Mikroniek

PROFESSIONAL JOURNAL ON PRECISION ENGINEERING 2010 (VOL. 50) – ISSUE 1

Volume 50

Improving micro-milling technology • DSPE's certification programme
2009 Precision Fair report • Micro-EDM crosses barriers in structuring ceramics
KETEN high-tech joint venture • Awards for precision engineering talent
Closing the successful IOP programme • High-tech roadmapping • MEMSland

DSPE

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

arcanol
Fraunhofer
TESTED
DEVICE
IPA

Mikroniek - 2010

In this issue

Publication information

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

Publisher
DSPE
PO Box 359
5600 AJ Eindhoven, The Netherlands
Telefoon +31 (0)40 – 296 99 11
Telefax +31 (0)40 – 296 99 10
E-mail info@dspe.nl

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

Editor
Hans van Eerden
E-mail hans.vaneerden@dspe.nl

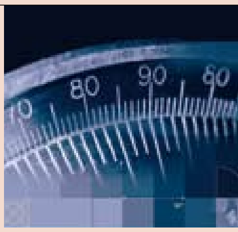
Advertising canvasser
Sales & Services
PO Box 2317
1620 EH Hoorn, The Netherlands
Telephone +31 (0)229 – 211 211
E-mail sns@wxs.nl

Design and realisation
Twin Media bv
PO Box 317
4100 AH Culemborg, The Netherlands
Telephone +31 (0)345 – 470 500
Fax +31 (0)345 – 470 570
E-mail info@twinmediabv.nl

Mikroniek appears six times a year.

ISSN 0026-3699

The cover photo (three-dimensional micro-EDM milling of a turbine impeller) is courtesy PMA division, Department of Mechanical Engineering, K.U.Leuven.



editorial

Ten years of precision engineering research

The Innovation-oriented Research Programme (Dutch abbreviation, IOP) Precision Engineering has ended. In the years 1997-1998, the then executive committee of DSPE asked the Dutch Ministry of Economic Affairs to initiate this programme. The request was honoured after some lobbying work, and it started in 1999. The overall objective of this IOP was to further precision engineering by stimulating the optimum coordination of public R&D to the long-term needs of industry, and by strengthening cooperation between universities and public research institutes, on the one hand, and large and small industrial companies, on the other.

A lot has happened since then. Of course, IOP cannot be credited for all changes; the 'arrow of time' has its own dynamics. However, it appeared that the profession of precision engineering is highly regarded by industrial companies. This was shown by the participation in industrial committees that closely monitored each of the 28 research projects initiated by IOP. On average, ten industrial engineers actively took part in each committee meeting.
A roadmapping activity in 2003 elucidated the industry's technical and organisational problems. It set off the establishment of a new network comprising technical managers of the companies involved. This network was further extended when IOP promoted the idea that the high-tech systems industry is a key asset for the Dutch economy. The Dutch government accepted this view in late 2004.

International developments now prompt many OEM companies to outsource the production of parts and components to Asian countries. This is a dubious trend, as these countries may, in the course of time, swallow engineering, development and the rest of the business as well. Therefore, through Point-One the government now actively supports concerted actions to further new OEMs, which base their business in new markets and make use of the available skills of Dutch suppliers to the high-tech systems industry, the 'masters of manufacturing'. It is the goal of these suppliers to invest further in their present strengths: precision engineering know-how, the ability to co-develop dedicated components and sub-modules with existing OEMs, and manufacturing experience. It is in their interest to actively build on existing networks with public R&D in mechatronic design and in manufacturing engineering.

DSPE and Point-One support these interests by initiating a new roadmapping effort. Please carry on and good luck with everything!

Lou Hulst
Chairman IOP Precision Engineering, 1999-2009,
and honorary DSPE member

A MILESTONE for Mikroniek

For almost fifty years, Mikroniek has featured articles on precision mechanics, precision technology and (in the last two decades) mechatronics. 2010 will see the 50th volume of Mikroniek and this milestone will be given extra prestige by a first for the magazine. The current volume is the first to be published entirely in English. For Mikroniek's publisher, the Dutch Society for Precision Engineering (DSPE), this represents a new step towards achieving its ambitions, namely the enhancement of the precision engineering & mechatronics community in the Netherlands and the propagation of Dutch precision engineering and mechatronics abroad.

Fine mechanics, precision engineering and mechatronics are seen as strengths in education, research and industry in the Netherlands. The Nederlandse Vereniging voor Precisie Technologie – which started operating under the name Dutch Society for Precision Engineering (DSPE) recently – has been thriving on these strengths for 55 years now. However, the field cannot escape advancing internationalisation and globalisation. Dutch companies – large OEMs and smaller suppliers alike – operate in a global market, with sales, purchasing and production branches in regions such as Eastern Europe or Southeast Asia. At the same time, ever more foreign knowledge workers are coming to the Netherlands to work at universities and companies. As a result, English is increasingly being used as the language in our field, also in the Netherlands.

For Mikroniek, this development is relevant for a number of reasons. Firstly, there are many (potential) readers in the Netherlands who cannot read Dutch and who could not, until recently, understand the magazine, even though it is richly illustrated. Another equally important point is the fact that there are an increasing number of (potential) authors working in the Netherlands who are English speaking. Of course, their contribution could always be translated into Dutch, but this would increase costs and limit the scope of their articles. Conversely, translation costs from Dutch to English are limited given that many Dutch authors write in English because, for example, they already publish in international (scientific) journals anyway.

In short, there are many reasons for Mikroniek to switch from Dutch to English. Individual English issues published in 2008 and 2009, for the international Summer schools organised by DSPE for example, were enthusiastically received. In both the Netherlands and abroad, circulation is increasing and agreements have already been reached with various organisations, including euspen, concerning distribution in Europe. Naturally, there are also negative aspects. An element of the specific Dutch character will be lost and there are readers for whom English will be an obstacle. Taking everything into account, however, the DSPE board has decided, after consulting with the members, to switch to a fully English Mikroniek (six issues a year). Bring on the next milestone.

Towards industrial

Micro-milling is an attractive technology for manufacturing micro-components. To enable its industrial application, some technical hurdles need to be taken. In this article, two important issues are addressed. First, a significant improvement in tool life is discussed, which was obtained by redesigning the geometry of the micro-endmill. Second, a solution for cutting force estimation is presented that uses the available signal information in active magnetic bearings. Using this cutting force information, tool failure can be detected and tool condition can be monitored.

• *Rogier Blom, Peiyuan Li, Hans Langen, André Hoogstrate, Han Oosterling, Paul Van den Hof and Rob Munnig Schmidt* •

The ongoing trend of miniaturization has led researchers to explore different ways to manufacture components in the micro-scale accurately and cost-efficiently. With continuous developments of high-precision machine tools, unit chip removal in the (sub-) micrometer range has become possible. This has triggered great interests among research institutes and industries, both worldwide and in the Netherlands, to investigate the feasibility to scale down conventional mechanical chip removal processes, such as milling.

Introduction

At first sight, the mechanics of micro-milling appear similar to those of macro-scale milling: material removal happens through the interaction between a rotating micro-endmill and a workpiece, where the milling tool tip traces a predefined contour along the workpiece through coordinated motion of the axes of the machine tool. The typical cutting diameter of commercial micro-endmills is in the range of 50-500 μm. Compared with currently used micro-fabrication processes, such as etching, LIGA (Lithography, Electroplating, Moulding), and micro-EDM (see the article in this issue), micro-milling offers many advantages, such as fast material removal rate and the ability to manufacture parts with true 3D features in a broad range of workpiece materials, including hardened tool steels. One of its potential applications is to make micro-moulds for mass replication of micro-parts by injection moulding.

However, micro-milling has shown some special characteristics that are fundamentally different from conventional milling due to the scaling effect. For example, when the chip thickness is in the same order of magnitude as the edge radius of the cutting tool, the cutting edge can not be assumed to be sharp anymore. The effect is that at the micro-scale it appears that the cutting takes place with a rather blunt tool. This causes the cutting mechanism to be rather different than at the macro-scale. Additionally, with chip sizes in the micrometer range, small disturbances (e.g. due to mass imbalance, or machine vibrations) have a significant influence on the cutting process. At this stage, these issues are not sufficiently understood and more research on micro-milling is required before it can be introduced in an industrial setting.

Scope

In this article two factors are addressed that may accelerate industrial application of micro-milling. The first concerns the lifetime of micro-tools. It is observed that the tool life of currently available commercial micro-endmills is too short to conduct a reliable cut, especially in hard milling applications. With these endmills, tool wear is severe, and catastrophic tool breakage is high. The research question that will be addressed first is how tool life of micro-tools can be extended, in particular by redesign of the tool geometry.

The second issue concerns the monitoring and control of the micro-milling process. To improve the micro-milling process, online process monitoring and control becomes of high importance. Due to reduced tool diameters, signs of problems are almost unnoticeable without the use of special equipment. Techniques are needed to detect and possibly even predict anomalies in the process, and to monitor online the condition of the cutting process. This information is then to be used to optimize the cutting process in a closed-loop control setting. It appears that milling spindles with active magnetic bearings (AMBs) are particularly interesting for development of such monitoring techniques [1]. It will be discussed how the cutting forces can be estimated using available sensor signal information from the AMBs.

Finally, an outlook is provided on both the tool-life improvement and the cutting force monitoring with AMB spindles, and it is discussed how effective monitoring and control can further extend the tool life of micro-endmills.

Improving micro-endmill tool life

In order to get a better understanding of the micro-milling process, some preliminary experiments were conducted with commercial Ø 0.5 mm 2-flute square endmills, as shown in Figure 1 [2]. All the endmills were TiAlN coated and the substrate material was ultra-fine grain tungsten carbide. The workpiece materials were hardened tool steels (such as SAE H11, H13, and D2, up to 56 HRC), which are commonly used in dies and moulds industries. The Fehlmann Picomax 60 HSC and Kern EVO were used as machine tools.

The tests showed that the tested micro-endmills suffered from severe tool wear at the cutting edge corners. As a result, the lifetime of micro-tools was shortened severely. A typical worn tool is shown in Figures 2a and 2b. It was observed that the dominant tool wear type was the breakage of cutting edge corners. Figure 2c shows the progress of tool wear. At the beginning of the machining (200 mm slot milling), a sudden change in the cutting diameter was observed, which was due to breakage of cutting edge corners. Afterwards, the reduction of tool

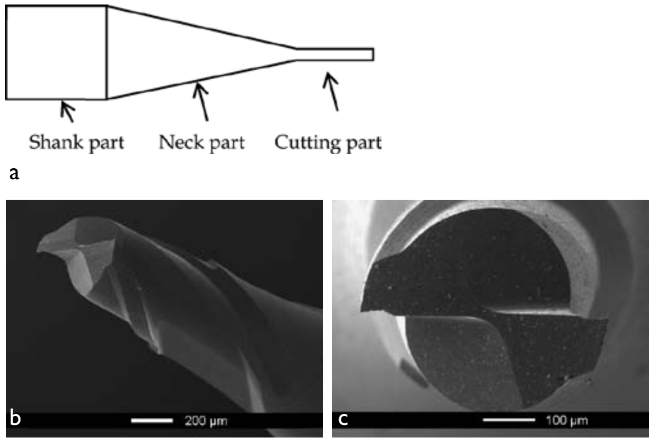


Figure 1. Geometry of a micro square endmill.
(a) Illustration of the global geometry.
(b) 3D view of the cutting part.
(c) Top view of the cutting part of a Ø 0.5 mm square endmill.

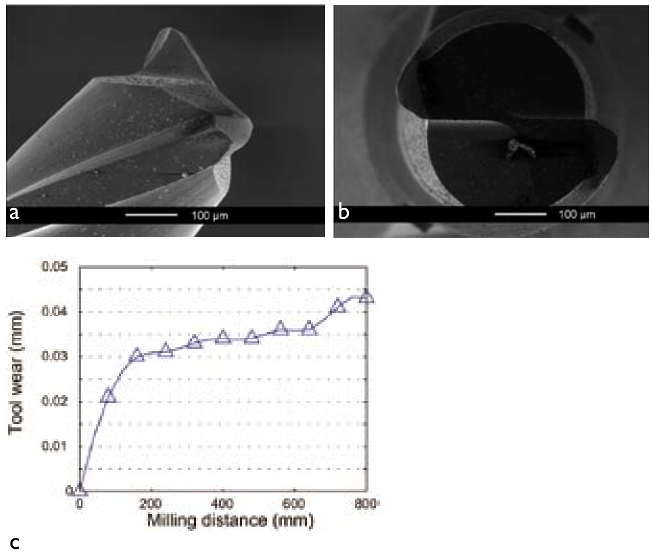


Figure 2. Wear of tested commercial Ø 0.5 square endmills.
(a) 3D view.
(b) Top view of the cutting part of a worn tool.
(c) Tool wear curve; tool wear was evaluated as reduction of the cutting diameter at the endface of the tool.

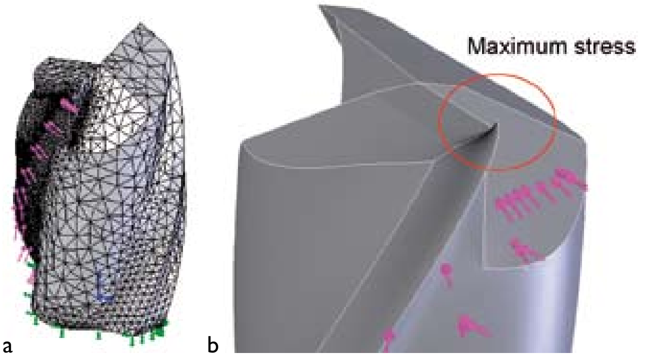


Figure 3. Study of tool geometry by FEM.
(a) CAD drawing of the cutting part of the commercial tool geometry.
(b) Stress distribution at the cutting edge corner.

diameter became gradual, which can be attributed to abrasion. This figure shows that in order to improve tool life, the breakage of cutting edge corners at the early stage of machining should be prevented.

The failure of micro-endmills can be attributed to many aspects, such as the quality of micro-cutting tools, workpiece properties, selection of machining parameters and tool paths, and performance of machine tools. Among these factors, the geometry of micro-endmills plays an important role since it directly influences the interaction between cutting tool and workpiece. Unlike in macro-scale milling, in micro-milling the cutting is mainly done by the cutting edge corners due to the small depth of cut. To study the effect of this, FEM analysis (finite element method) was performed on the geometry of tested commercial micro-endmills; see Figure 3. Under simulated cutting conditions, it was found that with this geometry the maximum stress in the tool tip is located at the cutting edge corners, as shown in Figure 3b. When this stress is higher than the transverse rupture strength of tungsten carbide, the cutting edge corners will break away, as observed in experiments.

This analysis was used as starting point to extend the tool life [3]. The main objective was to modify the geometry of the micro-endmills such as to improve the strength of the cutting edge corners. In order to achieve this target, the relationship between tool geometrical features (such as rake angle, relief angle, etc.) and tool performance (such as stress distribution along the tool and tool stiffness) should be understood. This was done by means of analytical modeling and FEM analysis. Having gained insight in this relationship, the geometry of the micro-endmill could be designed adaptively to achieve the required performance. Two new geometries were proposed to improve micro-tool performance. The CAD drawings of the cutting part of the newly-designed micro square endmills are shown in

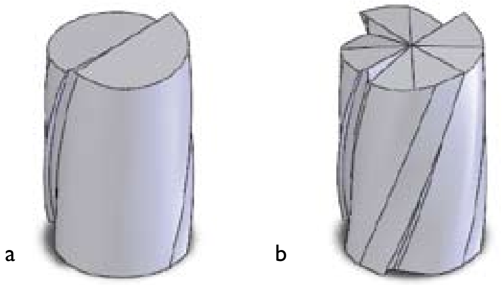


Figure 4. Cutting part of newly-designed micro-endmills.
(a) 2-flute endmill.
(b) 4-flute endmill.

Figure 4. Compared with the commercial tool geometry, the new designs have improved strength of cutting edges which makes them suitable for hard milling. Besides, the new geometries are relatively simple, making them easy to manufacture.

The new designs were manufactured and verified through experiments in comparison with commercial micro-endmills. The results show that tool life improved significantly when using the new designs, as shown in Figures 5a and 5b. Besides, since the wear of the newly-designed endmills reduced, the workpiece quality also improved accordingly, in terms of form accuracy and burr formation, as shown in Figures 5c and 5d.

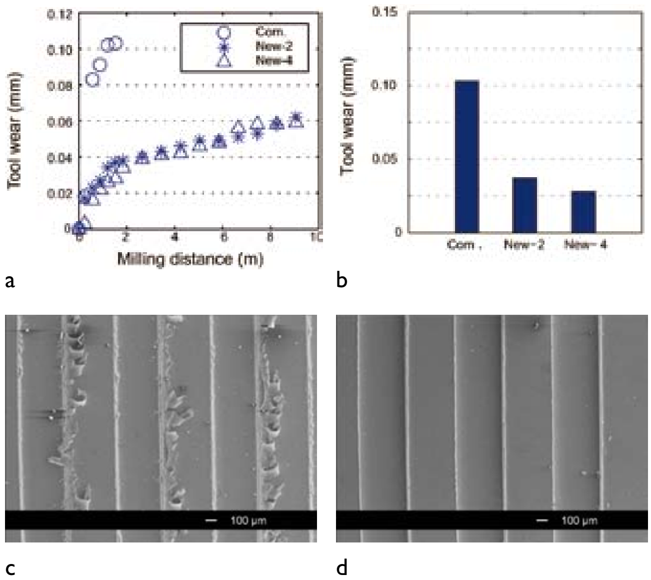


Figure 5. Results of experimental validation of new tool designs in comparison with commercial tools.
(a) Tool wear comparison after material removal of 5.3 mm^3.
(b) Comparison of milling distance.
(c) Top view of milled grooves by the commercial tool; burr formation was a serious problem.
(d) Top view of milled grooves by the newly-designed tool.

However, it was also realized in the research that the improvement of tool performance by only tool geometry is limited. As discussed earlier in this paper, the performance of micro-endmills is influenced by many factors. In order to achieve a reliable micro-milling process, efforts should also be made in other aspects such as process monitoring.

Force estimation

More than in conventional milling, it is important in micro-milling to monitor the cutting forces during machining in order to maintain a stable cutting process. These forces can be measured directly with force transducers, however commercially available systems are limited by their bandwidth and the additional space needed in the machine.

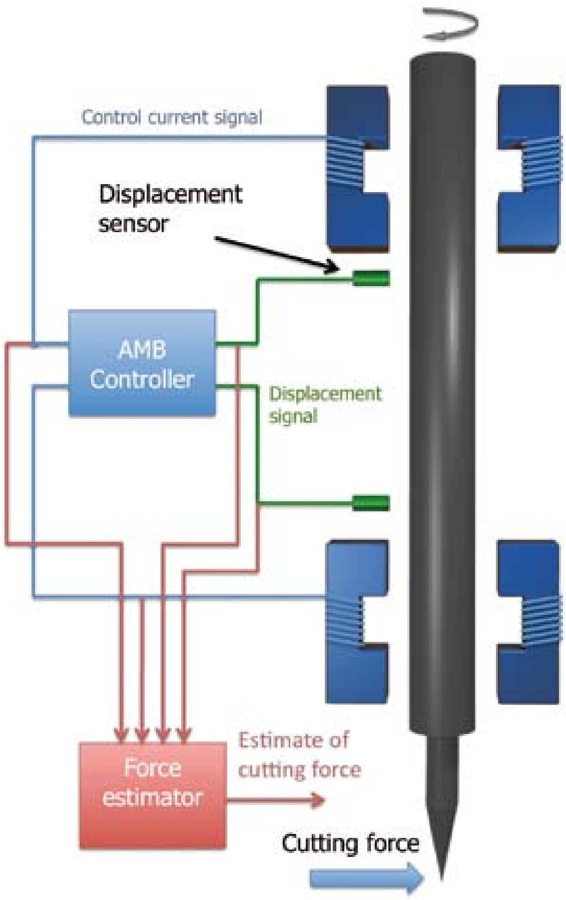


Figure 6. Schematic illustrating the concept of cutting force estimation with an AMB spindle. Cutting forces acting on the tip of the endmill can be estimated from the closed-loop current and displacement signals of the magnetic bearings.

