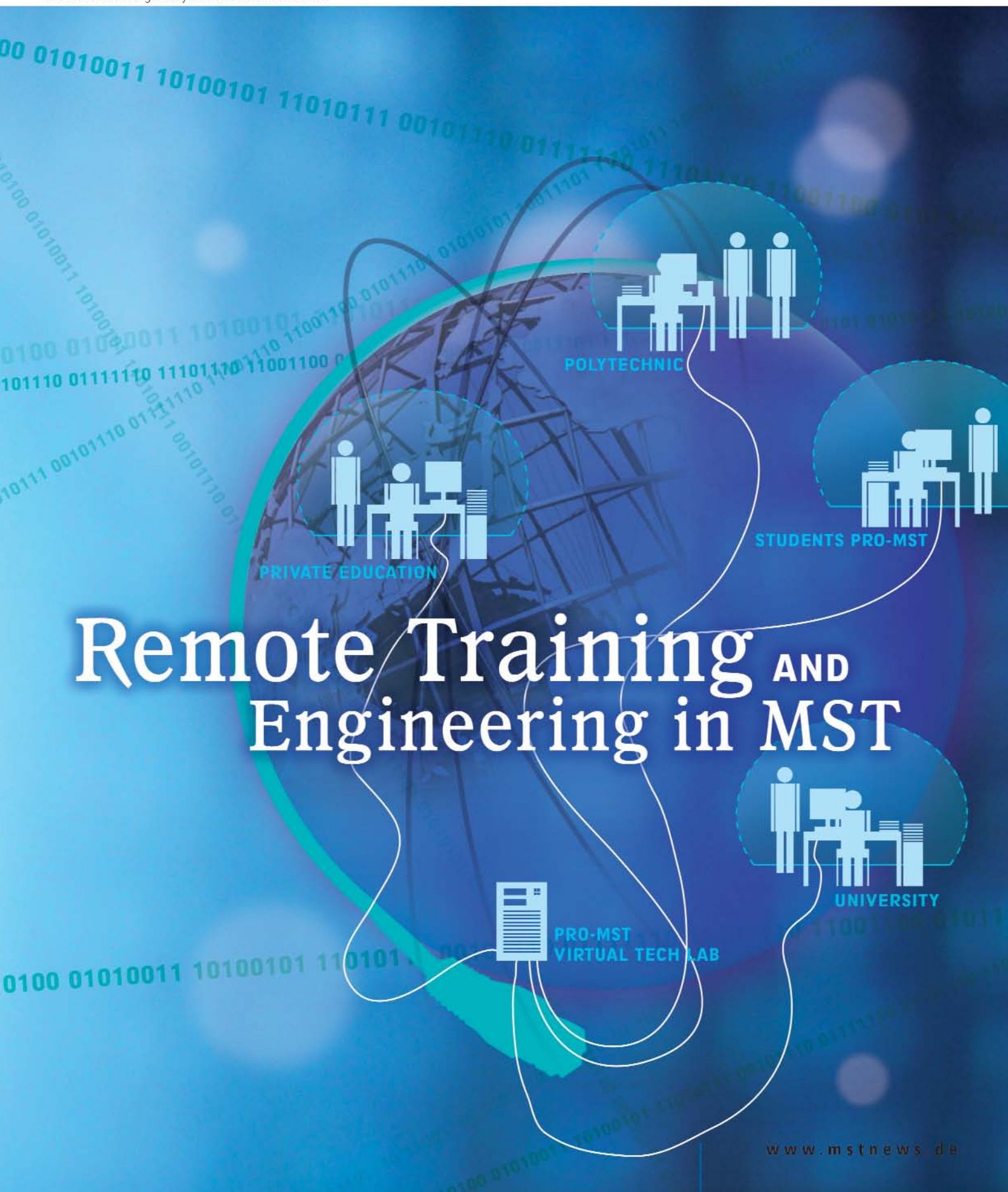
No. 6/06 - December 2006

international newsletter on
micro-nano integration

mst news

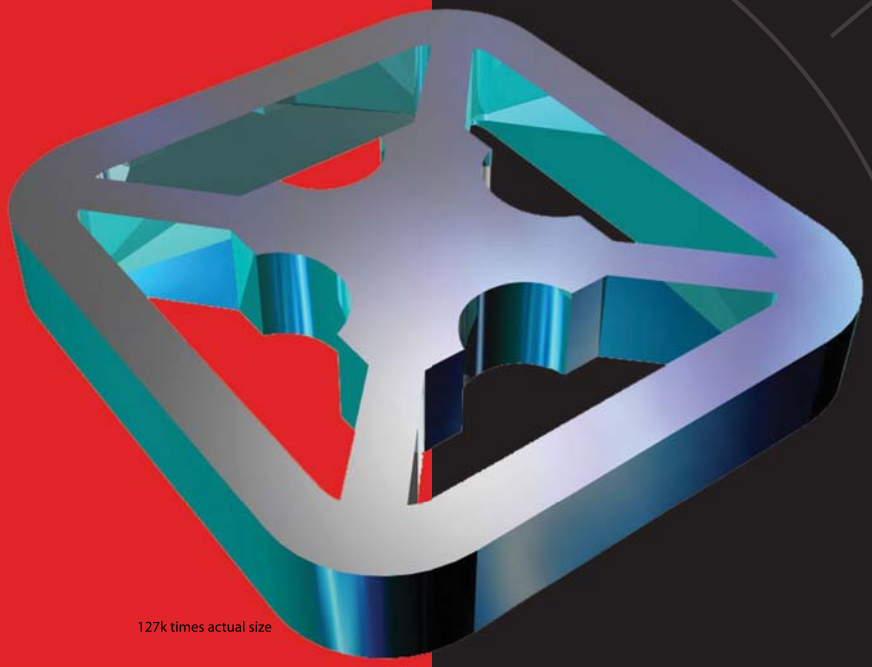
VDI/VDE-IT | NEXUS Association / NEXUSPLUS | EUROPRACTICE | EURIPIDES
Patent-DfMM | mst germany | NAoMITEC | MNT-ERANET



Remote Training AND Engineering in MST

www.mstnews.de

Discover SiTime



127k times actual size

Introducing the new SiTime SiRes™ product families.
Built to replace traditional Quartz Oscillators and Resonators.

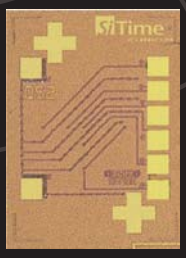
5.1 MHz 0.8 x 0.6 x 0.15 mm SiRes Resonator

1 to 125 MHz 2.0 x 2.5 x 0.85 mm SiRes Oscillators

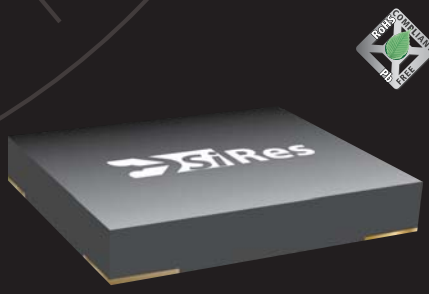
Lower cost compared to Quartz products

Survives 30,000 G Shock

Less than 0.100 ppm 1st year aging



SiT0100



SiT8002 and SiT1xxx

Request a sample at www.sitime.com

CompoTEK GmbH
Lindwurmstr. 97a
D-80337 München
Tel.: +4989544323-0
Fax: +4989544323-21
e-mail: info@compotek.de
www.compotek.de

München - Dresden - Wesel

SiTime™
It's about time

Contents

Look ahead to the next issues:

mstnews 1/07 on a) "Chemical Micro Process Engineering" and b) Cross-sectoral Applications of MST" in February 2007

This issue has two technical topics that will present a) an update on technologies from the field of chemical micro process engineering and b) examples for a possible way of expanding the dissemination and utilization of micro and nanotechnologies by making use of them in completely different application fields than initially intended.

