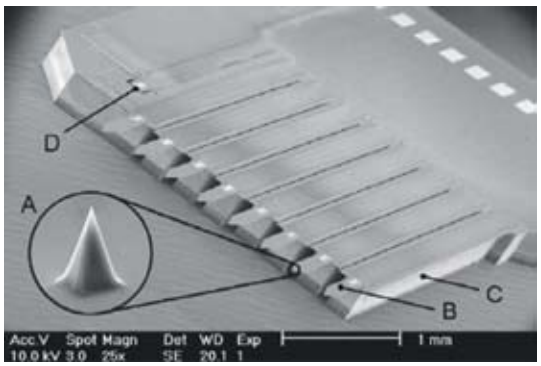


Figure 3. SFM chip of the MECA AFM [5].
(A) The tip.
(B) The cantilever with integrated, piezoresistive strain gauge.
(C) Support beam, which can be cleaved of.
(D) A reference resistor for a Wheatstone bridge.

Measurements on Mars

The first successful measurement was performed on a calibration sample, in the less demanding static operation mode. Then, changing from static to dynamic mode proved to be much more demanding than anticipated. On Mars, the motors were powered for a much longer time than in the laboratory tests and therefore heated up more. This led to thermal drifts and false detection of sample-tip contact. Once the problem was identified, the software was re-coded and validated to drive the motors faster and to preheat the electronics longer. Finally, images of a calibration grid in dynamic mode could be measured: we had accomplished our 'minimal success goal', the demonstration of SFM measurements on another planet. Soon thereafter, we could also measure particles; see Figure 4. Images like these were used to draw up a particle size distribution (PSD). Comparing this PSD with terrestrial data, allowed estimating how long the investigated soil might have been exposed to liquid water. A maximum of about 20,000 to 40,000 years (within the last 500 million years) was deduced.

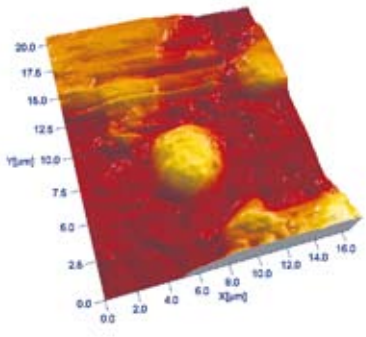


Figure 4. SFM image from Mars soil, showing individual particles. (Photo: NASA/JPL-Caltech/Univ. of Arizona/Univ. of Neuchâtel)

Nano-engineering

This Mars SFM example shows how technology contributes to science. On the other hand, basic science generates knowledge that enables new technologies. In my opinion, the academic engineering community should take care of making this wealth of knowledge available for technology implementations. Nano-engineering as I will conduct it in my research in Delft is focusing on the new knowledge developed in the emerging domain of nano-sciences, where chemistry, biology and physics meet at the

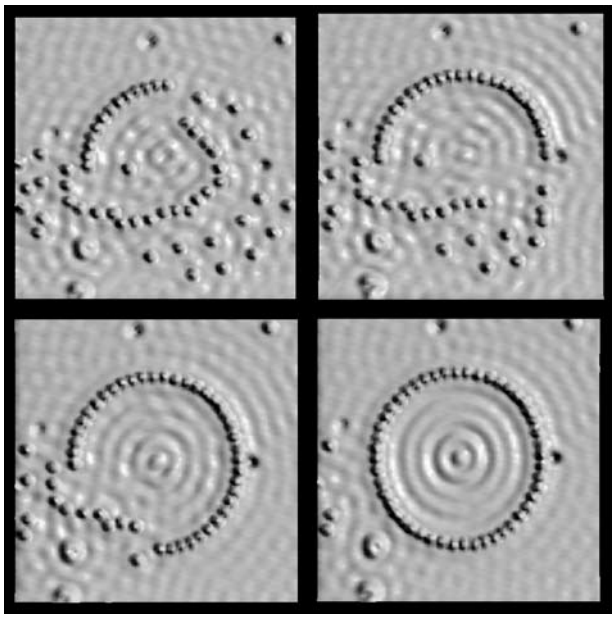


Figure 5. Arranging Fe atoms on a Cu(111) surface into a so-called quantum corral, at 4 K, using a STM [6].

nano-length scale. Note that this length scale is not the essential aspect in nano-science; rather it is a paradigm shift in the investigation. The individual, atomistic functional unit is addressed and its interaction with other units is experimentally interrogated. New scientific instruments were needed for that purpose, a prominent representative being the AFM.

Scale-up

These instruments or nano-tools have to bridge a dimension gap of about six orders of magnitude, from the lower nanometer to the millimeter scale range. Micro electro-mechanical systems (MEMS) technology offers this interface between the nano- and the macro-world. Widespread AFM use became only possible once MEMS technology was used to mass-produce miniaturized force sensors with reproducible and controllable properties. With them, scientific research on individual atoms and molecules exploded. People started thinking in molecules and atoms, moving them around (see Figure 5), probing them and measuring their optical spectrum. While scientifically highly relevant, this dealt with a technologically insignificant amount of units, e.g. a few atoms or molecules. One of the most prominent questions in nano-engineering, therefore, is that of scale-up.

Three approaches may tackle the problem of scale-up:

- "Self assembly", through interactions between individual functional units, the target configuration being the one where an energy minimum is achieved.
- "DNA nano-technology", inspired by the molecular recognition properties of DNA, viewed as mechanical building blocks of two- and three-dimensional structures.
- VLSI MEMS, Very Large Scale Integration of minute tools, nano-tools, that all work in parallel and at high speed.

Challenges for MEMS scale-up

Microfabrication

Shrinkage of MEMS systems is limited by functional conditions. A related problem is associated with actuators. Since they are part of a MEMS, they contribute to its footprint, increasing the separation between the MEMS units. Therefore, high stroke- and force-to-volume ratios in a small envelope are required, an issue we address in our micro-actuation research. Moreover, not all functionalities can be implemented by silicon-based MEMS. Hence, heterogeneous systems and their integration will be needed.

Architecture and systems integration

Each MEMS must be supplied with energy, information, and raw materials. Most likely, the associated bus lines demand for a three-dimensional integration, comparable to the interconnect layers in micro-electronics. Contact- or wireless solutions, e.g. for powering, may also be implemented. Given the gigantic data volume that a VLSI MEMS can produce, analysis and processing have to be performed locally in such a system. Hence, each MEMS or at least a cluster of MEMS will need some 'intelligence'.

Operations

VLSI MEMS-based manufacturing provides a generic solution, which requires a tight control of the tools for any specific assignment. This amounts to an enormous task for thousands of tools working in parallel. Some kind of local intelligence may be used to adapt control signals to local specificities, or to exploit the interaction between neighboring tools. One could even think of 'programming' the structure of the nano-product into the tool rather than into the individual elements of the product – a kind of "self assembly via the tool".

Current and near-future research

To address the above outlined challenges, several research activities have been started or existing ones were intensified by the Micro and Nano Engineering research group, in collaboration with other research groups in Delft.

Micro-assembly, for example, is used to assemble the VLSI MEMS out of different components, or for replacing

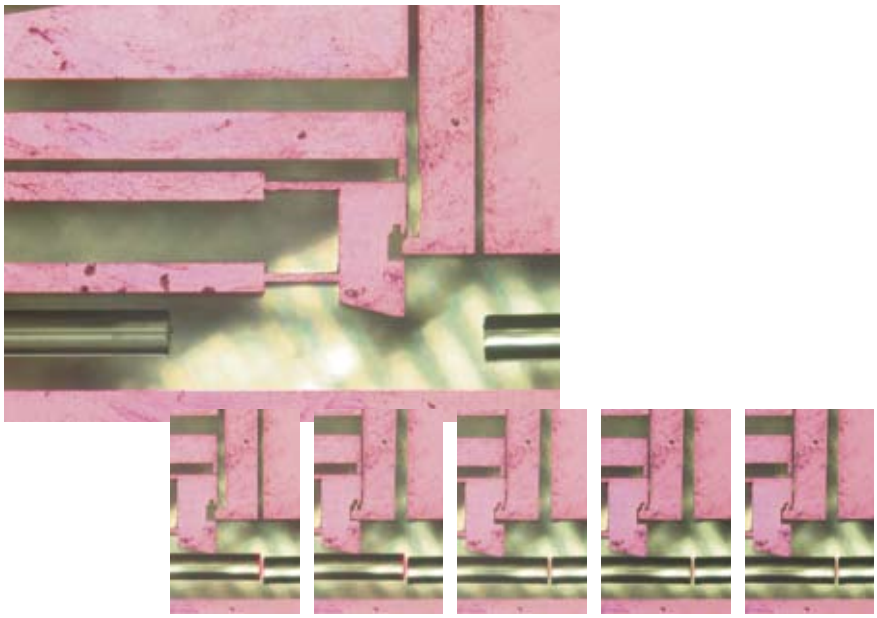
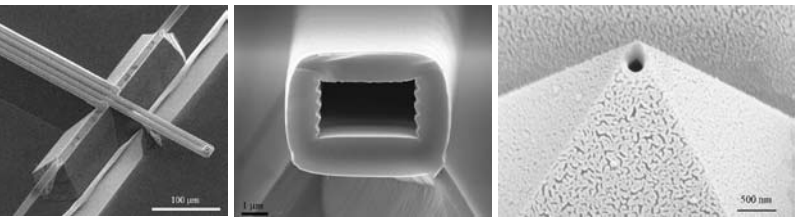


Figure 6. 1D fiber positioning and clamping sequence, from (left) fabrication position, to (right) maintaining the fiber in position without using power.

defective parts. Also, many production processes in nano-fabrication will directly rely on assembly steps. One could, for example, think of integrating carbon nano-tubes as electro-mechanical elements in a sensor. A central question concerns the fundamental steps of the assembly process and how they can be modeled. What key characteristics make a process suitable for industrial applications? At the same time, different steps in the assembly chain are being experimentally investigated, for example the displacement of an object over large distances with high final placement precision. Various driving forces can be applied for that purpose. For instance, mechanical vibrations combined with local electrostatic chucking, or asymmetric air cushions again combined with electrostatic or magnetic chucking. One of the current topics in research on micro-assembly is concerned with the clamping of an optical fiber; see Figure 6.

A new activity on micro-actuation was started, aimed at realizing a two-dimensional high-precision conveyor system. Such a device should be capable of positioning several micro-scale objects at the same time to different locations within in a limited but macroscopic area. Currently, the interaction between the object and the positioning system, by means of Van der Waals forces, is investigated.

The nano-tools that are being used limit their interaction with the object by means of a mechanical constriction. This constriction could be considered as “materialized focus”. This focus could be a simple cone, like in the case of an AFM tip, or it could be a tipped heat, current, or light source, or a measuring tool. Also the opposite of a tip, a small hole in a membrane can be used to localize the interaction. Such ‘nano-pores’ were employed to study e.g. DNA molecules. Combination of these two elements, by machining a small hole at the end of a hollow tip and cantilever, results in a ‘nano-pipette’; see Figure 7. It can be used to precisely deposit or take-up small amounts of liquids.



a b c

Figure 7. A nano-pipette.
(a) The hollow cantilever and tip are essential parts of this fluidic system.
(b) A cross-section through the channel.
(c) At the end of the tip, a small pore is drilled by means of a focused ion beam such that the hole is slightly off-axis and the tip apex stays intact.

In conclusion

When developing a new technology, scientific knowledge forms the repertory of building blocks. Investigating and establishing these building blocks for future technologies is an important part of academic technology research. In this endeavor, scientific instrumentation plays a key role: it is the natural link to scientific research and stimulates the dialogue among the sister disciplines. As an example, microfabricated elements and instruments were essential in the advancement of nano-science. If similar means, but now in the form of nano-tools, shall be used also in production, then micro-engineering has to overcome formidable challenges. Some of them I like to address together with my team. Is there a market need for such nano-technology? That is the wrong question! There is

never a need for a specific technology. The market needs solutions for certain problems – engineers may find them in knowledge developed in nano-science. Enabling this is the mission of nano-engineering!

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Information

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2010 conference

In June 2010, euspen is delighted to be hosting their 10th International Conference in the Netherlands at the historical city of Delft. The Society is very pleased to partner with the Department of Precision and Microsystems Engineering within Delft University of Technology to deliver the conference and associated exhibition.

The European Society for Precision Engineering and Nanotechnology was formed in 1998 when a number of leading industrialists and academics came together with a wish to provide a complimentary networking forum to that which existed in both Japan and the US. Initially funded by the European Commission, in 1999 the Society was established as a charity with a board of Directors drawn from leading companies and institutes across Europe.

Today eu**spen** is an entrepreneurial network of leading industrialists and researchers working in the field of precision, micro and nano engineering with representation across 32 countries worldwide with a focus on:

- Ultra/Nano-precision manufacturing;
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Special interest groups also address particular emerging challenges to industry such as: structured and free form surfaces, thermal effects in precision systems, and the implementation of microfabrication technologies into SMEs.

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First held in Bremen in 1999, eu**spen**'s international conference has an established reputation for providing a leading forum for organisations who set the standards for developments in the field of precision, micro and nano engineering. The meeting moves across Europe annually (see the map).
Each year, in conjunction with the society's core themes of ultra precision processes, machines and technologies, a focus is given to: key emerging technologies, neighboring technology areas of potential interest to the Society and who may benefit from its expertise and/or key strengths of the geographical area.
To date, over 3,000 experts in the field have been brought together through this forum. With a 50:50 ratio of commercial companies to research institutes, plus more than 30 countries worldwide typically represented, it represents a unique forum to survey or present latest knowledge, products, services and capabilities.

Delft 2010

In June 2010, eu**spen** will be hosting their 10th International Conference in the Netherlands at the historical city of Delft. The Society is very pleased to partner with the Department of Precision and Microsystems Engineering within Delft University of Technology to deliver the conference and associated exhibition.
The event is targeted at CTOs, research institute directors, leading engineers/technologists from industry and academia, technical sales and marketing personnel. Delegate numbers in excess of 500 are anticipated with over 50 companies taking part in the exhibition.

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Conference Technical Themes

- Emerging Patterning Technologies and Methods
- Wind Turbines – Precision Engineering Challenges
- Medical Applications of Precision Engineering
- Nano and Micro Metrology
- Ultra Precision Machines and Control
- High Precision Mechatronics
- Ultra Precision Manufacturing and Assembly Processes
- Important/Novel Advances in Precision Engineering and Nano Technologies

A perspective on leading international activities will be provided by the American and Japanese Societies for Precision Engineering, who will each deliver a set of invited keynote papers. Delegates will benefit from a full programme of review papers, state-of-the-art research papers, professional development tutorials and a comprehensive exhibition with industrial visits in the local area.

Information

For all conference and exhibition enquiries please contact:
Mrs Valerie Laird
valerie-laird@euspen.eu
tel. +44 (0) 1234 754064
www.delft2010.euspen.eu
www.euspen.eu

Exhibitors to date.

Poll: Mikroniek in English only?!

In line with the international ambitions of the Dutch Society for Precision Engineering, this year saw the publication of Mikroniek in English on a 50/50 basis (three English issues, three Dutch issues). This facilitated the distribution of Mikroniek to eu**spen** members on a European scale and enabled the magazine to promote the Netherlands as a prominent high-tech systems country. Additional reasons for publishing in English include the growing internationalisation of Dutch companies, universities and knowledge institutions, as well as the fact that an increasing number of staff come from abroad, meaning more and more (potential) authors and readers are English-speaking.

Hence the question: would it be wise to publish Mikroniek in English only? In order to gauge public opinion, a survey will be held at the Precision Fair. The poll is also available on the DSPE website. If you take part, please do so anonymously.

www.dspe.nl

Ultra-precision finish hard turning

Recently, Hembrug has introduced the next levels in ultra-precision finish hard turning technology, including the new Mikroturn® 300 Baseline. Its design features natural granite machine base, hydrostatic main spindle having 0,15 µm run-out and hydrostatic guideways for X- and Z-axis having 0,1 µm repeatability. The machine is equipped with a Fanuc control having 0.1 µm resolution and has a reasonable cost price, claims Hembrug, based in Haarlem, the Netherlands. Part diameters up to ø 300 mm and up to 250 mm in length can be accommodated. The optional tailstock allows hard machining of shafts up to ø 130 mm between centers and 350 mm in length.

www.hembrug.com

Mechatronics lectors unite

The characterisation of the Netherlands as a high-tech systems country that leads the way in the field of mechatronics and precision technology is fully supported by institutes for higher education and research. In early 2007, the three universities of technology established the 3TU.Federation, which has Centres of Competence in five areas, including High Tech Systems. Now the world of higher professional education is also coming into action, led by lectors in mechatronics and related subjects. The role of lector is relatively new in higher professional education (HPE) and is meant to enrich it through applied research into subjects taken from society and/or industry, especially the SME sector.

The seeds of this co-operative relation within HPE were sown at the Precision Fair at the end of November 2008. That is where Henk Kiela, Mechatronics lector at the Engineering institute of Fontys University of Applied Sciences in Eindhoven, and Erik Puik, lector in Microsystems Technology/Embedded Systems at Utrecht University of Applied Sciences (*Hogeschool Utrecht*, HU), got talking about the necessity of and the possibilities for co-operation. Joining them this year, Jos Gunsing started as Mechatronics lector at the Academy for Technology and Management of Avans University of Applied Sciences in Breda on 1 March.

"We have to unite to be able to carry out projects on a larger scale and to better help our clients, by referring to one another and working together", explains Puik. "Our first objective is to make it clear to everyone who does what, and what we are capable of together." Puik is thinking of bodies such as Point-One and the High-Tech

Erik Puik: "As lectors, we want to put forward a uniform standpoint on a higher level." (Photo: HU)

Systems Platform. "Professors from different universities set up programmes together, for instance. We do not yet have one voice as universities of applied sciences, but we are represented everywhere. Henk was already involved in Point-One, while I participated in MicroNed and Jos co-operated with the FEDA (Drive and Automation Federation, ed.). As lectors, we want to put forward a uniform standpoint on that higher level, next to that of the professors."

The co-operative relation started as a personal initiative of the lectors involved. They invite 'high-tech' lectors from other universities of applied sciences to join them and, if it is up to them, the co-operation will be formalised by the participating institutes in the future. For example, various lectors maintain joint education-related contacts with parties such as DSPE and the FEDA about, for instance, the demand for mechatronics professionals. They are also developing a joint Master's degree programme in Mechatronics and see possibilities for facilitating student exchange so that students can do their elective components (minors, placements, final projects) with the lector whose research is most relevant to their project.

Exactly one year on from the first conversation, the co-operating lectors want to go public. At the Precision Fair 2009 they will deliver a lecture. They will also staff a joint stand in the Technology Hotspot. In this way, higher professional education wants to grow to become a fully-fledged player in the high-tech systems research field.

Closing MEMSland Symposium

On Thursday 3 December 2009 at TNO Science and Industry in Eindhoven, the Netherlands, a closing MEMSland Symposium will be held. The objective of the MEMSland project, as part of the Point-One programme, was to develop and integrate all key competencies and technologies needed for the development of a comprehensive MEMS (micro electro-mechanical systems) packaging solution. Cooperation on a national scale was deemed necessary to achieve cost-effective options for new MEMS device creation. In addition, the project was to enhance the education of highly qualified experts in this complex field, resulting in a sustainable innovation environment and world class competitive strength of the Netherlands in the emerging sensor/actuator/MEMS business.

www.memsland.nl

In charge of the DSPE's Precision-in-Business days

One of DSPE's goals is to facilitate the exchange of knowledge and experience between members. For example through so-called Precision-in-Business (PiB) days, which offer DSPE members the opportunity to be introduced to applied precision engineering at OEMs, (system) suppliers and research institutes. Usually, a PiB day is an afternoon event at a member company including a corporate introduction, technical presentations, a guided tour and concluding with a drink. Three successful PiB days have been organised this year already, each attracting a large number of participants and receiving enthusiastic reactions from hosts and guests alike. Philips Applied Technologies, the NTS-Group in collaboration with MI-Partners, and OTB Solar opened their doors to offer DSPE members a look at their business and their technology roadmap.

Robert Swinckels: "We hope to give PiB day participants eye-openers in the broad field of precision engineering."

My name is Robert Swinckels and I am in charge of organising these PiB days on behalf of DSPE. I started my career in the early 90s at an engineering company, where I worked for five years in general mechanical engineering. The next step on my career ladder was Singulus Mastering, formerly ODME, which develops and produces equipment for optical media such as CD, DVD and Blu-Ray. At Singulus, I was responsible for the development and realisation of hardware for the exposure tool (laser beam recorder) at system level. In the thirteen years I worked there, shrinking features, increasing throughput and decreasing cost price were continuous drivers for new technology development. This enabled me to create a multi-disciplinary base of experience and knowledge in precision engineering, and to act at system level. Last year, I took the

opportunity to move to ASML in Veldhoven to become a team leader in the Immersion & Vacuum systems department.

Working at different companies and in various disciplines, which has been a recurrent theme throughout my career, now inspires me to organise Precision-in-Business days at widely varying companies. In view of the ongoing trend in industry concerning the outsourcing of development and manufacturing of complete modules, we hope that PiB days present a perfect marketplace for updating networks and being informed about what is happening in the world of precision engineering.

robert.swinckels@asml.com

CCM and Sioux select Verum's ASD:Suite

Verum, based in Waalre, the Netherlands, has announced that Dutch companies CCM and Sioux Embedded Systems have selected their ASD:Suite. This software design toolset eliminates all behavioural defects from complex software designs, dramatically cutting the cost of software development, testing and maintenance, so Verum claims. ASD:Suite automatic code generation further reduces the cost of software development by 30% per delivered line of code.

Nuenen-based CCM, the Centre for Concepts in Mechatronics, evaluated that the ASD:Suite would help manage their time-to-market, reduce the risk of project overruns, and increase product quality. Verum's CEO Robert Howe explains: "CCM is already successfully using tools such as MathWorks™ so we needed to clearly demonstrate ASD's added advantage. CCM appreciated that the ASD:Suite enables its engineers to complete the behavioural design and undertake design time verification before a single line of code has been written."

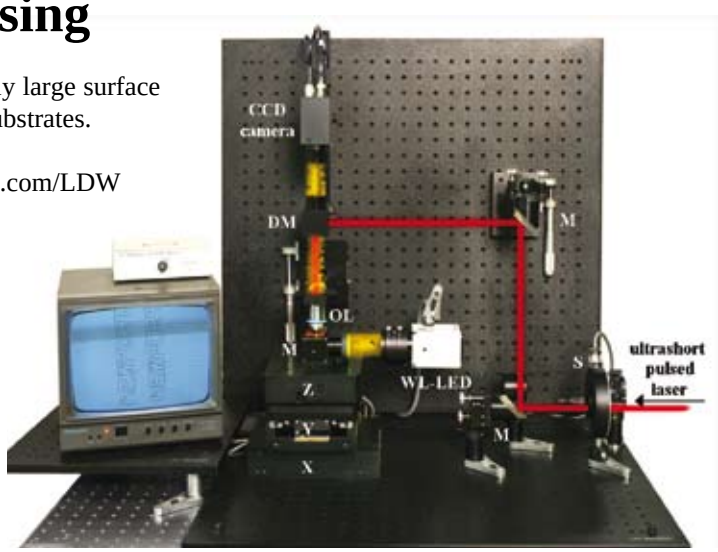
Eindhoven-based Sioux Embedded Systems compared conventional software development to that using Verum's ASD:Suite. The ASD:Suite performed strongly in terms of economics, productivity and quality, improving the design and coding productivity by 21%. "It helps you to think before you start implementing, so you get a better architecture and avoid unnecessary complexity. It also finds bugs that otherwise would only be discovered during the integration phase", said Ger Schoeber, Executive Consultant at Sioux.

www.verum.com

Laser Direct-Write Processing

Newport Corporation, a worldwide leader in lasers and photonics solutions, has introduced a new micromachining workstation specifically designed for high-precision laser direct-writing (LDW) and patterning. The flexible device can be integrated with several lasers to produce two- or three-dimensional patterning and writing on virtually any material. It is simple to assemble and easy to couple with continuous-wave, nanosecond, and femtosecond lasers. The advanced workstation can also be used to produce submicron resolution on significantly large surface areas of the substrates.

www.newport.com/LDW



AC Optomechanix: a mix of precision engineering, optics and metrology

AC Optomechanix is the company through which Lennino Cacace works as freelancer in the field of precision engineering, optics and metrology. He founded it a couple of months before receiving his Master's degree in Mechanical Engineering at Eindhoven University of Technology (TU/e) in 2006.

Lennino Cacace at the TU/e campus. (Photo: B. Jansen)

Lennino did his traineeships in the Constructions & Mechanisms group, part of the Control Systems Technology section. "Here I got the chance to dig into projects that incorporated a mix of precision engineering, optics and metrology, fields that interested me during my studies. Then, the choice to start as a freelancer was easy; it offers me more freedom to select projects, it allows me to see various work environments, and I had a project beforehand."

When he started as a freelancer, TNO hired him to continue working on his Master's project, the development of a sensor for NANOMEFOS. Last year's Precision Fair issue of Mikroniek featured an article on this universal measurement machine for freeform optical surfaces, which was the Ph.D. project of Rens Henselmans. The principle of operation of the machine required a novel sensor for surface distance measurement. Requirements included a range of 5 mm, a resolution of 1 nm and a 2σ uncertainty of 10 nm for no surface tilt up to 35 nm for 5° surface tilt. "I really liked the opportunity to experience the whole route from a sheet of requirements to a working prototype."

Some inventions resulted in a patent co-owned by TNO, WimOptik and AC Optomechanix. "Now that we have measurement results that demonstrate the benefits, we're looking for a partner in the sensor market to commercialize those inventions together." After professor Maarten Steinbuch had asked him, he started writing a thesis on the subject in the autumn of 2008. Meanwhile, he only did a small consulting job for the TU/e's Electrical Engineering department on the side. "They were experiencing troubles with the 3-axis interferometer used in their 3-DOF planar actuator set-up. I did some experiments to find the cause and advised them on a solution. It was very enjoyable, because your effort has a lot of leverage when you can give somebody with a neighbouring specialism advice concerning your own field."

Lennino will defend his thesis on 1 December 2009 at 16:00 h; after receiving a Ph.D., he intends to keep working for high-tech companies through AC Optomechanix.

Composite picture of the NANOMEFOS sensor measuring a freeform and a CAD drawing of the sensor design. (Photo: L. Ploeg; editing: L. Cacace)

Information

l.a.cacace@ac-optomechanix.com
www.ac-optomechanix.com

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Precision Fair 2009

Wednesday 2 and Thursday 3 of December 2009
NH Conference Centre Koningshof in Veldhoven

www.precisiebeurs.nl

Organisation:

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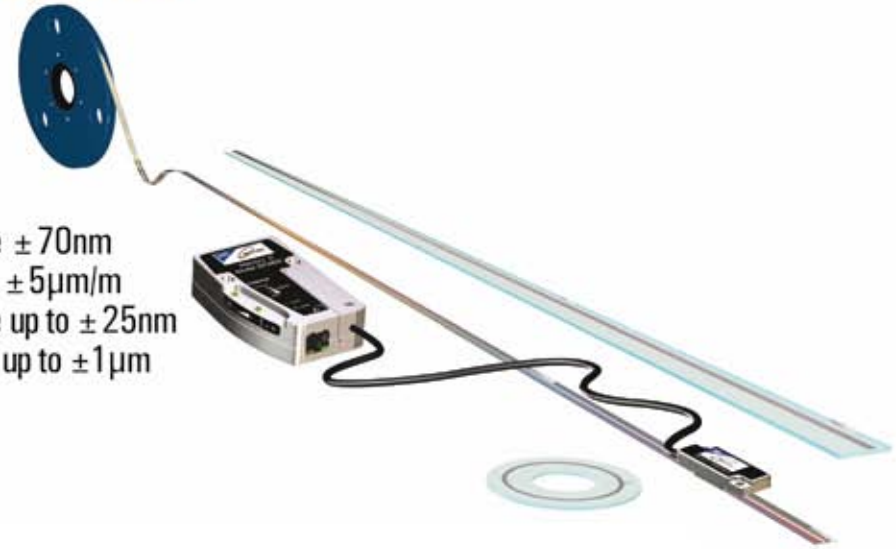

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INTERNATIONAL business opportunities

2009 Precision Fair

Organised by the Mikrocentrum, the ninth edition of the Precision Fair (or *Precisiebeurs*, in Dutch) will be held in NH Conference Centre Koningshof in Veldhoven, the Netherlands, on 2 and 3 December 2009. The Precision Fair has grown into *the* event on precision technology and has already acquired a national and international reputation.

This year, 'International business opportunities' will be the recurring theme of the main lectures, which will be given by two well-known foreign guest speakers and two Dutch entrepreneurs with proven international track records. They will paint a picture of international (market) opportunities for both large and small companies. In addition to the exhibition (including the Technology Hotspot), the lecture programme and the new Brokerage Event for SMEs from all over Europe, presentations will be given by Brainport (the Southeast-Netherlands high-tech innovation community) and eu**spen** (the European Society for Precision Engineering and Nanotechnology).

Technology Hotspot

For the third consecutive year, the Mikrocentrum is organising the 'Technology Hotspot' at the Precision Fair. Universities, universities of applied sciences and research institutions from the Netherlands, Belgium and Germany will be presenting their research in the field of precision technology and related areas. Scientists will also play a crucial role in the lecture programme. The Technology Hotspot will be supported by IOP Precisietechnologie.

TECHNOLOGY HOTSPOT

Largest Benelux precision trade fair

During this trade fair, some 200 specialised companies and knowledge institutions from the Netherlands, Belgium and Germany will be exhibiting in a wide array of fields: optics, photonics, precision etching, high-precision mechanics (micron range), nanotechnology, micro-systems technology (MST), mechatronics, embedded software, micro-assembly, micro-laser processing, micro-connection, sensor technology, motion control, vision systems, materials (composites, ceramics), precision machining, measuring machines, and piezo technology.