When the milling is performed by a spindle with AMBs (active magnetic bearings), the active nature of the bearings can be employed to observe the cutting forces from the signals of the bearings. In AMB spindles, the rotor is levitated by generating electromagnetic forces at the front and rear side of the rotor, as well as in the axial direction; see Figure 6. A stable system is obtained by using position measurements in a closed loop to control the currents of the electromagnets. Force estimation based on the current and position signals is attractive, as it eliminates the need for additional sensors, thus saving cost and space.

The problem of observing cutting forces from the signals of an AMB spindle can be considered an input estimation problem. This can be seen as follows. Modeling the open-loop AMB spindle dynamics as G and the controller as K, it follows that the cutting forces constitute an unknown input to a partially closed-loop dynamical system; see Figure 7. Measurements are available of the currents through the coils (denoted by y_1) and the displacement of the rotor (denoted by y_2). Having these available, the objective is to estimate the unknown input u_2, representing the cutting forces.

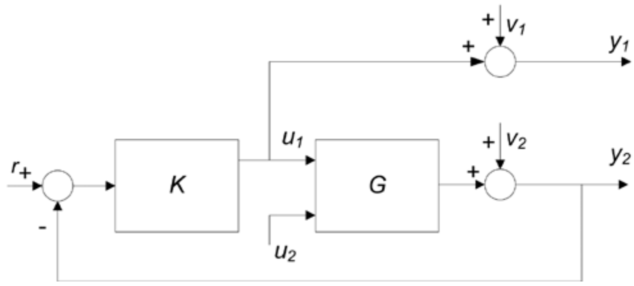


Figure 7. Block diagram of the closed-loop AMB spindle system. Cutting force estimation can be formulated as an input estimation problem, where the forces are the unknown input u_2 to a partially closed-loop system consisting of the AMB spindle dynamics G and controller K.

Optimal estimates $\hat{u}_2$ can be obtained by minimizing the mean square error $E\|\hat{u}_2(t) - u_2(t - N)\|^2$, where $N \geq 0$ is some fixed time lag. When the unknown input sequence is treated as white noise filtered by known dynamics, the optimal estimator will have a Wiener filter structure. The adjustable delay N allows to trade-off the estimation error against the lag in the estimation results [4].

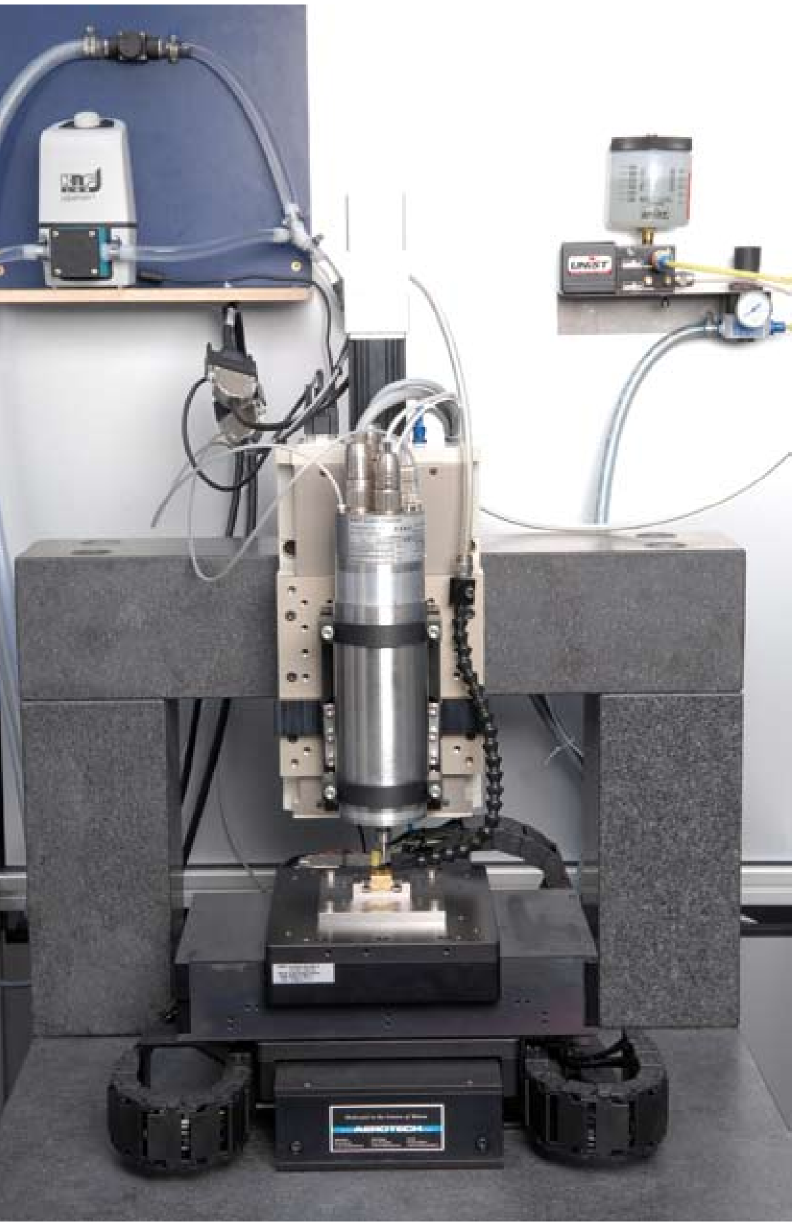


Figure 8. Micro-milling setup at Delft University of Technology, with an AMB spindle with max. rotational speed of 120,000 rpm.

In a simulation study, this concept is demonstrated by modeling of the AMB spindle in our lab; see Figure 8. This is a state-of-the-art AMB spindle from EAAT GmbH Chemnitz (Elektrische Automatiserungs- und Antriebstechniek), with a relatively high maximum rotational speed of 120,000 rpm. The rotor length is 250 mm and the rotor mass is 1.1 kg. The displacement sensors used in the bearings have a resolution of 0.1 μm. The AMB controller hardware also provides measurements of the currents through the coils with an accuracy of 1 mA. The magnetic bearings are controlled by analog PID controllers.

An analysis of the properties of the resulting force estimator reveals that the maximum estimation bandwidth that can be achieved with this spindle is 1.8 kHz. The resolution is 0.17 N. These numbers are dependent on the properties of the AMB spindle, and are found to improve when reducing the AMB spindle dimensions [5]. A time-domain simulation result is depicted in Figure 9. A known cutting force is applied to the AMB spindle, and current and displacement signals of all four radial bearings are used to estimate the cutting forces in X and Y direction. This figure, showing the result only in Y direction, illustrates the favorable results of the presented approach. Practical implementation of this approach hinges on the availability of a reliable model of the dynamics of the AMB spindle. Currently ongoing research is to obtain such model by system identification from measured data sequences.

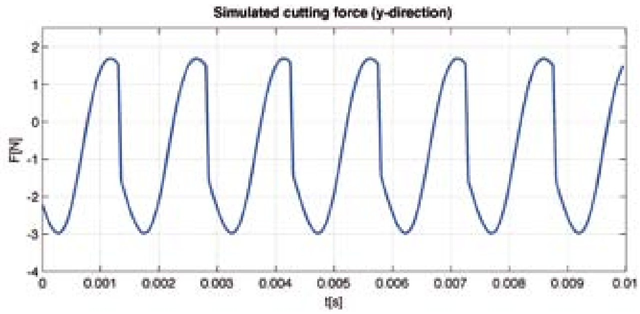
Force-based tool condition monitoring

In micro-milling, condition monitoring of the tool plays an important role to improve the reliability of the process. First, detection of tool failure is challenging due to the small cutting edge diameter and untimely detection of failure can cause damage to the workpiece and hours of work to be wasted. Second, monitoring of the wear status of the tool is important to maintain the quality of the workpiece and to avoid breakage due to progressed tool wear.

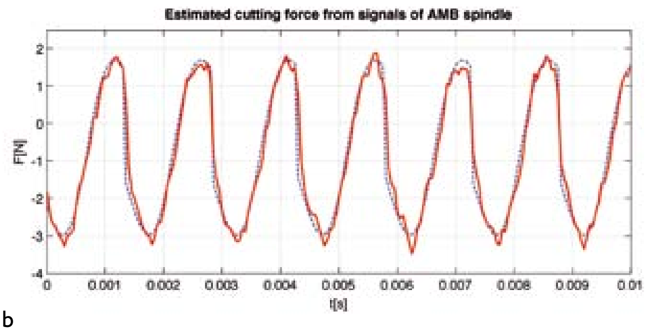
Cutting force information is essential for development of tool-condition monitor techniques. The above presented cutting force estimation approach is very suited to be utilized for this purpose and therefore offers opportunities to further improve tool life and performance of the micro-milling process.

Conclusion

Micro-milling is an attractive technology for manufacturing of miniature components, but additional research on different aspects of the process is needed to enable industrial application. Design of micro-endmill geometry needs to be driven by understanding of the micro-milling process. It was shown that this implied for hard milling applications that the cutting edge corners needed to be strengthened. Experiments demonstrated that newly-designed tools had significantly improved tool life. Monitoring of the cutting forces during milling can be achieved by employing the active character of spindles with active magnetic bearings. It was shown that forces can be estimated from the current and displacement signals of



a



b

Figure 9. Simulation results of cutting force estimation from the signals of the AMB spindle. Results are only shown for one direction.
(a) Simulated cutting force signal.
(b) Estimated cutting force.

the AMBs with sufficient bandwidth and accuracy. This offers opportunities to directly improve the reliability of the process.
These results may contribute to industrial application of the micro-milling process. Further research at Delft University of Technology and TNO Science and Industry is being undertaken.

Acknowledgement

This research is being conducted in cooperation between Delft University of Technology and TNO Science and Industry, and is supported by the Innovation-oriented Research Programme (IOP) Precision Engineering, MicroNed, and the Delft Centre of Mechatronics and Microsystems (DCMM). The authors wish to gratefully acknowledge Van Hoorn Carbide, the Netherlands, for the help in manufacturing the newly-designed endmills.

Authors' note

Rogier Blom is a Ph.D. candidate within the departments of Precision and Microsystems Engineering (PME) and Delft Center for Systems and Control (DCSC) of Delft University of Technology, the Netherlands. His research is on process monitoring and control of micro-milling using active magnetic bearing spindles. Peiyuan Li obtained his Ph.D. in micro-manufacturing technology in October 2009 within the PME department [2]. Hans Langen is associate professor in the PME department, Rob Munnig Schmidt is full professor in the same department. Paul Van den Hof is full professor in the DCSC department. Han Oosterling is senior scientist at TNO Science and Industry, Eindhoven, the Netherlands. André Hoogstrate is innovator and works in the same department of TNO.

References

[1] R.S. Blom, P. Li, H.H. Langen, P.M.J. Van den Hof, R.H. Munnig Schmidt, Micro-milling with Active Magnetic Bearing Spindles, Proc. of the Euspen Int. conf., Zürich, 2008, 526-529.
[2] P. Li, Micro-milling of hardened tool steels, Ph.D. thesis, TU Delft, 2009.
[3] P. Li, A.M. Hoogstrate, J.A.J. Oosterling, H.H. Langen, R.H. Munnig Schmidt, Experimental validation of micro endmill design for hard milling application, CIRP 3rd International Conference High Performance Cutting, Dublin, Ireland, 2008, 69-78.
[4] R.S. Blom, P.M.J. Van den Hof, Estimating Cutting Forces in Micro-milling by Input Estimation from Closed-loop Data, Proc. 17th IFAC World Congress, 2008, Seoul, South Korea, 468-473.
[5] R.S. Blom, M.H. Kimman, H.H. Langen, P.M.J. Van den Hof, R.H. Munnig Schmidt, Effect of miniaturization of Magnetic Bearing Spindles for micro-milling on actuation and sensing bandwidths, Proc. of the Euspen Int. conf., Zürich, 2008, 155-159.

Information

www.pme.tudelft.nl
r.s.blom@tudelft.nl

A real networking

The 2009 Precision Fair (Precisiebeurs) was the ninth in a series of successful yearly happenings. On one hand, it has become an excellent place to experience the power of Dutch precision industry, on the other hand it offers more and more the opportunity for "good old precision boys" to meet. Indeed, the 2009 theme "International market opportunities" involved a lot of networking, which this fair made amply possible. So, Dutch precision specialists could see and hear the novelties that English, German and other foreign companies showed in their booths. And booth holders could take take the opportunity to discover what their competitors/colleagues showed in their stands.

• *Frans Zuurveen* •

Of course, writing an evaluation of the event, see Figure 1, with its elaborate exhibition and accompanying lecture programme, is impossible within the limited scope of one article. And impossible within the context of a reviewer with a limited brain absorption power. So this again is not more and not less than an impression coloured by personal preferences that originate from education and experience.

Figure 1. Impressions of the 2009 Precision Fair. (Photos: Mikrocentrum)

platform

Moving

Mechatronics can be found everywhere on the fair, held on 2 and 3 December 2009 in Veldhoven, the Netherlands, for reason that controlling precision movements is impossible without thorough experience in that discipline. VarioDrive from Oud-Beijerland proves that statement by showing many of the components that they deliver for precision movements, together with their ability to calculate mathematical models of drive chains. An amusing set-up for positioning marbles demonstrates VarioDrive's capabilities; see Figure 2.

Figure 2. VarioDrive shows how marbles can be positioned.

Another interesting driving component in their stand is a very powerful actuator, the Narr Serac LH 100. It has the appearance of a hydraulic or pneumatic cylinder but functions completely mechanically. In principle it is no more than an ordinary screw-nut combination, but without the disadvantage of a bad efficiency. An extreme high power yield of 13,000 N within limited space has been attained by coupling screw and nut through grooved rollers. This reduces internal friction considerably; see Figure 3.

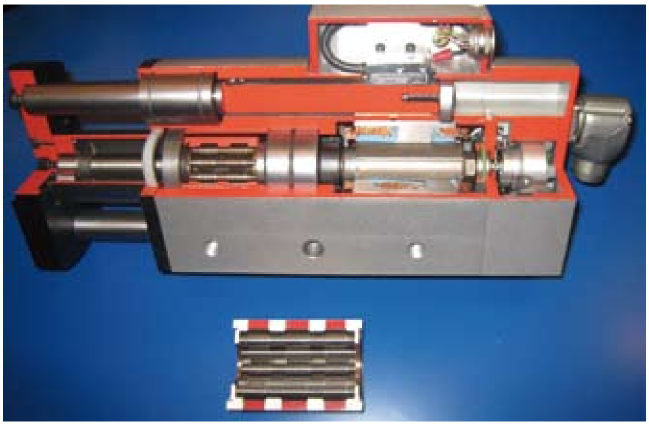


Figure 3. The Narr Serac LH 100 is a mechanical drive that might replace a hydraulic cylinder.

Modelling

Modelling of drive trains and other mechatronic assemblies asks for clever mathematical solutions. Cleverness is one's first impression when hearing Paul Lambrechts explain how international company The MathWorks can help to facilitate mathematical modelling. He shows a simple experimental set-up of a motor drive with flexible shaft. The shoot-over in extreme angle positions can be reduced by introducing a software-integrated back-coupled control loop; see Figure 4.

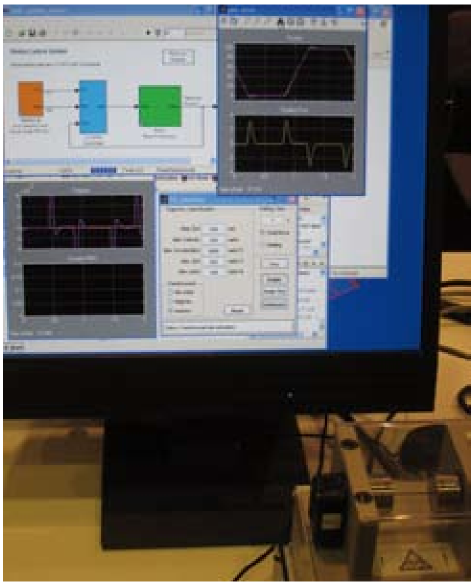


Figure 4. The MathWorks's results for calculating shoot-over caused by positioning with a motor with flexible shaft.

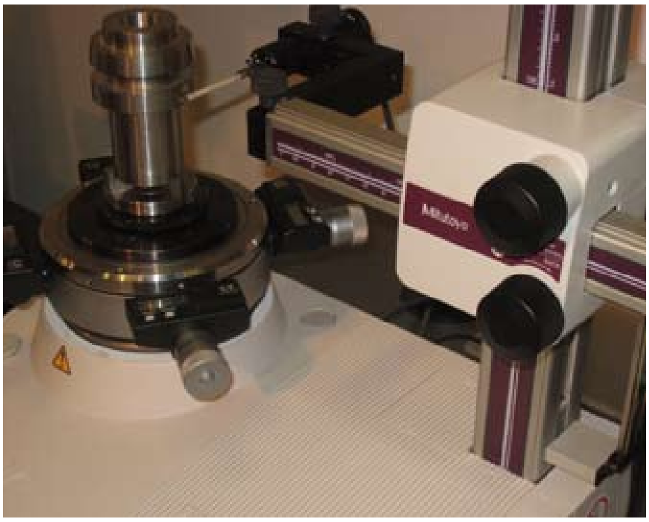


Figure 5. A Mitutoyo manual roundness tester.

The MathWorks's Simulink is a valuable tool for calculating non-linear dynamic systems. Their AutoSar program package helps to standardize integration into one central car-server of up to 70 microprocessors for controlling automotive functions.

Measuring

No exact positioning without measuring. Again, Heidenhain and Renishaw show their linear scales for determining positions of slides with sub-micrometer accuracy. And as usual, stands with stand-alone measuring machines, often highly automated, are amply present.

So, Bronno Schut of Schut Geometrische Meettechniek from Groningen demonstrates one of their DeMeet measuring machines. The largest in the series is the DeMeet 705 with a measuring range of 700 x 500 x 400 mm^3. The best accuracy achieved is 1.9 + L/400 µm, with L in mm. The machines are deliverable in two versions, with multisensory probe or with video observance of the object. It is interesting to hear that the granite base plates, columns and other parts are being manufactured in China, not as rough parts but finished in high dimensional accuracies.

Of course, Mitutoyo has an extensive booth to show examples from their wide range of measurement equipment. Product manager Ron Meijer explains that Mitutoyo not only manufactures its own measuring optics, but also delivers objectives to other companies, including competition. This way of keeping production in own hands originates from the philosophy of Yehan Numata, who founded Mitutoyo in 1934. A "poor man's" manual roundness tester, already deliverable for € 17,000, is provided with air bearings with a rotational accuracy of 0.04 µm; see Figure 5. However, this roundness tester is also available, of course against higher price, in a completely automated version, comparable to the universal

Figure 6. A ring rotating in air bearings made from New Way's porous carbon.

measuring machine Quick Vision Apex, which fully automatically measures workpieces against CAD-files.