Deadline for press releases, short news, events, and advertisement orders: January 15, 2007

Date of distribution: February 09, 2007

mstnews 2/07 on a) "Smart Factory with MST" and b) "Converging Technologies" in April 2007

The April issue with two technical topics that will report a) on applications of MST in industrial automation for implementing "smart" structures and functions in industrial production environments and b) on examples of possible systemic integration approaches with micro, nano, bio and information technologies and cognition science.

Deadline for abstracts: December 15, 2006

Date of distribution: April 05, 2007

Dear Readers,

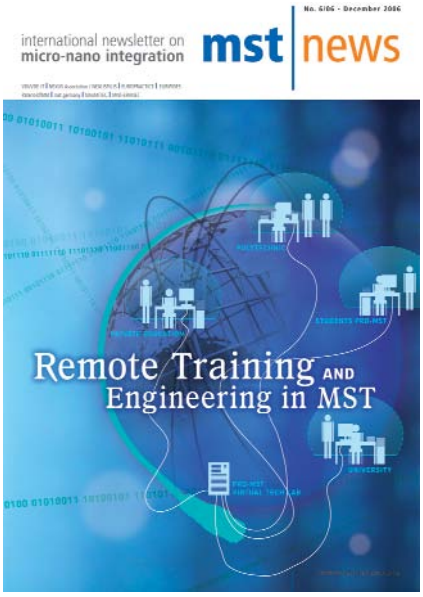
Micro and nano technologies (MNT) are highly attractive as means for innovating and creating new products, but on the other hand they usually require a high investment at the beginning. This serious barrier, which affects small and medium-sized enterprises in particular, is not only caused by expensive equipment for development and production processes, it is also built up by the initial lack of advanced engineering knowledge and the related technical experts and skilled workers.

One proven strategy for solving such problems is joining the efforts and sharing the costs. mstnews regards the dissemination of information about "best practices" as one of its basic tasks.

This issue is dedicated to present approaches to tackling the challenges in two selected fields that - by the way - show some overlap: the education and training in MNT and the engineering (modelling, design, simulation, testing ...) needed to develop and produce MNT-based solutions. We have been looking for examples where resources (such as new technical knowledge from research labs, manpower of teachers, computational power for modelling, simulation and virtual reality presentation, clean room facilities and so on) have been made accessible to a broad circle of users by different ways: on-line via the internet in "real-time" or not, and and off-line by multimedia CDROMs and other "learning packages". We hope that the given examples will inspire you to create or to make use of comparable solutions for your specific situation.

Coming to the end of 2006 we can look back at another successful year (of mstnews history). It is the 15th now! We'd like to thank you, our readers, for your interest and great support and wish you all the best for the new year of 2007!

Bernhard Wybranski
Chief editor



Scheme of a virtual training and education network

Main Topics of mstnews until April 2007

Issue	*Main Topics*	*Deadline for abstracts*
Feb. 07	a) Chemical Micro Process Engineering b) Cross-sectoral Applications of MST	passed
Apr. 07	a) Smart Factory with MST b) Converging Technologies	Dec. 15, 2006
June 07	a) Mobility b) Consumer Electronics and Mobile Communication	Feb. 15, 2007

Publisher:
VDI/VDE - Innovation + Technik GmbH (VDI/VDE-IT)
Steinplatz 1, 10623 Berlin, Germany

mstnews is published 6 times a year in February, April, June, August, October and December.

mstnews comprises newsletter pages from several European Networks (Nexus, Europractice, Eurimus, Patent-DfMM) and the German Microsystems Frame Programme.

Managing Editor / mstnews Office:
Bernhard Wybranski, VDI/VDE-IT
Steinplatz 1, 10623 Berlin, Germany
Phone: +49 30 31 00 78-167
Fax: +49 30 31 00 78-105
E-mail: mstnews@vdivde-it.de

Editors:
Alfons Botthof
Patric Salomon
Dr. Matthias Werner
Wiebke Ehret
(German MST Programme News)
Sabine Globisch
(Training/Education)

Assistant Editors:
Uwe Klädtke

Cover design:
ib-graphik

Setting:
klahr.de

Advertising:
We welcome sponsors and advertisers. Please visit www.mstnews.de to download our media data and advertising rates.