Date

Wednesday 2 and Thursday 3 December 2009 from 9.30 a.m. to 5.00 p.m.

Location

NH Conference Centre Koningshof
Locht 117
5504 RM Veldhoven (near Eindhoven)
The Netherlands

Visitor registration

You can register for this event and the congress via www.precisiebeurs.nl.
After receiving your registration we will send you a confirmation letter including your badge.

Free at the 2009 Precision Fair

Entrance to the fair – entrance to the lecture programme – valuable (digital) fair reference material – fair catalogue – coffee/tea – parking.

Organisation and Information

Mikrocentrum
P.O. Box 359, 5600 AJ Eindhoven, the Netherlands
Tel. +31 (0)40 - 296 99 22
seminar@mikrocentrum.nl
www.mikrocentrum.nl
www.hightechplatform.nl

Visitor information: Geneviève Sastropawiro
Exhibitor information: Hans Houdijk

Programme Wednesday 2 December

	Baroniezaal ▶ Design	Limburgfoyer ▶ Measurement - Innovation	Zaal 20 Technology Hotspot ▶ Micro Processing - Motion Control	Zaal 19 ▶ Piëzotechnology	
10.15-10.30	 **Plenair ▶ Baroniezaal** **De internationale ambities van Brainport in de regio ELAt (Eindhoven-Leuven-Aken)** dhr. Rob van Gijzel, Burgemeester van Eindhoven en Voorzitter van de Stichting Brainport Er zal toelichting worden gegeven op de internationale ambities van Brainport in de regio ELAt (Eindhoven-Leuven-Aken) en daarbuiten zowel in het algemeen als meer specifiek op het gebied van precisietechnologie en high tech systems.				9.30 EXHIBITION · EXHIBITION · EXHIBITION · EXHIBITION · EXHIBITION · EXHIBITION 17.00
10.30-11.10	 **Plenair ▶ Baroniezaal** **New products from international innovation*** mr. dr.ir. Henny Spaan, Managing director at IBS Precision Engineering BV, Eindhoven This presentation will cover the experience of a small company with the development of new products. The development started with research in an international EU project. Based on this knowledge a new device has been developed for calibrating machine tools, including special tooling to calibrate the system. The presentation will cover the complete chain from fundamental research to a successful product. In addition some other product developments will be discussed as well as how to get into these international networks. Next to the technical development also an international sales channel is necessary. As IBS Precision Engineering has already its own subsidiaries in Europe, this presentation will cover setting up a sales channel in Asia.				
11.20-11.50	1 **Productiviteitsverhoging door Multifysica simulaties** dhr. Gerard Hegemans, Managing Director bij COMSOL BV	6 **Realization of Isara 400: A large measurement volume ultra-precision CMM** dhr. ir. Rilpho Donker, Senior Designer bij IBS Precision Engineering	11 **Metal Precision Parts by Micro Nano Structuring*** mr. dr. O. Humbach, Managing Director bij temicon GmbH namens Etchform BV	16 **Enhancing the effect of your piëzo application; more power for your euro!** dhr. Jan Peters, Directeur bij Imotec BV	
12.00-12.30	2 **Ruggengraat voor printers** dhr. ir. Tjeu Naus, Technisch directeur bij NBG Industrial Automation BV en dhr. ir. Jos Gunsing, Projectleider bij NTS Mechatronics	7 **REAL ABSOLUTE** dhr. Corrie Fearon, Business Marketing bij Renishaw PLC	12 **High accuracy alignment stage** dhr. Robbert van der Kruk, Innovation manager bij Bosch Rexroth	17 **Piëzo Stage Design New Actuator for Aerospace** dhr. Hein Schellens, Directeur bij Heinmade BV, dhr. Cedric Gouëffon, Noliac	
13.00-13.30	3 **Six degrees of freedom vibration isolation in low frequencies** dhr. ir. Niek Rijnveld, System Engineer bij TNO Science & Industry	8 **From contour measurement to shaft measurement*** mr. dipl. ing. Jürgen Meyer, Sales manager Europe bij Dr. H. Schneider Messtechnik GmbH namens MuRaad BV	13 **Next Generation fiberlasers*** mr. Andrew Held Phd., Multiwave Photonics on behalf of Laser 2000 Benelux	18 **Haptic Feedback** dhr. ir. Jeroen Dekker, Aito Interactive BV	
13.40-14.20	 **Plenair ▶ Baroniezaal** **UK perspective on Ultra Precision and Structured Surfaces*** mr. Prof. Paul Shore, FREng, McKeown Professor of Ultra Precision Technologie, Head of Precision Engineering Centre of Cranfield University, UK This presentation will review UK research, development and knowledge transfer in the area of ultra precision and structured surfaces. An explanation of why such surfaces are considered important for enabling next generation products/processes will be provided. Specific examples of manufacturing technologies and facilities developed in partnership with UK companies will be reviewed. The presentation will close with a summary of some embryonic techniques considered to be of importance.				
14.30-15.00	4 **Closed-Loop MEMS Positioning Stage** dhr. Bram Krijnen MSc, Mechatronic Engineer bij DEMCON advanced mechatronics bv	9 **3D Vision met hoge precisie en snelheid** dhr. ir. Dietmar Serbée, Iris Vision BV	14 **Toegepast Mechatronisch onderzoek door de lectoraten verbonden aan Fontys/Avans en de Hogeschool Utrecht** dhr. ir. J.T.G. Gunsing, Lector bij Avans Hogeschool Breda, dhr. ir. H. Kiela Fontys, Lector bij Hogeschool Eindhoven, dhr. ir. E. Puik, Lector bij Hogeschool Utrecht	19 **Piëzo motor** ir. Michaël Houben, Research Engineer bij Katholieke Universiteit Leuven	
15.10-15.40	5 **Tussen Kunst en TRIZ - of het bereiken van een ontwerpdoorbraak** dhr. Tom Bijnagte, Directeur/eigenaar bij HiPrecision	10 **Point-One versterkt Innovatie in de Nederlandse High Tech industrie** dhr. Arjan Gelderblom, Office Director bij Point-One	15 **Waarom uitbesteden in het verre Oosten als het ook in Brabant kan ?** dhr. Albert van Heugten, Directeur bij Controlled Vonk Technologie BV	20 **Piëzo-technologies in Scanning Probe Microscopes and a SEM Nano-Manipulator** dhr. Dr. Gertjan van Baarle, Leiden Probe Microscopy BV	

** Presentation in the English language*

For further information about the lectures please visit www.precisiebeurs.nl

Programme Thursday 3 December

	Baroniezaal ▶ Design	Limburgfoyer ▶ Measurement - Software	Zaal 20 Technology Hotspot ▶ Micro Processing - Rapid Manufacturing
10.30-11.00	**1 Generator technologie voor windmolens** dhr. Johan Dams, Senior designer bij Magnetic Innovations	**6 Van 's werelds grootste kroket tot echte nanometers** dhr. Marijn van Veghel, Technisch consultant bij VSL	**11 Stereolithografie bestaat niet** dhr. Roel van der Burg, Projectleider Rapid Manufacturing Demo Centre bij TNO Industrie en Techniek
11.05-11.20	euspen **Plenair ▶ Baroniezaal** **The European Society for Precision Engineering and Nanotechnology*** mr. dr.ir. Henny Spaan, President euspen Euspen is an entrepreneurial network of leading industrialists and researchers working in the field of precision, micro and nano engineering. Euspen's most famous activity is its yearly international conference. To date, over 3000 experts in the field have been brought together through this forum. With a 50:50 ratio of commercial companies to research institutes, plus more than 30 countries world-wide typically represented, it represents a unique forum to survey or present latest knowledge, products, services and capabilities. But Euspen offers much more, like special interest groups addressing particular emerging challenges to industry or the Euspen Challenge. This presentation will give a short introduction to Euspen and these activities.		
11.20-12.00	 **Plenair ▶ Baroniezaal** **Hembrug slaat vleugels verder uit** dhr. drs. Robert Nefkens, Managing director bij Hembrug BV , Haarlem Tijdens de presentatie wordt ingegaan op de verwachte internationale omzetontwikkelingen van de machine tool sector de komende jaren, en de strategische consequenties daarvan voor de Nederlandse machinebouwer Hembrug. Tot op heden haalde Hembrug 85% van haar omzet binnen Europa, maar grotendeels buiten Nederland. Er wordt ook gekeken naar de vooruitzichten van precisie- en optische instrumenten in de diverse regio's.		
12.10-12.40	**2 Over-actuatie voor 450 mm wafer chucks** dhr. Dick Laro, System Architect bij MI-partners	**7 Aanpak van ontwerp, bouw en installatie van een snelle tester voor Optische Elementen voor de X-Box van Microsoft** dhr. Emile Asselbergs, Managing Director bij NTS Optel BV	**12 Nederlandse kansen voor de European Extremely Large Telescope** dhr. Ramon Navarro, Competentie manager optische-infrarood instrumentatie bij NOVA-ASTRON
13.10-13.40	**3 Dynamic Balancing for high speed and high precision** dhr. Volkert van der Wijk, Wetenschappelijk onderzoeker bij TU Delft	**8 Totaal oplossing voor Real-Time Linux** dhr. ir. Christian Kleijn, Directeur bij Controllab Products BV	**13 Internationale marktkansen van Precision Electro Chemical Machining** dhr. ir. Jan Reinder Fransens, Technology Development/Business Development bij BrainCenter
13.50-14.30	 **Plenair ▶ Baroniezaal** **Highlights van precisietechnologie bij onze oosterburen** dhr. ir. Wout van Wijngaarden, Hoofd technisch-wetenschappelijke afdeling, Ambassade van het koninkrijk der Nederlanden, TWA-Duitsland Duitsland heeft een leidende positie bij onderzoek en toepassing van precisietechnologie. Niet in de laatste plaats door het samenspel tussen overheid, onderzoekinstellingen en bedrijfsleven. In deze presentatie zal uiteengezet worden wat de strategie van de overheid is en in welke regio's dat geleid heeft tot zwaartepuntvorming van precisie-technologie. Ontwikkelingen in de precisietechnologie in Duitsland worden geïllustreerd aan de hand van enkele projectvoorbeelden. Ook zal u geïnformeerd worden wat het Nederlandse netwerk (TWA, EVD, NBSO) in Duitsland voor u op dit terrein kan betekenen.		
14.40-15.10	**4 Cascaded Control Enabling Precision, Robustness and Cost down** dhr. G. de Swart, Senior mechatronics design engineer bij NTS Mechatronics	**9 Highly dynamic identification of various gases with the UST Triplesensor®*** mr. dr. Olaf Kiesewetter, Managing director bij UST Umweltsensortechnik GmbH	**14 Semi-automatic assembly of micro-optics in small and medium quantities*** mr. dr. Egon Pfeifer, Managing Director bij ASKION GmbH
15.20-15.50	**5 Netwerk van high tech specialisten voor betere en snellere innovatie** dhr. Marty van de Ven, Partner bij The House of Technology	**10 Taking PRECISION beyond the limits "Model-Based Design workflow for FPGA's"** dhr. Stephan van Beek, The MathWorks BV	**15 Metal Rapid Manufacturing in de praktijk** dhr. Tom De Bruyne, Sales Manager bij LayerWise

9.30 EXHIBITION · EXHIBITION · EXHIBITION · EXHIBITION · EXHIBITION · EXHIBITION 17.00

** Presentation in the English language*

For further information about the lectures please visit www.precisiebeurs.nl

PRECISION FAIR 2009 – WHO SUPPLIES WHAT

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06 VDMA MICRO TECHNOLOGY

CALIBRATION

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55 D&M VACUÜMSYSTEMEN BV
170 FETERIS BV
138+162 LASER 2000 BENELUX CV
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172 IAI INDUSTRIAL SYSTEMS BV
134 IBS PRECISION ENGINEERING BV
140 ILT INDUSTRIËLE LASER TOEPASSINGEN BV
36 IMMS GMBH
70 IMOTEC BV
06 IMSTEC GMBH
168 KLEEVEN CONTROL BV
05 KML LINEAR MOTION TECHNOLOGY GMBH
48 KMWE PRECISION SYSTEMS & PRECISION COMPONENTS
138+162 LASER 2000 BENELUX CV
161 LEUVEN AIR BEARINGS
36 LLT
53 MARTEK BVBA
111 MECAL APPLIED MECHANICS BV
25 MECHAPHYSICS
07 MICRO LASERSYSTEMS
02 MIFA ALUMINIUM BV
184 MI-PARTNERS
166 MTSA TECHNOPOWER BV
124 MYTRI
110 NBG INDUSTRIAL AUTOMATION BV
31 NIJDRA GROEP
54 NTS GROUP BV
54 NTS MECHATRONICS BV
54 NTS SYSTENCE BV
108 Q-SYS BV
45 ROFIN-BAASEL BENELUX BV
160 ROMÉDES ENGINEERING BV
177 SARIX SA
41 SCHNEEBERGER GMBH
01 SCHUT GEOMETRISCHE MEETTECHNIEK BV
43 SCHUT PRECISIONPARTS BV
142 SENTECH SENSOR TECHNOLOGY BV
89 SOMATECH 3 DT BV
07 SRR LASER- EN SNIJTECHNIEK
123 ST INSTRUMENTS BV
181 STT PRODUCTS BV
118 TECHNISCHE HANDELSONDERNEMING DE RIDDER BV
86 TECHNOBIS GROUP
139 TEGEMA GROUP
102 TER HOEK VONKEROSIE RIJSSEN BV
34 TNO SCIENCE AND INDUSTRY
174 TOTAL SUPPORT BV
112 TRIOS PRECISION ENGINEERING
113 TRUMPF NEDERLAND BV
196 UTRECHT UNIVERSITY OF APPLIED SCIENCES
46 VACUTECH BV
82 WEISS NEDERLAND BV
167 YACHT

HIGH-PRECISION MECHANICS (MICRON RANGE)

197 3TU
150 ADMESY BV
91 AEROTECH LTD
35 AJB INSTRUMENT BV
70+136 APPLIED LASER TECHNOLOGY BV
156 BAKKER FIJNMETAAL
176 BOERS EN CO FIJNMETAAL GROEP
115 BOSCH REXROTH BV
108 BOTECH BV
12 BRAINCENTER
105 CCM CENTRE FOR CONCEPTS IN MECHATRONICS BV
125 CERATEC TECHNICAL CERAMICS BV
75 CZL TILBURG BV
154 DE ROOY SLIJPCENTRUM BV
119 DOEKO BV
88 ELECTRO ABI BV
30 EURO-TECHNIEK EINDHOVEN BV
33 FEINMESS DRESDEN GMBH
152 FIJNMECHANISCHE INDUSTRIE GOORSENBERG BV
47 FMI PRECISION
80 FÖHRENBACH APPLICATION TOOLING
104 FRENCKEN ENGINEERING
149 GEREEDSCHAPMAKERIJ GMI BV
39 GERMEFA BV
70 HEINMADE BV
59 HIPRECISION
40 HITTECH GROUP
76 HIWIN LINEAR TECHNOLOGIE GMBH
50 HOLLAND INNOVATIVE BV
134 IBS PRECISION ENGINEERING BV
140 ILT INDUSTRIËLE LASER TOEPASSINGEN BV
36 IMMS GMBH
06 IMSTEC GMBH
97 JTEKT EUROPE BEARINGS BV KOYO BENELUX OFFICE
05 KML LINEAR MOTION TECHNOLOGY GMBH

PRECISION FAIR 2009 – WHO SUPPLIES WHAT

48 KMWE PRECISION SYSTEMS & PRECISION COMPONENTS
56 KUSTERS METAALBEWERKING BV
151 LARSEN PREMIUM PRECISION PARTS
138+162 LASER 2000 BENELUX CV
161 LEUVEN AIR BEARINGS
94 LM SYSTEMS BV
04 MASÉVON TECHNOLOGY BV
111 MECAL APPLIED MECHANICS BV
25 MECHAPHYSICS
127 MEVI BV FIJNMECHANISCHE INDUSTRIE
184 MI-PARTNERS
109 MOLENAAR OPTICS VOF
166 MTSA TECHNOPOWER BV
124 MYTRI
169 NEDINSCO BV
133 NEWPORT SPECTRA PHYSICS
31 NIJDRA GROEP
188 NOVA-ASTRON
54 NTS GROUP BV
54 NTS MECHATRONICS BV
54 NTS SYSTENCE BV
104 OPTIWA BV
108 Q-SYS BV
147 RELIANCE PRECISION MECHATRONICS LLP.
45 ROFIN-BAASEL BENELUX BV
160 ROMÉDES ENGINEERING BV
41 SCHNEEBERGER GMBH
01 SCHUT GEOMETRISCHE MEETTECHNIEK BV
42 SMS STAMP TOOL TECHNOLOGIES BV
123 ST INSTRUMENTS BV
86 TECHNOBIS GROUP
139 TEGEMA GROUP
102 TER HOEK VONKEROSIE RIJSSEN BV
34 TNO SCIENCE AND INDUSTRY
174 TOTAL SUPPORT BV
112 TRIOS PRECISION ENGINEERING
196 UTRECHT UNIVERSITY OF APPLIED SCIENCES
19 WILTING COMPONENTS BV
167 YACHT

INNOVATION SUPPORT

156 BAKKER FIJNMETAAL
115 BOSCH REXROTH BV
12 BRAINCENTER
105 CCM CENTRE FOR CONCEPTS IN MECHATRONICS BV
121 COMSOL BV
55 D&M VACUÜMSYSTEMEN BV
129 DEMCON ADVANCED MECHATRONICS BV
88 ELECTRO ABI BV
36 ELEKTRONISCHE MESS- UND GERATETECHNIK THURINGEN EG
131 ENERGIEONDERZOEK CENTRUM NEDERLAND
192 ENTERPRISE EUROPE NETWORK
30 EURO-TECHNIEK EINDHOVEN BV
152 FIJNMECHANISCHE INDUSTRIE GOORSENBERG BV
47 FMI PRECISION
70 HEINMADE BV
59 HIPRECISION
50 HOLLAND INNOVATIVE BV
36 IMMS GMBH
70 IMOTEC BV
179 K. PEERAER BVBA - POLYTEC BENELUX
168 KLEEVEN CONTROL BV
94 LM SYSTEMS BV
184 MAGNETIC INNOVATIONS BV
92 MAXON MOTOR BENELUX BV
111 MECAL APPLIED MECHANICS BV
25 MECHAPHYSICS
109 MOLENAAR OPTICS VOF
110 NBG INDUSTRIAL AUTOMATION BV
188 NOVA-ASTRON
54 NTS GROUP BV
54 NTS MECHATRONICS BV
54 NTS SYSTENCE BV
147 RELIANCE PRECISION MECHATRONICS LLP.
41 SCHNEEBERGER GMBH
142 SENTECH SENSOR TECHNOLOGY BV
146 SKF BV
42 SMS STAMP TOOL TECHNOLOGIES BV
89 SOMATECH 3 DT BV
173 STAMHUIS LINEAIRTECHNIEK BV
181 STT PRODUCTS BV
139 TEGEMA GROUP
59 THE HOUSE OF TECHNOLOGY
34 TNO SCIENCE AND INDUSTRY
174 TOTAL SUPPORT BV
112 TRIOS PRECISION ENGINEERING
143 VSL
19 WILTING COMPONENTS BV
167 YACHT

LINEAR TECHNOLOGY

91 AEROTECH LTD
70+136 APPLIED LASER TECHNOLOGY BV
115 BOSCH REXROTH BV
108 BOTECH BV
12 BRAINCENTER
105 CCM CENTRE FOR CONCEPTS IN MECHATRONICS BV
125 CERATEC TECHNICAL CERAMICS BV
88 ELECTRO ABI BV
33 FEINMESS DRESDEN GMBH
80 FÖHRENBACH APPLICATION TOOLING
27 HEIDENHAIN NEDERLAND BV
76 HIWIN LINEAR TECHNOLOGIE GMBH
134 IBS PRECISION ENGINEERING BV
132 IKO NIPPON THOMPSON EUROPE BV
36 IMMS GMBH
70 IMOTEC BV
05 KML LINEAR MOTION TECHNOLOGY GMBH
138+162 LASER 2000 BENELUX CV
94 LM SYSTEMS BV
184 MAGNETIC INNOVATIONS BV
53 MARTEK BVBA
92 MAXON MOTOR BENELUX BV
02 MIFA ALUMINIUM BV
95 MIJNSBERGEN BV
184 MI-PARTNERS
110 NBG INDUSTRIAL AUTOMATION BV
144 PROMIS ELECTRO-OPTICS BV
108 Q-SYS BV
147 RELIANCE PRECISION MECHATRONICS LLP.
41 SCHNEEBERGER GMBH
142 SENTECH SENSOR TECHNOLOGY BV
146 SKF BV
173 STAMHUIS LINEAIRTECHNIEK BV
118 TECHNISCHE HANDELSONDERNEMING DE RIDDER BV
120 VARIODRIVE AANDRIJF- EN BESTURINGSTECHNIEK BV
18 VHE INDUSTRIAL AUTOMATION BV
82 WEISS NEDERLAND BV
19 WILTING COMPONENTS BV

MATERIALS (COMPOSITES, CERAMICS, GLASS)

108 BOTECH BV
105 CCM CENTRE FOR CONCEPTS IN MECHATRONICS BV
125 CERATEC TECHNICAL CERAMICS BV
194 FONTYS HOGESCHOLEN
163 FORMATEC TECHNICAL CERAMICS BV
145 FRIATEC TECHNISCH KERAMIEK
145 GLYNWED BV
135 LOUWERS GLASS AND CERAMIC TECHNOLOGIES
92 MAXON MOTOR BENELUX BV

41	SCHNEEBERGER GMBH
146	SKF BV
123	ST INSTRUMENTS BV
34	TNO SCIENCE AND INDUSTRY
167	YACHT

MEASURING MACHINES AND MEASURING EQUIPMENT

150	ADMESY BV
32	AIR-PARTS BV
15	ALL MEPP BV
176	BOERS EN CO FIJNMETAAL GROEP
108	BOTECH BV
12	BRAINCENTER
126	CARL ZEISS BV
105	CCM CENTRE FOR CONCEPTS IN MECHATRONICS BV
148	CNC-CONSULT & AUTOMATION BV
03	CONTROLLAB PRODUCTS BV
103	CVI MELLES GRIOT BV
129	DEMCON ADVANCED MECHATRONICS BV
36	ELEKTRONISCHE MESS- UND GERATETECHNIK THURINGEN EG
170	FETERIS BV
47	FMI PRECISION
27	HEIDENHAIN NEDERLAND BV
13+14	HEXAGON METROLOGY GMBH
50	HOLLAND INNOVATIVE BV
134	IBS PRECISION ENGINEERING BV
57	IMAGO GROUP BV
36	IMMS GMBH
06	IMSTEC GMBH
49	INSCOPE BV
100	JEOL (EUROPE) BV
179	K. PEERAER BVBA - POLYTEC BENELUX
38	KISTLER BV NEDERLAND
138+162	LASER 2000 BENELUX CV
161	LEUVEN AIR BEARINGS
53	MARTEK BVBA
111	MECAL APPLIED MECHANICS BV
157	METRIS
02	MIFA ALUMINIUM BV
184	MI-PARTNERS
09	MITUTOYO NEDERLAND BV
109	MOLENAAR OPTICS VOF
166	MTSA TECHNOPOWER BV
124	MURAAD BV
124	MYTRI
16	NATIONAL INSTRUMENTS NETHERLANDS BV
110	NBG INDUSTRIAL AUTOMATION BV
54	NTS GROUP BV
54	NTS MECHATRONICS BV
54	NTS SYSTENCE BV
155	OCEAN OPTICS BV
144	PROMIS ELECTRO-OPTICS BV
108	Q-SYS BV
164	RENISHAW BENELUX BV
01	SCHUT GEOMETRISCHE MEETTECHNIEK BV
146	SKF BV
89	SOMATECH 3 DT BV
123	ST INSTRUMENTS BV
37	STEEN METROLOGY SYSTEMS SA
181	STT PRODUCTS BV
83	TECHNEX BV
102	TER HOEK VONKEROSIE RIJSSEN BV
13+14	TESA BENELUX
34	TNO SCIENCE AND INDUSTRY
36	UMWELTSENSORTECHNIK
24	VEECO INSTRUMENTS SAS
126	W.J. ROELOFS MEETINSTRUMENTEN
107	WENZEL-BENELUX BV
167	YACHT

MICRO-ASSEMBLY

197	3TU
36	ASKION
12	BRAINCENTER
129	DEMCON ADVANCED MECHATRONICS BV
30	EURO-TECHNIEK EINDHOVEN BV
70	HEINMADE BV
06	HNP MIKROSYSTEME GMBH
140	ILT INDUSTRIËLE LASER TOEPASSINGEN BV
36	IMMS GMBH
117	IMS BV
06	IMSTEC GMBH
48	KMWE PRECISION SYSTEMS & PRECISION COMPONENTS
111	MECAL APPLIED MECHANICS BV
25	MECHAPHYSICS
147	RELIANCE PRECISION MECHATRONICS LLP.
45	ROFIN-BAASEL BENELUX BV
160	ROMÉDES ENGINEERING BV
43	SCHUT PRECISIONPARTS BV
123	ST INSTRUMENTS BV
139	TEGEMA GROUP
112	TRIOS PRECISION ENGINEERING
196	UTRECHT UNIVERSITY OF APPLIED SCIENCES
46	VACUTECH BV
19	WILTING COMPONENTS BV

MICRO-CONNECTION

197	3TU
36	ASKION
128	BOA NEDERLAND BV
140	ILT INDUSTRIËLE LASER TOEPASSINGEN BV
117	IMS BV
45	ROFIN-BAASEL BENELUX BV
123	ST INSTRUMENTS BV

MICRO-LASER PROCESSING

141	4PICO BV
98	BFI OPTILAS BV
12	BRAINCENTER
75	CZL TILBURG BV
36	ELEKTRONISCHE MESS- UND GERATETECHNIK THURINGEN EG
131	ENERGIEONDERZOEK CENTRUM NEDERLAND
20	HOSITRAD VACUUM TECHNOLOGY BV
140	ILT INDUSTRIËLE LASER TOEPASSINGEN BV
57	IMAGO GROUP BV
36	IMMS GMBH
117	IMS BV
138+162	LASER 2000 BENELUX CV
90	LASERTEC BV
182	LIGHTMOTIF BV
36	LLT
133	NEWPORT SPECTRA PHYSICS
11	PRECISION MICRO LIMITED
114	REITH LASER BV
45	ROFIN-BAASEL BENELUX BV
07	SRR LASER- EN SNIJTECHNIEK
123	ST INSTRUMENTS BV
113	TRUMPF NEDERLAND BV

MICRO-SYSTEM TECHNOLOGY (MST/MEMS)

197	3TU
36	ASKION
74	BEFORT WETZLAR OHG
36	ELEKTRONISCHE MESS- UND GERATETECHNIK THURINGEN EG
33	FEINMESS DRESDEN GMBH
70	HEINMADE BV
36	IMMS GMBH
117	IMS BV

PRECISION FAIR 2009 – WHO SUPPLIES WHAT

06 IMSTEC GMBH
135 LOUWERS GLASS AND CERAMIC TECHNOLOGIES
92 MAXON MOTOR BENELUX BV
111 MECAL APPLIED MECHANICS BV
110 NBG INDUSTRIAL AUTOMATION BV
41 SCHNEEBERGER GMBH
142 SENTECH SENSOR TECHNOLOGY BV
123 ST INSTRUMENTS BV
139 TEGEMA GROUP
102 TER HOEK VONKEROSIE RIJSSEN BV
36 UMWELTSENSORTECHNIK
196 UTRECHT UNIVERSITY OF APPLIED SCIENCES
167 YACHT

MOTION CONTROL

197 3TU
91 AEROTECH LTD
15 ALL MEPP BV
98 BFI OPTILAS BV
115 BOSCH REXROTH BV
12 BRAINCENTER
105 CCM CENTRE FOR CONCEPTS IN MECHATRONICS BV
125 CERATEC TECHNICAL CERAMICS BV
03 CONTROLLAB PRODUCTS BV
103 CVI MELLES GRIOT BV
129 DEMCON ADVANCED MECHATRONICS BV
88 ELECTRO ABI BV
23 ETEL BV
33 FEINMESS DRESDEN GMBH
170 FETERIS BV
80 FÖHRENBACH APPLICATION TOOLING
194 FONTYS HOGESCHOLEN
27 HEIDENHAIN NEDERLAND BV
70 HEINMADE BV
40 HITTECH GROUP
76 HIWIN LINEAR TECHNOLOGIE GMBH
36 IMMS GMBH
70 IMOTEC BV
168 KLEEVEN CONTROL BV
48 KMWE PRECISION SYSTEMS & PRECISION COMPONENTS
138+162 LASER 2000 BENELUX CV
94 LM SYSTEMS BV
53 MARTEK BVBA
92 MAXON MOTOR BENELUX BV
111 MECAL APPLIED MECHANICS BV
02 MIFA ALUMINIUM BV
95 MIJNSBERGEN BV
28 MINIMOTOR BENELUX
184 MI-PARTNERS
109 MOLENAAR OPTICS VOF
16 NATIONAL INSTRUMENTS NETHERLANDS BV
110 NBG INDUSTRIAL AUTOMATION BV
133 NEWPORT SPECTRA PHYSICS
54 NTS GROUP BV
54 NTS MECHATRONICS BV
54 NTS SYSTENCE BV
108 Q-SYS BV
147 RELIANCE PRECISION MECHATRONICS LLP.
41 SCHNEEBERGER GMBH
142 SENTECH SENSOR TECHNOLOGY BV
146 SKF BV
96 TE LINTELO SYSTEMS BV
86 TECHNOBIS GROUP
34 TNO SCIENCE AND INDUSTRY
112 TRIOS PRECISION ENGINEERING
18 VHE INDUSTRIAL AUTOMATION BV
19 WILTING COMPONENTS BV
167 YACHT