More measuring

Eindhoven-based IBS Precision Engineering shows its new Isara 400 CMM with a measuring range of 400 x 400 x 100 mm^3. It is said to be the most accurate measuring machine in the world, with a resolution of 1 nm and a one-dimensional measuring uncertainty of 45 nm, three-dimensional 100 nm. Its measuring principle complies with the Abbe criterion, which states that measuring trajectory and measuring scale are in line. This avoids first-order errors due to angular guiding deviations. BoTech in Helmond manufactures all granite parts.
IBS supplies porous-carbon air bearing material from New Way and therefore shows a ring that accurately rotates in air bearings; see Figure 6. Such bearings are easily made to measure from New Way's porous carbon. Really interesting are the inductive measuring probes with a resolution of 10 nm from Lion Precision, also represented by IBS. They can be integrated into precision manufacturing processes by coupling them to CompactRIO electronic modules in a handy and handsomely small rack system.

Figure 7. A model 1 : 10 of the Hembrug Nano-Focus 425 milling machine.

Machining

Hembrug, from Haarlem, does not show their precision hydraulic lathes and milling machines on full scale because of their dimensions, which obviously do not fit into one small booth. But their rather new, fully hydrostatic Nano-Focus 425 milling machine with five axes is prominently featured on scale 1 : 10, see Figure 7. The work piece accuracy amounts to 5 µm, whereas the positional accuracy of the hydrostatic guides is better than 1 µm. Comparable with the already well-known hard turning on Hembrug lathes, this machine is capable of hard milling, that is machining hardened material. This not only saves time and costs by avoiding finish grinding but also improves accuracy by eliminating work piece reclamping.
Also new is the relatively cheap hydrostatic lathe Mikroturn 300 Base Line, which becomes available at a base price of € 175,000. At the other end of the price range are Hembrug's Mikroturn vertical lathes (carrousel lathes) for finish hard turning. The largest machines accommodate workpieces up to a maximum of 1,400 mm diameter.
It is impressive to see a flat surface with a 2 µm deep recess machined by a miniature finger mill in hardened steel. The recess is clearly visible thanks to the stability of the time-consuming machining process taking more than one day. Needless to say that all hard machining tools are provided with PCBN chip plates (Polycrystalline Cubic Boron Nitride).

Figure 8. Ilse Buter demonstrates IMS's ProMicro assembly machine with manual feeding.

Mounting

IMS from Almelo is a member of the WWINN Group (World-Wide INNovations). IMS provides solutions for mounting problems. One of these solutions is ProFast, a high-speed flexible assembly platform. ProBot is another versatile assembly platform, for small to medium-sized series. Common feature of those platforms is a modular set-up, making them suitable for the fast realization of production mechanization.
Ilse Buter of IMS demonstrates a ProMicro machine, a semi-automatic assembly system with manual feeding of components; see Figure 8. In this demonstration the machine mounts loudspeakers for hearing aids and thus serves as a tool preliminary to the final mechanization. Another example shown is a ProFast machine for assembling mobile telephone loudspeakers out of seven different parts supplied by small vibratory hoppers. The machines not only bring parts with micrometer accuracy to their final place, but also accomplish processes like laser welding and gluing with UV hardening of two composites.

Manufacturing

As usual, many precision-engineering companies show their skills with lots of examples of narrow-toleranced products. One of these firms is Nijdra from Midden-Beemster; see Figure 9. Their slogan "precision is our profession" becomes reality in three production facilities with a conditioned measuring room each.

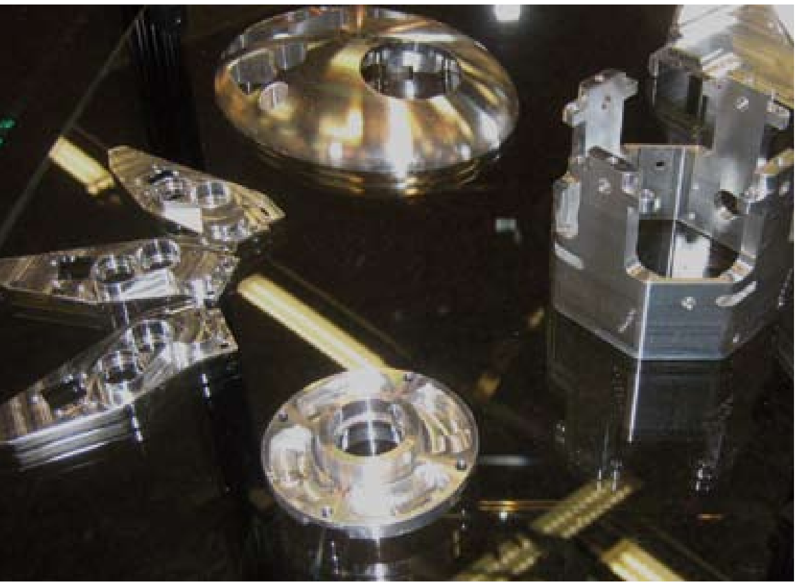


Figure 9. Aluminium precision parts manufactured by Nijdra.

Quite different precision products are the optical components manufactured by Anteryon in Eindhoven; see Figure 10. Their machining abilities include sand blasting, grinding, lapping, etching and coating. For instance, Anteryon delivers two million miniature lenses a month for mobile telephones.

Figure 10. Optical components manufactured by Anteryon.

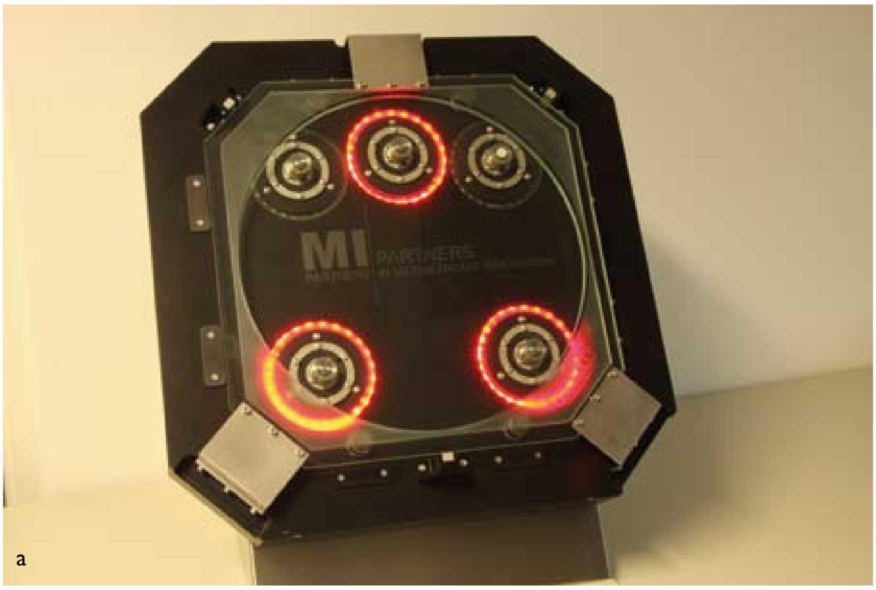
As last but not the least, manufacturing firm D&M Vacuum Systems from Budel is to be mentioned. D&M fabricates complete vacuum systems, including stainless steel recipients, pumps, valves and control units; see Figure 11.

Figure 11. A welded stainless steel recipient, fabricated by D&M.

Magnetics

Above the stand of Magnetic Innovations towers a donQi Urban Windmill that got an improved generator designed by Magnetic Innovations; see Figure 12. Johan Dams tells that his firm, based in Veldhoven, offers electromagnetic

Figure 12. Impression of a donQi Urban Windmill; this type of windmill was fitted with an improved generator designed by Magnetic Innovations. (Photo: donQi)



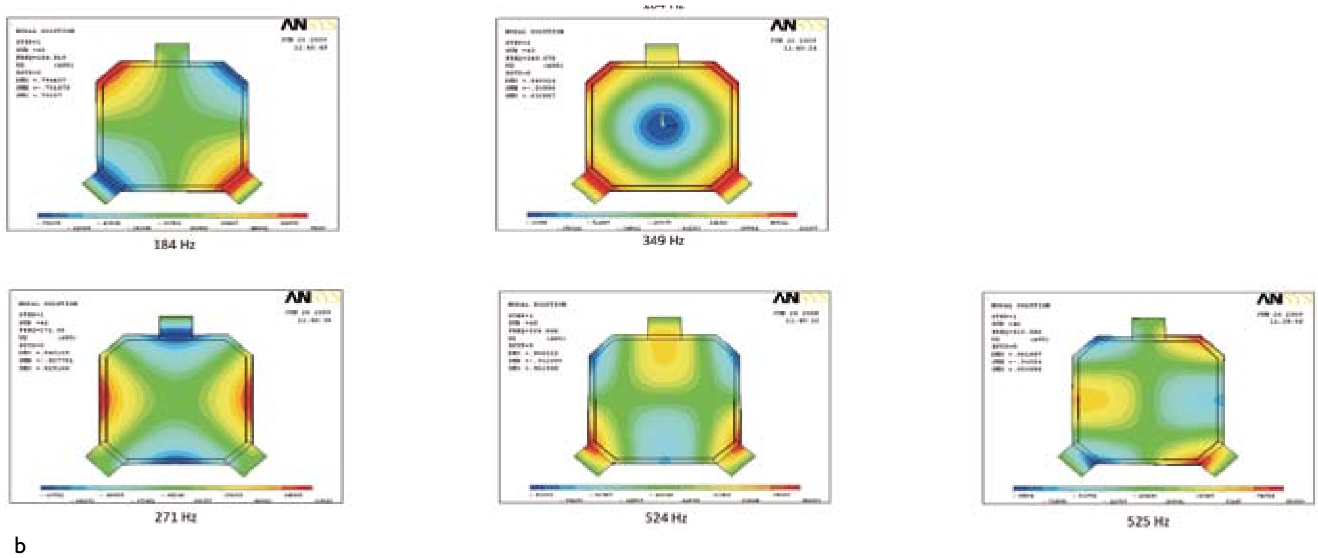


Figure 13. MI-Partners developed a magnified model of a silicon wafer for solving vibration problems.
(a) The physical model: a large glass plate represents the wafer and three actuators excitate vibration modes.
(b) Five different vibration modes of the wafer model.

knowledge for customer-oriented projects, such as this windmill project and hub motors for electrical bicycles. Permanent and coil-excited magnets for actuators and sensors are the application area for his knowledge-driven firm. Dams explains that an improvement of generator efficiency from 80% to 90% does not look very impressive, but that this means a reduction of losses with a factor of two. And in most cases this is quite a challenge.

Miscellaneous

Another interesting stand is that of MI-Partners, Partners in Mechatronic Innovation. This small Eindhoven-based firm comprises a team of engineers specialized in problem solving and prototype building. They show a magnified model to solve a vibration problem of silicon wafers. A large glass plate represents the wafer and three actuators excitate five different vibration modes; see Figure 13.

MI-Partners proves that a fourth actuator can be used to compensate the unwanted vibrations by introducing counter-phase oscillations in the nodes.

Stefan Kuypers from JEOL Benelux shows the NeoScope, see Figure 14, a very small scanning electron microscope that can be acquired for no more than € 16,000, which is a relatively small sum for an electron microscope. The resolution amounts to about 25 nm, which yields much higher magnifications than light-optical microscopes can provide, of course. But the NeoScope has a lowest magnification of 10x, which is a remarkable low value for a SEM.
Laser2000 shows several optical components that can be used to build one's own laser set-up; see Figure 15. Also pulsed lasers with fibre optics are shown. They easily integrate into laser units for machining on submicron scale.

More visitors than ever before

With some 3,000 visitors, the 2009 Precision Fair confirmed the fair's status as the largest precision engineering event in the Benelux (Belgium, the Netherlands and Luxembourg). The fair was organized by Mikrocentrum, the Eindhoven-based, independent competence centre serving the high-tech industry, supported by DSPE and the IOP (Innovation-driven Research Programme) Precision Engineering.
Key figures:
- 218 exhibitors (companies and knowledge organizations);
- 3,000 visitors (5% more than in 2008): 89% from the Netherlands, 9% from Belgium, 1% from Germany, 1% from other countries;
- 40 lectures (6 plenary and 34 parallel) with in total 1,100 attendants;
- 80 appointments during the international matchmaking/ brokerage event.

The next edition of the Precision Fair will be held on 1 and 2 December 2010, once again in the NH Conference Centre Koningshof in Veldhoven, near Eindhoven, the Netherlands.

www.precisiebeurs.nl

The opening lecture was given by Rob van Gijzel, Mayor of Eindhoven and President of the Brainport Foundation. He stressed the importance and the strength of the high-tech industry in the Netherlands and in the Eindhoven region (Brainport) in particular. (Photos: Mikrocentrum)

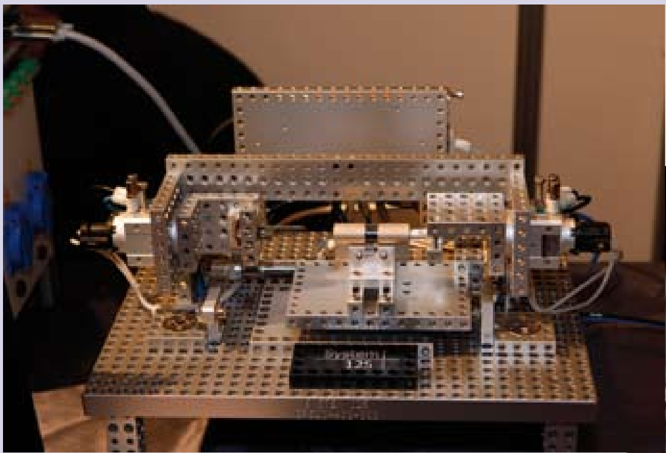


Figure 14. The NeoScope, a small SEM from JEOL, Japan.

Figure 15. Laser2000 supplies optical components to build a laser set-up: (from left to right) DPSS-lasers, mirrors, slides, beam dumps and (on the foreground) a laser energy meter.

In conclusion

With so many M's used in this text, one wonders if terms like "magnificent" or "marvellous" should be mentioned in this conclusion. That may seem a bit overdone, but "interesting" and "informative" certainly apply. So visiting the Precision Fair was more than worthwhile, for the technological aspects as well as for the networking. It amply allowed the visitors to explore "international market opportunities", which was the leading theme of the 2009 edition.

Author's note

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

Smart applications of design principles rewarded

During the 2009 Precision Fair in Veldhoven, two awards were presented that are named after two legends of precision engineering in the Netherlands. The biennial Ir. A. Davidson Award went to Krijn Bustraan of Philips Applied Technologies, and the annual Wim van der Hoek Constructors Award went to Raimondo Cau for his graduate work at Eindhoven University of Technology.

The Ir. A. Davidson Award was presented on the first day of the Fair, Wednesday 2 December. This prize is aimed at encouraging young talent and is intended for a young precision engineer who has worked for several years for a company or institute and has delivered demonstrable performances that are recognised both internally and externally. Their enthusiasm for the field must also have a positive effect on younger colleagues. The award is named after A. Davidson, the authority in the field of high-precision mechanical engineering at Philips in the 1950s and 60s. Davidson was the author of a handbook of high-precision technology that formed the basis for the engineering community at Philips.

The 2009 Ir. A. Davidson Award – a miniature row of books, rendered in metal, representing Davidson's handbook of high-precision technology – was made by students at the Leidse Instrumentmakersschool.

Krijn Bustraan, winner of the 2009 Ir. A. Davidson Award, with certificate and award.

Creative solutions

The Ir. A. Davidson Award is awarded biennially by DSPE. The winner of 2009 – the third time the award has been presented – was Krijn Bustraan of Philips Applied Technologies. According to the jury, which was led by Herman Soemers, professor of Mechatronic Design at the University of Twente, Krijn Bustraan demonstrated considerable aptitude for fathoming design problems and coming up with creative solutions to achieve innovations for customers as quickly as possible. This concerns a wide range of products, from modules for wafer scanners and patient tables for hospitals to consumer products such as electric razors.

In addition, Krijn Bustraan is active in the promotion and development of competences in the field of (mechanical) design principles, particularly their relevance to the design process and for the rapid achievement of practical solutions for the customer. He is now also teaching these competences and propagating the field widely within Philips Applied Technologies.

Reflecting telescope

One day later, on Thursday 3 December, the Wim van der Hoek Constructors Award was presented for the fourth time. This prize – created on the occasion of the 80th birthday of the grand old man of design principles, Wim van der Hoek– is awarded annually for the best graduation project in the field of construction in mechanical engineering at the three Dutch universities of technology.

The 2009 award was won by Raimondo Cau, whose graduation project at Eindhoven University of Technology concerned the construction of a portable 300 mm reflecting telescope intended for advanced amateur astronomers. According to the jury, chaired by Jos Gunsing, lecturer in Mechatronics at Avans Hogeschool, Cau won the award on account of his original choice of subject, his thinking about how to define the degrees of freedom and the associated choice in favour of overconstraints, and the detailed elaboration of the optomechanical design.

Winner of the Wim van der Hoek Constructors Award, Raimondo Cau, with (left to right) jury member Piet van Rens, eponymous Wim van der Hoek and jury chair Jos Gunsing.

Exciting product

MEMSland, the first and for a long time largest programme under the Point-One flag has come to an end. In the Closing Symposium, held on 3 December 2009 at TNO's in Eindhoven, the Netherlands, project leaders, participants and others looked back at an extremely successful programme. The co-operation between small and large companies, universities and research institutes was exemplary, resulting in a series of promising business cases, and the Netherlands was firmly put on the MEMS map. However, MEMSland has not yet led to a net increase in MEMS-related jobs.

• *Jan Kees van der Veen* •

MEMSLand

In his opening speech, Jan Eite Bullema of TNO, host of the meeting, stated that the MEMSland programme has given our country a headstart in MEMS and that the Dutch industry is ready to take its share of the expected multi-billion dollar market for MEMS products. Fred van Roosmalen, vice chairman of the Point-One innovation programme for nano-electronics, embedded systems and mechatronics, added that MEMSland is a benchmark for collaboration between companies, universities and research institutes. It is exactly the kind of ecosystem that innovation programmes like Point-One wish to create and MEMSland can, as such, be considered as Point-One in a nutshell.

Point-One vice president, Fred van Roosmalen: "MEMSland is a benchmark for collaboration between companies, universities and research institutes."

ideas, challenging industrialization

During the symposium a selection of successful MEMSland business cases and technology demonstrators was presented. Two business cases (Anteryon's WaferOptics technology and Bluebird's IC packaging) will feature in forthcoming issues of Mikroniek.

Successful in many ways

"Not only was MEMSland a successful programme", stated Peter Magnée, overall MEMSland project leader, looking back at four intensive years, "but it was fun to do as well!" When the programme started back in 2006, its main objective was "to develop, on a national scale, key competencies and technologies for cost-effective MEMS packaging solutions". Companies, universities and institutes were to work together in a number of concrete MEMS development projects, build international partnerships, create knowledge, and recruit and educate people. End target was to realize a sustainable MEMS innovation environment and a strong competitive position of the Netherlands.

Overall MEMSland project leader, Peter Magnée: "Not only was MEMSland a successful programme, but it was fun to do as well!"

At the end of the MEMSland programme, not all business cases have resulted in business (yet), but all have contributed to new MEMS technical know-how. Business case participants exchanged experiences within the framework of seven work packages: technology platforms and business carriers; functional modeling and design; wafer processing and packaging; material characterization and design for reliability; design for manufacturability and

What is MEMS?

MEMS stands for Micro Electro-Mechanical Systems. Another term, often used in Europe, is MST (Micro-Systems Technology). In MEMS, electronic and mechanical engineering – and, incidentally, other disciplines like optics, chemistry and biology – meet at micrometer scale. MEMS covers a broad range of (mechanical, optical, etc.) sensors and actuators with sizes < 1 mm or even < 100 μm, normally integrated in an IC package with additional electronics for processing or communication. If dimensions get smaller, below micrometer-scale, we speak of NEMS (Nano Electro-Mechanical Systems). The biggest issue for MEMS is the packaging: building a working prototype is nice, but the real challenge is cost-effective mass production of reliable products. Where possible, one uses (with special tricks) the well-known and -controlled CMOS-IC process, used for 90% of electronic integrated circuits, but for many MEMS dedicated solutions have to be developed. Often these solutions are also derived from proven semiconductor technology for mass production. The worldwide MEMS market will hit $10B by 2011, doubling from $5B in 2005.

Examples of successful MEMS:

- accelerometers, as used in airbags and in the Nintendo Wii;
- digital micromirror devices, as used in video projectors (Digital Light Processing, DLP);
- pressure sensors for many applications;
- microphones for hearing aids;
- nozzles for inkjet printing.

testability; fast prototyping and industrialization; and dissemination.

When MEMSland started, the initiators had five objectives in mind. Magnée elaborated on these objectives and on the extent to which they have been achieved.

- Put the Netherlands on the MEMS map
  Yes. Publications on various MEMS topics were received well in the world and made our country visible in MEMS. Striking examples are the MEMS-XO Oscillator with world-record Q-factor and BAW (Bulk Acoustic Wave) filters.
- Create new employment
  New jobs were created in MEMS innovation activities, but overall employment in MEMS remained stable. In view of the global crisis this can be considered positive. The step to large-volume manufacturing was not taken; the road to industrialization in Europe is hard!
- Align universities/institutes and industry
  Yes. Cooperation was excellent. Strong and sustainable contacts resulted.
- Stimulate small / medium-sized enterprises
  Yes. Participation of SMEs in the consortium was strong. There was good cooperation between SMEs and large companies like Philips and NXP.
- Contribute to MEMS standardization
  No. MEMS have appeared to be too diverse to be caught under one standardization umbrella. Internationally, this is not a big issue anymore.

Magnée also indicated some pluses and minuses of the MEMSland programme.

+	-
• The co-operation between the partners at business case/ demonstrator level. • The involvement of the SMEs. • Effectively bridging the gap between research demonstrator and industrial prototype. • The 39 scientific publications. • The fun!	• The delays in decisions and approvals. • The administrative burden, particularly the yearly financial reports. • The rather disappointing interaction between participants at work package level.

RF-MEMS

Mobile phones are the driving force behind many developments in electronic miniaturization. One is radio-frequency (RF) MEMS switches. Modern mobile phones have to be able to operate in many frequency bands: GSM, UMTS, WLAN, Bluetooth, GPS, and others. Current state of technology is that a phone has separate RF-circuitry for each band, but it would save space and power, both precious in a mobile phone, to have just one circuit tunable to different frequency bands.

An RF-MEMS switch makes this possible, as explained by Marcel Giesen from Epcos Netherlands in Nijmegen. In fact, it is a miniaturized variable capacitor with moveable top electrode. By applying a DC voltage the two electrodes move towards each other and the electrical capacitance sharply increases; see Figure 1. Electrical characteristics meet RF-requirements (high C_{on}/C_{off} ratio, low losses, high power handling and high linearity). CMOS switches cannot meet these requirements and are unusable. By combining a number of these switches and placing them in the antenna circuit the resonant frequency can be modified to accommodate various frequency bands.

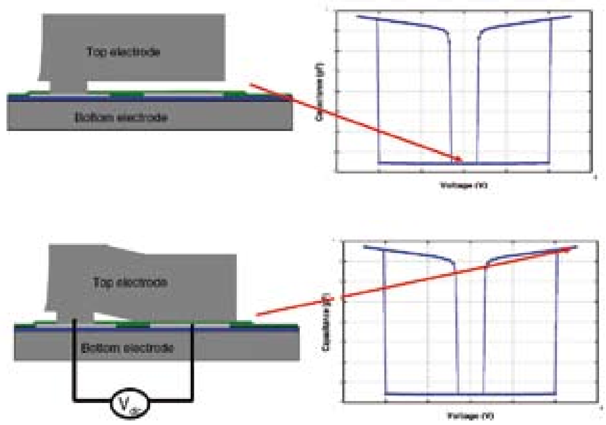


Figure 1. The principle of operation of an RF-MEMS switch.

The RF-MEMS idea is not new. It has for 15 years been a promise, but proved to be too tough to fulfil, until now. Most companies have stopped their activities in this field, mainly due to reliability issues. Epcos Netherlands (originally an NXP development group) has succeeded, within the MEMSland project, but it required many cycles in the development process, perseverance and a lot of time, far more than planned. One of the big issues, solved after several research efforts, was the technology to be used for the sacrificial layer, the layer between the two electrodes that, at a certain moment in the process, is removed ("sacrificed"). Big lesson learned: reliability starts day one of MEMS device development. Reliability testing of early samples is key to steer technology development and it is necessary to have one FTE (full-time equivalent) staff available over the entire project for testing hardware and software.

The outlook for business success of RF-MEMS is excellent. Without MEMSland it would have been impossible to successfully complete this project, considering the long development time and the changing business environment.

Gas chromatography

Another MEMS application is gas chromatography. Vincent Spiering from Enschede-based company C2V presented the C2V-200 micro GC (= Gas Chromatograph). Using MEMS technology, size and weight of the instrument could be brought down an order of magnitude compared to conventional GC's: hand-sized instead of table-top size; see Figure 2. In addition, analysis can be done faster (30 seconds instead of 30 minutes), quality of the result is higher and cost of ownership is lower. Within the MEMSland project a series of demonstrators was built, like the micro TCD (Thermal Conductivity Detector) in 2007, the micro GC cartridge in 2008 and again in 2009, and integrated chip moulding in 2009.
The compact instrument opens up many new application areas for GC and the commercial outlook is excellent (C2V has recently been acquired by US multinational company Thermo Fisher Scientific).

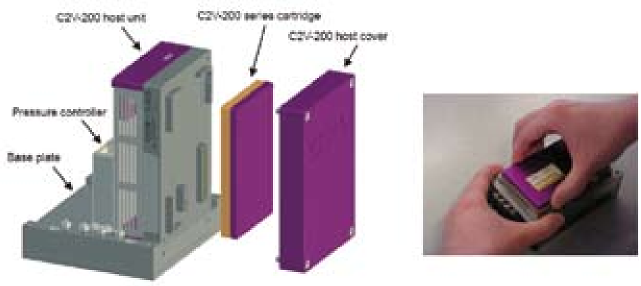


Figure 2. C2V reduced a gas chromatograph to hand size in a MEMSland project.

Liquid metal alloy interconnects

Integrating electronic systems on one chip (SoC) has a disadvantage: above a certain complexity the cost per function and the time to market increase dramatically, see Figure 3. Other, more flexible solutions like System in Package (SiP) or 3D packaging then are preferable. But this requires flexible bonding solutions as well. As set forth by Erik Veninga, TNO has, within MEMSland, done research into a flexible low-temperature bonding solution, using a liquid metal alloy.

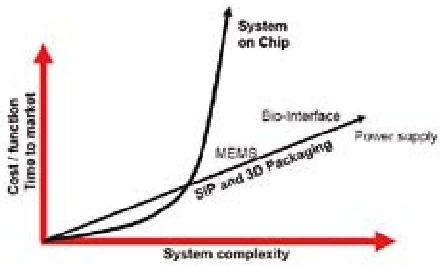
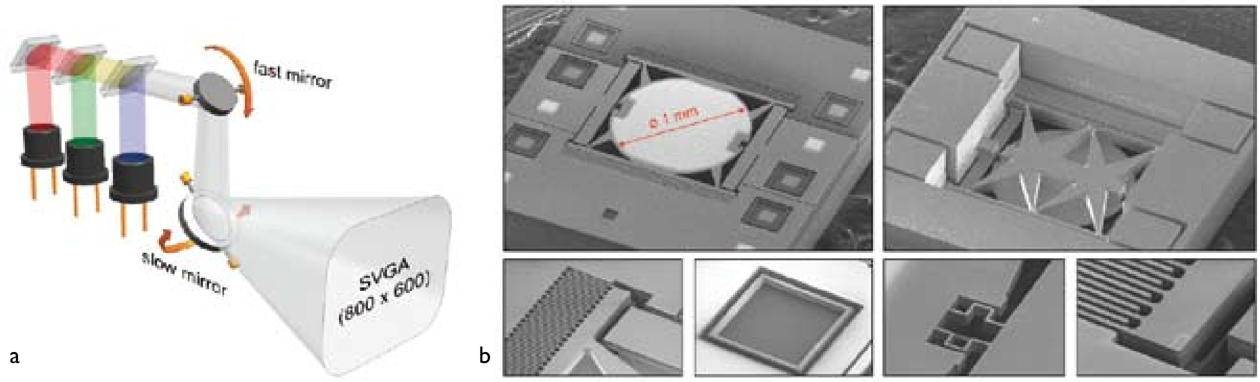


Figure 3. Cost per function and time to market of MEMS increasing with complexity. (Source: Fraunhofer IZM, Berlin, Germany)

The alloy chosen is a Gallium-Indium eutectic composite solidifying at 15.3 °C. Bonding can be done below 100 °C, which offers several advantages: no high-temperature induced reliability issues, easy repair/reuse/prototyping, no problems with CTE mismatches (CTE = Coefficient of Thermal Expansion), and possible use of low-cost materials and heat-sensitive components. Electrical and thermal conductivity of the alloy are reasonable. There was one disadvantage: the interconnection process had to be entirely redesigned. TNO developed a method where cavities are created in the substrate, the cavities are filled with alloy and flip chips are placed upon them and finally glued. The substrate can also be foil material. The first results are promising but a lot of research is still required.

MEMS mirror for miniature laser projection

The miniprojector is a hot new product, applicable in for example cars (head-up display), mobile phones, cameras, laptops, etc. Nikon was the first in September 2009 to launch a camera with built-in miniprojector. Miniprojectors are based on LED beamers, which is a rather bulky concept. As explained by Diederik van Lierop from Philips



In a MEMSland project, Philips Applied Technologies developed the new concept of a miniprojector based on a laser and two scanning mirrors.
(a) Principle of operation.
(b) Realization of the scanning mirror in MEMS.

Applied Technologies, a miniprojector based on a laser and two scanning mirrors can be made much smaller. Additional advantages are high power efficiency, higher contrast, infinite depth-of-focus and lower cost in the long run.

As a MEMSland demonstrator project, full-color miniature laser projection was studied, targeting SVGA resolution (800 x 600 pixels) and a projection module size of only 6 x 8 x 16 mm^3. Scanning is done with two MEMS mirrors (Ø 1 mm, one resonating at > 18 kHz). However, available MEMS mirrors did not meet the requirements: many mirror designs had mechanical shortcomings or neglected basic mechanical design principles. Thus, a new design had to be made; see Figure 4. In collaboration with MEMSland partners, modeling and verification studies were done on control loops, capacitive measuring system, non-linear dynamics, etc. Simulations corresponded nicely with measurements conducted on a prototype.
Collaboration with the partners was fruitful, and essential to achieve these results.

MEMS oscillators

Since several decades, the quartz oscillator is the standard timing reference, the “beating heart” for numerous electronic applications where frequencies must be highly accurate and thermally stable, like radio, TV, watches and computers. With on-going miniaturization the disadvantages of quartz become more and more apparent: quartz crystals are (very) large compared to modern ICs, they are hard to integrate on a chip (System on Chip) or in a package (System in Package) and they are relatively expensive. MEMS oscillators will be the solution to this problem, as explained by Joost van Beek of NXP.

The heart of a MEMS oscillator is a resonating beam in a cavity. The size of the cavity depends on the frequency range and is typically 30 µm high and 100 to 500 µm wide/long. The cavity is vacuum-sealed, pressure inside is below 10 mbar. MEMS resonators can be made on silicon wafers, using regular IC production technologies, with special process steps added. For example, sacrificial layers have to be made, and removed later on in the process to create a cavity. The process is quite complex and took considerable time to develop. On a 200 mm wafer more than 100,000 devices can be made.

MEMS resonators are small (for example a 15 kHz MEMS resonator is 0.4 x 0.4 x 0.15 mm^3 compared to 2.5 x 2.5 x 0.55 mm^3 for a quartz resonator), cheap and scalable, and they allow integration with driving and other electronics in a package. Electronic performance is nearing low- and mid-end quartz: high Q (e.g. ~100.000 for a 26 MHz resonator), low phase-noise, high manufacturing accuracy and low temperature drift.

MEMS oscillators are a disruptive technology in a well-established and growing timing market. NXP and its partners have managed, thanks to MEMSland, to obtain a good position in this estimated 100 M$ market.

Discussion

A plenary discussion, moderated by Jan Eite Bullema, was held to close the symposium.
Some conclusions:

- “No one expects that MEMS technology will create substantial numbers of high-tech jobs in the Netherlands at short term, but maybe in a couple of years. The small companies (start-ups) will have to be the engines in creating new employment.”
- “To make MEMS business in the Netherlands more than an academic success, students have to be drawn into it. Push the subject hard at universities. Stimulate entrepreneurship among students. Industrialization is a big problem in our country, it will be extremely hard to

Jan Eite Bullema of TNO, host of the meeting, moderated the concluding discussion of the MEMSland Closing Symposium.

“fill a MEMS foundry”, so production will probably go abroad.”
- “Creating a MEMS Institute to pull science out of the lab into new products, sounds like a good idea, but there is scepticism whether this will work. What we really, really need is entrepreneurs.”
- “Subsidies to make large companies, small & medium-sized companies (SMEs), universities and research institutes work together to make MEMS business more successful are ok to get things “moving”, but in the end we should be able to do without them…..!”

Author’s note

Jan Kees van der Veen is a freelance technical journalist living in Son, the Netherlands.

MEMSland facts & figures

- First and largest R&D programme under the Point-One flag.
- Programme objective: to develop and integrate all key competencies and technologies for the development of a comprehensive MEMS packaging solution.
- Programme duration: 3.5 years (June 2006 ~ December 2009).
- Total programme 36 M€; Point-One funding 14 M€.
- 22 Partners (universities, institutes, large companies, SMEs)
- Programme organised in seven business cases and four demonstrators, as “carriers” for MEMS knowledge development.

Business Case (BC) / Demonstrator (D)	**Participants (the first partner mentioned is in the lead)**
BC1 BAW filters	NXP, ALSI, Philips Applied Technologies (Apptech), University of Twente
BC2 RF MEMS switch	Epcos, NXP, Fraunhofer
BC3 MEMS XO Oscillator	NXP, Eindhoven University of Technology, Bruco
BC4 microGC gas analyzer	C2V, ALSI, Boschman, AppTech
BC5 Non-volatile memory chip	Cavendish Kinetics, ALSI, IMEC
BC6 Optical sensor	Lionix
BC7 1×32 info planar splitter	Lionix, Boschman, MA3 Solutions
D8 Miniature camera packaging	Anteryon, Boschman, MA3 Solutions, TNO
D9 Fingerprint and pressure sensor	Boschman, TNO
D10 Scanning mirror	Philips AppTech
D11 Large area micro assembly	TNO

www.memsland.nl

Crossing barriers in

With products and components getting smaller and smaller, micro-EDM (Electrical Discharge Machining) is a promising technology for machining micro ceramics components. However, the challenges are formidable. Extremely precise machine tools and machining processes with an ultra-small machining unit are essential. This requires generation of low-energy, ultra-short electrical pulses. And knowledge of physical and mechanical properties is needed to gain insight in the dominant material removal mechanisms. Extended applications for ceramic components with an appropriate material-specific, structural design, as well as feasible and cost-effective manufacturing methods are an absolute must to make micro-EDM applicable to future innovations.

• *Kun Liu, Bert Lauwers and Dominiek Reynaerts* •

Anyone who has ever seen what happens when a bolt of lightning hits the ground, has seen the working force of the EDM process in its most primitive form. EDM, short for Electrical Discharge Machining, also often called spark erosion, is an electro-thermal machining process by which the material is removed through a series of discrete discharges between a workpiece and a tool electrode. Each discharge heats both conductive electrodes locally, which causes mainly the workpiece material to melt and evaporate and leaves a tiny crater on the surface; see Figure 1. Both electrodes are submerged in a dielectric medium which functions as a cooling agent, ejects the resolidified debris, and isolates the gap to assure optimal conditions for subsequent spark generation. Because there is no direct physical contact, the forces due to the spark erosion process are negligible, and any electrically conductive material independent of its hardness or brittleness can be machined by various EDM techniques; see Figure 2.

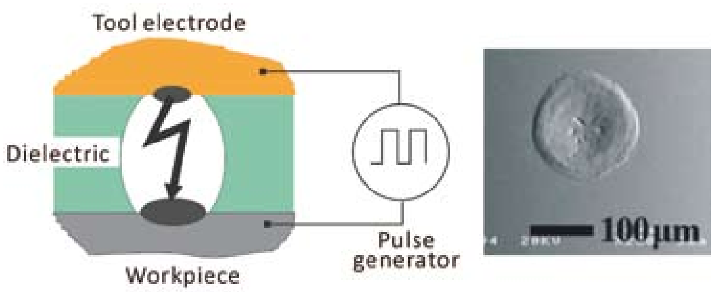


Figure 1. The EDM principle and an image of a crater after discharge.

structuring ceramics

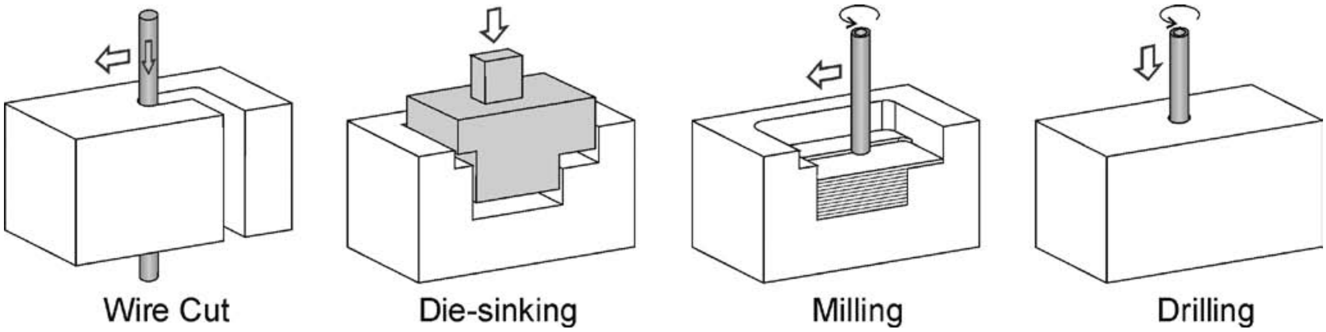


Figure 2. Most commonly used configurations of (micro-) EDM.