OPTICS

197 3TU
141 4PICO BV
70+136 APPLIED LASER TECHNOLOGY BV
36 ASKION
74 BEFORT WETZLAR OHG
98 BFI OPTILAS BV
176 BOERS EN CO FIJNMETAAL GROEP
12 BRAINCENTER
105 CCM CENTRE FOR CONCEPTS IN MECHATRONICS BV
103 CVI MELLES GRIOT BV
75 CZL TILBURG BV
129 DEMCON ADVANCED MECHATRONICS BV
30 EURO-TECHNIEK EINDHOVEN BV
47 FMI PRECISION
27 HEIDENHAIN NEDERLAND BV
172 IAI INDUSTRIAL SYSTEMS BV
57 IMAGO GROUP BV
49 INSCOPE BV
138+162 LASER 2000 BENELUX CV
111 MECAL APPLIED MECHANICS BV
25 MECHAPHYSICS
07 MICRO LASERSYSTEMS
02 MIFA ALUMINIUM BV
09 MITUTOYO NEDERLAND BV
109 MOLENAAR OPTICS VOF
124 MURAAD BV
169 NEDINSCO BV
133 NEWPORT SPECTRA PHYSICS
188 NOVA-ASTRON
54 NTS GROUP BV
54 NTS MECHATRONICS BV
54 NTS OPTEL BV
11 PRECISION MICRO LIMITED
144 PROMIS ELECTRO-OPTICS BV
147 RELIANCE PRECISION MECHATRONICS LLP.
142 SENTECH SENSOR TECHNOLOGY BV
123 ST INSTRUMENTS BV
37 STEEN METROLOGY SYSTEMS SA
96 TE LINTELO SYSTEMS BV
86 TECHNOBIS GROUP
34 TNO SCIENCE AND INDUSTRY
113 TRUMPF NEDERLAND BV
107 WENZEL-BENELUX BV
19 WILTING COMPONENTS BV
167 YACHT

PHOTONICS

70+136 APPLIED LASER TECHNOLOGY BV
36 ASKION
74 BEFORT WETZLAR OHG
98 BFI OPTILAS BV
176 BOERS EN CO FIJNMETAAL GROEP
103 CVI MELLES GRIOT BV
129 DEMCON ADVANCED MECHATRONICS BV
57 IMAGO GROUP BV
138+162 LASER 2000 BENELUX CV
111 MECAL APPLIED MECHANICS BV
07 MICRO LASERSYSTEMS
109 MOLENAAR OPTICS VOF
169 NEDINSCO BV
133 NEWPORT SPECTRA PHYSICS
188 NOVA-ASTRON
54 NTS OPTEL BV
155 OCEAN OPTICS BV
11 PRECISION MICRO LIMITED
144 PROMIS ELECTRO-OPTICS BV
147 RELIANCE PRECISION MECHATRONICS LLP.
45 ROFIN-BAASEL BENELUX BV
142 SENTECH SENSOR TECHNOLOGY BV
96 TE LINTELO SYSTEMS BV

86 TECHNOBIS GROUP
34 TNO SCIENCE AND INDUSTRY

PIEZO TECHNOLOGY
70 AITO INTERACTIVE BV
70+136 APPLIED LASER TECHNOLOGY BV
98 BFI OPTILAS BV
115 BOSCH REXROTH BV
125 CERATEC TECHNICAL CERAMICS BV
129 DEMCON ADVANCED MECHATRONICS BV
33 FEINMESS DRESDEN GMBH
70 HEINMADE BV
70 IMOTEC BV
38 KISTLER BV NEDERLAND
138+162 LASER 2000 BENELUX CV
95 MIJNSBERGEN BV
28 MINIMOTOR BENELUX
109 MOLENAAR OPTICS VOF
133 NEWPORT SPECTRA PHYSICS
70 STICHTING APPLIED PIËZO
86 TECHNOBIS GROUP

PRECISION ETCHING
137 ETCHFORM BV
06 IMSTEC GMBH
109 MOLENAAR OPTICS VOF
175 NV CUMATRIX
11 PRECISION MICRO LIMITED

PRECISION PACKAGING
197 3TU
06 HNP MIKROSYSTEME GMBH
06 IMSTEC GMBH
168 KLEEVEN CONTROL BV
87 PROKONPACK NEDERLAND BV
174 TOTAL SUPPORT BV
196 UTRECHT UNIVERSITY OF APPLIED SCIENCES

PRECISION PLASTICS PROCESSING
30 EURO-TECHNIEK EINDHOVEN BV
06 HNP MIKROSYSTEME GMBH
56 KUSTERS METAALBEWERKING BV
89 SOMATECH 3 DT BV
123 ST INSTRUMENTS BV
174 TOTAL SUPPORT BV

PRECISION TOOLS (DIAMOND)
15 ALL MEPP BV
122 BKL ENGINEERING BV
75 CZL TILBURG BV
36 ELEKTRONISCHE MESS- UND GERATETECHNIK THURINGEN EG
149 GEREEDSCHAPMAKERIJ GMI BV
111 MECAL APPLIED MECHANICS BV
54 NTS SYSTENCE BV
144 PROMIS ELECTRO-OPTICS BV
123 ST INSTRUMENTS BV
118 TECHNISCHE HANDELSONDERNEMING DE RIDDER BV
34 TNO SCIENCE AND INDUSTRY
174 TOTAL SUPPORT BV

SENSOR TECHNOLOGY
141 4PICO BV
32 AIR-PARTS BV
98 BFI OPTILAS BV
176 BOERS EN CO FIJNMETAAL GROEP
12 BRAINCENTER
105 CCM CENTRE FOR CONCEPTS IN MECHATRONICS BV
129 DEMCON ADVANCED MECHATRONICS BV
36 ELEKTRONISCHE MESS- UND GERATETECHNIK THURINGEN EG
170 FETERIS BV
39 GERMEFA BV
27 HEIDENHAIN NEDERLAND BV
70 HEINMADE BV
59 HIPRECISION
134 IBS PRECISION ENGINEERING BV
57 IMAGO GROUP BV
36 IMMS GMBH
70 IMOTEC BV
179 K. PEERAER BVBA - POLYTEC BENELUX
38 KISTLER BV NEDERLAND
138+162 LASER 2000 BENELUX CV
184 MAGNETIC INNOVATIONS BV
53 MARTEK BVBA
111 MECAL APPLIED MECHANICS BV
25 MECHAPHYSICS
02 MIFA ALUMINIUM BV
09 MITUTOYO NEDERLAND BV
54 NTS OPTEL BV
155 OCEAN OPTICS BV
144 PROMIS ELECTRO-OPTICS BV
164 RENISHAW BENELUX BV
142 SENTECH SENSOR TECHNOLOGY BV
146 SKF BV
123 ST INSTRUMENTS BV
139 TEGEMA GROUP
13+14 TESA BENELUX
34 TNO SCIENCE AND INDUSTRY
36 UMWELTSENSORTECHNIK
196 UTRECHT UNIVERSITY OF APPLIED SCIENCES

SOFTWARE, TECHNICAL/SCIENTIFIC
12 BRAINCENTER
126 CARL ZEISS BV
105 CCM CENTRE FOR CONCEPTS IN MECHATRONICS BV
148 CNC-CONSULT & AUTOMATION BV
121 COMSOL BV
03 CONTROLLAB PRODUCTS BV
129 DEMCON ADVANCED MECHATRONICS BV
88 ELECTRO ABI BV
36 ELEKTRONISCHE MESS- UND GERATETECHNIK THURINGEN EG
131 ENERGIEONDERZOEK CENTRUM NEDERLAND
179 K. PEERAER BVBA - POLYTEC BENELUX
168 KLEEVEN CONTROL BV
138+162 LASER 2000 BENELUX CV
16 NATIONAL INSTRUMENTS NETHERLANDS BV
110 NBG INDUSTRIAL AUTOMATION BV
01 SCHUT GEOMETRISCHE MEETTECHNIEK BV
146 SKF BV
89 SOMATECH 3 DT BV
123 ST INSTRUMENTS BV
13+14 TESA BENELUX
178 THE MATHWORKS BV
78 WIDENHORN INDUSTRIËLE AUTOMATISERING BV
167 YACHT

SURFACE TREATMENT
75 CZL TILBURG BV
06 HNP MIKROSYSTEME GMBH
172 IAI INDUSTRIAL SYSTEMS BV
06 IMSTEC GMBH
138+162 LASER 2000 BENELUX CV
182 LIGHTMOTIF BV
02 MIFA ALUMINIUM BV
124 MYTRI
54 NTS GROUP BV
54 NTS MECHATRONICS BV
11 PRECISION MICRO LIMITED
45 ROFIN-BAASEL BENELUX BV
146 SKF BV

123	ST INSTRUMENTS BV
174	TOTAL SUPPORT BV
113	TRUMPF NEDERLAND BV
	TRAINING
195	AVANS HOGESCHOOL
115	BOSCH REXROTH BV
12	BRAINCENTER
148	CNC-CONSULT & AUTOMATION BV
55	D&M VACUÜMSYSTEMEN BV
88	ELECTRO ABI BV
194	FONTYS HOGESCHOLEN
70	HEINMADE BV
59	HIPRECISION
192	LEIDSE INSTRUMENTMAKERS SCHOOL
60	MIKROCENTRUM
09	MITUTOYO NEDERLAND BV
16	NATIONAL INSTRUMENTS NETHERLANDS BV
146	SKF BV
34	TNO SCIENCE AND INDUSTRY
113	TRUMPF NEDERLAND BV
143	VSL
78	WIDENHORN INDUSTRIËLE AUTOMATISERING BV
	VISION SYSTEMS
74	BEFORT WETZLAR OHG
98	BFI OPTILAS BV
12	BRAINCENTER
105	CCM CENTRE FOR CONCEPTS IN MECHATRONICS BV
129	DEMCON ADVANCED MECHATRONICS BV
08	DVC MACHINEVISION BV
57	IMAGO GROUP BV
117	IMS BV
06	IMSTEC GMBH
49	INSCOPE BV
10	IRIS VISION BV
111	MECAL APPLIED MECHANICS BV
157	METRIS
02	MIFA ALUMINIUM BV
95	MIJNSBERGEN BV
09	MITUTOYO NEDERLAND BV
109	MOLENAAR OPTICS VOF
124	MURAAD BV
110	NBG INDUSTRIAL AUTOMATION BV
169	NEDINSCO BV
54	NTS OPTEL BV
54	NTS SYSTENCE BV
144	PROMIS ELECTRO-OPTICS BV
108	Q-SYS BV
01	SCHUT GEOMETRISCHE MEETTECHNIEK BV
142	SENTECH SENSOR TECHNOLOGY BV
37	STEEN METROLOGY SYSTEMS SA
139	TEGEMA GROUP
13+14	TESA BENELUX
107	WENZEL-BENELUX BV

Precision in performance

- Clamping plates
- Contact springs
- Cooling plates
- Covers & housings
- Deposition masks
- Electrode grids
- EMI/RFI shielding
- Encoder discs
- Filters
- Fuel cell plates
- Gaskets
- Heat sinks
- Inserts
- Lead frames
- Medical implants
- Meshes
- Shims
- Sieves
- Solar cell connectors
- (Spring) connectors
- Tubes

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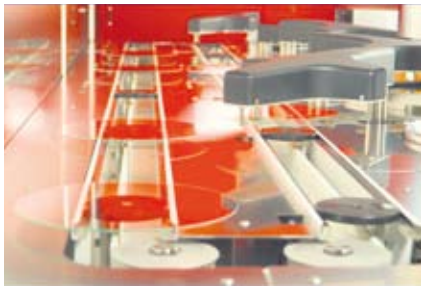
3TU 197

The three leading universities of technology in the Netherlands – Delft, Eindhoven and the University of Twente – have joined forces in the 3TU.Federation. This federation maximizes innovation by combining and concentrating the strengths of all three universities in research, education and knowledge transfer. During the Precision Fair we would like to show examples of research that focuses on technologies that, with precision and sensitivity, can support or take over human action. In our interactive booth located at the Technology Hotspot, you will find a range of research, varying from MEMS to Bicycle Dynamics and Telemanipulation to Automated Design Optimization.

3TU
Mekelweg 2, 2628 CD DELFT (NL)
Contact person: Mrs. Inge van Marion
t +31 (0)15-2782711
i.n.vanmarion-rehorst@tudelft.nl
www.3tu.nl

4PICO BV 141

4PICO is an innovative engineering company with a proven track record in the optical media industry. We combine optics, electronics, motion and automation. A powerful combination that perfectly fits your request. Not only state of the art in technology, but also highly cost effective. Whether it is a completely automated production machine or a simple high power light source. In addition to our engineering services we offer a range of ready-to-use products. Such as laser and light sources and high precision distance sensors. Still not convinced? We welcome you at booth 141!



4PICO BV
Jan Tinbergenstraat 4B,
5491 DC SINT-OEDENRODE (NL)
Contact person: Mr. J.A. Houter
t +31 (0)413-490708
info@4pico.nl
www.4pico.nl

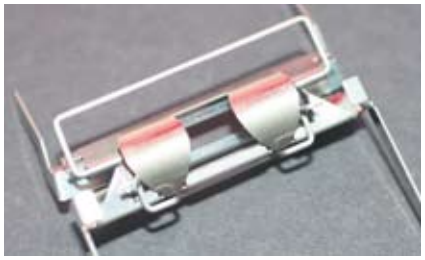
ADMESY BV 150

Since 2006 Admesy has been developing and marketing advanced measurement systems for in-line and at-line use. Our products are based on a long history of in-line testing and a conviction that today's high quality demanding market needs and benefits from 100% quality control. Although our main products range consists of colour and appearance measurement devices, Admesy also provides Test & Measurement solutions by customer's specification. At the Precision Fair we will be showing our own products as well as the products of Unice E-O, our partner in Taiwan. Unice E-O is an ISO 9001:2000 certified company that manufactures high quality mechanical positioning equipment and optical components.

ADMESY BV
Beneluxstraat 7,
6014 CC ITTERVOORT (NL)
Contact person: Mr. S. de Kort
t +31 (0)475-600232
stephan.dekort@admesy.nl
www.admesy.nl

ADVANCED CHEMICAL ETCHING LTD 175

Advanced Chemical Etching Ltd is a manufacturer of metal components by means of photochemical etching.



With varying complexity, thickness, form and finish we produce components from a simple round shim to complex high pin count semi conductor leadframes. Technical support is of paramount importance for ACE. We constantly develop new processes for etching of special metals such as titanium, tungsten, molybdenum, hastelloy, constantan and tantalum. Starting from data we produce fully functional, formed, heat-treated and plated first samples within a matter of days.

ADVANCED CHEMICAL ETCHING LTD
Kerkhovensesteenweg 420,
B 3920 LOMMEL (B)
Contact person: Mr. Roger Peeters
t +32-11402872
peeters@cumatrix.com
www.ace-uk.net

AEROTECH LTD 91

Aerotech delivers the essential micro and nano positioning performance for demanding precision engineering applications across all areas of manufacture and research. The comprehensive range includes technically superior linear and rotary positioning stages and advanced motion controls that are individually supplied or interconnected to form high performance sub assemblies or completely custom engineered systems. With over 100,000 positioning axes installed world-wide, Aerotech provides low cost of ownership solutions for challenging motion control in semiconductor, flat panel, medical device, life science, laser processing, electronics manufacture & test, photonics, solar panel, automotive, military/aerospace, and many other markets requiring high precision, high performance motion control solutions.

AEROTECH LTD
Jupiter House, Cavella Park, RG7 8NN ALDERMASTON
BERKSHIRE (UK)
Contact person: Mr. N. Johnson
t +44-1189409404
njohnson@aerotech.com
www.aerotech.com

AIRCONET BV 93

Airconet is a service providing company, certified with ISO 9001, VCA and Stek.
Airconet is specialized in sales, rental, service and engineering of compressed air systems of amongst others Boge and Ekomak compressors and industrial process cooling of amongst others MTA waterchillers and liquid coolers.
Airconet rents, designs and builds various compressed air and cooling systems and provides service and maintenance to all compressed air and cooling systems.
CUSTOM IN COMPRESSED AIR AND COOLING

AIRCONET BV
Coenecoop 745,
2741 PW WADDINXVEEN (NL)
Contact person: Mr. H.W. Neuteboom / Mr. M. Klomp
t +31 (0)182-633009
webmaster@airconet.nl

AIR-PARTS BV 32

Air-Parts is a value added trading company with a scope of high end test and measurement equipment. Air-Parts focuses on two specialist disciplines:

Microwave & Optical Solutions (M&OS)
- MOD electrical, optical, passive and active components and systems
- SATCOM monitoring and communication subsystems
- TELECOM wireline and wireless test & measurement
- BROADBAND test & measurement and installation equipment

Electrical Power & Analysis (EP&A)
- POWER SUPPLIES - DC, AC, power supply test systems
- GENERAL PURPOSE TEST
- TEST-/MEASUREMENT EQUIPMENT, CE, EMC, etc.
- HIGH AND MEDIUM VOLTAGE test equipment and components

In the field of monitoring Air-Parts presents the extensive portfolio of Kaman Instrumentation for precision distance measurements. Sensors for distance, width and alignment as well as statical and dynamic displacement and positioning. Ranges: 0.5 mm – 60 mm. Resolving capability: 0.1 µm – 6 µm.

AIR-PARTS BV
Postbus 255, 2400 AG
ALPHEN AAN DEN RIJN (NL)
Contact person: Mr. Wim van Hoof
t +31 (0)172-422455
hoof.w@air-parts.com
www.air-parts.com

AITO INTERACTIVE BV 70

Aito technologies includes various piezo switch solutions, light guides and Braille design, basically in consumer and high volume industrial products. With engineering, research and prototyping in the Netherlands and Finland, and licensed manufacturing in Singapore and China, we aim to be the perfect link between users and products. Our team will support you to integrate everlasting piezo touch Technologies in any product. Depending on our own resourses, our support ranges from consulting to complete product development, fast prototyping and high volume manufacturing.

AITO INTERACTIVE BV
Industrieweg 61,
1521 NE WORMERVEER (NL)
Contact person: Mr. René de Vries
t +31 (0)75-6475530
rene@aito-interactive.com
www.aito-interactive.com

A.J.B. INSTRUMENT 35

The vision of precision.

AJB Instrument means products tailored closely to customers' requirements. Its main customers are the medical instrument industry, high technology industry, general high-precision mechanical engineering and die-making. The latest technology enables AJB Instrument to produce these products. Flexibility and effectiveness are the key concepts. Professional engineering and a flexible logistic organization allow them to guarantee the quality of the products and the required services.

A.J.B. INSTRUMENT
Zuidzijde 7,
3181 LR ROZENBURG (NL)
Contact person: Mr. A.J. Bouwknegt
t +31 (0)181-213377
a.j.bouwknegt@ajbinstrument.nl
www.ajbinstrument.nl

ALL MEPP BV 15

All MEPP BV is an independent engineering agency that designs and constructs high-tech equipment, special machines and tooling according to the client's specifications.

We offer engineering services, from concept design to testing of first products. Our competences include mechanical and electrical engineering, software, prototyping and assembly.

At the Precision Fair we show our latest engineered products:

- Decapper for laboratory industry (decapping of tubes).
- X-ray tube tower for conditioning of X-ray tubes.
- XYZ positioning system with the XY motors on the base frame.
- Pneumatic metrology systems for measuring thickness and shape of for example solar cells.

ALL MEPP BV
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t +31 (0)40-2488505
p.v.vught@allmepp.nl
www.allmepp.nl

ASKION GMBH 36

ASKION is your reliable outsourcing partner to realize your new device conception starting with the feasibility and ending with a serial product.
We offer from one hand:

- System design, including electronic hardware and software, optoelectronics, mechatronics and control, test and measurement equipment.
- Hybrid Optoelectronic Systems on ceramic and metal substrates.
- Prototyping and ramp up production.
- Serial production, quality management in agreement with EN ISO 9001 and ISO 13485, and FDA-listed manufacturer.

ASKION GMBH
Gewerbepark Keplerstrasse 17-19,
D 07549 GERA (G)
Contact person: Mr. Dr. Egon Pfeifer
t +49-3653753200
egon.pfeifer@askion.com
www.askion.com

APPLIED LASER TECHNOLOGY 70+136

Applied Laser Technology supplies lasers, (fiber) optics, products for nanopositioning and high-precision mechanics for industry, science and research. On our booth we exhibit the latest in long-travel, high-resolution piezo-drive technology plus the required sub-Angström measurement sensors and electronics. As a company, we distinguish ourselves through a personal approach, thorough knowledge and no-nonsense service.

APPLIED LASER TECHNOLOGY
De Dintel 2, 5684 PS BEST (NL)
Contact person: Mr. E. Keune
t +31 (0)499-375375
info@alt.nl
www.alt.nl

ACADEMIE VOOR TECHNOLOGIE & MANAGEMENT (ATM) AVANS HOGESCHOOL BREDA 195

Lecturers:
practical researchers
Developing and applying mechatronics knowledge is of the utmost importance for innovative companies. Since March 2009 the mechatronics lecturer and the teachers in Avans University of Applied Sciences apply their knowledge and experience for research and innovation. Students – tomorrow's professionals – can work together with companies and scientific institutes in (final) projects, applied research or a traineeship. This is extremely interesting for companies wishing to develop new products and/or services. It will also lead to modernization of education, professional upgrading of teachers and improved knowledge distribution. The lectureship is already occupied with a first project in gripper technology for robotics in several application fields.

ACADEMIE VOOR TECHNOLOGIE & MANAGEMENT (ATM) AVANS HOGESCHOOL BREDA
Lovensdijkstraat 61-63,
4818 AJ BREDA (NL)
Contact person: Mr. W.C. de Graaf
t +31 (0)76-5250500 / 06-17986920
wc.degraaf1@avans.nl
www.avans.nl

BAKKER FIJNMETAAL 156

Bakker Fijnmetaal produces fine mechanical parts for a wide range of constructions, components and applications. These precision components are meticulously produced and widely tested before they leave our factory. Our completely automated machinery guarantees you a short lead time and cost-efficient production. The materials used include copper, brass, stainless steel, aluminum, titanium and various plastics. In the assembly hall and the cleanroom, Bakker Fijnmetaal's experienced professionals carry out the assembly work. All the

means required to clean and assemble your products are there. To develop customer-specific products, Bakker Fijnmetaal uses CAD software to draw your design. Nothing is impossible!

BAKKER FIJNMETAAL
Postbus 139, 5690 AC SON (NL)
Contact person: Mr. M.A. Elling
t +31 (0)499-473416
rien@bakkerfm.nl
www.bakkerfm.nl

BEFORT WETZLAR OHG 74

- Optical and mechatronical design and construction.
- Manufacturing of fineoptics and mechanics.
- Coatings for service.
- Assembly of opto-mechatronical systems.

BEFORT WETZLAR OHG
Braunfelser Str. 26-30,
D 35578 WETZLAR (G)
Contact person: Mr. Peter Befort
t +49-6441-92410
p.befort@befort-optic.com
www.befort-optic.com
www.optischesysteme.de

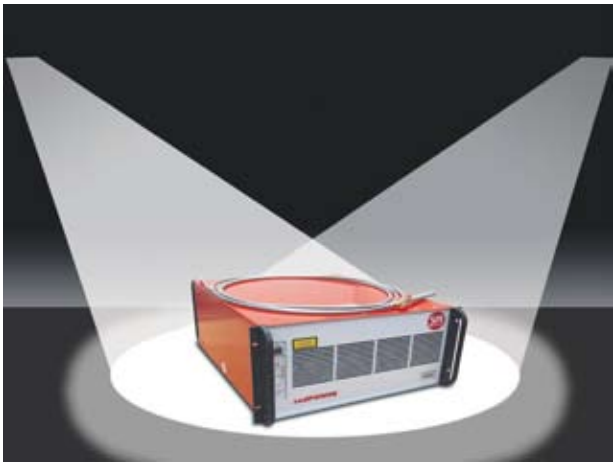
VAN DEN BERG KUNSTSTOFBEWERKING BV 165

v/d Berg Kunststofbewerking is specialised in processing plastics to customer specifications. A combination of factors makes v/d Berg Kunststofbewerking stand out from its competitors. For example, we like to think with our customers right from the start. And in our level of service, we like to go further than other companies and provide support throughout the entire production process. Years of experience, know-how and a unique, highly advanced machine park makes us a number one player in this field. Irrespective of whether you need prototyping, or a small to medium-sized product series, at v/d Berg Kunststofbewerking you've come to the right address.

VAN DEN BERG KUNSTSTOFBEWERKING BV
Postbus 1671,
5602 BR EINDHOVEN (NL)
Contact person:
Mr. E.M.B.T. Claassen
t +31 (0)40-2670101
info@vdberg-kunststof.nl
www.vdberg-kunststof.nl

BFI OPTILAS BV 98

Due to the near perfect beam quality, long life time, low maintenance costs and small footprint, the number and diversity of fiber laser applications is still increasing. Fiber lasers can be supplied in either pulsed or CW/ modulation mode. At the Precision Fair 2009 we will show a complete fiber laser marking system, complete with 20 W pulsed fiber lasers, software and scan system. For monitoring lasers and other light sources BFi OPTiLAS has a very broad program with high-end optical measuring equipment. You are kindly invited to visit our booth and meet our well-trained and experienced sales team.



BFI OPTILAS BV
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2400 AE ALPHEN AAN DEN RIJN (NL)
Contact person: Mr. Anton Schotel
t +31 (0)172-446060
photonics.nl@bfioptilas.com
www.bfioptilas.nl

BKL ENGINEERING BV 122

BKL Engineering develops and builds special machines and customer-specific service tools.

1. Service tools.
Next to development and fabrication the company has the expertise in the field of inspection, official approval and testing. BKL is accredited for complete inspection of tools by the "Raad voor Accreditatie" (Dutch Accreditation Council) worldwide. Maintenance and certification is done at BKL in Nuenen, but also worldwide at the customer's location.

2. Special machines.
The development of special machines means precision engineering of mechatronic solutions; this for well-known OEMs working in diverse industries and sectors. Production takes place in a workshop of our own, containing a cleanroom environment.

BKL ENGINEERING BV
Duivendijk 7,
5672 AD NUENEN (NL)
Contact person: Mr. Albert van Bakel
t +31 (0)40-2951444
info@bkl.nl
www.bkl.nl

BOA NEDERLAND BV 128

BOA shows high-precision flexible stainless steel piping and pipe work for OEM applications. BOA specialises in the design and manufacturing of hoses, bellows and complete assemblies. BOA also offers cleaning and cleanroom capacities for manufacturing, assembling and packing of its products. A novelty is the BOA hybrid, a high-purity hose for vacuum and pharmaceutical applications.

BOA NEDERLAND BV
Postbus 214,
5000 AE TILBURG (NL)
Contact person: Mr. C. van der Gaag
t +31 (0)13-5350625
chris@boanederland.nl
www.boanederland.nl

BOSCH REXROTH 115

Bosch Rexroth is one of the leading specialists worldwide in drive and control technology. Using the brand name of Rexroth, tailor-made solutions for power, control and actuator systems are created for application in industrial automation, semi-conductor equipment as well as in renewable energy. The Drive & Control Company is the supplier of choice to more than 500,000 customers for high-quality electrical, pneumatic and mechatronic components and systems. In more than 80 countries Rexroth is a reliable partner for its customers, supporting their production of safe and efficient machines and thereby contributing to the economical use of natural resources.

BOSCH REXROTH
Kruisbroeksestraat 1,
5281 RV BOXTEL (NL)
Contact person: Mr. Hans ten Hagen
t +31 (0)411-651290
hans.tenhagen@boschrexroth.nl
www.boschrexroth.nl

BOERS & CO FIJNMETAAL GROEP 176

Boers & Co fijnmetaal groep is a company with more than one hundred years of history. Accuracy and quality is what Boers & Co delivers in the field of precision parts. Our well-equipped company can maintain a high level of accuracy because of the close contact between our clients and our well-trained professionals. Using automated machines, which require low human input during production, helps keeping a fair price level for those operating in a competitive field of business. Boers & Co fijnmetaal groep is your partner in precision parts, can you be ours?

BOERS & CO FIJNMETAAL GROEP
Fokkerstraat 495,
3125 BD SCHIEDAM (NL)
Contact person: Mr. Marc de Vreede
t +31 (0)10-4373622
marc.de.vreede@boers.nl
www.boers.nl

BOTECH BV 108

BoTech BV provides complete solutions in large and stable high-precision bases, supports and moving parts. We are a high-tech company that specializes in the design, manufacturing and assembly of precision machine components and assemblies. We have over 25 years of experience in products in granite, metal, carbonfibre-epoxy, ceramics and combinations of these. Our products are used in numerous applications, often combined with airbearings. Our extensive manufacturing facility contains numerous advanced CNC-machine centers for a large range of products, up to 2.5 x 7 meters in one piece. In our conditioned production and assembling areas the products are finished to micron-precision accuracies.

BOTECH BV
Postbus 6052,
5700 ET HELMOND (NL)
Contact person:
Mr. Ir. R.A.A. van Mil
t +31 (0)492-551875
info@botechbv.com
www.botechbv.com

BRAINCENTER 12

BrainCenter is an industrial knowledge centre, geared towards designing, engineering and realization of inspiring, innovative and 'custom-made' industrialization solutions: complete operational units, or part thereof in the form of (improvement of) production units, machines, organization and systems.

BrainCenter has over 30 years expertise in production optimization. 200 high-quality knowledge workers generate 'custom-made' solutions; partly participating in project teams internal or external, that offer 'turnkey' projects and solutions.