Micro

Micro-EDM (or µ-EDM) refers to the manufacturing of miniaturized components by the EDM process. At first glance, there is no real difference between conventional and micro-EDM except for the drastically reduced geometrical scale. Micro-EDM saw light in the early sixties as a process for small-hole drilling and die-sinking at Philips Research Lab (NatLab, Eindhoven, the Netherlands) and found specific applications such as the objective diaphragm in an electron microscope and high-precision profiled holes in diamond drawing dies. Later in the eighties, it recaptured the attention with the invention of WEDG (Wire Electro-Discharge Grinding, see Figure 3) by Prof. T. Masuzawa (Tokyo University), which allowed fabricating micropins as tool electrodes to a record-breaking diameter of 3 µm and microholes with a diameter less than 5 µm at that time. In the meantime, micro-EDM milling was also introduced by applying a cylindrical CNC-controlled tool electrode moving over a programmed tool path to generate a required geometry on a die-sinking EDM machine.

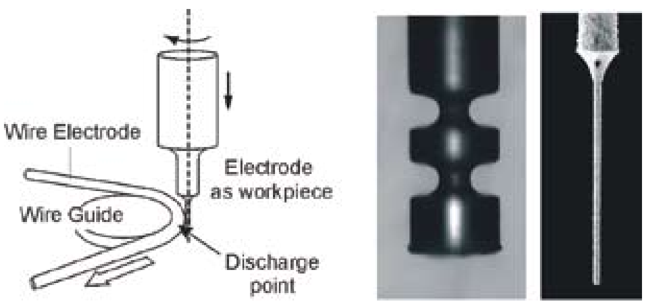


Figure 3. Schematic view of WEDG (Wire Electro-Discharge Grinding) and examples of shaped tool electrodes Ø 0.3 mm (left) and Ø 20 µm with aspect ratio of 20 (right).

Main requirements

Notwithstanding the unchanged working principle, quite a few more factors have to be considered for realizing micro-EDM. First of all, extra precise machine tools and machining processes with an ultra-small machining unit are essential. An extreme positioning resolution of ± 0.1 µm and 1 µm accuracy for some table-top micro-EDM machines can be easily realized thanks to the development in modern drive concepts, motors design and nanopositioning systems (e.g. Sarix S.A., Switzerland; Panasonic, Japan; Smalltec, USA; Makino, Japan; Ocean, Taiwan; etc.).

A small machining unit is defined as the smallest amount of workpiece material which can be removed in a controllable way. Thus the energy input for each discharge is reduced from a few mJ for conventional EDM to a few hundreds or tens of µJ, or even a few tens of nJ for micro-EDM, in order to produce smaller or shallower craters on the surface. More traditional static pulse generators that work through opening and closing of transistors and thyristors are no longer able to provide this condition. Relaxation generators with very small capacitors and a short, solid, and thick cable connection directly to the electrodes are used, to reduce the effects of impedance and inductance. New electronic layout designs are implemented

Table 1. Performance comparison between micro-EDM and alternative micro-manufacturing methods.

	Micro-EDM	Micro-milling	Laser machining	FIB[a] machining	Lithography DRIE[b]	Lithography Anisotropic Etching	Lithography LIGA[c]
Smallest feature size (µm)	5	50	5	0.005	1-2		0.2
Best surface roughness R_a (µm)	0.05-0.1	0.1-0.2	0.1-0.2	< 0.1	0.2	< 0.1	0.02
Accuracy (µm)	1	1	1	< 0.5	0.1	1	0.3
Maximum aspect ratio	20-40	5-10	1-2	15	30	>> 1	50
Workpiece geometry	3D	3D	2D-3D	3D	2½D	2½D	2½D
Hard and erosive material	++	-	+	++	+	+	-
Applicable materials	++	++	+	++	-	-	-
Process speed	-	+	+	--	++	++	++
Investment (+ being low)	+	+	-	--	--	-	--

[a] FIB = Focused Ion Beam.

[b] DRIE = Deep Reactive Ion Etching.

[c] LIGA = Lithographie, Galvanoformung, Abformung (Lithography, Electroplating, Moulding).

to give extremely short pulse duration (< 30 ns), low discharge current (< 0.5 A) and adaptable pulses. Furthermore, a working gap size typically down to 1-5 µm is essential to attain an adequate accuracy and flushing conditions. In micro-EDM, the demand is for a generator that can generate pulses that are sufficiently short and high in frequency, and for a sensitive servo control for fast reaction to any abnormal gap conditions.

For mass production, micro-tool electrodes can be acquired commercially with minimum outer diameter of 40 µm or tubular tool electrodes down to an outer diameter of 80 µm, covering a wide range of materials including tungsten carbide, graphite, brass, copper, etc. Special attention has to be paid to the precise mounting of the miniature tool electrode. In order to assure the accuracy of the process, this calls for measures such as the development of high-precision clamping devices with a repeatability of less than 1 µm, adding ceramic guides to the electrodes, reducing the number of clamping procedures caused by tool electrode wear, integration of measurement devices into a machine tool such as CCD cameras, chromatic confocal microscopes, etc. The implementation of a WEDG unit on the machine gives more versatility and benefits to the micro-EDM process: the electrodes can be shaped to a diameter of a few tens of micrometers, with an aspect ratio up to 40; see Figure 3. Without reclamping the tools, eccentricities and run-out errors can be avoided. A variety of electrodes can be made to axisymmetrical or non-axisymmetrical shapes, even non-prismatic or customized geometries.

Comparisons

Compared to mechanical machining methods like micro-milling, the ability of micro-EDM to machine hard and brittle materials is one of the strongest points in favor of applying this highly accurate technique. Though other contactless micro-fabrication techniques like laser machining or lithography are also able to machine a variety of materials, their drawback is, however, that the ability to produce very high aspect ratio structures is limited. Furthermore, lithography has such a limitation on fabricating three-dimensional free-form components. With a view on cost-effectiveness, micro-EDM becomes an excellent alternative choice for prototyping and small batch production. Table 1 lists comparisons between the micro-EDM process and alternative micro-manufacturing techniques.

Ceramics

Engineering ceramics like ZrO_2, Al_2O_3, SiC, and Si_3N_4, processed from fine powders, are becoming more and more popular and important in modern engineering because of their outstanding mechanical and physical properties. Therefore they find tremendous applications such as cutting inserts and tools, bearings, engine and heat components, gas turbines, and even dental prostheses, synthetic bones and joints, etc. These diverse ceramics and their composites provide hardness, toughness, wear resistance and chemical stability at high temperature and extreme conditions; see Table 2.

However, those high-performance ceramic materials also bring along difficulties in directly structuring them into desired sizes and shapes. Traditional economic casting and sintering, or even more complex methods such as injection moulding or 'hot wax moulding', can satisfy most of the demands in precision yet with flaws like shrinkage, demoulding and debinding defects, not to mention the very limited capability in producing three-dimensional and micro-parts. Mechanical processing like grinding which is often applied as the finishing technique, gives very good

Table 2. Comparison of physical and mechanical properties of steel, hard metal, ceramics and their composites.

	Composition	**Density**	**Hardness**[a]	**Thermal conductivity @ 20°C**	**Fracture toughness K_{ic}**	**Young's Modulus**	**3-Point flexural strength @ 20°C**
		(g/cm³)	(GPa)	(W/m·K)	(MPa·m$^{1/2}$)	(GPa)	(MPa)
HSS (e.g. Böhler S590)		8.1	62-64 [HRC]	24	20-50	242	
WC-Co	Balance/ 12 wt% Co	14.08	12.8 [HV_{10}]	95	> 15	563	4,280
Si_3N_4		3.17	16 [HV_{10}]	29	6.8	309	900
Si_3N_4-TiN	64/36 vol%	3.95	15 [HV_{10}]	28	8.7	333	980
SiC		3.22	26 [$HV_{0.5}$]	125	4.6	456	670
SiSiC	88 vol% SiC	3.05	12-28 [$HV_{0.5}$]	150	4.1	360	320
Al_2O_3		3.98	18 [HV_{10}]	30	5.2	380	420
Al_2O_3-TiCN	60/40 vol%	4.45	21.2 [HV_3]	–	2.5	417	700
ZrO_2		6	13 [HV_{10}]	3	10	220	900
ZrO_2-TiN	66/34 vol%	5.81	13.7 [HV_{10}]	8	12.5	290	1,500
TiB_2		4.5	25 [$HV_{0.5}$]	96	6.2	240	400
B_4C		2.5	32 [$HV_{0.5}$]	40	3.0	450	400

[a] HRC: Rockwell scale hardness; HV: Vickers scale hardness.
Sources: Saint-Gobain ceramics; Böhler Special Steel; K.U.Leuven.

results regarding surface quality and geometrical accuracy, but the slow machining speed leads to a rise in production costs and unit price. Thus, (micro-) EDM as a flexible, inexpensive and precise method is called in for filling in the gap.

Solving difficulties

The most obvious problem is the electrical conductivity. Experience shows that the boundary of electrical conductivity for the EDM process is around 10^{-2} S/cm. Therefore, conductive ceramics like TiB_2, TiN and tungsten carbide (WC) can be directly structured using EDM. Some silicon carbides and B_4C, however, are on the transition zone and their machinability by EDM largely depends on the applied technology. Nevertheless, a large variety of ceramic materials like alumina, zirconia, and silicon nitride are too resistive to be machined; see Figure 4. For that reason, by mixing one or two electrical conductive phase(s) such as borides, nitrides or carbides of transition metals into the ceramic matrix at the powder stage, some composites show greatly improved electrical conductivity. The most popular applied secondary phases are TiN, TiCN or TiC, since they also help further improving the mechanical properties such as toughness, strength and hardness of the composites.

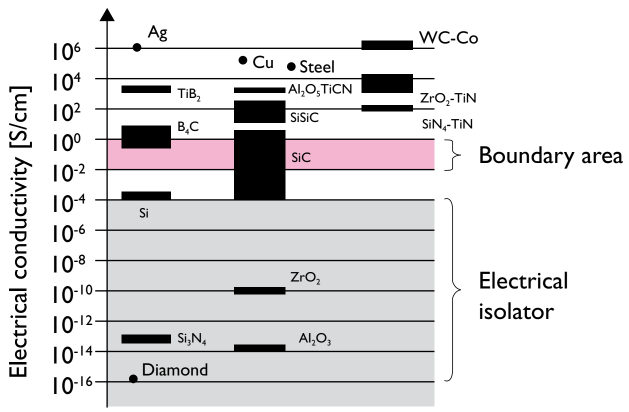


Figure 4. Overview of materials with their electrical conductivity.

Quite a few ceramic processing companies like Saint-Gobain (France), ESK (Germany) and FCT-Keramik (Germany), etc., commercialize a range of electro-conductive materials such as ZrO_2-TiN, Al_2O_3-SiC_w-TiC (subscript w stands for whiskers reinforced Al_2O_3-TiC ceramic composite), SiSiC (silicon infiltrated SiC) and Si_3N_4-TiN, etc., for specific industrial applications. At K.U.Leuven, the effects of a variety of secondary phases on physical and mechanical properties as well as the EDM machining performances of the ceramic composites are being investigated by varying electrical conductive phases with different percentages, grain sizes, sintering aids, binding materials, processing techniques, etc.

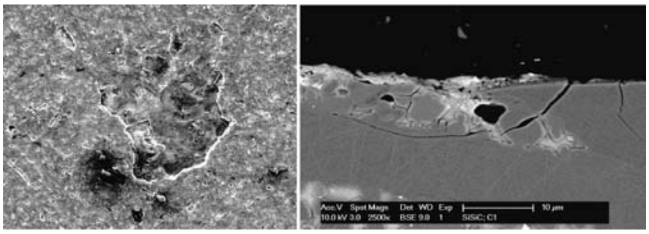


Figure 5. Spalling effects of micro-EDM on SSiC (left) and SiSiC, respectively.

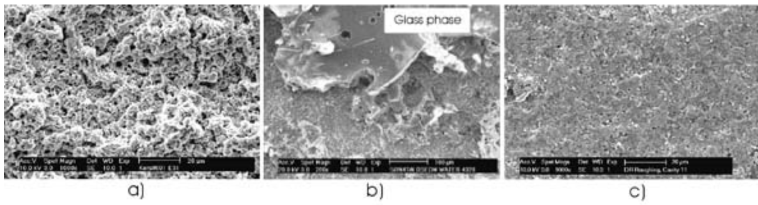


Figure 6. Various material removal mechanisms of μ-EDM on Si_3N_4-TiN, as explained in the text.

Technology drives

The practical difficulties can be credited to the fact that the efficiency of EDMing ceramic materials is largely depending on the proper knowledge of the ‘process-material interaction’. Each ceramic or its composite will react distinctively under diverse discharge conditions during the EDM process. As a result, the cross-linking of the material properties with the process characterization is most important but also very difficult. In micro-EDM, extreme-low-energy and ultra-short-duration pulses would give unexpected performances thus requiring additional investigation.

Variations in material removal mechanisms

As we all know, in EDM of metallic materials, melting and evaporation are the only forms of material removal from the workpiece. However, the machining phenomena are not exactly identical when EDMing ceramics. Research has shown that other types of material removal are coexistent with melting and evaporation under variable machining conditions, for example ‘spalling’ and chemical reactions. Spalling is removal of solid particles due to thermal shocks and disintegration of structural elements because of the melting of the binder phase. It is often related to the generation of large micro-cracks (perpendicular and parallel to the top surface) during the EDM process. These big micro-cracks make the separation of a (larger) volume during successive discharges much easier. These effects are noticed more frequently on the ceramic composites with lower toughness, strength and thermal conductivity, e.g. materials such as SiSiC and SSiC (Sintered SiC), Al_2O_3-TiCN, and B_4C. Even with small pulse energy and short pulse duration during micro-EDM, this phenomenon persists and sometimes dominates as the main material removal format; see Figure 5.

The conductive phases in the ceramic composite matrix are often chemically unstable at high temperature and in oxygen-rich conditions. Chemical reactions such as decomposition and oxidation thus become another important type of material removal mechanism (MRM) during (micro-) EDM. For example, TiN, TiCN and TiB_2 are easily oxidized into gasified TiO_2 and B_2O_3, etc., accompanied with nitrogen gas bubbles. When the EDM process is happening in a water environment, the oxidation gets even more dominant. The generation of these gases, in most of the cases, leads to a porous, foamy and sponge-like surface structure; see Figure 6a.

On the other hand, materials like Si_3N_4 are already experiencing decomposition at relatively low temperature around 1,700°C:

$$Si_3N_4 \rightarrow 3\ Si + 2\ N_2\ (g)$$

The liquid Si quickly reacts with oxygen to SiO_2 and contributes to the generation of more gas. When using deionised water as dielectric, the Si also reacts with O_2 forming a glassy and non-conductive SiO_2 phase, preventing further EDM machining; see Figure 6b.

Chemical reactions as material removal mechanism often have a very high impact on the machining performance, regarding speed, surface quality, as well as tool wear. Comparing to micro-EDM of metal, simply reducing the input discharge energy for improving the surface quality on a ceramic composite sometimes is not adequate. For example, when machining Si_3N_4-TiN, experiments confirm that by finetuning the discharge pulse duration, the dominant material removal mechanisms can alter from decomposition and oxidation to melting and evaporation, and a better surface quality can be obtained even with moderate discharge energy input; see Figure 6c.

Adapted machining parameters

Apart from a variation in MRMs, another important issue for machining some ceramics is the voltage drop on the workpiece during a discharge because of their lower electrical conductivity. The impedance of the material consumes energy and changes the shape of discharge pulses. This might be in a favor of improving the surface quality but apparently part of the machining speed is sacrificed, along with possibly more tool consumption (electrode wear). More importantly, the traditional servo-feed control needs to be adjusted for overcoming the elevated discharge voltage, avoiding abnormal machining conditions and further improving the machining efficiency. Table 3 presents comparisons of machining performances of a few frequently-used engineering ceramics and ceramic composites by micro-EDM.

Table 3. The optimized micro-EDM milling performances on ceramics and ceramic composites.

Material	Dielectric/ tool	Energy scale[a] (μJ)	Material removal rate (mm^3/min)	Tool wear ratio (%)	Surface roughness R_a (μm)	Main material removal mechanisms
SiC	Oil/WC	24.5×10^3	0.12	19	0.82	Spalling
		320	0.03	13	0.20	Melting and Evaporation
SiSiC		400	0.65	19	1.50	
		12	0.05	10.5	0.43	
Si_3N_4-TiN		215	0.36	1.8	2.45	Foamy surface; chemical reactions
		8	0.05	6.0	0.70	
		600	0.32	5.4	2.10	Non-foamy surface; melting and evaporation
		8	0.04	8.3	0.54	
		16	0.003	~ 20	0.25	Non-foamy surface with modified RC generator
ZrO_2-TiN		150	0.20	5.2	1.08	Melting and Evaporation
		3	0.012	7.7	0.31	
Al_2O_3-TiCN		150	0.20	8.1	0.72	
		3	0.02	8.3	0.24	
TiB_2	Oil/Brass	150	0.09	69.2	1.20	Oxidation
		3	0.005	27.3	0.29	
	Water/Brass	150	0.09	31.0	1.26	
		3	0.014	19.4	0.33	

[a] Total energy consumption including voltage drop in the material and discharge.

Application examples

Nowadays, a tremendous amount of applications for ceramic components can be found in industry. The high hardness, wear resistance, thermal and chemical stability make these modern engineering materials an excellent choice for applications such as adhesive spray nozzles, cutting tools, medical devices, heat exchangers, even turbine impellers in micro-scale power-generation systems (see www.powermems.be), and of course gears, die inserts and moulds. A few examples in various ceramic materials and dimensions are shown in Figure 7. The versatility of the micro-EDM process allows machining prototypes and parts in a much more economic way. For example the ZrO_2-TiN planetary transmission gears from maxon motors (Germany) have a 50% longer lifetime than pure ZrO_2 gears made by classical methods. By combining different EDM machining processes like micro-EDM milling, (micro-) wire EDM and (micro-) sinking EDM, very complex-shaped structures can be produced, and even with improved machining efficiency. For example, by combining EDM die-sinking and EDM milling for making B_4C spray nozzles, processing-time reductions up to 50% can be obtained. Besides, instead of using its original material (metal alloy), the lifetime of the nozzle is increased by a factor of at least five. Another recent high-tech example – the micro-turbine impeller shown in Figure 7a – is a result of sinking EDM and wire EDM or can be directly machined by micro-EDM milling; see Figure 8.

Challenges for future research

With the future perspective that products and components are getting smaller and smaller, plenty of challenges still exist for the micro-EDM process and structuring of micro ceramics components. On one side, for most conventional EDM machine tool builders, micro-EDM is inevitably an additional domain for competition in the market. The development of ultra-high-precision machines not just requires a thermal- and vibration-isolated, extremely stable base, or simply ‘down-scaling’ the conventional machine. The requirements on the pulse generator, servo control, the ability to machine free-form products, and automation for clamping/unclamping of tool/workpiece, are difficult and intricate tasks for the machine builders, uniquely so for micro-EDM. On the other hand, the process knowledge base is often still restricted to metal and cermets manufacturing. A rich database for ceramic materials requires a vigorous investigation as mentioned before regarding material variations and their effects on the machining processes. The lack of a proper knowledge database and experience in the current situation and the large variety of choices in materials make this task an exceptionally challenging one. Extended applications for ceramic components with an appropriate material-specific, structural design, as well as feasible and cost-effective manufacturing methods are an absolute must to make micro-EDM applicable to future innovations.

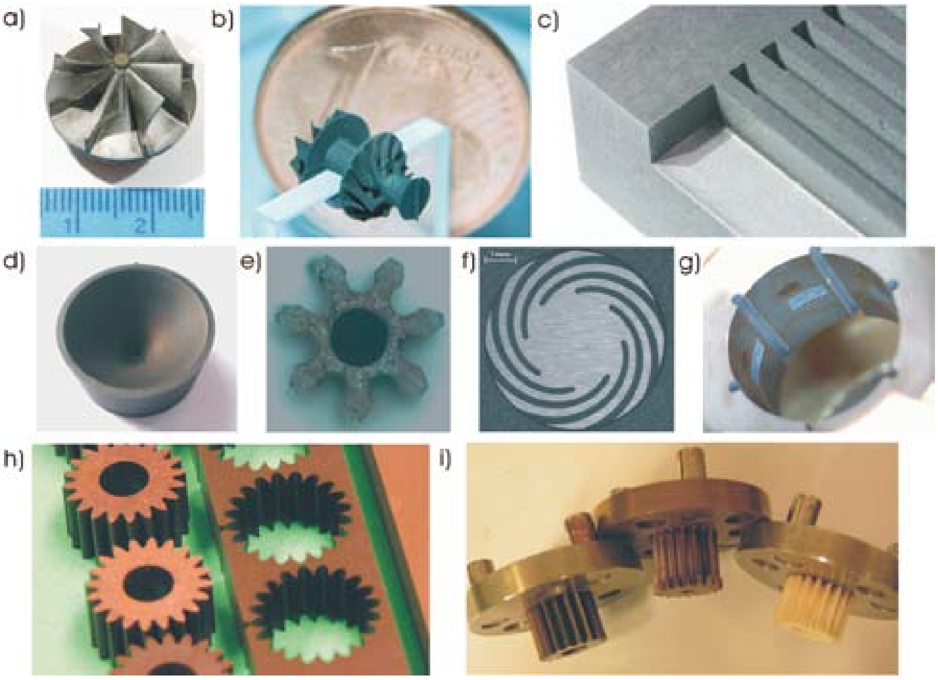


Figure 7. Application examples of ceramics and ceramic composites manufactured by micro-EDM.

(a) Ø 20 mm Si_3N_4-TiN turbine impeller aiming at rotation speed of 500,000 rpm and service temperature of 1,200 K.
(b) Si_3N_4-TiN turboshaft with a Ø 5 mm compressor and a Ø 5 mm turbine impeller.
(c) Partial image of a heat exchanger component in SiSiC with a grid width of 1 mm.
(d) B_4C nozzle with a spray hole Ø 0.7 mm.
(e) Ø 1 mm miniature gear wheel in AlN-TiN by wire EDM.
(f) Ø 6 mm ZrO_2-TiN aerodynamic thrust bearing.
(g) Ø 6 mm Si_3N_4-TiN journal air bearing with micro-EDMed pockets and Ø 0.2 mm air feeding holes, reached working speed at 438,600 rpm.
(h) ZrO_2-TiN transmission gears by wire EDM.
(i) Assembled ZrO_2-TiN transmission gears (SMS & WTS, the Netherlands; maxon motors, Germany).

Figure 8. Three-dimensional micro-EDM milling of a Si_3N_4-TiN turbine impeller in progress.

Authors' note

Kun Liu received her M.Sc. in mechanical engineering, specialisation production technology, from Delft University of Technology, the Netherlands, in 2005. She is currently pursuing a Ph.D. on micro-EDM of ceramics and their composites in the PMA division, Department of Mechanical Engineering, Katholieke Universiteit (K.U.) Leuven, Belgium, under the supervision of Prof. D. Reynaerts and Prof. B. Lauwers.

Bert Lauwers received his Ph.D. in 1993 and is currently a full professor at the Department of Mechanical Engineering, K.U.Leuven. He is active in education and research related to advanced and computer-supported manufacturing processes.

Dominiek Reynaerts is actively involved in research and education in precision engineering, micro-mechanical systems, advanced actuators and design methodology. He is also an active member of IEEE and euspen, and currently is full professor and chairman of the Department of Mechanical Engineering, K.U.Leuven.

Acknowledgement

Part of the research was sponsored by the Institute for the Promotion of Innovation by Science and Technology in Flanders, Belgium. It was carried out within the framework of the EC Network for Excellence 4M (Multi-Material Micro Manufacture: Technologies and Applications) and the EU FP6 projects Moncerat and EuroTooling. The authors would like to thank Prof. J. Vleugels from MTM, K.U. Leuven, dr. P. Bleys, dr. J. Peirs, and dr. E. Ferraris from PMA, K.U.Leuven, for their contributions to the research; and J. Wijers for reading and correcting this article.

Information

www.mech.kuleuven.be/en/pma

DSPE launches its first certification programme

To maintain the world-class quality of precision engineering in the Netherlands, the availability of precision engineering courses needs to be urgently revitalised. DSPE has, therefore, taken the initiative to set up a certification programme for post-academic courses. DSPE will not develop courses itself but will propose existing courses provided by a variety of institutes, and stimulate institutes to develop courses that are currently unavailable. Participants are awarded a sub-certificate for each course, and if a precision engineer gains nine sub-certificates in three to four years, they qualify for the full certificate (Certified Precision Engineer).

• *Joannes Collette* •

Mechatronic precision engineers are considered to be specialists in their field. But they also need to be team workers with broad knowledge of the areas of work of their fellow engineers. This makes them ideal team members for innovative teams, whose task it is to come up with new solutions, new concepts and new designs. Since they are experts in their field and also oversee adjacent fields, they can provide a major contribution in the further detailing and exploration of these new concepts and designs within their team. In recent years, there have been many examples of very successful teams composed of members with these skills (knowledge, experience and attitude).

Continuous education

Until a decade ago, OEMs would secure high-quality, in-house courses for their own precision engineers. In recent decades, there has been a decrease in the number of precision engineering courses on offer, while the precision engineering activities of the OEMs have been outsourced. An illustrative example is the recent termination of activities at the Philips Centre for Technical Training (CTT).

In order to continue the successes achieved in the Dutch high-precision industry, and to cope with the increasing competition, it is essential to have a sufficient number (quantity) of well-trained (quality) engineers with lots of experience to oversee the ever-increasing complexity. This can only be achieved by continuous education and life-long learning. While this demands that the engineer, line management and HRM have the correct mindset, there must also be an adequate and consistent education programme in place. Therefore, DSPE has taken the initiative to set up a certification programme for post-academic precision engineering courses.

Sub-certificates

To maintain the world-class quality of precision engineering in the Netherlands, the availability of courses needs to be urgently revitalised. Since the know-how is still available (but not for long), DSPE has launched the certification programme. It offers a balanced and high-quality set of courses with which the Dutch precision engineering industry and institutes can educate their personnel. DSPE will not develop courses itself but will propose existing courses provided by a variety of institutes, and stimulate institutes to develop courses that are currently unavailable. Participants are awarded a sub-certificate for each course, and if a precision engineer gains nine sub-certificates in three to four years, they qualify for the full certificate (Certified Precision Engineer).

Last year, a programme committee began to set up a balanced programme of courses and course suppliers for the precision mechatronics engineer, and the first sub-certificates were awarded during the 2009 Precision Fair. A first overview is listed in the box. Further steps will be taken to invite course providers to develop and offer courses in the areas not yet provided for.

HRM

This initiative provides a well-balanced programme for the precision engineer to negotiate personal development activities with their line manager and HRM manager. It enables the line manager to offer this programme to promising young precision engineers and provides the company's HRM or education manager with tools to plan precision engineering education programmes for the company.

Certification reinforces the professional image of experienced and well-educated precision engineers and strengthens the position of these professionals. This is considered essential to maintain the world-class position of precision engineering and the high-tech systems industry in the Netherlands. It enables SMEs to educate their personnel in accordance with the needs of the OEMs.

Certification programme, first course content proposal.

1. Basic
- Mechatronics
- Control
- Dynamics & Modelling
- System Architecture & Engineering

2. Specialisation
- Optics
- Opto-mechanics
- Opto-mechatronics
- Construction Principles
- FEM
- Actuators and Electromechanics
- Sensing, Calibration, Measuring Principles
- Vision

3. Expert
- Advanced Motion Control
- Multi-body Dynamics
- Applied Optics
- Exotic Materials (incl. plastics?)
- Connection Techniques
- Manufacturing Techniques
- Coating, Corrosion
- Thermal Design
- Tribology
- Vacuum Technology
- Noise Control Engineering
- Contamination Control
- Methodic Design
- Electronics for Precision Engineers
- IT for Precision Engineers

Support

The certification programme must be marketed to make it a success. The courses can be revitalised if the industry provides adequate support. Supplying sufficient participants to the individual courses will also help to improve the quality of the content of these courses. DSPE stimulates this initiative by organising the buy-in of the industry, institutes and universities. The initiative is supported by the DSPE Advisory Board (comprising professors from universities in the Netherlands and executive representatives of the Dutch OEM precision industry) and the DSPE Industrial Board of HRM managers.

By providing a uniform education, the certification programme creates a consensus between the working methods of the different parties, both OEM, SME and institutes, and, therefore, stimulates collaboration and partnerships. It also stimulates networking between professionals in industry (OEM and SME), institutes and universities, which will then contribute to strengthening the position of the Netherlands as a high-tech systems competence centre.

Author's note

Joannes J.M. Collette is chairman of the DSPE certification programme committee and lecturer in Industrial Automation at Avans Hogeschool in Den Bosch, the Netherlands.

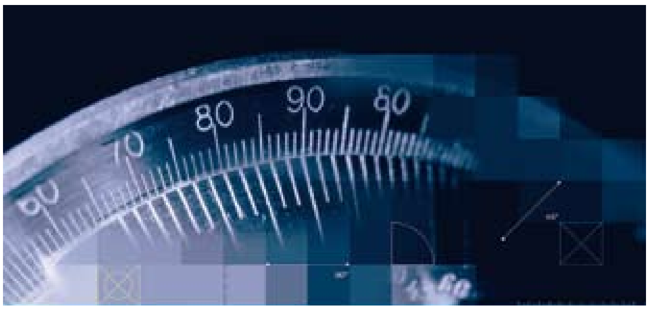
Information

www.dspe.nl

A prosperous

On 8 December 2009, Burgers' Zoo in Arnhem, the Netherlands, was the venue for the final IOP Precision Engineering symposium. Launched in 1998, this Innovation-oriented Research Programme (IOP, in Dutch abbreviaton) has seen 33 doctoral students and two postgraduates conduct research as part of 28 different projects.

• *Daphne Riksen* •



Willem Zwalve, innovation director of SenterNovem (now part of Agentschap NL), opened the symposium with an overview of the results. "This IOP has been very successful in creating joint ventures between knowledge institutes and the business sector. In addition, the IOP has played a significant role in developing an international position in the field of mechatronics and precision engineering. It was a fantastic IOP."
IOP Precision Engineering chairman Lou Hulst looked back on the origins of this IOP, the groundwork for which was laid in 1997 by companies such as Philips, Thales, Océ and ASML. The ensuing years have seen significant changes, according to Hulst: "While the preliminary study talked about a shift from micro to nano range, we are already embarking on the picometre range in precision engineering."

Lou Hulst acted as chairman of the IOP Precision Engineering in its 1999-2009 term. He was awarded the DSPE honorary membership for his contribution to the succes of the programme. (Photos: Horizon Photoworks)

future for precision engineering

Embedding knowledge

Embedding the knowledge gained is safeguarded in a number of ways, explained Hulst. “Because the 3TU Federation (of the three Dutch universities of technology, ed.) has designated precision mechatronics as one of its spearheads, the knowledge gained is securely embedded. In addition, the IOP has resulted in four lectureships in higher professional education, with a further three companies being founded by doctoral students. The other researchers have taken their knowledge and experience with them into the business sector.” The IOP has also ensured that precision engineering has gained more prominence in the Netherlands. For example, the key area of High Tech Systems has been assigned to the Innovation Platform, the number of researchers working in the field of precision engineering at universities of technology and TNO has doubled to 450 since 1998 as a result of all activities, and there was a special knowledge transfer committee which organised such events as Precision-in-Business days.

DSPE president Hans Krikhaar (left) thanked IOP programme manager Eddy Schipper for his dedication.

Enormous boost

The Mikrocentrum – which organises the annual Precision Fair – and DSPE commended the contribution that the IOP Precision Engineering has made to the development and growth of the discipline in the Netherlands. “This IOP has been able to mobilise people and give the field an enormous boost”, said Mikrocentrum’s director, Geert Hellings.

Mikrocentrum director Geert Hellings: “This IOP has been able to mobilise people and give the field an enormous boost.”

‘Dutch Precision’

The speakers at the final symposium looked to the future as well as the past. Maarten Steinbuch (Eindhoven University of Technology), professor and scientific director of the 3TU Center of Competence High Tech Systems, discussed developments in the Netherlands in the field of robotics. “It’s still a marginal subject in the Netherlands, while the possibilities are endless”, he explained. “Fortunately, the 3TU Federation has chosen this as a spearhead, which has created greater focus.” Professors Rob Munnig Schmidt and Jan van Eijk (both from Delft University of Technology) explained to the participants what the new challenges are and why research will continue to be necessary. Munnig Schmidt: “Precision engineering is a groundbreaking discipline. You have to continue making improvements and study every aspect down to the tiniest detail.” While this relates to precision engineering for Munnig Schmidt, Van Eijk is concerned with nano-mechatronics. “With the kind of solutions and the way in which we design nano-mechatronics in the Netherlands, we are in a category all our own”, he said and went on to advocate better international marketing of ‘Dutch Precision’. Doede Kuiper from ASML presented the challenges facing mechatronics developers of lithography machines.

Roadmap

The contributions by speakers from Berenschot consultancy and Point-One, the innovation programme for nanotechnology, embedded systems and mechatronics, were also focused on the future. The new roadmap for precision engineering (see elsewhere in this issue) to which Berenschot is currently putting the finishing touches, provides an overview of trends in the field of system technology, manufacturing techniques and components. This assignment is being carried out by Berenschot at the behest of Point-One, Meesters in de Maakindustrie (Masters in Manufacturing), and DSPE. The roadmap must form the basis for the implementation of R&D projects and aims to clarify the necessary organisational and technological investments. For Point-One, a growing association with 140 current members from within the industry, the roadmap is one of the means that will enable the High Tech Systems key area to grow significantly. The five areas that this relates to (healthcare, energy & power, ICT, lifestyle & leisure, transport logistics & security) account for a total turnover of €20 billion. The aim is to increase this to €30 billion over the next four years.

Landed

To illustrate where the 33 young researchers who did their Ph.D. within the IOP Precision Engineering ended up, six of them were questioned during the afternoon session. All of them have since landed jobs in the industry and with knowledge institutes (they work for ASML, Demcon, TMC Physics, University of Twente, and TNO), or have used their doctoral research to have a go at starting their own company. Max Groenendijk of Lightmotif even came into contact with his first clients through the IOP: in the supervisory committee. The other start-up, Xpress, was founded by Edwin Bos and is active in high-precision 3D tactile sensors, which it supplies to manufacturers of coordinate measurement machines and others. They were all in complete agreement about the added value of doctoral studies: “You have the time to get your teeth into the subject and acquire knowledge”, explained Roger Hamelinck, now working for TNO. “You have lots of freedom and can study multiple aspects of your subject”, added Suzanne Cosijns of ASML.

Three of the researchers who have landed jobs in industry after completing their IOP project.

To the sharks

Finally, under the guidance of Donatello Piras of the Netherlands Debate Institute, a lively discussion ensued between those present about the possibilities and impossibilities of robotics in the healthcare sector. Aside from the substantive value of the debate, the participants also learnt to respect yet be critical of the views of others. The best debater won a shiny trophy, while the most heated statement was also rewarded. The day concluded on a festive note under the motto “To the sharks with the IOP Precision Engineering” (‘Going to the sharks’ is a literal translation of a Dutch expression that means ‘going west’ or ‘going down the drain’) with drinks and snacks being served to participants alongside the enormous aquarium in Burgers’ Zoo. Out of reach of the sharks, fortunately.

Author’s note

Daphne Riksen is a freelance science journalist and copy-writer; this article was commissioned by SenterNovem.

A lively discussion, including voting sessions on three theses about the possibilities and impossibilities of robotics in the healthcare sector, closed the final IOP Precision Engineering symposium.

Information

www.senternovem.nl/iopprecisietechnologie

Sheet Metal Engineering – From Design to Production

Mikrocentrum now offers a new course to demonstrate the possibilities of sheet metal engineering. A strong focus is put on manufacturability, the decisive factor in terms of quality, reproducibility and costs.

The integration of functions in components for constructions often leads to practical problems, for example regarding stability. Sheet metal engineering makes it possible to integrate different functions into a construction's design. Numerous successful application examples can be found in high-tech equipment, cars and consumer electronics. Alas, unfamiliarity with the possibilities offered by sheet metal limits the integration of functions. Also, the limited accuracy of designs in folded sheet metal, as compared to the higher accuracy resulting from a cutting process, is considered a disadvantage.

(Photos: ilco, stock.xchng)

Course objective

The objective of "Sheet Metal Engineering – From Design to Production" is that the participants learn how to think in terms of sheet metal and box design in machine building, how to design functions in sheet metal, using knowledge of manufacturability, and how to design sheet metal components in relation to metal forming theory. The course is targeted at product designers and engineers who are active in the field of sheet metal product and/or product component design for use in machine building, equipment construction and precision mechanics.

Course content

Engineering

- Mechanical forces in sheet metal.
- Bringing stiffness in sheet metal constructions.
- Linear and non-linear effects regarding thickness.
- Determining degrees of freedom with sheet metal.
- Internal and external degrees of freedom with sheet metal.
- Mechanisms constructed in sheet metal.
- Building functions into sheet metal.
- Thermal effects and acoustical and radiation conductivity.
- Securing accuracy in sheet metal constructions.
- Reference systems.
- Practical cases.

Manufacturing

- Introduction into proto and small series manufacturing.
- Proto and small series technologies, such as cutting, punching, folding, jointing, laser cutting, CNC punch-nibbling, folding, edging, setting, stretch forming and deep drawing.
- Mechanical jointing techniques.
- Methods for mass production.
- Pressing and tracking tools.
- Strip lay-out (product being manufactured).
- Cutting, failure mechanisms, burrs, cutting clearance.
- Deep drawing, failure mechanisms, earing, bottom tearing, puckering, tensile stress diagram, material behaviour.
- Stretching versus deep drawing.
- Mechanical features in sheet metal, dimples, spouts.

Information

The "Sheet Metal Engineering – From Design to Production" course covers six days and one morning for two company visits. It will be held in Eindhoven, the Netherlands, starting on Friday, 12 March 2010. The course can also be held in-company and adapted to company needs.
f.bruls@mikrocentrum.nl (Frank Bruls)
p.reijnders@mikrocentrum.nl (Philippe Reijnders)
Phone +31 (0)40-296 99 33, www.mikrocentrum.nl

Offering the customer an integrated solution

Companies in the high-tech manufacturing industry looking to start production of a new product or optimising production of an existing product have to deal with various suppliers. Ultimately, decisions concerning how the individual components are combined are down to the company. There is no such thing as a single supplier that can optimally coordinate material choice, machine, CAD/CAM system, tooling and measuring system. For this reason, five suppliers have combined their knowledge to provide just this in the form of a consultancy under the name KETEN, offering the customer a fully integrated solution. The target group comprises SMEs in the metal industry, particularly companies that concentrate on the production of precision components.

• ***Erik Steenkist*** •

The name KETEN (meaning 'chain' in Dutch) is an acronym of Kennis En Technologisch Ervaren Netwerk (Knowledge and Technologically Experienced Network) and an initiative of five suppliers, each with specialist knowledge regarding a specific element of the production technology; see box. Joop Lahm, sales manager at Van Hoorn Carbide, outlines the idea behind this joint venture and the potential benefits of this initiative for the market.