Our main competences:
- Contactless Metal Shaping (e.g. Precision Electrochemical Machining, Laser, Electrical Discharge Machining)
- Vision and Sensor technology
- Custom made tooling for high-end applications
- Smart manufacturing
- Mechatronic solutions

BRAINCENTER
Oliemolenstraat 5,
9203 ZN DRACHTEN (NL)
Contact person:
Mrs. Sietske Roelinga
t +31 (0)512-592956
sietske.roelinga@braincenter.nl
www.braincenter.nl

BRANDT FIJNMECHANISCHE INDUSTRIE BV 26

Brandt Fijnmechanische Industrie BV is specialized in single and serial production of high-quality precision products by manufacturing, assembly, support, modification, overhaul and repair of machined parts, assemblies and equipment to customers specifications for aviation, space, defence and industrial applications. The strengths of the organization is based on the guiding principle: 'VISION ON PRECISION'.

BRANDT FIJNMECHANISCHE INDUSTRIE BV
De Strubbenweg 15,
1327 GB ALMERE (NL)
Contact person: Mr. H. Hoek
t +31 (0)36-5231398
h.hoek@brandtfmi.nl
www.brandtfmi.nl

B&S TECHNOLOGY BV 101

B&S Technology specializes in the design and manufacture of dies, moulds, high-precision components and assembled products in the high-quality segment of the market. In doing so, B&S offers a total solution and plays an influential role throughout, from the development of a product through to maintenance and after-care. Our customers are found mainly in the market segments of microelectronics, medical pharmaceuticals, automotive, and the glass and packaging industries.

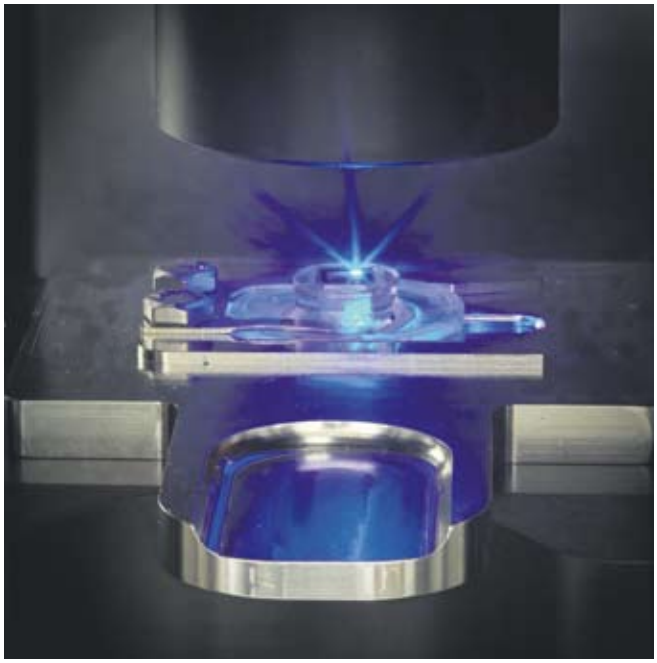
B&S TECHNOLOGY BV
Swaardvenstraat 2,
5048 AV TILBURG (NL)
Contact person:
Mr. John Schapendonk
t +31 (0)13-4625800
j.schapendonk@bstechnology.nl
www.bstechnology.nl

CARL ZEISS BV 126

New in the Netherlands: the DuraMax. A robust CNC-coordinate measuring machine with ZEISS scanning probe head. As of now scanning is the standard. The DuraMax is the perfect measuring machine for accurate 3D-measuring and suitable for the workshop or production environment between 18 and 30 degrees. The DuraMax is delivered completely including CALYPSO software. Please do not hesitate to inform about the price; you will be pleasantly surprised….

CARL ZEISS BV
Trapezium 300,
3364 DL SLIEDRECHT (NL)
Contact person:
Mr. Karel Gerritsen
t +31 (0)184-433551
k.gerritsen@zeiss.nl
www.zeiss.nl

CCM CENTRE FOR CONCEPTS IN MECHATRONICS BV 105



CCM has a long experience in inventing original concepts and is able to realize the entire development process up to a finished product or production equipment. Development is done by CCM in a professional way, which enables to control costs for realizing functionality, performance and time to market. In all project stages, from concept development up to realization and sustaining, CCM can be involved and can provide a competent and professional contribution. Projects that have been realized cover almost the entire field of mechatronical design and engineering (incl. optics and information technology).
You are most welcome to visit our stand.

CCM CENTRE FOR CONCEPTS IN MECHATRONICS BV
De Pinckart 24,
5674 CC NUENEN (NL)
Contact person:
Mr. Ir. H.W. van Doorne MBM
t +31 (0)40-2635000
info@ccm.nl
www.ccm.nl

CERATEC TECHNICAL CERAMICS BV 125

Ceramic materials offer unprecedented possibilities for many industries, especially when products and components with extreme material properties are required. Ceratec Technical Ceramics BV has specialised in industrial technical ceramic components since 1983. Ceratec's strength lies in the complete formula of problem analysis, development, prototyping and production. Ceratec Technical Ceramics BV has played a key role in applying technical ceramics in many ways. Our goal is to put the often extreme properties of technical ceramics to their best use. During the Precision Fair Ceratec will show its latest ceramic developments (Mechatronics, Semi-Conductor, Piezo, Solar, LED & Ceramic Composites).

CERATEC TECHNICAL CERAMICS BV
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4191 NZ GELDERMALSEN (NL)
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r.bruggeman@ceratec.nl
www.ceratec.nl

COMSOL BV 121

The COMSOL Group is a high tech engineering software company which provides software solutions for multiphysics modeling. The company was founded in July 1986 in Stockholm, Sweden. We have grown to include offices in Denmark, Finland, Norway, Germany, France, Switzerland, The Netherlands, U.S.A. and United Kingdom.
COMSOL Multiphysics is a modeling package for the simulation of any physical process you can describe with partial differential equations (PDEs). It features state-of-the-art solvers that address complex problems quickly and accurately, while its intuitive structure is designed to provide ease of use and flexibility.

COMSOL BV
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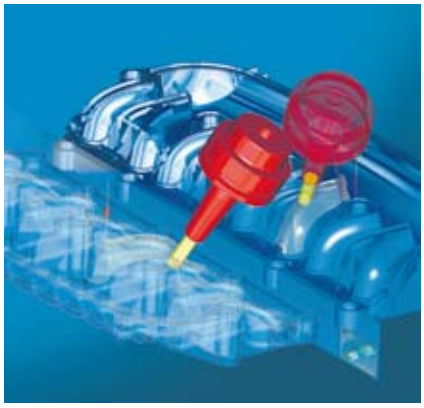
2719 DX ZOETERMEER (NL)
Contact person: Mrs. Saskia de Bruijn
t +31 (0)79-3634230
saskiadb@comsol.nl
www.comsol.nl

CNC-CONSULT & AUTOMATION BV 148



CNC-Consult helpt CAD/CAM-productieprocessen te stroomlijnen. Rendabel, overzichtelijk en gebruiksvriendelijk. Met onze consultancy en softwarepakketten leveren we eenvoudige en totaaloplossingen van hoge kwaliteit. CNC-Consult biedt u een breed scala aan CAD/CAM-oplossingen, Scan apparatuur en Rapid Prototyping.
Op de beurs zal de nieuwe versie van hyperMILL® worden gepresenteerd, versie 2009.1 Deze versie kenmerkt zich door de mogelijkheid het CAM-programmeren vergaand te automatiseren. Met Feature Technologie en macro programmering is grote snelheidswinst mogelijk.
Tevens zal er ruim aandacht zijn voor taster en laserscan apparatuur van Microscribe®, Baces3D® en METRIS® met bijbehorende Reverse Engineering software van Geomagic®.

CNC-CONSULT & AUTOMATION BV
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5221 CK DEN BOSCH (NL)
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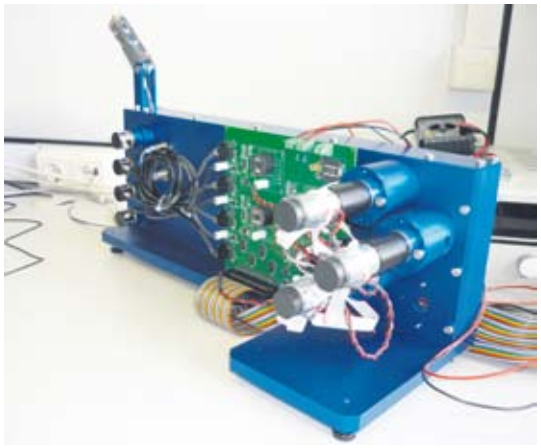
t +31 (0)73-6480166
m.van.teeffelen@cncconsult.nl
www.cncconsult.nl

CONTROLLAB PRODUCTS BV 03



Real-time Linux is getting into fashion for industrial control. The OS is open source and suited very well for embedded systems. Controllab is offering a complete solution to apply this OS. This solution contains an operator interface on a windows PC (the software package 20-sim 4C), an Ethernet connection to the hardware and the hardware itself (PC104, Embedded Arm SBC's). The real-time Linux OS (RTAI or Xenomai) is pre-installed. Several setups will be displayed to show how this solution works and how easy it is to implement a successful machine controller.

CONTROLLAB PRODUCTS BV
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7522 NB ENSCHEDE (NL)
Contact person:
Mrs. Jolanda Boelema
t +31 (0)53-4893096
jolanda.boelema@controllab.nl
www.controllab.nl

CONTROLLED VONK TECHNOLOGIE BV 59

Controlled Vonk Technologie (C.V.T.), boasting over 30 years of experience, is a true EDM-specialist. We know all the tricks of this special machining method and provide our customers with the most efficient solutions in high accuracy production. Our machines run almost autonomously allowing 24/7 production schedules. Because of this we have more machines than employees allowing us to work at a surprisingly competitive price level. EDM-machining represents a world of production possibilities which are continuously expanded. We are more than happy to share our knowledge with you and together with our customers we often find innovative solutions to challenging problems.

CONTROLLED VONK TECHNOLOGIE BV
Groenstraat 5a,
5528 NS HOOGELOON (NL)
Contact person:
Mr. Albert van Heugten
t +31 (0)497-541040
info@cvtbv.nl
www.cvtbv.nl

CVI MELLES GRIOT BV 103

CVI Melles Griot is a world-wide Leader in the Manufacture and Distribution of Optical Components and Assemblies for Electro-Optical and Laser Systems.
We manufacture (a)spherical lens elements, windows, mirrors, beamsplitters, waveplates and other flat optics, optical assemblies & electro-optical systems, electro-mechanical (shutters), and opto-mechanical assemblies optimized for use in the deep ultra-violet through to infrared spectral region. With our reliable products and business solutions, rapid delivery, willingness to customize, value, and customer service we distinguish us in the global market place.
Via the CVI Melles Griot catalog we offer also the widest range of off-the-shelf photonic components and laser systems.

CVI MELLES GRIOT BV
Postbus 272,
6900 AG ZEVENAAR (NL)
Contact person: Mr. K. Hop
t +31 (0)316-581381
khop@cvimellesgriot.com
www.cvimellesgriot.com

CZL TILBURG BV 75

In 2009 CZL Tilburg introduced SuNiCoat® Optics, cleanroom packaging and low-phosphorous electroless nickel plating as their new services. SuNiCoat® Optics is a diamond turnable nickel coating for optical moulds and inserts.
For over 30 years CZL Tilburg provides surface treatments and repairs high-value technical components. Our services includes e.g. Diarc® Diamond Coating, Dicronite® Dry Lube, MCP® (Micro Chrome Plating), SuNiCoat® Optics, HP-HVOF thermal spraying (carbide and metals), hardchrome plating, electroless nickel plating, black oxidizing, cleanroom packaging, micro-laser welding, cylindrical grinding, flat grinding and superfinishing.
All our processes and treatments are executed in accordance with EN/AS-9100 and customer specifications.

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www.czltilburg.nl

DEMCON ADVANCED MECHATRONICS BV 129

DEMCON realizes high-tech mechatronic systems and products through research, development and production. With its mechatronic approach to design, DEMCON generates high-end solutions for complex issues in various markets, ranging from semicon and medical to life sciences and defence. DEMCON supplies advanced systems to leading OEMs and is an excellent partner for small and medium-sized enterprises in the introduction of their innovative products to existing and new markets. DEMCON will present a range of products e.g. the Closed Loop Embedded Precision Stage (CLEMPS). CLEMPS focuses on the development of a MEMS stage for the positioning of small objects.

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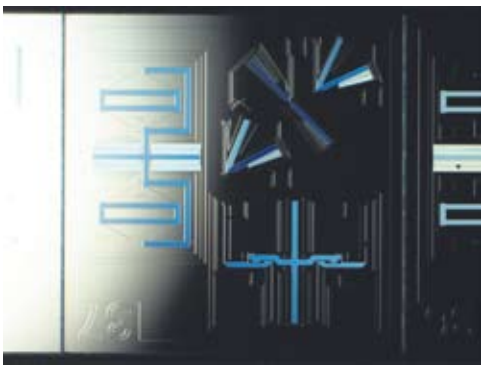

D&M VACUÜMSYSTEMEN BV 55

D&M Vacuümsystemen B.V. is specialized in offering turn-key solutions for (high-quality and complex) vacuüm systems. D&M Vacuümsystemen's competitive advantage is that we are able to offer all vacuum-related knowledge and services from internal sources(e.g. Engineering, CNC Manufacturing, Assembling and service), creating the best and most cost-effective solutions for our wide range of clients. D&M is a reliable and independent partner that has a specialized knowledge of high-end applications and related processes. To create this knowledge, D&M has its own engineering department, service workshop and production facility (for prototypes and smaller series) with an experienced team of vacuum specialists.

With these competences, D&M has received confidence and credits from various prestigious companies and institutes.

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DOEKO BV STEMPELS MATRIJZEN FIJNMECHANICA 119

DOEKO BV Stempels Matrijzen Fijnmechanica
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DVC MACHINEVISION BV 08

DVC machinevision B.V. (DVC) is a vision service provider distributing top-of-the-line, state-of-the-art components for Image Processing, Image Analysis and Machine Vision Systems.
Our customers – system integrators, OEMs, research institutes – appreciate our knowledge and expertise so they can focus on their own business, developing a complete vision inspection system using the best components they can purchase. DVC's product range covers both hardware and software, ranging from standard frame grabbers to high speed video processors with embedded ASIC technology, area & line scan cameras and comprehensive image analysis software packages. Our exclusive suppliers are Matrox, Sony, Basler, illunis, LMI technologies and Media Cybernetics.
DVC your partner in VISION!

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DSPE 63

The Dutch Society for Precision Engineering (DSPE) is a community of precision engineers in industry, university and institute. The mission of DSPE is to stimulate precision technology knowledge innovation, knowledge transfer and networking between professionals.
Members of DSPE are companies, institutes and universities that are active in precision technology. The major players in the Netherlands are member of DSPE.
Main interactions of DSPE are:

- Mikroniek, international magazine on precision engineering.
- www.dspe.nl, precision engineering portal with a lot of technical information for precision engineers.
- Certification of precision engineering postdoc education.
- Young Precision Network, where young engineers meet.
- Precision-in-Business days, where companies show their capabilities in a company visit.
- Roadmapping of technology.
- Yearbook on Precision Engineering.
- Summer & Winter schools.
- Seminars and events.

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www.dspe.nl

DYMATO BV 81

Dymato BV represents Röders from Germany.

Röders RHP series HSC machining centres are known for:
- High Speed Cutting and Jig Grinding with very high precision in one machine.
- Simple programming of the machining cycles for jig grinding.
- Grinding technology fully integrated (contact measurement of the abrasive pin, dressing spindle, grinding oil, CO_2 extinguishing system etc.).
- High precision of machine due to combined use of linear motors and absolutely friction-free hydrostatic guides in all axes.
- Maximum feed rate and acceleration limited to achieve highest possible precision.
- Outstanding damping characteristics due to hydrostatic system oil film in all axes.

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ECN ENGINEERING & SERVICES 131

Engineering & Services is the technical support and development group of ECN. This group of about 100 employees designs, engineers and realizes experimental installations, prototypes and high-tech components, conducts materials research, takes care of data acquisition, data processing and visualization and realizes scientific and technical software. Besides ECN, this group supports innovative institutes and companies. E&S is the problem solver for technological challenges.

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ELECTRO ABI BV 88

Electro ABI is focused on supplying automation and system solutions in the field of power transmission and motion control. Our areas of expertise include: motion control (servo, stepper and three-phase motors), electronically controlled drives, motors with integrated intelligence, linear motion systems, frequency converters, planetary gearboxes, couplings, custom-made drives, gear motors, stainless steal motors and stainless steel gear motors (in-house production under the KMF brand name). Calculation, selection and commissioning are a few of the available services offered by our experienced motion control specialists. Our engineering department supports customers with solutions in the fields of mechatronics.

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www.abi.nl

ELMUG EG + 5 COMPANIES 36

- ELMUG – Network for electronic measurement and equipment technology companies in Thuringia.
- ASKION - your reliable outsourcing partner to realize your new device conception starting with the feasibility and ending with a serial product.
- The IMMS gGmbH is a service provider in the field of application-oriented research for the development of microelectronics and mechatronics systems.
- LLT Applikation is a company with a high-tech profile offering the service its name implies, the application of laser technology to precision engineering.
- With TETRA's solutions it is now possible to solve tasks of industrial precision automation and quality control.
- UST Umweltsensortechnik GmbH: a globally acting company for development and production of ceramic sensor technology for gas and temperature measurement.

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ENTERPRISE EUROPE NETWORK 192

The Enterprise Europe Network offers support and advice to businesses across Europe and helps them make the most of the opportunities in the European Union. The services are specifically designed for small and medium enterprises (SMEs) but are also available to all businesses, research centres and universities across Europe.
The Enterprise Europe Network is made up of close to 600 partner organisations in more than 40 countries, promoting competitiveness and innovation at the local level in Europe and beyond.
The Network provides information on EU legislation, funding opportunities and helps finding a business partner Europe-wide with the help of a technology and business cooperation database.

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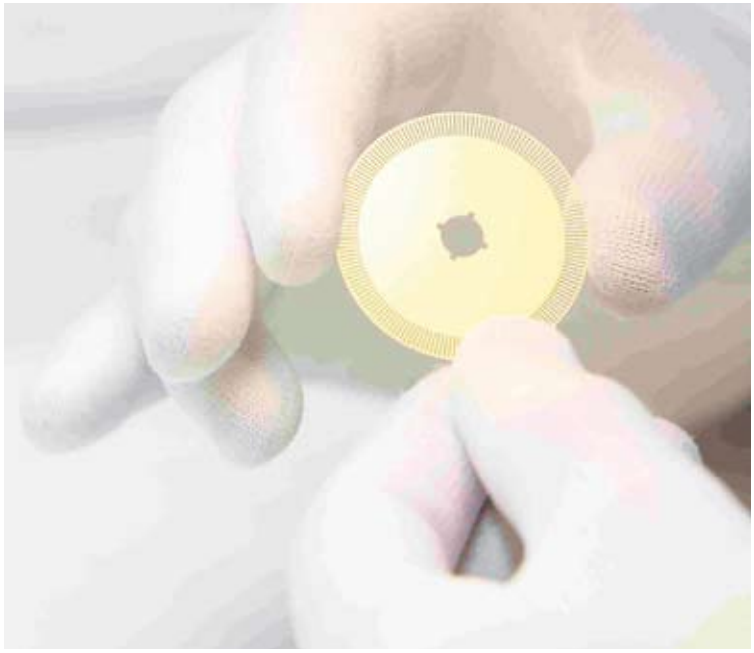
ETCHFORM BV 137



Etchform is a manufacturing and service organization for etched and electroformed metal precision parts.

Etchform provides customised solutions for metal precision parts.
- Production of thin metal precision parts by means of precision etching & electroforming.
- Standard copper and stainless steel alloys, but also specialties such as beryllium copper, Elgiloy/Phynox, gold, Invar/Kovar, molybdenum, silver and titanium.
- One-off and mass production.
- Additional surface and heat treatments as well as precision-mechanical, assembly and logistic services can be offered.

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www.etchform.com

ETEL BV 23

ETEL BV is the Dutch subsidiary from the Swiss ETEL. ETEL started in 1974 as one of the founders of the direct drive technology, now we have grown to market leader of direct drive motors.
The goal within the company is to look for the technical limitations and possibilities: increasing acceleration (> 20 G) and speed (> 20 m/s) and increasing precision in speed and accuracy needed for the microchip and optical industry. Therefore about 30% of the people work in the R&D department.
ETEL's focus is on the direct drive technology and has the complete solution: linear motors (iron core and ironless), torque-ring-motors (standard and high speed), electronics and integrated systems.

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FARO BENELUX BV 52

FARO develops and markets computer-aided coordinate measurement devices and software. Portable equipment from FARO permits high-precision 3D measurements and comparisons of parts and compound structures within production and quality assurance processes. The devices are used for inspecting components and assemblies, production planning, and inventory documentation, as well as for investigation and reconstruction of accident sites or crime scenes. Worldwide, approximately 9,500 customers are operating more than 20,000 installations of FARO measurement systems. The company's European head office is in Korntal-Münchingen near Stuttgart (G). FARO has European branch offices in France, Italy, the Netherlands, Poland, Spain, Switzerland, Turkey and the UK.

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EURO-TECHNIEK EINDHOVEN BV 30

Euro-Techniek is a specialist on metal forming and plastic molding. In these areas we take care of product and process engineering, design and construction of tooling, and manufacturing of components by molding and forming. Unique is the combination of these activities under a single roof. We are a technically driven company, take pride in our craftsmanship, knowledge and equipment. We work efficient and effective, resulting in high delivery accuracy, and a low level of complaints. We keep our overhead low with a short chain of command. We are ISO9001:2008 certified, and additionally are familiar with ISO-TS16949 (automotive), ISO13485 (medical) en HACCP (food).

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www.euro-techniek.nl

FEINMESS DRESDEN GMBH 33

Steinmeyer FMD is dedicated to the design and engineering of high-precision linear and rotary stages and offers an extensive line to help customize and tailor solutions for advanced equipment industry and microelectronics industry. For unique environmental requirements, Steinmeyer FMD has designed and shipped many multi-axis systems using non-magnetic materials, which are compatible with very high vacuum.

Offering superior quality, and performance reliability, Steinmeyer FMD has earned an excellent reputation in the global market.

FEINMESS DRESDEN GMBH
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www.feinmess.de

FETERIS COMPONENTS BV 170

Feteris Components is een toeleverancier van gespecialiseerde industriële componenten voor de machine-, apparaten- en scheepsbouw

alsmede de proces- en medische industrie. Het brede gamma omvat sensoren voor druk, kracht, verplaatsing, inclinatie, versnelling en vibratie, met bijbehorende meetversterkers/dataloggers.

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FIV BV 39

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FMTC 186

FMTC
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www.fmtc.be

FMI PRECISIE BV 47

FMI was originally a manufacturer of stamps, dies and moulds. Gradually the company developed into what it is today: a specialized manufacturer of one-off to medium-sized batches of fine precision components. FMI Precision works with extremely complex materials such as Hastalloy, Inconel, Duplex and other exotic materials. They manufacture the most accurate and/or complex components in the group and make the impossible possible. FMI Precision delivers products for the semiconductor, oil and gas, petrochemicals, aviation and space branches.

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www.fmi.nl

FÖHRENBACH APPLICATION TOOLING 80

From plain bearing or roller bearing precision guides over drives, fittings and mounting material up to our self-developed CNC control systems and software solutions, the Föhrenbach Group furnishes all the components needed to meet with highly demanding tasks. Our delivery programme covers plain bearing guides, roller bearing guides, rotary tables, linear and rotary direct drive motors, accessories, drives and control systems. On top of that, Föhrenbach Application Tooling distributes precision presses from the German press specialist Gechter. The program covers the following types of presses: manual rack-and-pinion, manual toggle, manual pneumatic aided, straight acting pneumatic, pneumatic toggle, hydro-pneumatic and lots of accessories.

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application.tooling@foehrenbach.be
www.foehrenbach.be

FONTYS HOGESCHOLEN 194

The department of Mechatronics is a knowledge center within the Fontys University of Applied Sciences. At the department there is knowhow about mechanical engineering, physics, computer technology and electrical engineering. The department of Mechatronics collaborates with companies that have an interest in the area of applied sciences. Typical research projects are “Low Cost Motion”, “Composites in Mechatronics”, “the Stalker” and “Remote Robotics”. An overview of these projects will be shown on the fair.

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FRAUNHOFER INSTITUTE FOR PRODUCTION TECHNOLOGY 185

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www.ipt.fraunhofer.de

FORMATEC TECHNICAL CERAMICS BV 163

Producer of ceramic components produced with one of the most efficient production methods, injection moulding. There is also the possibility of machining the ceramics for prototyping and low quantities. An important service of Formatec is our own development facility that translates your ideas and designs into production-feasible ceramic components. If there are ceramic as well as plastic components in your project we can provide these as well. Furthermore we can provide a supply chain solution because of our assembly section and purchasing department. Our quality department guarantees the high quality standard that is also a Formatec key focus.

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h.sneijers@formatec.nl
www.formatec.nl

MACHINEFABRIEK GEBRS. FRENCKEN BV 104

Machinefabriek Gebrs. Frencken B.V. is a trusted supplier to demanding customers in the analytical, medical, semiconductor, optical industries and aerospace. They chose us because we've repeatedly invested in the most sophisticated engineering equipment available today and in highly-motivated people, who have the skills and experience to produce complex components of the finest tolerances for many critical applications.
We work closely with customers' technical teams to engineer a cost-effective solution, balancing the right level of performance and precision with economical whole-life costs. Our factory has the flexibility and capacity to handle one-off prototypes or full batch production using the latest CNC multi-axis equipment as well as for machining sheet metal. We keep investing in the latest CNC equipment to achieve the standard of precision our customers demand.

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machinefabriek@frencken.nl
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FRIATEC TECHNISCH KERAMIEK / GLYNWED 145

FRIATEC AG is one of the most specialized manufacturers of ceramic components out of pure oxides, their registered trade mark is FRIALIT®DEGUSSIT®. Technical ceramics can be applied in various industries, laboratories, measurement and control technologies, machine building (O.E.M.), electrical engineering and electronics. Besides a large scale of standard products, custom-made products can be manufactured in aluminia oxides, zirconia oxides, silicium nitride and silicium carbides.
As associated firm of FRIATEC AG, Glynwed B.V. is responsible for consulting and sales of FRIALIT®DEGUSSIT® ceramics. A variety of ceramic components of FRIATEC AG is presented in booth number 145.

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FRENCKEN ENGINEERING 104

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IGS GEBO JAGEMA HIGH PRECISION 116

IGS Gebo Jagema combines the knowledge and experience of leading specialists to form an outstanding metal business. These are the qualities which underlie our broad coverage.

- Precision components for machinery and equipment.
- Tools, replacement parts and measuring devices for production processes.
- Components and subassemblies for manufacturers of tools and precision parts.

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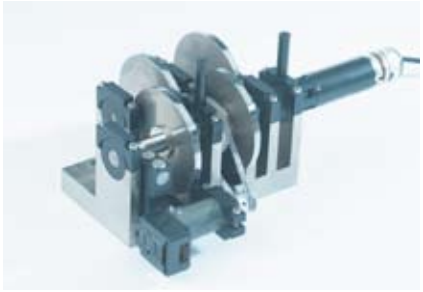
www.gebojagema.nl



GELDERBLOM CNC MACHINES BV 29

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GERMEFA BV AALBERTS INDUSTRIES 39

Aalbert Industries NV is a stock exchange listed international industrial group with two main activities, Industrial Services (Industrial products and Material Technology) and Flow Control. Aalbert Industries Industrial Services has contacts in several areas of the medical industry, is a longstanding partner of the semiconductor industry and the suspension market, is a qualified supplier in the aerospace industry and well-known in the automotive industry.
The combination of engineering, surface- and heat-treatment and production technologies makes the Aalbert Industries Industrial Services the right partner for many industries. Germefa, F.I.V., HFI and Technology Twente are companies which work strongly together and are strong in their flexibility and their short lead time.

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www.germefa.nl

FIJNMECHANISCHE INDUSTRIE GOORSENBERG BV 152

Fijmechanische Industrie Goorsenberg was founded in 1966. We produce components and assemblies according to customer specifications in small and medium series for sectors as the medical industry, textile industry, petro-chemical industry, aerospace, electrical equipment, high tech industry, machine building and engineering.
Our skilled professionals make quality products. We are equipped with modern machines for milling, turning and grinding. Our specialties are 4-axle and 5-axle milling, swiss machining, deep hole drilling, prototyping and engineering. In our acclimatised measuring room we have two 3D-measuring machines. By optimal process control and final inspection we guarantee a constant high quality level.

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GEREEDSCHAPMAKERIJ GMI BV 149

"Quality is produced by working together."
Since 1980, this business philosophy has provided GMI with an undisputed reputation. The development and production of both high-grade moulds and precision-mechanical components involve accuracy and reliability. This requires two parties that can implicitly trust each other's expertise, innovative thinking, operational speed and flexibility.
At GMI, quality is an obvious combination of product and delivery reliability. It is achieved by continuously probing the limits in our own business and collaborating with our customers to find the best solution. That's why we maintain long-term relationships with many of our clients.

GEREEDSCHAPMAKERIJ GMI BV
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W.L. GORE & ASSOCIATES 79

Gore's core competencies and proven track record in fluoropolymer technology and in the manipulation of expanded polytetrafluoroethylene (ePTFE) provide many advantages in signal transmission for demanding mechanical and environmental applications.
Gore's flat cables use insulation, buffering and jacketing materials that transfer fewer stresses, minimizing conductor fatigue. Options for self-supported cabling with controlled motion, eliminating the need for cable tracks in some applications, are available.
GORE™ High Flex Cables provide superior flex life performance and maximum resistance to severe mechanical and environmental stresses such as UV light or vacuum.