KETEN partners

- Somatech, CAD/CAM integrator;
- Agie Charmilles, manufacturer of machines for erosion and milling technologies;
- Nimadi, supplier of special steel;
- Renishaw, manufacturer of industrial measuring systems;
- Van Hoorn Carbide, tool manufacturer.

Agie Charmilles, which manufactures machines for erosion and milling technologies, is one of the partners in KETEN.

It's no longer everyone for themselves

"We realised that we were contacting one another more and more often with questions concerning production optimisation in the market. Each of us provided the customer with a partial solution depending on our individual expertise, after which the customer had to link them together themselves. Each of us acts in such situations from their own area of expertise, but as soon as a link is required, problems are frequently not coordinated between the various parties. Production optimisation involves too many parameters that determine the process, meaning that there is always a weak link. Moreover, an adjustment to one of these parameters can have an impact on another parameter. This sort of harmonisation should not be left up to the customer to coordinate, but should be solved within the group. This was the reason that we decided to get our heads together and suggested a joint venture to do this for the customer", explains Joop Lahm.

Feasibility and knowledge

In designing a new product, the accent generally lies on marketing, functionality and cost price, while little attention is paid to feasibility. This is why engineers should consult more often with their suppliers, says Lahm. "More focus on feasibility ultimately provides more profit and that is where KETEN wants to play a pivotal role."

Suppliers are also happy to consider feasibility at an early stage. After all, they have significant knowledge and experience in that field. However, Lahm notes: "A supplier will also have to gather its knowledge of the latest developments from the source and, in this case, that is the manufacturer or original supplier. A CAD programmer, for example, knows a lot about their system but never knows more than the person who developed it. In other words, the

Van Hoorn Carbide

Joop Lahm is sales manager at Van Hoorn Carbide. He coordinates the sale, technology and supply of hard metal milling endmills. With more than 30 years' experience in the metal industry, he is good judge of how processes should be implemented.
Van Hoorn Carbide manufactures endmills in Weert, the Netherlands, for more than thirty countries worldwide, including China, India, Canada and Germany. In the aerospace, energy, mechanical engineering and mould making industries, Van Hoorn endmills are renowned as reliable and high-quality tools. The production scale runs from 0.1 mm to approximately 25 mm in diameter. In addition to a standard programme, many endmills are custom-made according to customer specifications.

Lahm explains the choice to manufacture in the Netherlands: "Although customers look at the price of a tool, the market is more and more aware that reliability is much more valuable than the tool itself. Our high-quality Dutch industry demands that we manufacture tools correctly the first time. Utilising sufficient knowledge makes it possible to achieve far better results and thus lower production costs."
www.hoorn-carbide.com

KETEN primarily targets companies that concentrate on the production of precision components.

customer can never have more knowledge than the sum of the participants. It is important therefore to get your knowledge from the source."

Division of roles

The division of roles is as yet unclear within the new joint venture, as is the earning model. Lahm: "The costs and earnings will initially be divided among ourselves, with independent consultancy assignments generating the earnings. While this could result in an assignment for one or more suppliers within KETEN, this is not the final objective. The company that brings in the consultancy assignment is the project leader and introduces the project to the group."

When a project is presented for a new product or optimisation/innovation of an existing product, the group looks at the product from all disciplines. "We look at the processing strategy, tooling, choice of materials, etc. The key questions are: where is the weakest link and where can we achieve the greatest benefits? Requirements are often too high, thus making the cycle time unnecessarily long. We then pose critical questions and make recommendations that we coordinate with one another first. There are also aspects such as adjustments to the design and the processing requirements, such as the required surface roughness, radius, etc. In fact, we profess to go beyond where the engineers stop."

Precision

KETEN's consultancy concept is aimed at SMEs in the metal industry, particularly companies that concentrate on the production of precision components. "Multinationals such as Philips don't need us, they have in-house expertise. But for an SME there are just a few scientific institutes or universities to consult. For this target group the treshold to these institutes is often too high. KETEN wants to fill that gap."

Although KETEN has yet to be presented with any concrete projects, Joop Lahm names some practical examples that arose by allowing the individual disciplines to work together in the development. Van Hoorn Carbide was working with Siemens Nederland and a German software developer on the development of Hembrug's five-axle milling machine, the Nano Focus, which can process hardened metals with a hardness up to 70 Hrc and tolerances up to 5 µm. This project, in which various suppliers optimally coordinated the development of their parts, illustrates the KETEN philosophy.

Author's note

Erik Steenkist is a Haarlem-based freelance copywriter.

Information

www.keten-consulting.com

A new roadmap

In February 2010, the finishing touches were put to a new roadmap for the Dutch high-tech industry. In the following issues, Mikroniek will closely investigate this forecast, which is crucial for Dutch precision technology and mechatronics. But for now, here is a preview.

The new long-term technology investment roadmap offers an overview of trends in the fields of systems technology, manufacturing technology and component technology. This is a follow-up to the Precision Technology Roadmap from 2004. Where the previous roadmap was primarily focused on technology ('precise to within a nanometre, quick to within a micrometre'), the 2010 roadmap has a more strategic approach and is of particular interest to the various suppliers in the high-tech industry.

Building blocks

These 'masters of manufacturing' must continue to anticipate the ever dominant trend of functional outsourcing at a high bill of materials level by today's OEMs. The building blocks that are given to suppliers in this way are characterised by their low volume, high mix and high complexity – in other words, small numbers, multiple product versions and advanced technology. To create clarity in such a complex situation, the roadmap designates generic building blocks that can be identified in dozens of different systems for various application domains. Such building blocks include those for positioning, handling, conditioning and dispensing. By thinking about building blocks in this way, suppliers can utilize their specific expertise in different areas of application.

Components

This systems approach was also a key element in the previous roadmap and now prevails in Dutch industry. In addition to systems, there is currently also a strong focus on components. The industrial ecosystem in the Netherlands is not yet sufficiently geared to taking advantage of opportunities offered by emerging mixed component technologies, says Joost Krebbekx, who has primary responsibility for setting up the roadmap at Berenschot consultancy firm. He mentions photonic components, microfluidics and sensors/actuators as examples. "There is already a substantial amount of theoretical knowledge regarding these areas in the Netherlands, but still too little in the way of practical skills and markets."

New manufacturing technologies

The 2010 roadmap also places significant emphasis on manufacturing technologies. Krebbekx: "In the Netherlands, knowledge of manufacturing engineering is in danger of disappearing." And this at a time when exciting developments in manufacturing are taking place. Moreover,

During the concluding symposium of the IOP Precision Engineering on 8 December 2009 (see elsewhere in this issue), Berenschot's Joost Krebbekx outlined the contours of the new roadmap. (Photo: Horizon Photoworks)

– I. Preview

everything that is new in terms of systems and components must be manufacturable and affordable. Krebbekx points to the emergence of deposition technologies such as Atomic Layer Deposition (for the manufacture of nano-motors, nano-antennas and suchlike), electroforming and metal printing, and to new, promising combinations of processes such as ECM (Electro-Chemical Machining) with milling. New equipment has to be developed for all these (new) technologies. Furthermore, the online and contact-free measuring on machines will need to expand enormously due to the ever-increasing precision and decreasing sizes of work pieces and components. Krebbekx: “New OEMs can arise in the Netherlands for this too.” And in the field of connection technology, there are opportunities for integrators to develop new processes (i.e. machines) with an accent on the placement and connection of precision components.

Message

The roadmap outlines the opportunities and illustrates them with a list of a hundred prospective customers nationally and internationally for Dutch suppliers. However, gaps have also been identified, which is why the authors of the roadmap will offer recommendations, such as for the establishment of new R&D programmes in new manufacturing technologies.
To be continued in Mikroniek.

Roadmap partners

The new roadmap for the high-tech industry in the Netherlands will be set up by Berenschot at the behest of Point-One, Meesters in de Maakindustrie and DSPE.

Point-One is an open association of and for high-tech companies and knowledge institutes in the Netherlands working on research and development in nano-electronics, embedded systems and mechatronics. This field is the cornerstone of a worldwide value chain with applications in health care, energy & power, ICT, lifestyle & leisure, and transport logistics & security. For Point-One, the roadmap is a means of enabling High-tech Systems & Materials, a key field that includes the above-mentioned domains, to grow from a current turnover of €20 billion to €30 billion in four years.

Meesters in de Maakindustrie is an initiative of Brainport, the innovation network of the Southeast Netherlands top technology region, and now part of the Brainport Industries programme. The aim of this project is to enhance the industrial infrastructure in the region on the basis of the philosophy of open supply chain collaboration.

The Dutch Society for Precision Engineering (DSPE) is a professional community and interest group for precision engineers in the Netherlands. One of its ambitions is the promotion of ‘Dutch precision’.

With its head office in Utrecht, Berenschot is an independent management consultancy firm with more than 500 employees in the Benelux region. Berenschot’s competences include organisational development & management, research & benchmarking, and strategy & marketing. Joost Krebbekx is responsible for the roadmapping process at Berenschot, having been previously involved in setting up roadmaps on precision engineering and on photonic devices. In 2008, he was the co-author of ‘Innovatie in de Nederlandse industrie, op weg naar excellente productontwikkeling?’ [Innovation in Dutch industry; on the way to excellent product development?]

www.point-one.nl
www.brainport.nl
www.dspe.nl
www.berenschot.nl

DAF Engine Test

Within the framework of the Precision-in-Business days which DSPE organizes on a regular basis for its members, last December a visit was paid to the Engine Test Center of DAF Trucks in Eindhoven. Some 30 people participated in the highly interesting tour of this ultramodern test center and of DAF's advanced assembly line.

In 2008, the DAF Engine Test Center in Eindhoven, the Netherlands, was officially opened by Dutch prime minister Jan Peter Balkenende. Some € 50 million had been invested in the new facility. The number of engine test cells available was increased from 14 to 20, to meet the growing demand for research and development work related to severe emissions legislation. DAF engines will have to meet the demands of Euro 6 regulations, as well as also those of EPA 2010 in North America, home of DAF's parent company PACCAR .

Ultramodern

With an annual production of more than 50,000 engines (figure of 2008), DAF Trucks is one of the largest manufacturers of diesel engines for trucks in Europe. "The Test Centre will play an important role in the future development of more efficient and cleaner engines, and enable DAF to build on its leading position in engine development," said Aad Goudriaan, president of DAF Trucks, at the time. "The investment of over 50 million Euro in this ultramodern Test Centre also underlines the importance our parent company PACCAR attaches to the knowledge and experience that DAF has built up in more than fifty years of engine development and production." Apart from engines for DAF, the company also develops engines for Peterbilt and Kenworth, the other truck marques of PACCAR.

Cleaner engines

Over the decades, the diesel engine has undergone enormous changes particularly in the area of emissions. Increasingly stricter legislation in this area has led to cleaner engines. A modern truck or bus with a Euro 5 engine produces 75 percent less NO_x (nitrogen oxides) and 94 percent fewer particulates than a Euro 1 engine ten to fifteen years ago. "Incidentally, today's diesel engine has already reached the emission levels that a few years ago were only thought possible from gas engines. DAF is convinced the diesel engine will continue to play an important role in the future, and not just in combination with hybrid technology, which DAF is also developing", Goudriaan added.

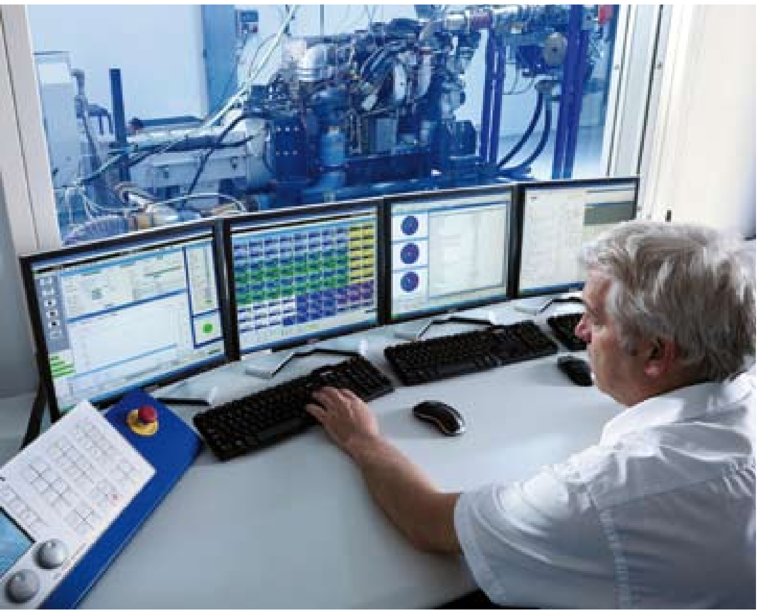
Endurance testing

A number of cells are equipped for endurance testing, where engines run for seven days per week, 24 hours per

The DAF Engine Test Center. (Photos: DAF)

Center

day at ambient temperatures of up to 50 °C. Low temperature tests of down to -20 °C and a complete range of noise, power and emission measurements can be conducted using state-of-the-art technology. Even altitudes of up to 4,000 metres can be simulated.

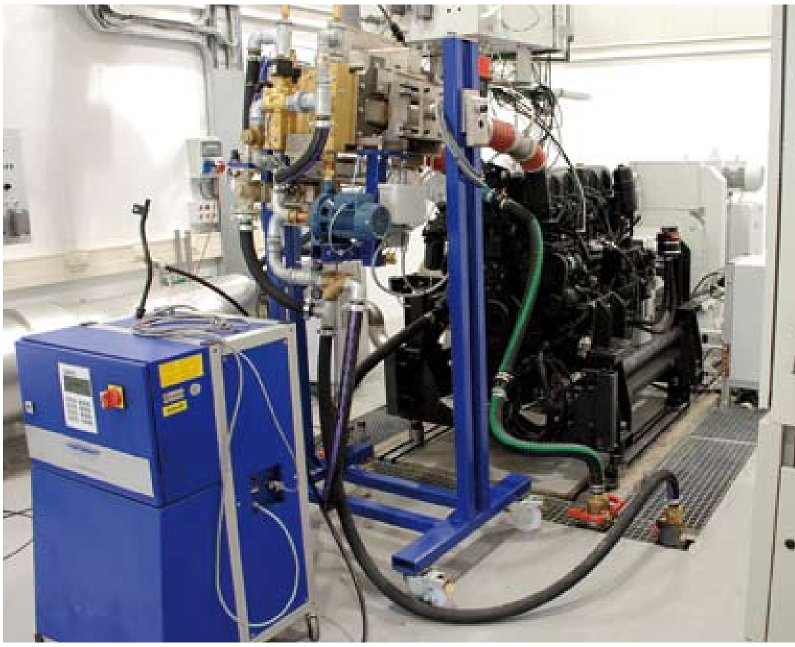


A new high-tech DAF engine test cell.

Dynamos

When designing the Test Centre, environmental design aspects were considered as important as the use of advanced technology. Electrical braking units were implemented instead of standard water brake test cells. During testing, forces are applied to the engines in accordance with what they would normally experience in practice, but at the same time they function as dynamos. These braking units deliver up to a combined capacity of 8 megawatts or some twenty per cent of the total electricity requirement of DAF in Eindhoven.

In addition to underground technical installations, the new building measuring 60 by 130 metres, comprises of two floors, one of which is used entirely for air and water treatment equipment. This equipment can re-circulate 36,000 m^3 of air per hour per test cell, cooling the engines with water, providing air for combustion and venting noise-dampened exhaust gases.



A test cell in operation.

Turbo

DAF has been a leader in engine development for more than fifty years. In 1958, DAF was one of the first truck manufacturers to use a turbo in diesel engines for more power and lower fuel consumption at the same cubic capacity. At the start of the 1970s, DAF was the first to introduce turbo intercooling, now used throughout the truck industry to achieve high performance, lower fuel consumption and low emissions. DAF is committed to achieving lower emission standards by leading engine development and research, and the company was one of the first truck manufacturers to deliver all its models complying with Euro 5 emission standards that were legally effective in 2009.

Information

www.daftrucks.com

Mechatronics Cluster Denmark

Two representatives of the Mechatronics Cluster Denmark, Soren Moller and Just Justesen, visited DSPE last month to explore the potential for collaboration. They were accompanied by intermediairy Luuk van der Laan, a solicitor based in Denmark and specialised in setting up alliances.

The Mechatronics Cluster Denmark is a network-based organisation, which works to enhance the competitiveness of the mechatronics industry in Denmark. The key focus of the organisation is to facilitate the flow of knowledge between industrial companies, competence institutions and universities. Activities range from organising learning networks, over commercial matchmaking to running joint network-based post-graduate rotational programmes. In addition to this, the cluster is involved in policy development and fundraising, where the focus is on building competencies and linkages between science communities and the industry. This also goes for the international contacts, such as the meeting with DSPE.

The Danish mechatronics cluster has its focal point around the city of Sonderborg in the very southern part of Denmark, right next to the Danish-German border. This is the area with the highest concentration of mechatronics industry in Denmark, and the highest concentration of engineers outside the capital. Within a perimeter of only 20 km, more than 10.000 employees in 70 companies strive to develop world-class mechatronics solutions every day. The companies range from large corporations as Danfoss, Sauer-Danfoss and Siemens Flow Instruments, to a wide range of quite smal high-tech development companies with typically 40-50 employees. The research and education lead partner is the University of Southern Denmark, which has mechatronics as its key focal area, up to the Master of Science level.

The Mechatronics Cluster Denmark is constantly looking for joint cross-border projects, company matchmaking or possibilities for the exchange of students and researchers, and would welcome any request from the Mikroniek/DSPE community very much.

ssm@cfe.dk (Soren S. Moller, cluster facilitator)

www.mechatronics.dk

From left to right, Luuk van der Laan, Just Justesen and Soren Moller, representing the Mechatronics Cluster Denmark, and DSPE president, Hans Krikhaar. (Photo: Arno Ottevanger)

2nd Aachen Precision Days

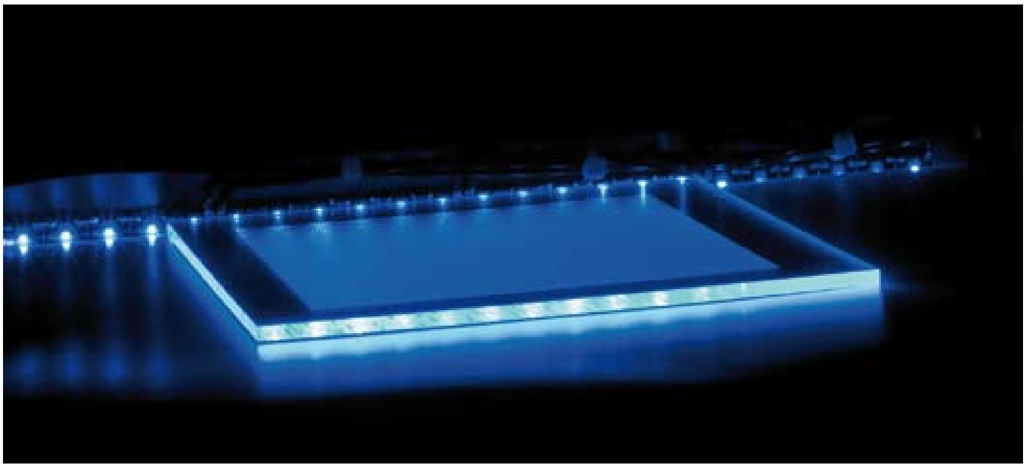
On 18 and 19 May 2010, the Fraunhofer Institute for Precision Technology (IPT) will be hosting the second edition of the "Aachen Precision Days", an international conference with a thematic, interdisciplinary focus on precision and ultra-precision manufacturing for participants from the fields of industry and research.