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ptillman@wlgore.com
www.gore.com

HEIDENHAIN NEDERLAND BV 27

DR. JOHANNES HEIDENHAIN GmbH develops and manufactures linear and angle encoders, rotary encoders, digital readouts, and numerical controls. HEIDENHAIN supplies its products to machine tool builders and manufacturers of automated machines and systems, in particular for semiconductor and electronics manufacturing.

Having a worldwide presence HEIDENHAIN has always sought a dialog with science and research on the one hand and with users and customers on the other.
Today, HEIDENHAIN is represented in more than 50 countries – most of them with wholly-owned subsidiaries. Sales engineers and service technicians support the user on-site with technical information and service in the local language.

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www.heidenhain.nl

HEINMADE BV 70

HEINMADE focuses on development and supply of piezo ceramic solutions. To enhance your development process, we provide piezo components and (sub-) systems, give support or develop a customized solution. HEINMADE closely works together with Nanomotion, Noliac and Piezomechanik, which are all leading in their specific piezo technology field for known quality and performance. Some typical solutions are: Ultra High Vacuum stages (see picture), Ultrasonic transducers, Positioning stages at sub-nanometer accuracy, Active vibration dampers, Dynamic systems with fast response times of less than 1 msec, Low speed systems at 1 nm/sec, Customized piezo actuators and Multiple axis controllers.

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HEMBRUG BV 106

Hembrug is the specialist with more than 40 years of experience in the design, manufacturing and worldwide sale of ultra-precision fully hydrostatic turning machines. The Hembrug Mikroturn® machine range is at the leading edge of what is possible with hard turning today. Hembrug offers finish hard turning solutions for workpieces up to a diameter of 1,400 mm having hardness 58-68 HRC. Shape accuracies 0,1-2 micron, dimensional accuracies < 2 micron and surface finish accuracies of 0.1-0.4 micron have been obtained. The Hembrug Mikroturn® machines are supplied to various industries such the bearing industry, the automotive industry and the die and mould industry.

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HEXAGON METROLOGY GMBH 13+14

When the issue is metrology, Hexagon Metrology is without question the specialist. With the most comprehensive product range on the market, a marked international orientation and an eye for top quality we are very well equipped to optimally meet our customers' requirements.
Hexagon Metrology is part of the Hexagon AB Group and includes leading metrology brands such as Brown & Sharpe, CE Johansson, CimCore, CogniTens, DEA, Leica Geosystems (Metrology Division), Leitz, m&h Inprocess Messtechnik, PC-DMIS, QUINDOS, ROMER, Sheffield, Standard Gage and TESA. On the Precision Fair we show the Leitz Micra CMM and the new ROMER Infinite 2.0 measuring arm.

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7141 CX GROENLO (NL)
t +31 (0)544-475000
info@hfibv.nl
www.hfibv.nl

HIPRECISION 59

HiPrecision provides all competences needed for fast and efficient development of equipment and machinery. HiPrecision clarifies specifications, provides creative input into the concept design, and applies systematic design methods. Systematic and function-oriented design leads to an efficient use of staff and resources, and a design that is functioning reliably and predictably. In the proto-typing stage HiPrecision develops test plans, and takes care for the tests and for analysis of the results. HiPrecision makes it work!

HIPRECISION
Kerkstraat 10,
4196 AB TRICHT (NL)
Contact person: Mr. Ir. A.A. Bijnagte
t +31 (0)345-618676
tom.bijnagte@hiprecision.nl
www.hiprecision.nl

HITTECH GROUP 40

Hittech Group BV is a group of independent companies that together function as system supplier, extended workshop and partner to OEM companies.

The separate companies within Hittech Group create the flexibility of an independent enterprise, while the Group generates a powerful synergy when operating as one business. Hittech Group supplies systems, machines, (sub)modules and separate components.
The Hittech Group organization is geared to continuous improvement. It applies the principle that there is always room for improvement, whether in the area of product quality, or cost price or our production processes. That's why our partners consider us "masters in improvement".

HITTECH GROUP
Postbus 197,
7100 AD WINTERSWIJK (NL)
Contact person: Mr. H.J. te Winkel
t +31 (0)543-551212
harm.tewinkel@bihca.nl
www.hittech.nl

HIWIN GMBH 76

The right product for every application. We are your ideal partners in the field of linear technology. Our various product lines are designed to guide and generate linear movements. Either we have the right product for you or we can develop it. HIWIN produces and sells linear guide ways, ball screws as well as direct driven linear axis and rotary tables.

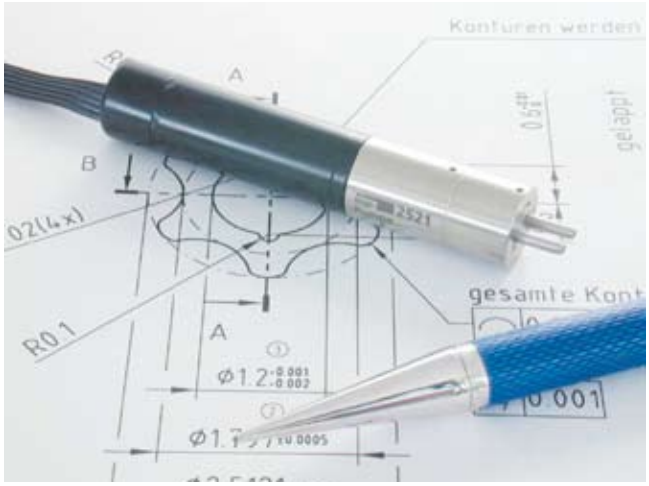
HIWIN GMBH
Brücklesbünd 2,
D 77654 OFFENBURG (G)
Contact person:
Mrs. Nicole Reichenbach
t +49-0781932780
info@hiwin.de
www.hiwin.de

HIWIN LINEAR TECHNOLOGIE GMBH 76

HIWIN LINEAR TECHNOLOGIE GMBH
Kamille 7,
3892 AJ ZEEWOLDE (NL)
Contact person: Mr. H. Schimmel
t +31 (0)6-12128505
han.schimmel@hiwin.nl
www.hiwin.nl

HNP MIKROSYSTEME GMBH 06

HNP Mikrosysteme is a Germany-based highly innovative company with 35 employees. The company produces micro annular gear pumps which are miniaturized rotating displacement pumps for dosage of lubricating and non-lubricating liquids. These innovative micro pumps are ideally used where fast and highly precise dosage is required, e.g. in analytical instrumentation, biotechnology, chemical processing, production systems, fuel cells and polyurethane fillings. Furthermore, the modular series allows customized material selection for each component of the pump depending on chemical compatibility with the manipulated liquid. The high-precision series guarantees a flow rate from 1 µl/h to 1152 ml/min as well as a dosing precision of less than 1 % C.V. with 1 µl of water and enables high pressure up to 80 bar.



HNP MIKROSYSTEME GMBH
Juri-Gagarin-Ring 4,
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Contact person: Mr. Dörte Hoffmann
t +49-3871451300
info@hnp-mikrosysteme.de
www.hnp-mikrosysteme.de

HOLLAND INNOVATIVE 50

Holland Innovative and Mecon deliver experience and expertise in product and process development, engineering and project management of complete projects.
The focus of Holland Innovative is Project Management and Product and Process development with modern methods like “Design for 6 Sigma” and “Reliability Engineering”.
Together with Mecon, specialized in engineering of precision mechanics, optics and mechatronics, we are able to conduct complete projects. We believe that successful projects are only possible while managing all relevant project variables (including the “human factor”) instead of just cost, time and quality, hence the name integral (www.holland-innovative.nl, www.mecon.nl).

HOLLAND INNOVATIVE
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t +31 (0)40-8514610
info@holland-innovative.nl
www.holland-innovative.nl

TER HOEK VONKEROSIE RIJSSEN BV 102

Hoek een leverancier waarbij u met elke vraag op dit gebied terecht kunt en die u, door de brede kennis, steeds weer goed en deskundig kan adviseren omtrent de mogelijkheden.

Flexibel, zorgvuldig en betrouwbaar; de belangrijkste kenmerken van Nederlands grootste specialist op het gebied van de unieke verspaningstechniek vonkerosie. Met geavanceerde machines die werkstukken aankunnen tot 1000x900x500 mm en een nauwkeurigheid tot 0.001 mm is Ter

TER HOEK VONKEROSIE RIJSSEN BV
Propaanstraat 1,
7461 JJ RIJSSEN (NL)
Contact person:
Mr. G.D. ter Hoek
t +31 (0)548-540807
info@terhoekvonkerosie.nl
www.terhoekvonkerosie.nl

HOSITRAD VACUUM TECHNOLOGY 20

The Hositrad Vacuum Technology team has more then 40 years of highly engineered experience in the Ultra High Vacuum market. We supply standard vacuum products CF, KF and ISO components from stock in addition to making specials according to customized drawing in our fully equiped workshop. These custom assemblies include vacuum chambers, special flanges with electrical feedthroughs or bellows. We are experts with TIG and Laser welding and vacuum leaktesting till 10^{-10} mbar l/sec. We have in-house production and an AutoCAD design office in Holland and India.

Come to Hositrad for all your UHV product requirements including bellows, electrical feedthroughs, isolators, viewports, glass to metal seals, manipulators and mass-spectrometers among others.

HOSITRAD VACUUM TECHNOLOGY
Postbus 114,
3870 CC HOEVELAKEN (NL)
Contact person: Mr. J.L.J. Tomassen
t +31 (0)33-2537210
info@hositrad.nl
www.hositrad.nl

THE HOUSE OF TECHNOLOGY 59

The House of Technology is a network of high-tech specialists that can help innovative companies to support their projects.
The high-tech industry is very fast-moving. Speed of innovation is crucial for companies who want to stay ahead of the competition. That is why they are constantly working on technical developments. However, issues can arise for which they do not have the proper expertise in house. An extensive network of specialists with many years of experience in the high-tech industry can often provide the required solution.
At the fair you can find an overview of our experts and their specialties.

THE HOUSE OF TECHNOLOGY
Postbus 7505,
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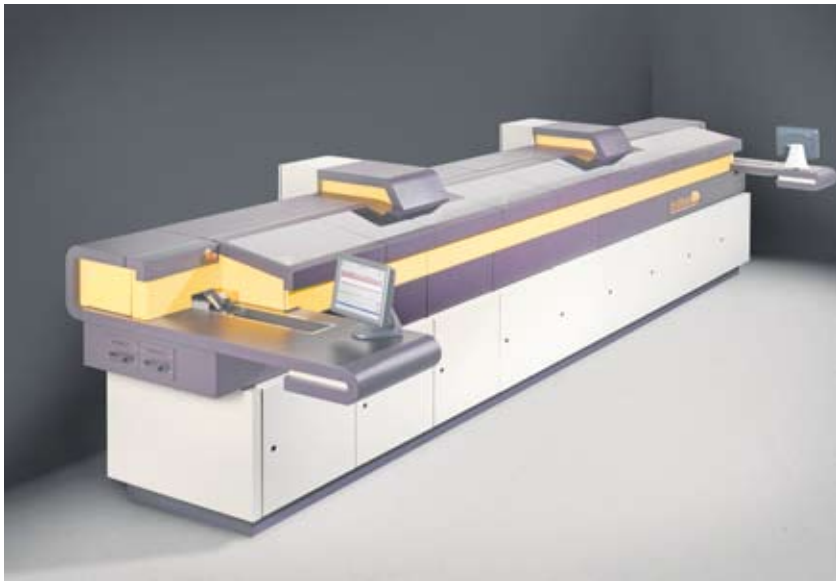
t +31 (0)6-19864495
marty.van.de.ven@thehouseoftechnology.nl
www.thehouseoftechnology.nl

IAI INDUSTRIAL SYSTEMS BV 172

IAI industrial systems B.V. ontwerpt en bouwt high-tech systemen, o.a. voor de personalisatie van paspoorten en identiteitskaarten. Ook ontwerpt en bouwt IAI systemen voor de solar-industrie. In de systemen worden tal van technische disciplines verenigd, zoals laser-graveren en -perforeren, optica, besturingssoftware, product handling, vision, precisiemechanica en (ink) jettechnologie. Op de Precisiebeurs wordt het CardMaster Desk systeem getoond, een desktop systeem voor het lasergraveren van identiteitskaarten en rijbewijzen.

IAI INDUSTRIAL SYSTEMS BV
De Run 5406,
5504 DE VELDHOVEN (NL)
Contact person: Mr. J.I.M. Cobben
t +31 (0)40-2542445
info@iai.nl
www.iai.nl



IBS PRECISION ENGINEERING BV 134

Based at Eindhoven in the Netherlands and with offices in Evry, France and Stuttgart, Germany, IBS Precision Engineering is a leading innovator in the field of high-precision engineering – reflecting the spirit of great Dutch scientists, artists, philosophers and corporations. The company specializes in the development of custom-engineered measurement and positioning solutions, machine tool calibration / inspection systems, non-contact precision sensors and air bearings. Through its extensive commitment to Research and Development, both at a national and international level, IBS Precision Engineering has established close relations with many leading knowledge centers and is actively involved with standards development.

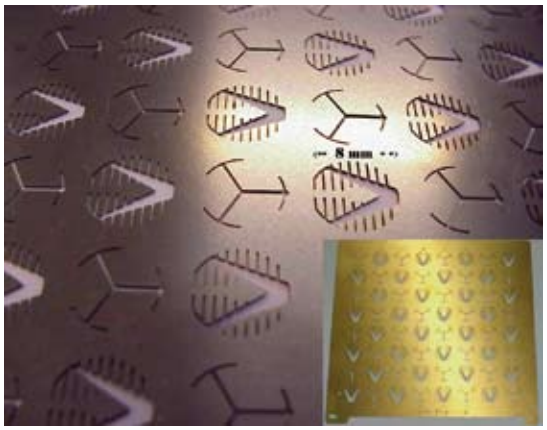
IBS PRECISION ENGINEERING BV
Esp 201, 5633
AD EINDHOVEN (NL)
Contact person: Mr. D. Smits
t +31 (0)40-2901270
smits@ibspe.com
www.ibspe.com

IKO NIPPON THOMPSON EUROPE BV 132

Founded in 1950, the company has accumulated numerous proprietary technologies and a wealth of experience that it uses to develop innovative products. Nippon Thompson has become an established leader in three specialties: Needle Roller Bearings, Linear Motion and Mechatronic Products. Marketed under the IKO brand, these products have established a worldwide reputation for high quality and originality.
The European affiliate, Nippon Thompson Europe, has its head office in the Netherlands with own warehouse and facilities to modify linear motion products according customer specification.
At the Precision Fair we will show our latest development of maintenance-free linear ways and mechatronic products.

IKO NIPPON THOMPSON EUROPE BV
Sheffieldstraat 35-39,
3047 AN ROTTERDAM (NL)
Contact person: Mr. A. Visser
t +31 (0)10-4626868
nte@ikonet.co.jp
www.ikont.co.jp

ILT INDUSTRIËLE LASER TOEPASSINGEN BV 140



Fine-mechanical laser processing.
ILT specializes in producing highly accurate laser made products for customers in the field of fine mechanics, microelectronics, medical systems, etc. Our main fields of expertise are:

- Laser (micro) cutting
- Laser (micro) welding
- Laser (micro) drilling
- Laser engraving.

Production badges range from 1 (prototyping) to 5,000 pieces.
Laser (micro) cutting; Small and accurate parts, projection masks etc. Cutting widths down to 20 microns.
Laser (micro) welding; Materials: stainless steel, Titanium, Gold, etc.
Laser (micro) drilling; Orifices from 10 microns to 0.5 mm, Laser engraving, Moulds for compact discs, chip cards. Reproduction of identity codes of transponders, etc.

ILT INDUSTRIËLE LASER TOEPASSINGEN BV
Tinsteden 30,
7547 TG ENSCHEDE (NL)
Contact person: Mr. P. Bant
t +31 (0)53-4282874
info@ilt.nl
www.ilt.nl

IMAGO GROUP BV 57

Imago Group BV, since 1972, is an exclusive Benelux distributor for Machine Vision products (CCD and CMOS cameras, optics, frame grabbers, lasers, lighting, cables, software etc.) as well as Teleconferencing products. Our aim is to offer our customers "one stop shopping" including excellent technical support. Offices in Zaventem-Brussel and Eindhoven. During the Precision Fair 2009 we will present our latest machine vision products from Dalsa, Matrix Vision, Ccam and Baumer.

IMAGO GROUP BV
Weegschaalstraat 3,
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Contact person:
Mr. Mart Mijnsbergen
t +31 (0)40-2163572
mmijnsbergen@imagogroup-benelux.com
www.imagogroup-benelux.com

IMOTEC BV 70

Innovation! Competition amongst equipment manufacturers and consumer product creators around the world forces them to constantly innovate, reduce production costs and improve price/performance ratios. Imotec has the knowledge, the experience and the products to help those companies achieve their goals now and in the future by development of optimal combinations of electromechanical, control, and information processing systems. This is what we call advanced intelligent mechatronics. Imotec will show examples of knowledge-driven innovation in mechatronics to improve the market position of equipment manufacturers and consumer product creators. Key specialties are piezo technology, (bio-)mechatronics, model based design and intelligent control.

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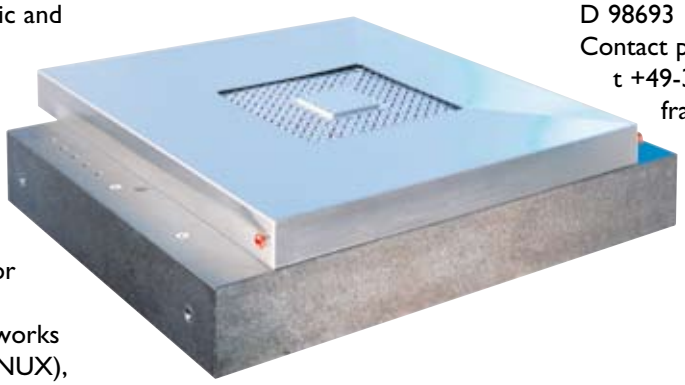
7556 GX HENGELO (NL)
Contact person: Mr. Jan Peters
t +31 (0)74-2505907
info@imotec.nl
www.imotec.nl

IMMS GMBH 36

R&D in the field of model based system design for innovative complex microelectronic and mechatronics systems, high-precision multi-axis drive systems and machinery. IMMS develops microelectronic and mechatronical systems for/as special customer applications by way of model based system design. The developments range from customized ASICs and electronic boards, control systems and power supplies for specific applications, wireless communication, real time networks and operating systems (e.g. LINUX), control algorithms and software to high-precision linear and planar direct drives and high-precision multi-axis processing machines (e.g. for laser-micro-processing). Another emphasis is the simulation and test of MEMS.



IMMS GMBH
Ehrenbergstraat 27,
D 98693 ILMENAU (G)
Contact person: Mr. Dr. Frank Spiller
t +49-3677695561
frank.spiller@imms.de
www.imms.de

IMS BV 117

IMS offers worldwide manufacturing solutions to customers in the high-precision, electric and medical industry. Our method is characterized by a strong focus on the customer business case and a close cooperation with our customers.
At the Precision Fair, the IMS stand will feature a live exhibit of the ProMicro platform. ProMicro is the semi-automatic work cell for Microsystems and commonly used in micro assembly projects for low to medium production volumes. Key aspects are its modular build up and the focus on automating the customers' value added processes, resulting in a cost-effective solution for micro assembly challenges.

IMS BV
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7600 AC ALMELO (NL)
Contact person: Mr. Martin Langkamp
t +31 (0)546-805521
martin.langkamp@ims-nl.com
www.ims-nl.com

IMSTEC 06

IMSTec is offering integrated and innovative manufacturing solutions. Starting with a structured process to develop the user requirement specification by detailed analysis and process FMEA and followed by realisation and implementation phases we are helping our customers to improve their productivity and quality levels. All solutions are optimised for the customer's needs. This includes semi-automated solutions as well as E2E solutions of completely automated manufacturing lines including MES. Examples in the medical industry: Automated stent manufacturing lines including bare metal stents as well as coating lines, measurement equipment for balloon and final assembly of catheters, micro-system and semiconductor manufacturing solutions.

IMSTEC
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D 55131 MAINZ (G)
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Mr. Edgar Maehringer-Kunz
t +49-61319066910
emk@imstec.de
www.imstec.de

INNOSPORTNL 187

Sports & Technology and InnosportNL have bundled their strength to improve innovations in sport by taking the demands and needs of sport itself as its starting point. Sports & Technology has a local scope in Brabant where InnoSportNL has a national scope. But our goals are the same. We link the demands and needs of sport to trade and industry and knowledge institutes. Thanks to this unique combination of sport, trade and industry and knowledge institutes, we are able to translate knowledge and expertise into new methods and systems, innovative products and services and, in some cases, even into new activities. We want to challenge you to help us find a solution to several technical challenges in sport.

INNOSPORTNL
Postbus 143,
6800 AC ARNHEM (NL)
Contact person: Mr. George de Jong
t +31 (0)26-4834598
info@innosport.nl
www.innosport.nl

INSCOPE BV 49

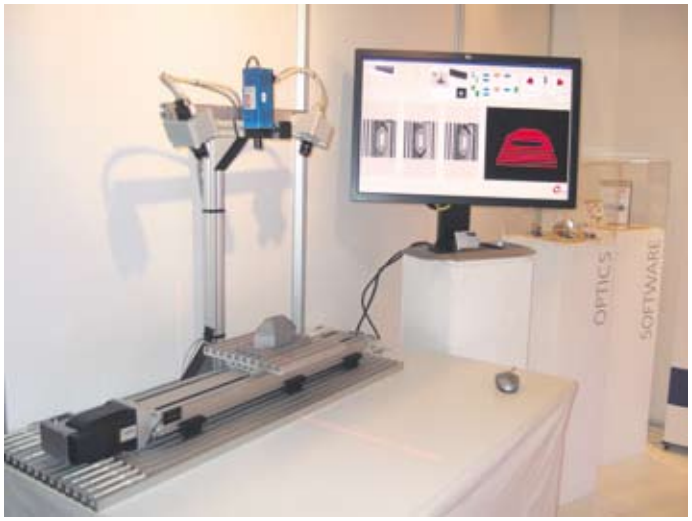
Vision Engineering's (Optical) microscopes and measuring systems. MANTIS-LYNX-KESTREL-FALCON-HAWK and others.

INSCOPE BV
Oeverkruid 1, 4941 VV
RAAMSDONKSVEER (NL)
Contact person: Mr. R. Pels
t +31 (0)162-677547
info@inscopebenelux.com
www.inscopebenelux.com

IRIS VISION BV 10

Iris Vision supplies the latest industrial machine vision products and systems. We show a selection of the newest cameras, laser, frame grabbers, hardware processors and software. At this years fair we also present the high-precision and very fast 3D Scanner. Please feel free to bring your own products for inspection to our booth.

IRIS VISION BV
Joppelaan 82a,
7213 AE GORSSEL (NL)
Contact person: Mr. Dietmar Serbée
t +31 (0)575-495159
info@iris-vision.nl
www.iris-vision.nl



JEOL (EUROPE) BV 100

JEOL is a leading worldwide supplier of scanning electron microscopes (SEMs), transmission electron microscopes (TEMs), scanning probe microscopes (SPMs), mass spectrometers, NMR spectrometers and semiconductor tools for scientific and industrial purposes. JEOL provides applications-specific solutions that advance customers' diverse objectives – from routine analysis of organic and inorganic specimens to breakthroughs in nano technological development. This combined with top service makes JEOL a partner to rely on. New is the JCM-5000 NeoScope SEM, economically complementing both optical microscopes and traditional SEMs. The NeoScope makes it easy to obtain high-magnification images with high resolution and large depth of field using a microscope that is as simple to operate as a digital camera, but has the powerful electron optics of a SEM.

JEOL (EUROPE) BV
Lireweg 4,
2153 PH NIEUW-VENNEP (NL)
Contact person:
Mr. A.J. van der Meer
t +31 (0)252-623500
vandermeer@jeolbenelux.com
www.jeolbenelux.com

JEVEKA BV 85

For over 70 years a leading specialist in fasteners and tools. An independent, customer-oriented organisation, known for its reliability and service. Jeveka stocks not only many standard parts, but can also supply a wide range of special products. An added advantage is that Jeveka has its own production facilities. It can fill custom-designed orders of any size, adapt standard products or make prototypes to your specifications. Jeveka is the official supplier of many well-known brands, including Unbrako and Holo-Krome cap screws, Kato tangless inserts and Fibro standard parts for tool and die-making. Furthermore, Jeveka is specialised in fasteners for vacuum and EUV applications.

JEVEKA BV
Keienbergweg 8,
1101 GB AMSTERDAM (NL)
Contact person: Mrs. Tiny Collewijn
t +31 (0)20-3420342
info@jeveka.com
www.jeveka.com

KATHOLIEKE UNIVERSITEIT LEUVEN, AFD. PMA 186

The PMA division of the Department of Mechanical Engineering at K.U.Leuven has an international reputation in product and machine design, production technology, robotics and automation, control, noise and vibration engineering, metrology, and micro and precision engineering.
In the domain of micro and precision engineering, PMA focuses on piezodrives, air bearings, nanomanufacturing and measurement equipment, micromanufacturing processes such as micromilling and micro-EDM, micro-actuators, microsensors, and microsystem applications such as medical instruments and high-tech machinery for the semiconductor and optics industries.
It is the policy to operate in close collaboration with industry to make the know-how available. This already resulted in ten spin-off companies.

KATHOLIEKE UNIVERSITEIT LEUVEN, Afd. PMA
Celestijnenlaan 300b-b2420,
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t +32-16322480
secretariaat.pma@mech.kuleuven.be
www.mech.kuleuven.be/pma

KENTEQ KENNIS-CENTRUM VOOR TECHNIEK 183

KENTEQ KENNISCENTRUM VOOR TECHNIEK
Postbus 81,
1200 AB HILVERSUM (NL)
Contact person: Mrs. Leonore Pop
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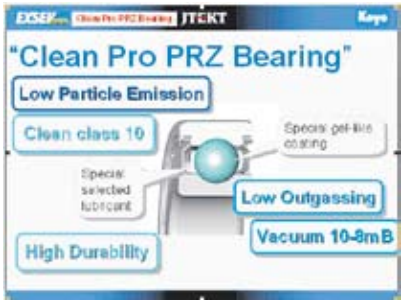
leonore.pop@kenteq.nl
wwww.kenteq.nl

JTEKT EUROPE BEARINGS BV KOYO BENELUX OFFICE 97

JTEKT, world leading bearings supplier to the automotive industry and innovator for engineered bearings for high-end industrial applications, presents the KOYO EXSEV, roller bearing ranges.
These bearing ranges in stainless steel, ceramic and ceramic-hybrid are specially developed for use in extreme applications like (high) vacuum, clean room, high temperatures, high speed, electro-magnetic and corrosive environments.
On the exhibition we pay special attention to the "PR" range of CLEAN PRO" series, designed for industrial CLEAN (class 10) and vacuum (10^{-7} mB) applications.
Included are the "PRZ" series with solid lubricant, resulting in 50% less particle emission, 10 times higher lifespan, higher temperature range and moreover less out-gassing.



JTEKT EUROPE BEARINGS BV KOYO BENELUX OFFICE
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2965 ZG NIEUWPOORT (NL)
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jan.blonk@jtekt.nl
www.koyo.nl

KISTLER BV 38

Kistler is the manufacturer of (piezo electric) sensors and analytic equipment. We measure pressure, force, torque and acceleration. Kistler sensors provide:

- Accurate, repeatable and extremely fast measurement over a very wide measuring range.
- Small and compact sensor design (sensors diameter from 1 mm!)
- Quasi-static to extremely high dynamic measurements.

In your (production) process Kistler can measure forces, pressures or moments for every production cycle. By monitoring every production cycle 100%, product control is easily feasible. Next to this, quality control, failure analysis and process optimisation can be done fast and effectively. Our more than 50 years of experience can save your company a lot of money and above all time.

KISTLER BV
Leeghwaterstraat 25,
2811 DT REEUWIJK (NL)
Contact person: Mr. E. van Veen
t +31 (0)182-304444
sales.nl@kistler.com
www.kistler.com

KLEEVEN CONTROL BV 168

Kleeven Controls is specialized in development and assembly of machine and process controls and system parts, designing Electronics and embedded software, control technology and LED applications. Kleeven Control has as its company philosophy that automation should contribute to an effective production process. With more than 25 years of experience and constant contact with the market, Kleeven Control constantly implements new knowledge in its products. Kleeven is also an active member of Mechatronics Partners (www.mechatronicspartners.com), a strategic partnership of five manufacturing companies from the south of the Netherlands, each having their own competence. So, Mechatronics Partners will be a strong and competitive player in the industrial engineering market that will be able to initiate and realise innovations from start to finish.

KLEEVEN CONTROL BV
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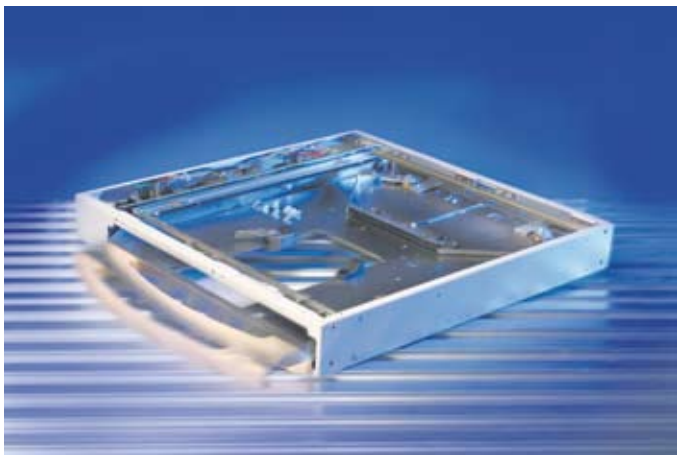

KML LINEAR MOTION TECHNOLOGY GMBH 05

A manufacturer of complete movement systems. With rotative movement systems and complex applications of direct driven movement systems it is our task to know the national and international developments in every area of business where high-precision and high-dynamic movements are required. Therefore we develop highly sophisticated solutions for different customers. Our customized movement systems are supplemented by a wide variety of standardized and modular Linear Motor Systems.