The two-day conference in Aachen (Germany) will highlight new process chains for the production of high-tech components – both for specialised single-item production systems and for the production of low-priced, high-end products suitable for mass production. The technical presentations will offer participants of the Aachen Precision Days insight into new process variations as they relate to the production of technologically demanding precision and micro-components. Both new methods and opportunities for the combination of new and conventional processes will be playing an important role in current and future research into micro-precision and are, therefore, among the main topics of the conference.

The speakers from the industry and from renowned precision and ultra-precision technology research institutes will use examples of different production sequences involving a wide variety of technological topics to provide an interdisciplinary insight into the current 'state of the art' and future developments.

The conference will be hosted by the Fraunhofer IPT, which develops integrated systems solutions for production companies, with a special focus on new and further development of production methods, production measurement technology as well as the related equipment and machine concepts. Completing its range of services are quality, technology and purchasing management with which to integrate new technologies into mature corporate structures.
The Fraunhofer IPT's Centre for Precision and Microtechnology (ZPM) combines technological competences in the field of ultra-precision and microtechnology. Competent process and measurement technology and machine development contacts are available for bilateral and multilateral development projects.

www.ipt.fraunhofer.de



Hallmark of the Aachen Precision Days, an optically functionalised surface. (Photo: Fraunhofer IPT)

High-tech mechatronics event

On Thursday, 25 March 2010, Techwatch organises the fourth edition of Hightech Mechatronica at the Evoluon in Eindhoven, the Netherlands. The conference and exhibition for research, development and implementation of mechatronic systems is a pre-eminent networking event for technical managers and highly-qualified developers of mechatronical systems. Techwatch is publisher of Bits&Chips and Mechatronica Magazine.

www.hightechmechatronica.nl/en

2010 Photonics Event

On Tuesday, 30 March 2010, Fotonica Evenement 2010, the knowledge and networking platform for the Dutch photonics industry, will be held in Nieuwegein's Business Center (NBC) in Nieuwegein, the Netherlands. The conference programme, with distinguished speakers from TNO Science and Industry, Philips Research, XiO Photonics, Avantes, and other companies and knowledge institutions, focuses on photonic innovations and opportunities in industry, medical technology, and telecom as well as other branches; current developments in fibre, LED, OLED and laser technology and applications; and research and education. The event includes a Knowledge Exhibition, Hands-on Photonics, MatchMaking, and a Photo Contest.

After starting with a plenary session, the event offers parallel sessions on:

- Healthcare & Lifescience
- Sustainability & Optical Sensing
- Information & Communication Technology
- Fundamental Research Photonics
- Photonics in Daily Life
- Industrial Photonics
- Demonstration of Optical Design Software

The Fotonica Evenement 2010 is being organised by Mikrocentrum and Photonics Cluster Netherlands and is empowered by the IOP Photonic Devices (executed by Agentschap NL).

Challenging Technical ASML Cases

Mechanical and electronic engineering students are invited to attend the ASML Open Days on 20 and 27 May 2010, respectively. On both days, attendants will be presented with a challenging technical case. The Open Days also include a technical presentation and a tour of the clean room.

www.asml.com

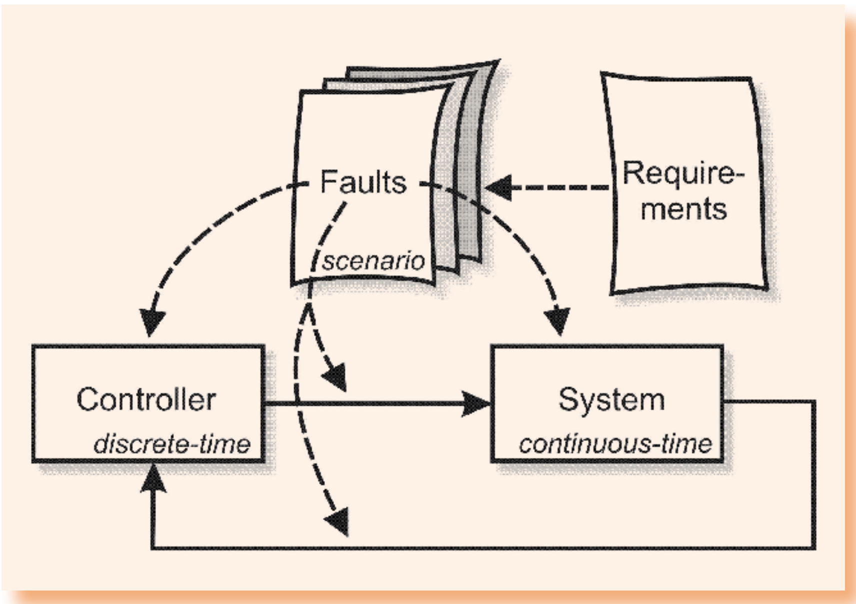
Impression of an ASML Open Day. (Photo: ASML)

Collaborative design of embedded systems

Products containing embedded computers have transformed our lives in the last thirty years but they are among the most challenging of systems to design. The teams that work on embedded products cover many disciplines, including mechanical and electrical engineering, physics and software. Different design models have to be built to meet the needs of each discipline, so that responding to a new product opportunity or a change in components involves considerable re-working, leading to sub-optimal designs and long development lead times.

The European Union's research project DESTECS (Design Support and Tooling for Embedded Control Software) is about developing methods and tools that combine continuous-time application system models with discrete-event controller models. The objective of DESTECS is to support a cost-effective development of dependable embedded control systems. The target is to substantially reduce the effort spent in design iterations compared to current best practice for fault-tolerant embedded control systems.

DESTECS will advance model-driven development by focusing on two engineering domains: (1) discrete event modeling of controllers and architectures, and (2) continuous-time modeling of physical systems. By coupling these domains through co-simulation, cross-domain design issues can be tackled even in the early stages of a design process. DESTECS will exploit co-simulation as a basis for modeling faults and analysing fault tolerant designs for predictably resilient systems.
The DESTECS design methodology will be supported by an open tools platform to provide an integrated design environment. The platform will be flexible to allow an easy extension to other engineering domains, and it does not replace current industry practices but it will support the heterogeneity of tools and encourage collaborative design by integration of domain-specific best practices.
The achievements of the project will be monitored through the realization of industrial case studies by the industrial partners and new exemplary challenge problems gathered from DESTECS's Industrial Follow Group, which consists of sixteen, mostly larger, companies.



The DESTECS design methodology.

DESTECS has been awarded a research grant in the European Seventh Framework Programme on ICT. The project team consists of three academic groups: University of Twente, the Netherlands; Newcastle University, United Kingdom; and Engineering College Aarhus, Denmark; and four companies of which three are SMEs: Chess, Controllab Products, and Neopost Technologies, all from the Netherlands; and Verhaert, Belgium. The total budget is 3.8 M€, of which 2.75 M€ is funded by the European Commission. The project started on 1 January 2010 and runs for three years.

www.destecs.org

TValley 2010

On Thursday, 15 April 2010, the Mechatronics Valley Twente Foundation organises its seventh TValley Conference in Enschede, the Netherlands. Focusing on innovation and business in the high-tech industry, this time the application of mechatronics in widely varying industrial and societal sectors will be highlighted. Next to robotic surgery and rehabilitation training, smart solar cell fabrication, advanced printing technologies and high-end materials processing will be reviewed.

The Mechatronics Valley Twente Foundation started in 2001, to join forces of the University of Twente and mechatronics companies in the Twente region, in the Eastern part of the Netherlands. The foundation funds the chair of Mechatronics Design at the university, stimulates collaborations between its members and participates in regional and national research programmes and business development initiatives.

www.tvalley.nl

Impression of TValley 2009. (Photo: University of Twente)

IOP 'Photonic Devices' part 2

The Innovation-oriented Research Programme (IOP) 'Photonic Devices' has been given a follow-up until 2015, funded by the Ministry of Economic Affairs with € 12.4M. In 2010, new research proposals can be submitted by knowledge institutions and companies.
The IOP 'Photonic Devices' started in 2006, and was aimed at strenghtening the innovative power of Dutch industry by applying new photonic devices in new products and systems. The IOP was executed by SenterNovem, which has become a part of Agentschap NL.

www.senternovem.nl/iop_photonicdevices

Leadership in Precision Engineering & Mechatronics

Eindhoven-based Settels Savenije van Amelsvoort (see elsewhere in this issue) and the Noord-Brabant Development Agency (BOM) have founded a new platform/institute for training and education in precision engineering and mechatronics, in cooperation with experts from amongst others ASML, Océ, VDL ETG, FEI, Frencken, NTS, IBS, DEMCON, Eindhoven and Delft Universities of Technology, and Fontys and Avans Universities of Professional Education.
The focus of the institute is on the improvement of leadership and craftsmanship of technology professionals. Members of the advisory board of the Institute Leadership in Precision Engineering & Mechatronics are: Prof. Dr. Maarten Steinbuch, Prof. Dr. Jan van Eijk, Drs. Marijke Lingsma and John Blankendaal.

www.ilpm.nl

Newport cuts prices and lead times

Newport Corporation, a worldwide leader in photonic solutions to “make, manage, and measure light”, recently announced reduction in lead time and substantial price reduction for optics in Europe. Newport has added more parts in stock in its European facility to cut the shipping time from across the border for customers. Also, effective February 1, 2010, prices for optics have been reduced by an average of 15% in the UK, 30% in other European countries and 15% in related export countries.

Newport has been manufacturing optical components and coatings for more than thirty years. Its standard catalog optics and custom optics offering includes a wide variety of broadband metallic & dielectric optical mirrors, spherical & aspherical lenses, cylindrical lenses, achromatic lenses, polarizers, waveplates, prisms, retroreflectors, objective lenses, telecentric lenses, beam expanders, filters and many other optical components for UV to IR wavelengths. This broad product offering is assisted by technical support and detailed technical information available via web, application engineering and an advanced product development team.

www.newport.com

Pfeiffer Vacuum expands

Pfeiffer Vacuum Technology, headquartered in Asslar, Germany, has acquired Trinos Vakuum-Systeme of Göttingen, Germany. By expanding the Pfeiffer Vacuum portfolio to include the high-quality vacuum components, chambers and systems from Trinos Vakuum-Systeme, the company can now offer its customers throughout the world even more comprehensive solutions for their vacuum needs, according to a press release.
The expertise possessed by the two companies in developing and engineering new technologies is complementary. All regions and market segments are to benefit from this acquisition, in particular the North America region and the analytical, coating and research & development segments. Pfeiffer Vacuum plans to retain and expand the Trinos location in Göttingen, along with all of its employees. The two former owners will remain with the company as managing directors.

www.pfeiffer-vacuum.de

The Sense of Contact 12

The possibilities of sensors and their applications are enormous. The twelfth edition of the Sense of Contact, on 8 April 2010 in the Woudschoten Conference Centre in Zeist, the Netherlands, will showcase the potential of sensors to solve current issues and challenges. Dutch universities, institutes and industry will present their recent sensor research and development according to challenges in art, safety and autonomous sensors. During the day, a broad scope of challenges will be shown, by speakers and students with their latest work. For a hands-on experience several demonstrations will show the possibilities of sensor applications. In the afternoon, three real-life cases will present technical challenges of sensor development.

Target sectors of the event range from high-tech equipment, industrial automation and automotive to laboratory & medical technology, academic hospitals and microsystem and nanotechnology companies. The Sense of Contact 12 is organised by FHI Federation of Technology Branches and the STW Technology Foundation.

www.fhi.nl/senseofcontact

The Sense of Contact 12 will take place at the Woudschoten Conference Centre in Zeist, the Netherlands. (Photo: Woudschoten)

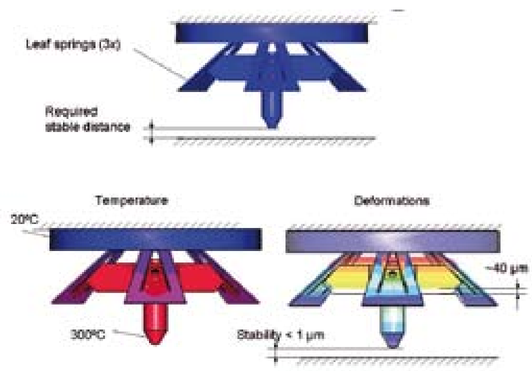
Settels Savenije van Amelsvoort

when business, people & technology need an impulse

Founded in 1987 and located in Eindhoven, the Netherlands, Settels Savenije van Amelsvoort is a leading firm in the development of high-tech products and equipment, the improvement of their reliability, performance and yield, and cost reduction. Our focus is threefold: R&D, Strategic Management Consultancy and HRM.

Research, Development & Engineering

Our core technology is mechanical engineering, process modeling and process engineering, based on in-depth knowledge of and experience in analysing, specifying, developing and engineering high-tech products, processes and equipment. We are experts in the translation of the specifications of complex physical processes into working mechanical products. For example, we combine mechanical and thermal modeling in vacuum and molecular gas flows. We manage and implement product creation processes for our customers. Using our creativity, we translate complex challenges into simple solutions; the figure shows an example.



An insulating suspension of a heated element in vacuum. In the temperature range of 20-300 °C the tip is stable within 1 µm.

Strategic Management Consultancy

In our consultancy practice, we audit technology enterprises and/or their departments. We implement and manage (organisational) change to improve their performance. Often, we combine change-over programmes with the personal coaching of managers, directors and their teams.

HR services

Key success factors in technology-based enterprises are qualified and motivated people whose profiles exactly match their challenges in innovation and technology. We are experts in recruiting, outplacing, training, and coaching (teams of) technology professionals at all levels of seniority.
"IMPACT", our personal development & mentoring programme, in which all professionals working for our company (currently forty) participate, is key to our success, growth and company spirit. We assist technology enterprises in achieving a high level of professionalism in their HR approach, based on expert knowledge and understanding of performance within high-tech innovation and complex technology.

The board of directors: ir. John H.M. Settels (left) and ir. Guustaaf P.W. Savenije, both major shareholders and principal consultants, leading various strategic projects.

Information

Settels Savenije van Amelsvoort
Tel. +31 (0)40 – 851 20 00, www.sttls.nl

ADVERTISERS INDEX

Mikroniek guide

Bearing- and linear technology

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

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

Development

TNO Industrie en Techniek
Postbus 155
2600 AD Delft
T +31 (0)15 2696969
E wegwijzer@tno.nl
W www.tno.nl

member DSPE

Education

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

member DSPE

Lasersystems

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

member DSPE

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

member DSPE

Metal Precision Parts

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

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

member DSPE

Micro Drive Systems

Minimotor Benelux

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

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

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

member DSPE

Motion Control Systems

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

Motion Control Systems

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

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

member DSPE

Optical Components

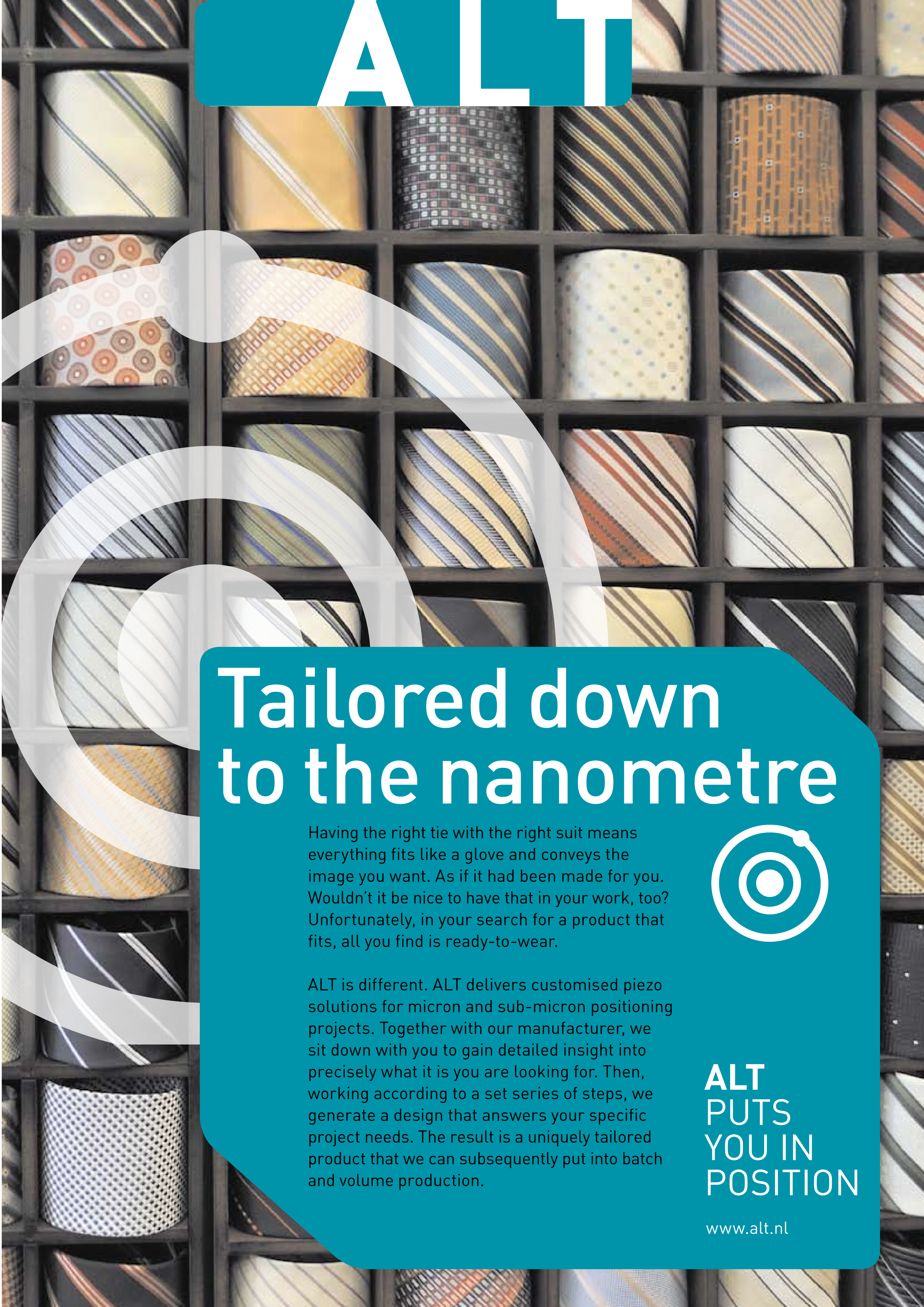
Molenaar Optics
Gerolaan 63A
3707 SH Zeist
Postbus 2
3700 AA Zeist
T +31 (0)30 6951038
F +31 (0)30 6961348
E info@molenaar-optics.nl
W www.molenaar-optics.eu

member DSPE

Piezo Systems

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

Distributor of Nanomotion,Noliac and Piezomechanik


ALT
Tailored down to the nanometre
Having the right tie with the right suit means everything fits like a glove and conveys the image you want. As if it had been made for you. Wouldn't it be nice to have that in your work, too? Unfortunately, in your search for a product that fits, all you find is ready-to-wear.
ALT is different. ALT delivers customised piezo solutions for micron and sub-micron positioning projects. Together with our manufacturer, we sit down with you to gain detailed insight into precisely what it is you are looking for. Then, working according to a set series of steps, we generate a design that answers your specific project needs. The result is a uniquely tailored product that we can subsequently put into batch and volume production.
ALT PUTS YOU IN POSITION
www.alt.nl