KML LINEAR MOTION TECHNOLOGY GMBH
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A 1100 VIENNA (AU)
Contact person:
Mr. Reinhard Mauerschitz
t +31 (0)043-164150300
office@kml.at
www.kml.at

KMWE PRECISION SYSTEMS & PRECISION COMPONENTS 48

KMWE offers total solutions in precision handling and motion systems and the assembly of modules on behalf of the high tech industry. With 200 employees KMWE carries out engineering, prototyping, robotized machining of parts up to 2,500 mm, assembly and testing, all under its own roof. Lean Manufacturing, smart manufacturing technologies and process control for low/medium volume - high mix applications are deeply integrated. New developments can be manufactured quickly by KMWE's own prototyping facility and the experience that is gained can be used for a quick launch of serial production. Combined with an international network in sourcing, a sharp eye on market developments and dedicated account teams KMWE is your source for repeated quality and security in production and assembly.

KMWE PRECISION SYSTEMS & PRECISION COMPONENTS
Postbus 7930,
5605 SH EINDHOVEN (NL)
Contact person: Mrs. I. Verheggen
t +31 (0)40-2561669
i.verheggen@kmwe.com
www.kmwe.com

KUSTERS METAALBEWERKING OSS BV 56

Since its creation in 1973 Kusters has developed into a modern subcontractor in the field of machining. Almost all metal machining processes, with regard to the most widely divergent types of metal and synthetic materials, can be performed by us to perfection. The activities mainly consist of the production of (fine) mechanical parts for widely divergent trades, like the building of machines and apparatus, the food, chemical and electronics industry. The size of the produced series varies from single pieces to several thousands. Because of the flexibility, the quality consciousness of the organisation and the versatile, modern machinery, high-grade products and a short production cycle can be realized.

KUSTERS METAALBEWERKING OSS BV
Saksenweg 31, 5349 AX OSS (NL)
Contact person: Mr. J.A. Kusters
t +31 (0)412-633328
info@kustersmetaal.nl
www.kustersmetaal.nl

KUGLER GMBH 06

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Heiligenberger Strasse 100,
D 88682 SALEM (G)
t +49-7553 92000
info@kugler-precision.com
www.kugler-precision.com

LARSEN PREMIUM PRECISION PARTS 151

Fine-mechanical parts of undeniably high quality are essential to the workings of a machine and are decisive for a company's reputation. This is our field of activity. Larsen is the specialist in premium milling and turning work. We are fully equipped with the knowledge and technology required to produce special parts made of stainless steel, aluminum, synthetic or exotic materials. We work for demanding clients who cannot and will not accept anything less than premium precision parts.

LARSEN PREMIUM PRECISION PARTS
Ambachtsweg 36,
3899 AR ZEEWOLDE (NL)
Contact person:
Mr. Frank te Hennepe
t +31 (0)36-5220931
info@precisionparts.nl
www.precisionparts.nl

LASER 2000 BENELUX 138+162

Booth 1
Laser 2000 Benelux is exhibiting the latest developments in intelligent positioning systems, piezo nanopositioning, optomechanics, laser power/energy meters and (fiber) lasers.

Booth 2
This year we show on our theme stand the latest development on LED screen correction. LED screen displays are built from individual LEDs. Each of these LEDs has its own characteristics with respect to brightness and color. Even if the color and brightness of the displays are tuned perfectly by the supplier, after some time of use, the brightness of each of the LEDs will change differently. As a result the display with show patchiness and not create the image as required by that user (and advertiser).

LASER 2000 BENELUX
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3645 GV VINKEVEEN (NL)
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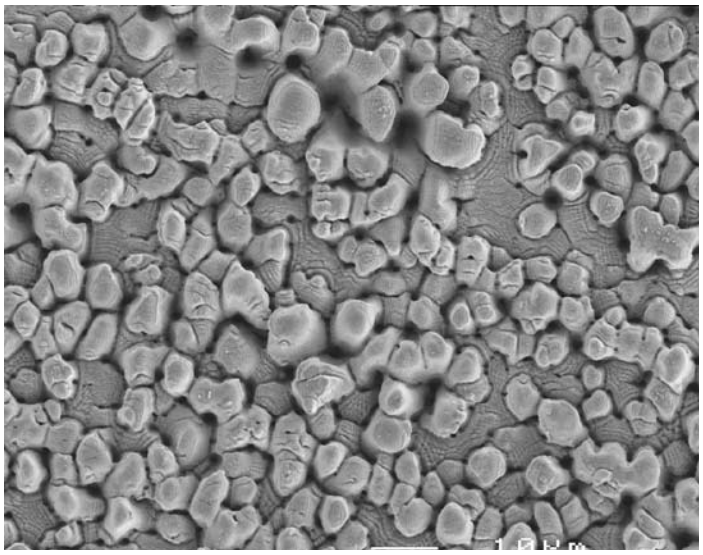
t +31 (0)297-266191
info@laser2000.nl
www.laser2000.nl

LASERTEC BV 90



Our expertise comes from experience.
For more than 15 years now, Lasertec has been a strong and reliable partner in the world of laser technology. Thanks to its high levels of knowledge and practical experience, Lasertec can build bridges between the conceptual stages and technical execution. During the past years, this has resulted in a number of remarkable cases in which the level of knowledge of Lasertec and its strategic partners fired the imagination.

Keywords:
- 3D ultraviolet treatment in picoseconds
- Custom made applications
- Innovative power
- Non-impact measurement solutions

LASERTEC BV
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richard.huiberts@lasertec.nl
www.lasertec.nl

LEIDSE INSTRUMENTMAKERS SCHOOL 192

The LiS is a school for vocational training and offers one-of-a-kind state-financed high-grade education in fine-mechanical engineering. Students are prepared to work in projects and create fine-mechanical instruments made of metal, glass, ceramics or optical devices.
During the fair we will demonstrate a selection of the finest projects our students realised in the past year.

LEIDSE INSTRUMENTMAKERS SCHOOL
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info@lis-mbo.nl
www.lis-mbo.nl

LEMO CONNECTORS BENELUX 44

The Original Push-Pull Connector. LEMO is the acknowledged leader in the design and manufacture of precision custom connection solutions. LEMO offers her customers high-quality push-pull connectors in a variety of challenging application environments including test and measurement, medical, industrial control, telecommunications and cable assemblies solutions. Terms as fibre optic, coax, high voltage, triax and several combinations indicate our specialty.

LEMO CONNECTORS BENELUX
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1967 DC HEEMSKERK (NL)
Contact person: Mr. Rene Lengers
t +31 (0)251-257820
info@lemo.nl
www.lemo.com

LEUVEN AIR BEARINGS 161

Leuven Air Bearings develops and produces linear and rotational air bearings for high-speed and high-precision applications. Miniature air bearings with 5 mm axial diameter, up to heavy load 1,000 mm diameter air bearings can be produced. LAB is an innovative partner for companies in the industrial automation, process control, compressor and power generation industries. LAB offers custom-designed air bearings and systems based on air bearings. Recently, LAB developed a new series of high-rotation tables, which will be presented at the precision fair. LAB rotation tables achieve very high rotational accuracies (< 50 nm) for excellent stiffness and damping values.

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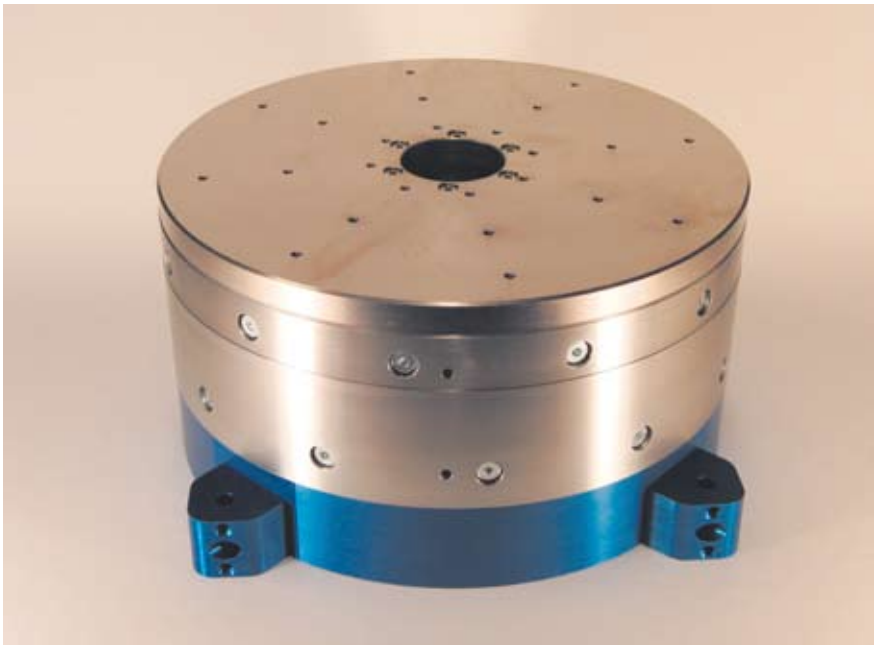

LIGHTMOTIF BV 182

Lightmotif is specialized in micro and nano materials processing using ultrafast pulsed lasers. We are active in both research and applications development. We develop new technologies and applications for micromachining as well as for surface micro- and nanotexturing for functional materials. The possibilities in micromachining range from drilling of micrometer-sized holes to thin film removal or cutting with no heat input and burr formation. All materials regardless of hardness or optical properties can be machined with sub-micrometer precision and roughness. Lightmotif was established as spin-off company from the University of Twente and the M2i institute and approaches micromachining with an academic background and extensive analysis capabilities.

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info@lightmotif.nl
www.lightmotif.nl

LLT APPLIKATION GMBH 36

LLT Applikation is a company with a high tech profile in the field of laser technology to high-precision engineering. Design and manufacture of custom-made precision laser processing systems – from technological analysis to the complete processing system – we offer everything in one hand. A second business field is a laser job shop. We make one-off and/or mass produced parts with highest precision. The sophisticated measuring and testing equipment we use guarantees consistent high quality. Microcut 2000 is a high precision laser cutting machine designed and developed for universal use on thin metal sheet to assist in the manufacture of precision parts.

LLT APPLIKATION GMBH
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D 98693 ILMENAU (G)
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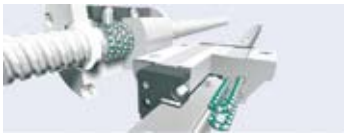
t +49-367746330
info@llt-ilmenau.de
www.llt-ilmenau.de

LM SYSTEMS BV 94



LM Systems BV is located in Veenendaal and is the exclusive Dutch Service Supplier for THK. THK's creative ideas and unique technology have made the company worldwide pioneers in the development of Linear Motion (LM) products and made THK a leading manufacturer in the industry. Today, THK's Linear motion products are indispensable in mechanical and electronic equipment in a wide variety of systems used in all industries.
At the Precision Fair we exhibit our wide program with unique mechanical products and focus on THK's miniature program of ball rails, ball splines and balls screws.
THK "the Mark of Linear Motion".

LM SYSTEMS BV
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3905 TG VEENENDAAL (NL)
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www.thk.nl

LOUWERS GLASS AND CERAMIC TECHNOLOGIES 135

Louwers vormt in vele gevallen de ontbrekende schakel bij de ontwikkeling en productie van glazen en keramische precisiecomponenten voor tal van high-tech industrieën. Louwers kenmerkt zich met name als kennisondersteunende partner bij de ontwikkeling en de toepassing van velerlei precisiecomponenten. Niet alleen conceptontwikkeling, verificatie en prototyping, maar ook de vervaardiging van de nulseries en de productieseries kan in zijn geheel door Louwers worden verzorgd. Tevens heeft Louwers een zeer ruime ervaring met verregaande mechanisatie, smart engineering en volledig SPC-gestuurde processen, waardoor ook serieproductie voor uiterst concurrerende prijzen, met behoud van de welbekende hoge Louwers kwaliteit kan worden gerealiseerd.

LOUWERS GLASS AND CERAMIC TECHNOLOGIES
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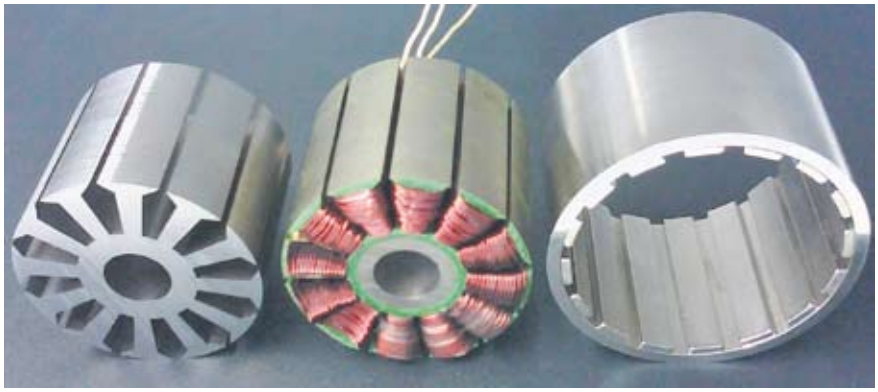
www.louwers.nl

MAGNETIC INNOVATIONS BV 184

Magnetic Innovations is an advanced knowledge centre in the area of electromagnetic/ thermal designs for rotary motors/generators, linear actuators, magnetic bearing, etc. We offer our knowledge in several ways, such as consultancy, feasibility studies and customer-specific developments with a prototype including amplifier and control software.



High-Torque motors
Our concept/product is a direct drive, high-efficiency high-torque motor with excellent characteristics.

High-Efficiency Generators
Magnetic Innovations takes a step forward in reducing CO_2 emissions and the dependence on fossil fuels by creating a new generation of highly compact direct drive generators for the windmill market and automotive applications.

MAGNETIC INNOVATIONS BV
Oude Kerkstraat 61A,
5507 LB VELDHOVEN (NL)

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bart.van.den.broek@
magneticinnovations.com
www.magneticinnovations.com

MARTEK SPRL 53

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

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B 1082 BRUSSEL (B)
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info@martek.be
www.martek.be

MASÉVON TECHNOLOGY BV 04

Masévon Technology is an experienced manufacturer of micro assembly equipment and vacuum-related photovoltaic equipment and parts. As a part of the Triumph Group, Masévon joined forces with Vernooy Vacuum Engineering and Machinefabriek Tuin, realizing an in-house capacity for designing and manufacturing of parts and complete systems.

With decades of experience we deliver systems for well-known multinational companies, universities and research institutes, all over the world.
The latest development is the completion of the new assembly site in Hardenberg, the Netherlands, were all the necessary utilities and space are available for future developments.

Masévon Technology, your partner for designing and manufacturing of high-precision equipment!

MASÉVON TECHNOLOGY BV
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7770 AG HARDENBERG (NL)
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t +31 (0)523-238560
aja@masevon.com
www.masevon.com

THE MATHWORKS BV 178

The MathWorks is the world's leading developer of mathematical computing software. This includes MATLAB® and Simulink® for data analysis, algorithm development, numeric simulation and design of multi-domain embedded systems. Together with a wide range of optional add-on products, these establish the most powerful environment for Model-Based Design currently available 'off-the-shelf'. It enables engineers in high-tech mechatronic industry to go from 'innovative idea' to 'actual product' in the shortest possible time and in accordance with the highest possible quality and/or certification standards. Founded in 1984, The MathWorks employs more than 2,100 people in 15 countries. For additional information, visit www.mathworks.nl.

THE MATHWORKS BV
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info@mathworks.nl
www.mathworks.nl

MAVOM BV 51

Since 1938 MAVOM has been a specialist in the production, marketing and sales of chemical specialty products for industrial applications. During the Precision Fair we will be present with our complete line of:

- Adhesives & Sealants
- Specialty Lubricants
- Electronics (Conformal Coatings, potting compounds etc)

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t +31 (0)172-436361
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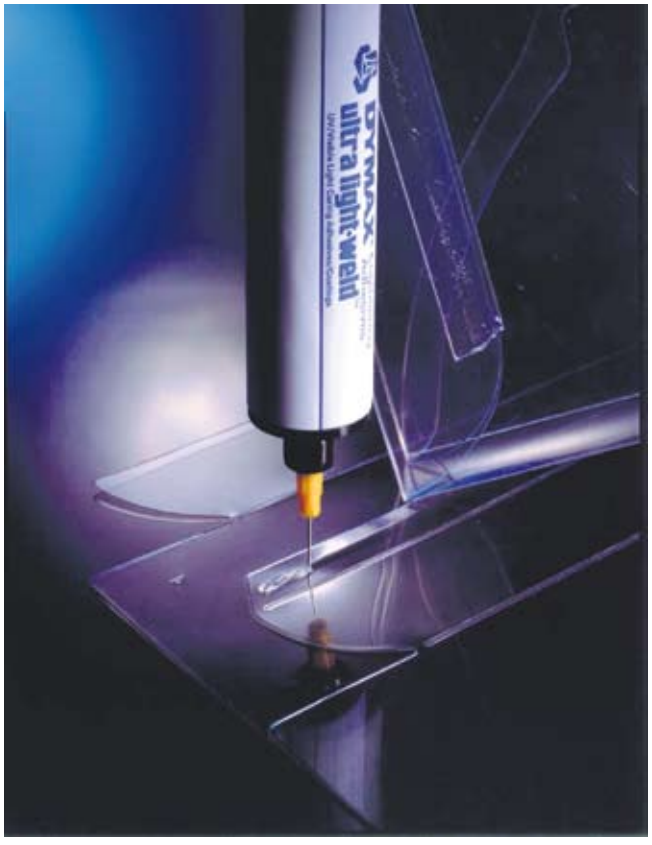
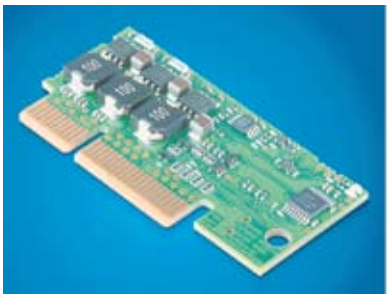


MAXON MOTOR BENELUX BV 92



The solution is always a matter of the right combination.
maxon motor develops and produces brushless and brush DC motors with a unique ironless maxon winding, up to 500 watts. Our modular program is complemented by flat motors with an iron core. The modular system with planetary, spur and special gearheads, sensors and control electronics, completes the range. High-tech CIM and MIM components are produced in a special competence center. maxon motor stands for top quality, innovation, competitiveness and a worldwide distribution network. We combine motor, gearhead and electronics according tot customers' specific requirements to create an integrate total solution. We are driven by your specific requirements.

MAXON MOTOR BENELUX BV
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t +31 (0)53-4864781
matthijs.roorda@maxonmotor.nl
www.maxonmotor.nl

MECAL APPLIED MECHANICS BV 111

Mechatronic Development
MECAL is specialised in analysis, design and realisation of mechatronic systems in the Semiconductor and related High Tech Industry. Our unique project approach and long standing experience make MECAL the ideal development partner to leading equipment builders world-wide. In the past 20 years, MECAL developed into a global engineering company with 100+ professionals and offices in the Netherlands, USA and Japan.

Markets
MECAL servers leading manufacturers of wafer processing equipment, SMT assembly, inspection systems, and solar manufacturing equipment.

Our development services include:
- Project management
- Simulation - Modeling
- Qualification - Test
- Concept - Feasibility Study
- Design - Engineering
- Prototyping - Small Series Production

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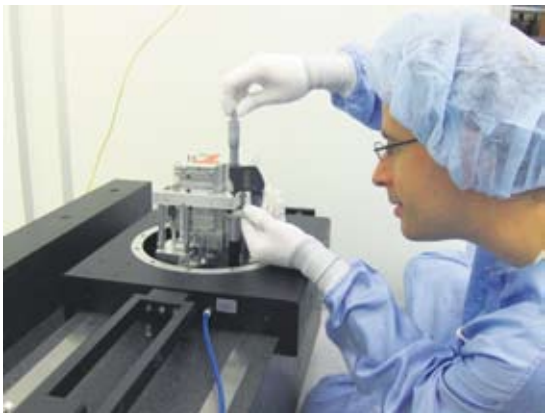
semicon@mecal.eu
www.mecal.eu

MECHAPHYSICS BV 25

Passion for technology
Mechaphysics is the precision engineering division of the Vision Dynamics Group.
Concept research and design is our passion. We design according to physical principles with the accent on mechanical principles. To fulfil the requirements for our customers the base, the concept, must be right.
We also implement integration of precision mechanics for vacuum and clean room environment.



Supporting our customers by:
- Fundamental Research
- Concept Research
- Technical Design
- Prototyping
- Turn-key Solutions

Mechanical solution:
- Precision Mechanics
- Mechatronics
- Cryogenic Technology
- Sensor Technology
- E-beam Technology
- Vacuum
- Optics

MECHAPHYSICS BV
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5627 JM EINDHOVEN (NL)
Contact person: Mr. E. Bos
t +31 (0)40-2566745
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www.visiondynamics.nl

METRIS 157

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METRIS
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riet.stegen@metris.com
www.metris.com

MEVI FIJNMECHANISCHE INDUSTRIE BV 127

The Mevi Group, with its principal office in Helmond, the Netherlands, and operating companies in Belgium and the Czech Republic, is a main supplier and valuable partner in the field of development, engineering and realisation of complete (prototype) machines and modules, to customer specification. Together with specialist companies in electronics and machine control, complete projects are realised for customers active in the fields of semi-conductors, copying attachments, the CD and DVD industry, automotive and the electronics industry. The Mevi Group is furthermore specialised in the production of high-precision mechanics (micron range) and parts, in any type of material required and in quantities ranging from single items to several hundreds.

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MICRO LASERSYSTEMS BV 07

Micro Lasersystems performs service on existing laser equipment. Micro Lasersystems is the official service center for Lasag in the BeNeLux, in coorporation with SRR Laser & Snijtechniek. Besides this, Micro Lasersystems supplies lasersystems for micromachining of various materials (Marking/Engraving, Abblation, Cutting, Drilling and welding).
Both standard systems as well as custom-built machines are available with wavelengths from UV till far infrared.

Thanks to the new cooperation with Lumera Laser, Micro Lasersystems is capable of supplying micromachining centers based on picosecond lasers.

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ramon@microlasersystems.nl
www.microlasersystems.nl

MIJNSBERGEN BV 95

Mijnsbergen is specialised in dynamic precision positioning systems and vision solutions. Beside selection of components, Mijnsbergen realizes projects from engineering up to installation. At the Precision Fair, Mijnsbergen shows an extended range of components such as AKRIBIS direct drive linear and rotary motors, circular and rectangular voice coil modules, piezo modules and ELMO servo drives. The motors and actuators are available as separate components or as complete modules, including linear guides, encoders and cabling. New in the Mijnsbergen product range are intelligent cameras and vision systems. Experienced engineers offer support with the selection of components and offer the most efficient solution for your application needs.

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t +31 (0)297-285821
info@mijnsbergen.nl
www.mijnsbergen.nl

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MIFA ALUMINIUM
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5928 PX VENLO (NL)
Contact person: Mr. Ivo van Galen
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sales@mifa.nl
info@mifa.nl
www.mifa.nl

MIKROCENTRUM 60

MIKROCENTRUM offers a comprehensive array of short, to-the-point practical courses and workshops on all educational levels ranging from hands-on technical up to academic.
The courses are held at various locations in the Netherlands and Belgium. MIKROCENTRUM offers these courses open to individual registration as well as in a corporate setting. MIKROCENTRUM teachers are themselves professionals in their line of expertise, highly skilled and educated as well as enthusiastic. Currently it is possible to choose from more than 195 different course topics starting at various points in time.
For additional information, please contact Mr. Frank Bruls, department manager Courses, f.bruls@mikrocentrum.nl.

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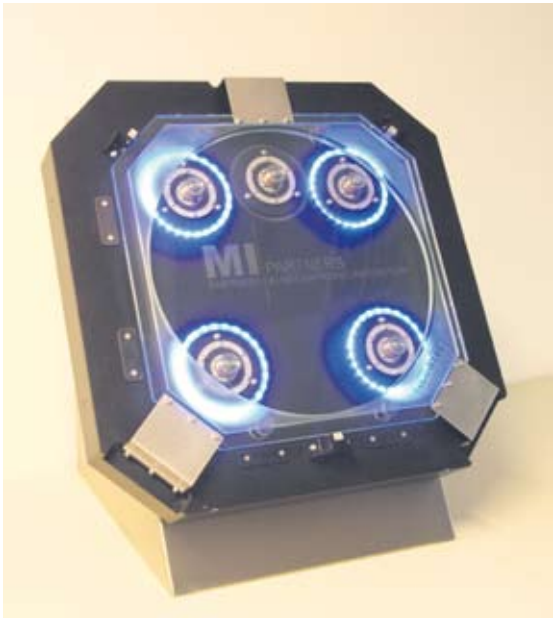
opleidingen@mikrocentrum.nl
www.mikrocentrum.nl

MI-PARTNERS BV 184

In future, 450 mm wafers will lead to larger wafer chucks. To maintain high eigenfrequenties, the chuck can be made thicker. This has the disadvantage that the mass will increase significantly, resulting in a need for greater actuator forces. An alternative is to make use of additional actuators, so-called over-actuation. MI-Partners shows how to achieve nanometer performance on a relatively weak 450 mm wafer chuck using a relatively simple control theory and over-actuation. The design and the results of our demonstration model will be shown at our booth.



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www.mi-partners.nl

MINIMOTOR BENELUX 28

As a member of the FAULHABER® Group, MINIMOTOR Benelux takes care of the sales & support of the FAULHABER® products in the Benelux.
The FAULHABER® product range consists of miniature electrical drive systems: brushed & brushless DC-motors, stepper motors, linear motors, gearboxes, tachos, encoders, drivers & motion controllers. All products are characterized by the highest power-to-volume ratio, high efficiency, precision and reliability. FAULHABER® offers solutions based on standard or semi-standard products, as well as completely customized designs.
Typical applications are found in instrumentation, medical equipment, optical devices, factory automation, robotics, military and space industry.

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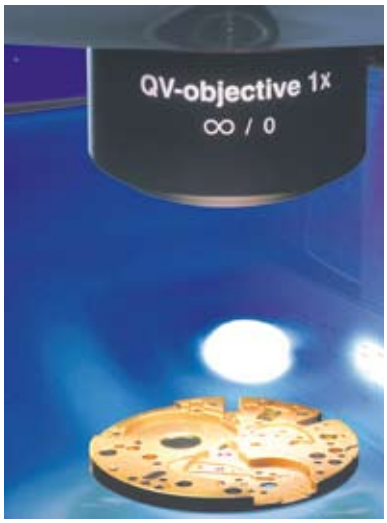
MITUTOYO NEDERLAND BV 09

Mitutoyo Nederland BV is a full daughter of the Japanese Mitutoyo Manufacturing Corporation Ltd, the worlds biggest manufacturer of precision measuring instruments. In the Netherlands, Mitutoyo offers besides the full product range of more than 5,000 different precision instruments, also full service support, product and general metrology training and a RVA-accredited calibration service.
Most instruments are operational in the over 400 m² showroom in Veenendaal. At the Precision Fair, Mitutoyo will display the latest generation of form measuring instruments, vision and tactile 3D measuring machines and a selection



of products out of the comprehensive product range.

MITUTOYO NEDERLAND BV
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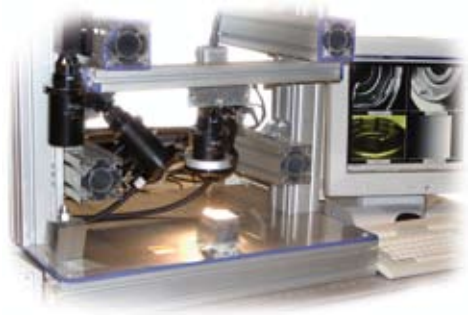
MOLENAAR OPTICS VOF 109



MOLENAAR OPTICS VOF
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info@molenaar-optics.nl
www.molenaar-optics.eu

Molenaar Optics offers innovation support for applications using optical and opto-mechanical components. Designs may contain both standard as well as custom-made parts. Optical components comprise simple lenses, mirrors, prisms and complex multi-element laser objectives for materials processing or telecentric camera lenses for vision systems. Opto-mechanical part series consist of holders for optics as well as manual and motorized positioning systems. Molenaar Optics also advises on and offers optical measuring instruments, from basic microscopes and modular microscope components to digitally controlled profile projectors.

MURAAD BV 124

We advise and sell the measure equipment you need. We represent for example: Dr-Schneider, Walter UHL, T&S, Peter Müller Lehre, Tesa, Bowers, CVInstruments. We show you the new equipment from T&S und Dr-Schneider.

MURAAD BV
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t +31 (0)38-3765858
info@muraad.nl
www.muraad.nl

MTSA TECHNOPOWER BV 166

MTSA Technopower is a renowned technology company and producer of high-quality mechatronic parts and modules according to customer specification. We excel in manufacturing complex high-quality products and parts as one-off pieces or small series for OEM in semiconductor, analytical, pharmaceutical, engineering and process industries, as well as for technical institutes, research centres and service companies. If you require precision and/or electronic parts and/or compound products as a prototype and/or a series, please contact us. Our experts will be happy to help. MTSA Technopower: your partner in manufacturing your mechatronic parts and compound products.

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www.mtsa.nl

MYTRI BV 124

Mytri B.V. has been an established name within the precision measuring industry since 1957.
Mytri produces precision granite surface plates, concentricity test benches, measuring beams, straight-edges, squares, as well as basic components for various measuring machines. Mytri uses Fine Black Granite as their standard. This granite has a very fine-grained structure and is leading to the following three important properties: Durability - Stability - Accuracy.

Small overview of our delivery program:
- precision granite surface plates;
- (cheaper alternatif) MµCal "Low Budget Line" granite;
- precision light weight granite surface plates;
- granite concentricity test equipment;
- Mytri Cleaning and maintenance products.

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www.mytri.nl

NATIONAL INSTRUMENTS 16

National Instruments offers an embedded design and prototyping platform that combines the LabVIEW graphical development environment with off-the-shelf, microprocessor and FPGA-based measurement and control hardware for design, simulation, rapid prototyping, implementation, validation and verification of embedded systems. Using the intuitive LabVIEW graphical dataflow programming environment, engineers and scientists can rapidly develop and iterate on designs, reducing the time from concept to prototype. After prototyping and validating the design, domain experts can then deploy these custom designs to an extensive range of off-the-shelf NI hardware or to custom hardware. Come to our booth 16 for more information.

NATIONAL INSTRUMENTS
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info.netherlands@ni.com
www.ni.com/netherlands

NBG INDUSTRIAL AUTOMATION BV 110

NBG Industrial Automation develops hardware and software for industrial and medical purposes.

Your versatile partner:
- Developing hardware and embedded software
- Designing and building test equipment
- Automation for machine and equipment manufacturers
- Developing custom software
- Project management using multidisciplinary collaboration
- Innovative concept development jointly with regional partners

We show:
- Fluido, blood warmer
- Foot insole proto
- AED cabinet
- Fireworks igniter

NBG INDUSTRIAL AUTOMATION BV
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marie-louise.nooijen@nbg-industrial.nl
www.nbg-industrial.nl

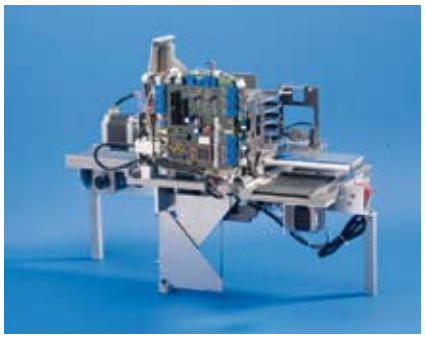
NEDINSCO BV 169

Nedinsco ontwikkelt, ontwerpt, kwalificeert en produceert hoogwaardige systemen volgens klantspecificatie. Hierbij wordt gebruik gemaakt van de technologieën optiek, mechanica, elektronica en software. Nedinsco is in staat het volledige traject van idee tot serieproductie voor haar klanten te verzorgen. De klanten waarvoor Nedinsco werkt, bevinden zich voornamelijk in de halfgeleider-, defensie-, medische en optische industrie.

NEDINSCO BV
Jan van Riebeeckweg 5,
5928 LG VENLO (NL)
Contact person:
Mr. E. van Bokhoven
t +31 (0)77-3558777
sales@nedinsco.nl
www.nedinsco.nl

NIJDRA GROEP 31

The Nijdra Group is specialized in precision metal working and consists of the following business units:
- Fine Mechanical Industry (turning & milling);
- High-tech Mechanical Industry (grinding);
- Nijdra Special Products (assembly);
- Medical Product Technology (orthopaedic & orthodontic implants).



NIJDRA GROEP
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1462 VM MIDDENBEEMSTER (NL)
Contact person: Mr. M.C. Schulz
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info@nijdra.nl
www.nijdra.com

NEWPORT SPECTRA-PHYSICS GMBH 133

Newport Corporation is a globally recognized leader in advanced technology products and solutions for fields such as Research, Life & Health Science, Aerospace & Defense, Industrial Manufacturing, Semiconductors, and Microelectronics. With decades of experience in motion control, Newport has both the capability and the capacity to provide the optimum solution for your individual needs, whether it be a standard product, an OEM solution or a fully customized engineered system. At the Precision Fair, Newport main displays will include nanopositioning linear stages, controllers, hexapod and the New Focus™ family of picomotor actuators and components.

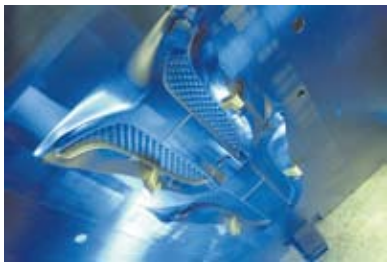
Newport
Experience | Solutions

Spectra-Physics
A Division of Newport Corporation

NEWPORT SPECTRA-PHYSICS GMBH
Guerickeweg 7,
D 64291 DARMSTADT (G)
Contact person: Mrs. Bettina Heil
t +49-61517080
germany@newport.com
www.newport.com

NORMA GROEP BV 17

Norma, Your System Integrator
Norma employs more then 400 motivated people divided over three locations in Europe and one location in Asia. Norma has secured a strong position as a "low volume-high mix" system supplier over the entire life cycle of complex modules. We offer our OEM-clients a service throughout the complete value chain. From development, production, assembly, testing and service.



Capabilities:
- Development, construction – Build to specification
- Configuration Management
- Ultra-precision machining – sizes: 0,5 m^3
- Precision machining – sizes: 5 m^3
- Dipbrazing, vacuum brazing
- Machining of alloys, titanium, inconel, high-grade aluminium.
- Module assembly, also in clean room conditions (10,000 class)
- UHV and UCV production
- Design, manufacture of composite products and assemblies
- RF expertise (wave guides manufacturing, testing)
- Complex cabling & electrification

Field of experience:
- Semiconductor
- Automotive
- Defence
- Aerospace
- Consumer Lifestyle

NORMA GROEP BV
Granaatstraat 54,
7554 TR HENGELO (NL)
Contact person: Mr. R. Roozeboom
t +31 (0)74-2916579
rob.roozeboom@norma-ups.nl
www.normabv.nl

NOVA-ASTRON 188

NOVA-ASTRON both have their mission to make discoveries in astronomy happen, via the development of novel and innovative technologies and to carry out front-line astronomical research. At the Precision Fair, we show our latest developments on infrared spectroscopic systems (www.astron.nl/r-d-laboratory/competence-and-support-groups/mechanical-design/mechanics) for the world's most advanced space and ground-based telescopes.
During the exhibition, you can discuss with NOVA-ASTRON experts and experience how our technology opens new possibilities for your applications. You can also learn about opportunities for your business in realization of the European Extremely Large Telescope (E-ELT).

Techniques include:
- precision milling;
- extreme light weighting e.g. suitable for precision positioning systems;
- polished aluminum mirrors.

Spectacular hardware is on display, including:
- the JWST–MIRI Qualification model;
- the X-shooter extreme light weight balance arm;
- polished aluminum mirrors for cryogenic applications.

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7990 AA DWINGELO (NL)
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t +31 (0)521-595100
halfwerk@astron.nl
www.astron.nl

NTS GROUP BV 54

NTS Group develops, engineers, manufactures and optimizes mechatronic systems, modules and components. This enables OEMs to supply high quality machines with a short time to market, maximum flexibility and at competitive prices.
NTS Group takes responsibility and is committed to support our customer's success by constantly seeking realistic and effective ways to manufacture and optimise their products.
NTS Group is an international group of specialized companies in the Netherlands, Czech Republic, China and Israel. We offer service in Engineering, System Supply, Sheet metal, Machining and Finishing. Check us out and find what we can offer to increase your success.

NTS GROUP BV
Dillenburgstraat 9,
5652 AM EINDHOVEN (NL)
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frank.theuws@nts-group.nl
www.nts-group.nl

NTS MECHATRONICS BV 54

NTS Mechatronics takes responsibility for the development, engineering, manufacturing and optimization of mechatronic systems and modules. This enables our customers to supply high quality machines with a short time to market, maximum flexibility and at competitive prices.
NTS Mechatronics offers flexibility in ramp-up/ramp-down situations, a one-stop shop for engineering and manufacturing including transfer to low-cost countries and committed project management.
NTS Mechatronics is part of NTS Group, an international group of specialized companies in the Netherlands, Czech Republic, China and Israel. Check us out and find what we can offer to increase your success.

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frank.theuws@nts-group.nl
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NTS OPTEL BV 54

NTS OPTEL is specialised in creating and building dedicated optical solutions. In case off-the-shelf products do not solve your problem, we are able to help you. Either we can help to improve your process by measuring with light, laser, vision, or spectrometry, or we can design and build your product which incorporates (any kind of) optics.

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6546 BG NIJMEGEN (NL)
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www.nts-group.nl

NTS SYSTENCE BV 54

NTS Systence specializes in multidisciplinary engineering, integration, realization and service support for complex and high-quality systems in small series. NTS Systence also seconds mechanical, software and hardware specialists to its customers. NTS Systence offers high-end system solutions in machine building for specific sectors, with a unique position in the chain from 'idea' to 'series production' through the 'prototype' and 'zero-series' phases. With its range of services NTS Systence concentrates on mono- and multi-disciplinary projects within the specialist disciplines Mechanical Engineering, Electrical Hardware and Software. NTS Systence focuses on the delivery of added value to market segments in which quality and speed are very important to customers.

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www.systence.nl

NUMERIK JENA GMBH 22

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OCEAN OPTICS EMEA 155

Ocean Optics will be showing many new and exciting products like the NIRQuest spectrometer for analysis in the near-infrared range. This new generation of small footprint, near-infrared spectrometers is ideal for spectral measurements in medical, pharmaceutical, environmental and process applications, such as analysing moisture content in food and beverage products and analysing trace metals in wastewater. We will also show you the new Jaz light meter. This pre-configured spectrophotometer is the ideal tool for analyzing any type of lighting. With the Jaz light meter you can measure the spectral characteristics and calculate key parameters like Lux, Lumen and PAR values.

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info@oceanoptics.eu
www.oceanoptics.eu

OPTIWA BV 104

More possibilities in complex precision parts.
Optiwa is a supplier of complex accurately machined parts and mechanical assemblies. Optiwa is able to offer you efficient production for parts with tolerances down to 0.5 µm accuracy (dimensional, form and location tolerances within the sub-micron range.)
In addition to turning and milling processes, Optiwa offers: grinding, hard turning, polishing, lapping and all possible surface and heat treatments. Various parts of the production area are climate controlled. Several CNC machines are automated by robot installations.
Parts are used in electron microscopes, air bearings, optical modules and specific medical and analytical equipment.

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optiwa@optiwa.nl
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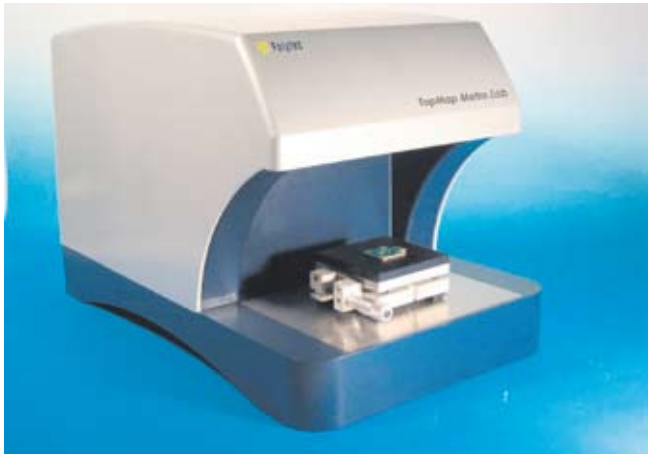
POLYTEC GMBH 179



Polytec offers optical metrology for surface topography, vibration analyzes and speed monitoring. On the booth we display easy-to-use surface topography equipment. From microscopically small fields up to 27x38 mm^2 (without stitching) the TMS product range can measure roughness, step heights, waviness and more. Resolution in the sub 0.1 nm is feasible. The user-friendly software gets you started quickly. The variety of post-processing functions yields the results you need. Beside the instruments, Polytec offers the system integration for productive automated solutions.

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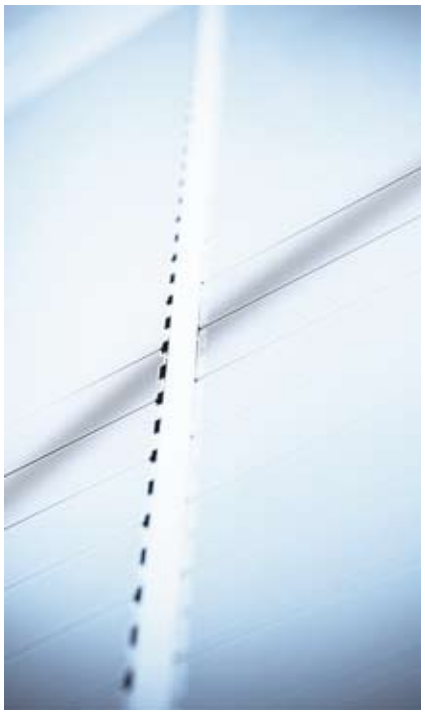
PRECISION MICRO LTD 11



Now the largest independent manufacturing operation of its kind in Europe, PRECISION MICRO specialises in the manufacture of precision flat profile and three dimensional components for automotive, communications, aerospace, electronics, medical, military and other 'high tech' engineering applications.

PRECISION MICRO offers a unique range of manufacturing technologies including:

- Photochemical Etching & Laser Enhanced Etching Process (LEEP)
- Electroforming & Laser Enhanced ElectroForming (LEEF)
- Technical Finishing & Plating
- Wire EDM
- Forming

PRECISION MICRO LTD
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t +44-1213800100
lee.weston@precisionmicro.com
www.precisionmicro.com

PROKONPACK NEDERLAND BV 87

Prokonpack is the supplier of protective packaging materials for the industrial market and we would like to take the challenge with you!
By using this service, you can be sure that your package contains the minimum amount of material necessary to ensure its safe transit through its distribution life cycle.

Korrvu®
Innovative and excellent product protection.

Instapak RT
Instapak Quick® Room Temperature (RT) foam packaging offers users quickly and easily a custom-fit protective foam cushion. Instapak Quick® Room Temperature (RT) foam packaging is ideal for small to medium packaging quantities. Instapak Quick® RT protective foam packaging can be activated right out of the box and requires no additional equipment.

PROKONPACK NEDERLAND BV
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5652 AD EINDHOVEN (NL)
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t +31 (0)40-2919393
angela@prokonpack.nl
www.prokonpack.nl

PROMIS ELECTRO-OPTICS BV 144

Promis Electro Optics (PEO) is a modern trading company with over 30 years of experience in the field of electro-optics and radiation technology QA and safety. We offer specialized measurement and detection solutions to optimize your processes using light, position, colour and radiation. Our PEO core values are: knowledge, quality, innovation and support.
PEO knowledge comes together with field experience and an established network of professionals. A high standard in Quality, Innovation and Support is reached through selecting the best possible suppliers which are up-to-date with the latest technology. We deliver professional support in a personal way.
All measured by customer satisfaction.

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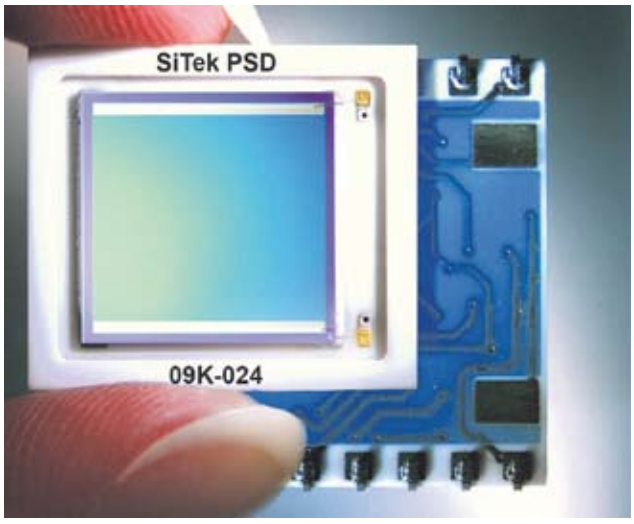
6600 AD WIJCHEN (NL)
Contact person: Mr. Vincent Kroeze
t +31 (0)24-6488688
info@gotopeo.com
www.gotopeo.com



Q-SYS BV 108

Q-Sys offers a complete service, from initial application assessment, through feasibility and costing studies, system design, manufacture, calibration and commissioning. Bespoke system design is a speciality and we also offer a complete turnkey capability for multi supplier configurations. Additionally we provide comprehensive technical support to maintain system availability at a maximum. Q-Sys offers cost-effective solutions for all motion control and positioning requirements. Some examples are: large-format digital printing, laser welding and cutting, flat-panel display mastering, X-ray and optical inspection and holographic master creation.

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Contact person: Mr. Henry Over
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h.over@q-sys.eu
www.q-sys.eu

RELIANCE PRECISION MECHATRONICS LLP. 147

Reliance is an independent, specialist engineering company, with over 50 years of experience in providing high-reliability, precision instrumentation to customers in a diverse range of markets. We provide custom-built electro-mechanical and high-vacuum sub-systems together with an extensive range of standard components.
The width of our products and services allows us to support our customers throughout the product life cycle: from initial design, into manufacture, through to end-of-life.

We are dedicated to delivering the highest standards, where accuracy, performance and reliability are critical, and to ensuring that our customers receive the very best value.

RELIANCE PRECISION MECHATRONICS LLP.
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Huddersfield HD8 OLE (UK)
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t +31 (0)76-5040790
jb@rpmechatronics.co.uk
www.rpmechatronics.co.uk

REITH LASER BV 114

For more than 20 years, Reith Laser b.v. is the leading supplier of laserprocessed products in Europe. By using completely automatic production processes, we are capable to produce just one piece, but also larger series.
You can find our products all over the world and even beyond…. With our extensive and modern laser equipment (15 laser installations), we can offer you a great diversity of laser material processing activities:
- Laser (micro) cutting
- Laser drilling
- Laser welding
- Laser engraving
- Laser micromachining

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

REITH LASER BV
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6604 LK WIJCHEN (NL)
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t +31 (0)24-3787564
info@reithlaser.nl
www.reithlaser.nl

RENISHAW BENELUX BV 164

Renishaw is world leader in the field of metrology and will show at the Precision Fair its recent innovations in encoder systems: RESOLUTE, a truely absolute encoder system with excellent dirt immunity and extensive redundancy in scale code. Immediately upon switch-on the absolute position is read from a single track optical scale without battery backup and with no need for reference returns. Outstanding positional stability is achieved by using new optics that read a fine pitch 30 micron scale with

low noise levels (10 nm RMS). This is the world's first absolute encoder with 27-bit resolution at 36,000 rpm. A resolution of 1 nm can be achieved at up to 100 m/s for both linear and angular.

RENISHAW BENELUX BV
Nikkelstraat 3, 4823 AE BREDA (NL)
Contact person:
Mr. Philippe Reinders Folmer
t +31 (0)76-5431100
benelux@renishaw.com
www.renishaw.nl

TECHNISCHE HANDELS-ONDERNEMING DE RIDDER BV 118

Submicron-machining demands experienced partners on the highest level. De Ridder THO is your "sparring partner" when you have to make things smaller and even more precise. Famous and reliable names like Sodick, Kugler and Schleifring stand for defining your process in the very best sub-micron machining configuration. De Ridder helps you realize the (almost) impossible.

TECHNISCHE HANDELSONDERNEMING DE RIDDER BV
Westerwerf 10,
1911 JA UITGEEST (NL)
Contact person: Mr. J. Wegman
t +31 (0)251-314450
wegman@ridder.net
www.ridder.net

ROELOFS MEETINSTRUMENTEN BV 126

Roelofs Meetinstrumenten has built a reputation as a sales organisation of measuring instruments, which are manufactured in the Netherlands, Germany, UK and Switzerland, for geometrical measuring techniques. We shall introduce the TR-Scan, manufactured by Trimos S.A., that will create undoubtedly the most remarkable changes in the field of non-contact measuring of surface structure. The exceptional high measuring speed coupled with an accuracy range of a nanometer form the main advantages of the TR-Scan.

This exceptional acquisition speed allows ignoring all problems traceable to vibrations, the traditional enemy of the majority of optical measuring systems.

ROELOFS MEETINSTRUMENTEN BV
Kernreactorstraat 42-44,
3903 LG VEENENDAAL (NL)
Contact person: Mr. Michel Roelofs
t +31 (0)318-521580
info@roelofsmeetinstrumenten.nl
www.roelofsmeetinstrumenten.nl

ROFIN-BAASEL BENELUX BV 45

Rofin is een vooraanstaande leverancier van industriële lasers en lasersystemen voor materiaalbewerking. Op onze stand zal een nieuw type laserlassysteem worden getoond. Met dit systeem kan zowel handmatig als ook m.b.v. CNC worden gelast. Ook zal er een nieuw lasermarkeersysteem worden voorgesteld (de zgn. CombiLine Cube met fiber laser). Naast bovenstaande zaken kunt u op onze stand o.a. terecht met vragen over laserlassen, -snijden, -perforeren, -structureren, -ableren, -herstellassen van matrijzen en kunststoflassen.

ROFIN-BAASEL BENELUX BV
Edisonweg 52,
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Contact person: Mr. Hans Matser
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info@rofin-baasel.nl
www.rofin.com

DE ROOY SLIJPCENTRUM BV 154

De Rooy Slijpcentrum (Grinding Centre), founded in 1939, has been a reliable supplier to a number of well-known industrial companies for many years. The company has developed the last decade into a centre of allround grinding and milling excellence.

Capabilities:
- Flat and profile grinding 7000 x 1750 x 1500 mm
- Surface grinding 6000 x 1400 x 500 mm
- Cylindrical grinding Ø 1000 x 4000 mm
- Internal grinding Ø 2000 x 1300 mm
- Milling 8000 x 2500 x 1000 mm

Further, De Rooy is specialized in delivery of complete precision components.

De Rooy's extensive, modern machine park offers a high level of both flexibility and precision. De Rooy Slijpcentrum quality control system conforms with – and is qualified by – TÜV-Nederland for ISO 9001:2000.

DE ROOY SLIJPCENTRUM BV
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info@rooy.nl
www.rooy.nl

ROMÉDES ENGINEERING BV 160

Romédes Engineering is an energetic company, which characterises itself by enthusiasm, drive and precision. The group of engineers is an energetic team of highly qualified and well-attuned specialists. Based on the question c.q problem definition, with a clearly defined process, Romedes will generate a resourceful solution. The realised projects consist of fast moving machines for precision engineering industries, assembly machines for electronics components, handling equipment for the medical and related industries. We show several fast moving machines that function with approx. 600 strokes per minute with a positioning accuracy within 10 µm. Real engineers should not let the opportunity pass by to get acquainted.

ROMÉDES ENGINEERING BV
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t +31 (0)544-356180
sales@romedes.nl
www.romedes.nl

SADECHAF UV & IR TECHNOLOGY 21

Sadechaf is a one-stop-house for high-tech adhesive applications. We always select possible types of adhesive with the demands of your project in mind. In the end, we will come up with an adhesive by which we can realize a joint that matches with all your requirements.
To reach this goal, we will use 2K epoxies as well as dual-cure systems or, when necessary, UV adhesives. If no suitable adhesive is available, our chemical know-how will permit us to design whatever adhesive your project needs.
By this approach, we can cover innumerable applications within the medical, electronics and automotive area.

SADECHAF UV & IR TECHNOLOGY
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B 2300 TURNHOUT (B)
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t +32-14411119
info@sadechaf.eu
www.sadechaf.eu

SARIX SA 177

Always at the leading edge of the highest micro-machining performance, SARIX offers a new machining concept, the 3D Micro EDM Milling.
Complexes cavities can be achieved down to real micro scale of 10 micron with accurate tolerance down to 1 micron within high surface finishing of R_a < 0.1.
SARIX designs, manufactures and markets highly efficient Micro-EDM equipment typically used in many industries, such as medical, die-making, microelectronics, automotive, aerospace as well as universities.
With its reliable machine concept, using all in one the Micro-Drilling and -Sinking and the EDM Milling, SARIX contributes to the development of new high-tech products from R&D to mass production reliability.

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SCHNEEBERGER GMBH 41

Schneeberger ontwikkelt en produceert lineaire geleiders, geleide-systemen en complete "turn-key" positioneersystemen/stages voor de high-tech markt. Dit voor diverse marktsegmenten en toepassingen in "reguliere" omgevingen, cleanroom- en vacuümomgevingen waar µm- en nanometernauwkeurigheid gevraagd wordt. Daarnaast worden er ook machine-bedden gegoten uit materiaal met zeer hoge dempende eigenschappen. Schneeberger is sterk global georiënteerd en heeft wereldwijd meerdere vestigingen en vertegenwoordigingen.

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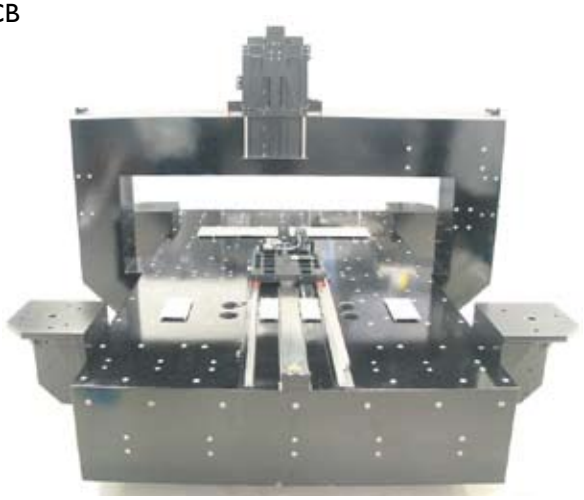
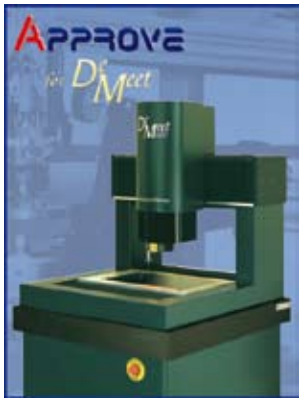


SCHUT GEOMETRISCHE MEETTECHNIEK BV 01



In addition to products from well known manufacturers like Sony Precision Technology (electronic scales, gauges and counters), TESA (measuring tools and gauge blocks), Witte (Alufix mounting systems), Peak (magnifiers and microscopes), LMW (thread gauges) and Schwenk (internal micrometers), Schut Geometrical Metrology offers an extensive range of measuring equipment in several price ranges. Other products from Schut Geometrical Metrology are the universal 3-D CNC co-ordinate measuring machines DeMeet-220, -400, -404, -443 and -705 in video and Multi-Sensor version and a new DeMeet-A7 in the touch probe version. SPC software Approve with interfaces to connect a range of instruments for automation of process, incoming and outgoing control.

SCHUT GEOMETRISCHE MEETTECHNIEK BV
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9700 GE GRONINGEN (NL)
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t +31 (0)50-5877877
schutnl@schut.com
www.schut.com

SCHUT PRECISIONPARTS BV 43

Schut PrecisionParts is a state-of-the-art subcontractor for mechanical parts and assemblies. We are specialised in precision machining, assembly and grinding.
Our company offers a fully conditioned production facility, high-tech machinery, a certified quality system and 3D measurement facilities. A combination of these high standards and services enables us to function as a reliable partner.

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info@schutprecisionparts.nl
www.schutprecisionparts.nl

SENTECH SENSOR TECHNOLOGY 142

Thinking about and acting on sensor applications is typical for Sentech Sensor Technology Ltd. The specialized trading company provides integrated sensor solutions that are tailored to the specific application situations of the client. In many cases, Sentech provides off-the-shelf sensors to which the assembled housing, the plug, the cable or connector have already been added. This product often contains ingenious all-sensor solutions to sensor questions that ask for a solution in client-specific situations. Sentech not only provides, Sentech advises, integrates and assembles.

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SKF BV 146

SKF Group is the leading global supplier of products, solutions and services within bearings, seals, mechatronics, services and lubrication systems. Services include technical support, maintenance services, condition monitoring and training. SKF is represented in over 130 countries and has has more than 100 manufacturing sites and also sales companies supported by 15,000 distributor locations. SKF groups its technologies in five platforms: Bearings and units, Seals, Mechatronics, Services, and Lubrication Systems. By utilizing capabilities of the platforms, SKF develops tailor-made offers for each customer segment, helping customers improve performance, reduce energy use and lower total costs, while bringing increased added value.

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www.nederland.skf.com

SMS STAMP TOOL & MOULD TECHNOLOGIES BV 42

SMS is part of the ART holding and provides a one-stop-shopping concept in stamp tool & mould technology and is the ideal partner for integrated solutions for metal, plastic combinations including handling and automations. SMS creates, coordinates and validates tailor-made solutions in dies from single cutting tools till complex progressive dies with ceramic components for mass production processes for high-production volumes. Within the ART concept we provide also high tech moulding solutions from proto typing till different types of 2/3k moulds. Services include the whole value added supply chain including spares, maintenance and emergency turnarounds in break down situations.

SMS STAMP TOOL & MOULD TECHNOLOGIES BV
Hermesstraat 8,
5047 TS TILBURG (NL)
Contact person:
Mr. Simon van den Berg
t +31 (0)13-5720550
sales@artooling.com
www.artooling.com

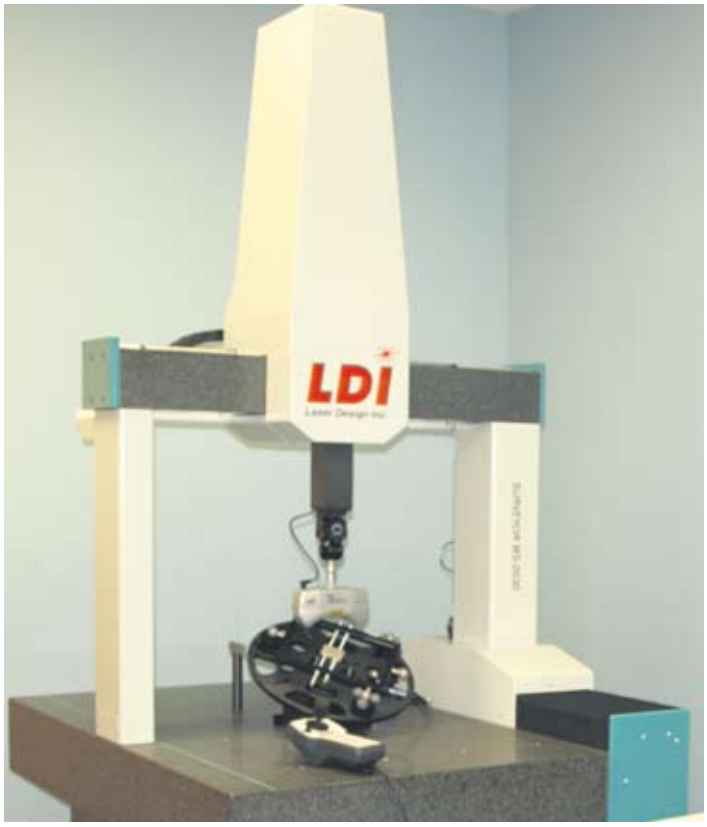
SMART MATERIALS & MORE 77

For almost everything you get help at Smart Materials & More. The most important condition is that Smart M&M can add value in the form of knowledge and service and can guarantee top quality. Only then the product fits in the concept of Smart M&M.

Smart M&M provides value added services. There are sufficient trade companies around, but you seek confidence, quality and flexibility. Smart M&M provides you with that in abundance, as large customers from the semiconductor industry, wafer industry and the academic world can confirm.
Smart M&M provides products and services on a broad scale, from PFA/PVDF materials to dosing pumps and from clothing for cleanrooms to innovative products for the medical line. And more.
Smart Materials & More, technical service bureau and more.

SMART MATERIALS & MORE
Kerkenbos 1020H,
6546 BA NIJMEGEN (NL)
Contact person: Mr. Joop Hendriks
t +31 (0)24-3734988
jhendriks@smart-mm.com
www.smart-mm.com

SOMATECH 3DT - MEMBER OF THE SOLVAGROEP 89



Somatech have nearly twenty five years experience as both a system supplier and integrator within the manufacturing industry. The Somatech team consists of over thirty professionals that support organisations manufacturing plastic, metal and wood products by delivering solutions and services. The company focus on four key areas: sheet metal, machining, rapid prototying and software development and integration with other business and engineering systems. Solutions are available for CAD, CAM, PLM, sheet metal, simulation, tool management, networking data systems and services such as consultancy, training, implementation and support. For Rapid Prototyping we provide a number of solutions from leading vendors for customers to generate their own models or we can offer a bureau service for 3D Printing and Rapid Prototyping / modelling.

SOMATECH 3DT - member of the Solvagroep
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aart.van.wijngaarden@somatech.nl
www.somatech.nl

SPORTS AND TECHNOLOGY 187

Sports & Technology and InnosportNL have bundled their strength to improve innovations in sport by taking the demands and needs of sport itself as its starting point. Sports & Technology has a local scope in Brabant where InnoSportNL has a national scope. But our goals are the same. We link the demands an needs of sport to trade and industry and knowledge institutes. Thanks to this unique combination of sport, trade and industry and knowledge institutes, we are able to translate knowledge and expertise into new methods and systems, innovative products and services and, in some cases, even into new activities. We want to challenge you to help us find a solution to several technical challenges in sport.

SPORTS AND TECHNOLOGY
Theo Koomenlaan 7,
5644 HZ EINDHOVEN (NL)
Contact person: Mr. Cees van Bladel
t +31 (0)40-2381464
bladel@sportsandtechnology.com
www.sportsandtechnology.com

SRR LASER- EN SNIJTECHNIEK 07

Leverancier voor de Benelux van o.a.: LASAG, FOBA, AlphaLaser, en Laserline.Tevens service aan – en installatie van – lasers en aanverwante systemen. Spare parts voor alle bekende lasersystemen. Vertegenwoordiger van UNIVET, leverancier van laserbrillen.

Supplier for the Benelux of laser systems from the following suppliers: Lasag, FOBA, AlphaLaser and Laserline. Service on and installation of lasers. Sales of spare parts for all well-known laser brands. Distributor of Univet, supplier of laser safety glasses.

SRR LASER- EN SNIJTECHNIEK
Wolvenburg 17,
2994 DK BARENDRECHT (NL)
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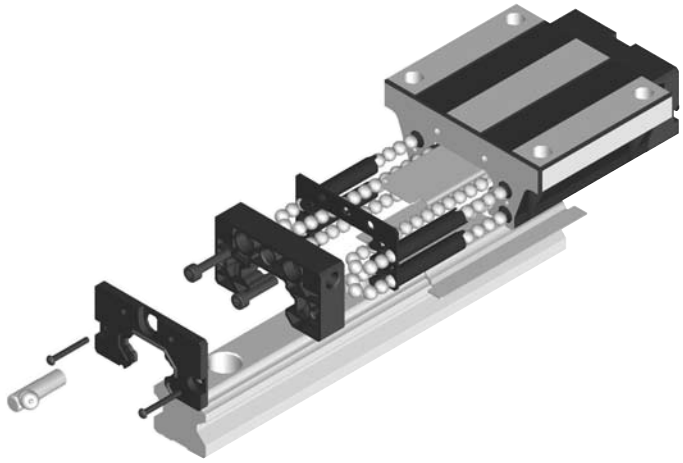
t +31 (0)6-22792925
frank@srr-laser.nl
www.srr-laser.nl

STAMHUIS LINEAIRTECHNIEK BV 173



The market in Linear Motion is moving rapidly. The machine builders are being challenged to achieve higher levels in precision, accuracy and speeds, in addition to maintaining good price levels. STAMHUIS Lineairtechniek continuously invests in people and is continually searching for the latest technical improvements in Linear Techniques. We claim that we offer the best innovative solutions at a good price ratio making your machines economical en environmentally friendly.

Please visit our booth, number 173, and see our latest products:

- Schneeberger Miniature Linear Guide ways integrated Measuring systems.
- SBI Ball Guide ways offering higher stiffness, better seals, unexcelled smooth running and less noise.
- Guide ways Ray-dent coated on demand.
- Ball Screws in Stainless Steel.
- Dynamic balancing module, to reduce vibrations, in collaboration with Delft University of Technology, Mr. Volkert van der Wijk MSc.

STAMHUIS LINEAIRTECHNIEK BV
Postbus 84, 7390 AB TWELLO (NL)
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t +31 (0)571-272010
info@stamhuislineair.nl
www.stamhuislineair.nl

STEEN METROLOGY SYSTEMS 37

SMS, sinds 1982, biedt een compleet programma in de geometrische meettechniek met bijbehorende service in eigen meetlaboratorium, volledig uitgerust met verschillende meetmachines uit haar verkoopprogramma. Op de Precisiebeurs zal er voornamelijk MicroVu Vision CMM & Taylor Hobson Form Talysurf Intra gepresenteerd worden.

STEEN METROLOGY SYSTEMS
Rue T. Gerkens 74,
B 4052 CHAUDFONTAINE (B)
Contact person: Mr. R. Steenacker
t +32-43687080
sales@smsbenelux.be
www.smsbenelux.be

STICHTING APPLIED PIËZO 70

- Creates new business in piezo actuators and sensors.
- Promotes piezo technology.
- Stimulates knowledge development and innovation.
- Provides a network where knowledge, expertise and products can be exchanged.

We make piezo work for you!

Todays industry can profit from the unique properties of piezo technology. Purpose-designed services based on advanced scientific knowledge and innovative technology aimed at the support of industry will translate the opportunities of piezo technology into existing and new products. Use of these unique qualities will open a world of unexploited possibilities and applications.

STICHTING APPLIED PIËZO
Postbus 42,
1520 AA ZAANSTAD (NL)
Contact person: Mr. R. de Vries
t +31 (0)74-2505907
info@applied-piezo.com
www.applied-piezo.com

ST INSTRUMENTS BV 123

ST Instruments is a company specialized in micro- and nanotechnology for surface analysis. Our product portfolio consists of a broad range of instruments in the field of profilometry, film thickness measurements, hardness, scratch and tribology testers, Atomic Force Microscopy, Surface analysis, 3D software for SEM etc. ST Instruments will present several optical profilometry technologies. The new Plu Neox combines confocal, interferometry and spectroscopy in a single instrument and the InfiniteFocus can measure samples 360°, for form, dimensions and surface parameters.

ST INSTRUMENTS BV
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3360 AA SLIEDRECHT (NL)
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t +31 (0)184-640000
info@stinstruments.com
www.stinstruments.com

STT PRODUCTS BV 181

STT Products develops and builds machines, appliances, auxiliary equipment and test equipment for manufacturing and production companies, laboratories and research institutes. Our range of products varies from simple tools and production machines to advanced production lines that are delivered as completely finished 'turnkey' systems. New products regularly developed by our customers will, as a result, also require the development of new and often faster machines to facilitate their production. STT introduced at the Precision Fair 2008 their own developed modular system System125®. This system offers engineers the possibility to build in short time and in a flexible way their own proto-types, test-equipment and measurement constructions.

STT PRODUCTS BV
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Contact person:
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t +31 (0)594-514445
info@sttproducts.nl
www.sttproducts.nl

TECHNEX BV 83

Technex is the specialist in high-precision instruments, advanced testing & analysis equipment for laboratories and industry. For more than 35 years, we are one of the most reliable partners (supplier of high tech equipment) for our customers and we have built up a customer database of > 1,250 companies, research institutes and universities in the Benelux. During the tradeshow we will present the following instruments: Hardness testers (AFFRI), Tensile/compression machine (Lloyd Instruments), Climate chamber (Binder), Melt Flow Indexer (CEAST), X-Ray Fluorescence Spectrometer (Skyray) and Thermal analysis equipment (Netzsch). For a long relationship with our customers, Technex has its own calibration and customer support department.

TECHNEX BV
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1521 NE WORMERVEER (NL)
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Mr. D.J. van der Meulen
t +31 (0)75-6474567
info@technex.nl
www.technex.nl

TECHNOBIS GROUP 86

Technobis Group is an international developer and supplier of high-tech instruments and modules for many dedicated OEM-companies in the Netherlands, Germany and USA.
Technobis Mechatronics, Uitgeest: this company is a specialist in carrying out complete development trajectories to come from an idea to a successful turnkey special product, prototype or series product. More then 12 years of experience has brought us to the level of being a supplier of mechatronic (sub)systems for many companies in various markets.
Technobis Fibre Technologies, Eindhoven: specialized in the development and supply of high-speed/multi-sensor fibre interrogator modules and sensors.

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TECHNOLOGY TWENTE BV 39

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www.technologytwente.nl

TETRA 36

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t +49-367786590
www.tetra-ilmenau.de

TEGEMA GROUP 139

The Tegema Group is a mechatronic engineering projects organization in the area of product and system development, production automation and company mechanization.
Tegema develops, innovates and realizes solutions for its customers in the broad market of high-tech systems, special machines and vehicle development. Tegema has a strong track record in product and system development, production automation and mechanization.

The Tegema Group has been your partner in the development and realization of complete solutions for more than 30 years.

TEGEMA GROUP
Science Park 5080,
5692 EA SON (NL)
Contact person:
Mr. Martin van Acht
t +31 (0)40-2677677
mvacht@tegema.nl
www.tegema.nl

TE LINTELO SYSTEMS BV 96

Te Lintelo Systems is specialized in sales and services in the field of optical, opto-electronical and laser components and systems. In this field we represent prominent suppliers for the Benelux. In cooperation with well-educated engineers with a long experience in optics, opto-electronics and mechanics, Te Lintelo Systems designs and produces custom-made systems as well.
We will demonstrate SIOS Laserinterferometric vibrometers, which are ideal for accurate, contactless determination of position changes of objects or surfaces.

TE LINTELO SYSTEMS BV
Postbus 45,
6900 AA ZEVENAAR (NL)
Contact person:
Mr. Ben te Lintelo
t +31 (0)316-340804
sales@tlsbv.nl
www.tlsbv.nl

TESA BENELUX 13+14

Tesa is a swiss manufacturer of precision measuring instruments since 1942 and has more than 5,000 instruments and systems in its delivery programme. At the 2009 edition of the Precision Fair they will show the new Multi Gage with the Reflex-software, known from their Micro Hite 3D CMMs. Also the Visio 200 with Tesavista and PCDMIS software + profile measurement with the Rugosurf 90 will be demonstrated.

TESA BENELUX
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Contact person: Mr. Pascal Siebens
t +31 (0)40-2220608
pascal.siebens@hexagonmetrology.com
www.tesabs.ch

TNO SCIENCE AND INDUSTRY 34

TNO Science and Industry is presenting its optomechanic and mechatronic activities at the Precision Fair 2009. TNO has years of experience and expertise in design and realization of high tech equipment. In this field we are a research and development partner for the Semicon, Medical, Space, Process and Manufacturing Industry. The picture below shows the GAIA AFMA setup as it was assembled at TNO. It is used during ground testing of the GAIA satellite and is able to rotate its 90 kg heavy SiC mirror with great stability and high accuracy.

TNO SCIENCE AND INDUSTRIE
Stieltjesweg 1, 2628 CK DELFT (NL)
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t +31 (0)15-2692458
tom.duivenvoorde@tno.nl
www.tno.nl

TOTAL SUPPORT BV / INNOTEQ 174

The core competence of the Total Support Group is technical knowhow with a focus on product design and mechanical engineering. The group consists of independently operating companies and employs approximately 120 people. The company executes turn-key technical projects, but also offers support on customer site. As a full-service partner the Total Support Group discusses new innovative product or mechanization ideas with its customers, proposes a design, industrialises the design proposal, manufactures prototypes and is able to bring the product into production. The group has a long and international experience in various market segments such as the medical market, the automotive market, the professional market and the food sector.

TOTAL SUPPORT BV / INNOTEQ
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Mr. F. van Stiphout
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f.vanstiphout@totalsupport.com
www.totalsupport.nl

TRIOS PRECISION ENGINEERING 112

TRIOS Precision Engineering is a mechanical engineering firm offering high-grade, durable solutions in product development, product innovation and machine building. TRIOS specializes in developing precision-engineered solutions that perform under extreme conditions suchs as high vacuum and cryogenic temperatures. Constructing these solutions with high-performance metals and fabrics had become one of TRIOS' core competences, as well as transport and handling under cleanroom conditions. Over many years, TRIOS has acquired experience in various industrial sectors, with applications for equipment in the semiconductor industry, medical equipment, the food industry and space travel.
TRIOS maintains a well-equipped production facility.

TRIOS PRECISION ENGINEERING
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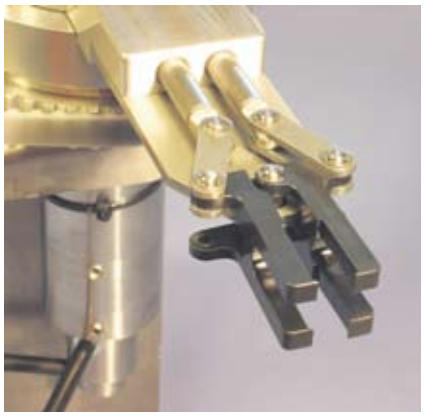
t +31 (0)545-280130
h.dijkstra@trios.nl
www.trios.nl



TRUMPF NEDERLAND BV 113

TRUMPF is a world leader in industrial lasers and laser system technology. TRUMPF laser technology encompasses CO_2 lasers, solid-state lasers, marking lasers, and laser systems.
It is difficult to find a manufacturing application that is not suitable for laser technology. Whether cutting, welding, marking, or forming – our wide spectrum of lasers and laser systems offers you a punctual, highly accurate solution.
The customers of our laser technology business field mainly come from the automotive industry and its suppliers, electronics and precision engineering, mechanical engineering, tool and mould making as well as medical technology.

TRUMPF NEDERLAND BV
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www.nl.trumpf.com

UTRECHT UNIVERSITY OF APPLIED SCIENCES 196

The Microsystems Technology/ Embedded Systems Research Group (MST), at the Utrecht University of Applied Sciences, concerns itself with the improvement and industrialisation of microsystems. Microsystems, often autonomous sensor systems for measuring the environment, are undergoing rapid development. There are, however, significant problems with the start-up and increase of the production. The sector concentrates on high-precision systems, and these are the most difficult to produce. The origin of the problems often lies in the product development process, which didn't take these challenging production technologies sufficiently into account in the past. By skimming through these, production drop-outs and a too low output (resulting in increased production costs) will occur. But mainly, project delays will occur when investments have already been made.

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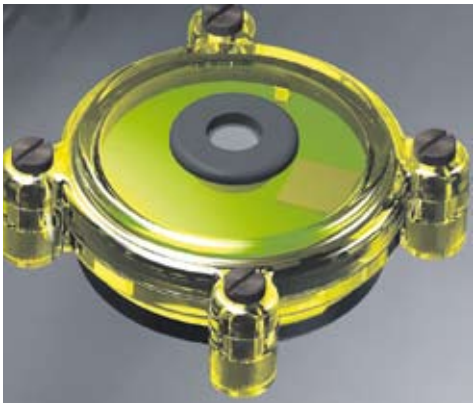

UST UMWELTSENSOR-TECHNIK GMBH 36

UST Umweltsensortechnik GmbH is a medium sized enterprise, recognised internationally as a leading company for development and production of ceramic sensor technology for gas and temperature measurement, successfully acting in the global market.

Product range:
- MOS gas sensors for CO, H_2, C_2H_5OH, CH_4, NO_2, O_3, NH_3, Hydrocarbons, refrigerants, VOCs, a. o.
- Platinum temperature sensor elements (Pt 10 … Pt 10000, -200°C to +1,000°C)
- Semi-finished temperature probes (-100°C to +1,000°C)
- Portable gas detectors for H_2, CO_2, CH_4, refrigerants (R134a), a. o.

Certifications: ISO/TS 16949:2002, DIN EN ISO 14001:2005, ATEX RL 94/9/EG Annex IV DIN EN 13980:2003.

UST UMWELTSENSOR-TECHNIK GMBH
Dieselstrasse 2,
D 98716 GESCHWENDA (G)
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o.kiesewetter@
umweltsensortechnik.de
www.umweltsensortechnik.de

VACUTECH BV 46

Vacutech has been creating high-quality technical solutions for a wide range of industries since 1982. We are a trusted and critical partner for the manufacture of precision-mechanical and vacuum products for industrial applications.
Vacutech employees are highly skilled and have flexible, state-of-the-art equipment at their disposal. In addition to our production department we have a specially equipped assembly department.
We produce, assemble, and test products, always in close consultation with our customers. We focus on professional and intensive collaboration, a process that is central to our philosophy. It makes us a partner you can talk to at your own level. Together we'll make it work!

VACUTECH BV
Polakweg 4a,
2288 GE RIJSWIJK ZH (NL)
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t +31 (0)70-3990390
jeroen.van.westing@vacutech.nl
www.vacutech.nl

VARIODRIVE AANDRIJF- EN BESTURINGS-TECHNIEK BV 120

Variodrive is specialist op het gebied van high-end Motion Control, waarbij het toeleverancier is voor de machinebouwers met besturingssystemen, servoregelaars, servomotoren, zowel lineair als roterend, tot complete actuators in het submicrometer-bereik. Alle berekeningen voor uiteindelijke bepaling van de juist in te zetten componenten behoort tot onze standaardwerkzaamheden.

VARIODRIVE AANDRIJF- EN BESTURINGSTECHNIEK BV
A. van Leeuwenhoekstraat 22,
3261 LT OUD-BEIJERLAND (NL)
Contact person:
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t +31 (0)186-636280
sales@variodrive.nl
www.variodrive.nl

VDMA MICRO TECHNOLOGY 06

The Micro Technology Association intends to analyse markets of specific importance, tap them jointly and use the VDMA network as a forum for a mutually beneficial dialogue between the players of the industry.
Industrial Sector Dialogues: The VDMA network is open for the members of the Micro Technology Association to come in contact with other industry sectors within VDMA.
Expert Groups: The industry sector dialogues becomes concrete, when experts meet to discuss questions about standardisation or process organisation.
Technology Roadmapping: The association will offer its membership technology road maps helping them to make the right choices to find their way into the future.

VDMA MICRO TECHNOLOGY
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t +49-6966031315
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www.vdma.org/microtechnology

VEECO INSTRUMENTS 24

Veeco is a leading provider of Metrology and Process Equipment. Our products are critical enabling instruments used in the advancement of scientific research, life sciences and nanotechnology.

- Wyko® NT9100 Optical Profiling System, the choice for Research and Low-Volume production.
- Dektak® 150 Surface Profiler, the industry's best-performance, best-repeatability, and largest standard scanning range.
- NEW VCM™ Optical Profiler System combines the latest in confocal technology and nanometer-scale height measurements with the ease-of-use of a conventional microscope.
- NEW NPFLEX™ 3D Metrology System provides the most flexible, non-contact 3D area surface characterization available on the market for large samples.

VEECO INSTRUMENTS
Verlengde Poolseweg 16,
4818 CL BREDA (NL)
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t +31 (0)76-5244850
jflach@veeco.com
www.veeco.com

VHE INDUSTRIAL AUTOMATION BV 18

vhe | Industrial automation

VHE Industrial automation is an acknowledged specialist in the field of machine controls. We design and build complete systems and modules and also represent a number of renowned producers of components for driving and controlling machines.

Our employees' technical knowledge and expertise guarantee inventive, innovative and cost-efficient solutions. Our key drive is boosting the success of our customers, because that is the best imaginable safeguard for continuity.

VHE INDUSTRIAL AUTOMATION BV
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VERNOOY VACUÜM ENGINEERING 04

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www.vernooybv.nl

VSL (PREVIOUSLY NMI VAN SWINDEN LABORATORIUM) 143

VSL (previously NMi Van Swinden Laboratorium) is the Dutch national metrology institute. As such, VSL is responsible for the national measurement standards in the Netherlands and for the development of new standards and measurement methods to support innovation in industry. VSL provides traceability to the International System of Units for industry and society, guaranteeing the reliability of measurement results. In this way, VSL makes an essential contribution to quality assurance, fair trade and technical innovation. At the Precision Fair we will present the services offered by VSL to the precision industry: calibrations, custom measurements, development of customer-specific measurement solutions, metrological consultancy, and training.

VSL (previously NMi Van Swinden Laboratorium)
Thijsseweg 11, 2629 JA DELFT (NL)
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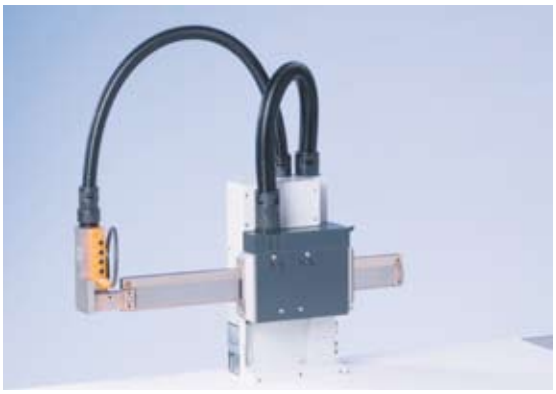
Mr. Marijn van Veghel
t +31 (0)15-2691500
vsl@vsl.nl
www.vsl.nl

WEISS NEDERLAND BV 82

We are an innovative company that has been very successful in manufacturing modules for assembly machinery for more than forty years. Optimum technical advice and consultation ensures that our products are used to maximum efficiency in your systems.



At the Precision Fair we show our latest developments concerning direct drives:

- pick&place system HP140T with highly dynamic linear motor drive, freely programmable in the Y and Z-direction;
- freely programmable, highly dynamic linear motor axes HN;
- freely programmable, highly dynamic rotating units TO, ST and SW
- linear parts transport LS280, a modular linear assembly system with tried and tested cam drive.

WEISS NEDERLAND BV
Kruisstraat 4,
7573 GJ OLDENZAAL (NL)
Contact person: Mr. Marcel Klieverik
t +31 (0)541-853524
info@weiss.nl
www.weiss.nl

WENZEL-BENELUX BV 107

To measure or not to measure! Measurement is the basis to ensure quality and improvement! People readily demand high accuracy of an instrument, but they forget that knowledge of reading drawings, form and position tolerances, roughness values, measurement strategies, etc. have a huge impact on the final accuracy of the measurement process. Therefore, Wenzel-Benelux is your partner not only for geometrical instruments but also for the entire implementation within your company. Measuring instruments alone do not ensure and improve your quality. With Wenzel-Benelux you have a partner who will listen and think with you, give advice, training and education. Wenzel-Benelux wants to be your "Quality Keeper", your partner for many years in the measurement technique. Challenge us and let our knowledge work to your advantage!

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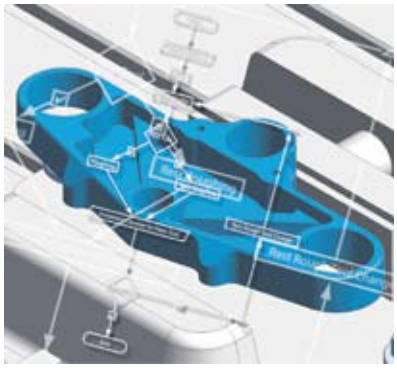
www.wenzel-benelux.com

WIDENHORN INDUSTRIËLE AUTOMATISERING BV 78

Widenhorn is already more than 25 years active as a supplier of CADCAM & DNC / Machine Monitoring. The activities of Widenhorn have a big variety with one specific goal, to make its customers more successful than their competitors, with advanced software solutions, professional education and excellent support. To give you an idea, below some of our activities:

- CADCAM Consultancy
- CADCAM Workshops
- High-end CADCAM Implementation
- CADCAM & CNC training
- Customer-specific software solutions
- Helpdesk
- NC-programming



Our main CADCAM products are:

- Edgecam
- SpaceClaim
- Seiki Systems
- Partmaker
- JETCAM
- PROfirst
- AutoPOL

WIDENHORN INDUSTRIËLE AUTOMATISERING BV
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3161 GD RHOON (NL)
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t +31 (0)10-5013277
info@wia.nl
www.wia.nl

WILTING COMPONENTS BV / WILTING MODULES BV 19

Als partner van de high-tech industrie produceert Wilting Components BV onderdelen in kleine en middelgrote series. Wilting Components heeft haar processen daarbij vergaand ingericht op "24/7-productie". Wilting Modules BV richt zich op schone montage van fijnmechanische onderdelen en het organiseren van de bijbehorende logistieke en inkoopactiviteiten. Wilting Modules heeft hiertoe de beschikking over een moderne cleanroom.

WILTING COMPONENTS BV / WILTING MODULES BV
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Booth: 91

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Precision Electro Chemical Machining (P-ECM) Process Research

Booth: 12

Technology

BrainCenter has a Process Engineering group with the competences and capabilities for performing P-ECM process investigations. P-ECM is mainly applied in serial and mass production of precision components. In early stages of innovation projects in that application field fact based data is needed in choosing manufacturing technologies. BrainCenter can give support to customers in that selection procedure by carrying out feasibility studies and producing test series. With such studies and in close cooperation with customers process settings, tooling design and sometimes even product design are optimized for the best results regarding product specifications, investments and operational costs.

Benefits

- Detailed insight in benefits and costs of the P-ECM process at an early stage of innovation projects.
- Sharing BrainCenter know how with customers regarding process knowledge for optimum results regarding tooling design, equipment engineering, costs and process quality
- Available process research facilities enable quick and accurate feasibility studies

Product Applications

- P-ECM process optimization
- tooling design
- fundamental material research

More information about P-ECM research

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Precision in Performance

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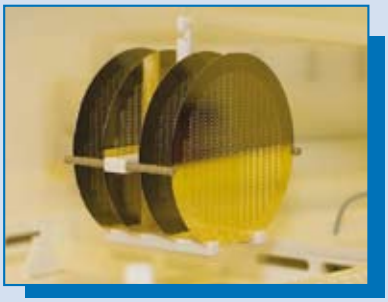

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ETCHFORM

Laser 2000 Benelux introduces a specialised manufacturer of direct driven motor stages in the Benelux

Booth: 138 + 162

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This type of linear motion is directly reproduced by the electromagnetic transducer without mechanical transmission. Exactly this determines the reliability and durability of the machines of Ruchservomotor. This also guarantees stable and high accuracy as well as stable and high dynamic characteristics during intensive usage for a long period of time. The modular construc-tion and absence of a mechanical transmission allows for creating precision multicoordinate systems, that guarantee moving of objects on a trajectory of any complexity with high dynamics as well as high accuracy at the same time.

Amongst the realized systems are one- and multi-coordinate systems, and special precise systems according to customer's requirements.

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Applications:
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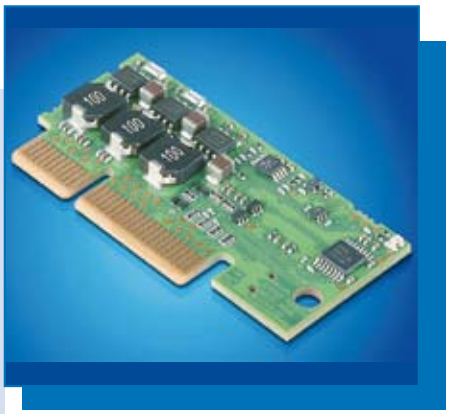
LASER 2000

maxon motor benelux at Precisiebeurs 2009

Booth: 92



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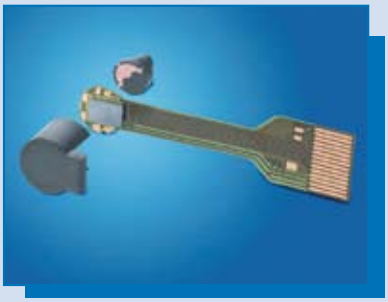

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