Subscriptions:
Subscriptions are free of charge to qualified readers in Europe.
Readers from outside Europe and commercial resellers may order a subscription at an annual rate of 120.- Euro.
Please make use of our online subscription service at www.mstnews.de

Submission of Articles:
Your submissions are appreciated. The main topics of the future issues are listed on the left, but other interesting articles that do not fit into this scheme are also welcome. Please send your abstract to the mstnews office. Guidelines for authors are available on www.mstnews.de

Announcements, New Products, Books, Studies, Company Information:
mstnews publishes selected announcements, product and company news free of charge. Please send your news (100 to 200 words preferred) to mstnews@vdivde-it.de.

Opinions expressed by the authors are not necessarily those of mstnews.

SUSS Engineers Help You Climb New Heights

AltaSpray coating technology from SUSS MicroTec represents the ultimate solution for your 3D lithography application. AltaSpray equipment masters the challenge to reliably coat over severe topography and cover sharp edges while avoiding the accumulation of resist in trenches.

SUSS AltaSpray coaters offer a variety of features that let you widen your process window:

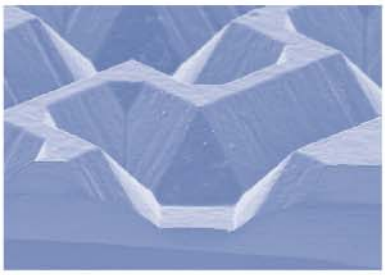
. Process flexibility to handle a large variety of photo resists

. Conformal coatings over various step heights

. Capable to cover sidewall slopes from 0° to 90° and more

. Proprietary spray design for optimal reproducibility and cleanliness

. Substrate sizes from pieces up to 200mm round and 6“x6“ square



SUSS MicroTec test structure with a great diversity in the structure orientation and a topography variation of 200µm.
Spray coated with 4µm Clariant AZ4999 positive resist.

SUSS. Our Solutions Set Standards

www.suss.com/AltaSpray
For more information on AltaSpray contact: info@suss.com

SÜSS MicroTec

Remote Learning and Engineering

Sabine Globisch

Why is this topic of importance for successful innovation processes in the high-tech industry? It is not the task of mstnews to contribute to the overall discussion of how to tackle the problems of less developed skills in mathematics and the natural sciences. Although it would be worth thinking about a new integrated concept of technical education from Primary School to Continuing Education of ageing employees, we will focus on specific challenges in the fields of Microsystems technology requiring solutions for the benefit of firms and esp. engineers in research and development units as well as in production. Undoubtedly, skilled personnel and successful recruiting strategies will be of increasing importance for companies to remain competitive or to strengthen their competitiveness e.g. in high-price niche markets. Companies compete with each other in recruiting the best staff. Losers can already be identified: research institutions and SMEs. Major problems with training skills and the transfer of knowledge esp. for small and medium-sized enterprises in the high-tech field are:

- Time-consuming absence from the workplace for training purposes: In times of economies of scale every production factor is well calculated. The time to consumer must be minimised without any stock-keeping. Any capital lockup should be avoided. This has implications for what is now the human factor. Companies regard time-consuming absence from the workplace due to training courses as equivalent to expenses for training and educations. Thus training activities are expensive and will be reduced to an absolute minimum.
- Access to high-tech equipment just for educational purposes: The opportunity of access to appropriate high-tech equipment decides whether researchers and engineers can participate in recent technological developments or not. Since training facilities for Microsystems Technology should correspond to a certain high-tech standard, they are expensive and must be profitable at least. The use of manufacturing technologies for the purpose of education and training is also less reasonable because of the adjustment for training and manufacturing.
- Integration of training into the workflow and the daily tasks of an employee in the high-tech business: The acceleration of research and development at the edge of the technological evolution is crucial for the competitiveness and economic exploitation of both companies and research institutions. In order to shorten the time gap between research findings and their applications and to abridge the process of both research and application, it is of high interest to enable employees at their place of work to benefit from new technological findings during their daily work.

The idea of decentralized web-based further education seems not to be very common. Practical experience and examples are seldom enough in general but especially in technical areas. Nevertheless e-learning and blended learning concepts are valuable options in comparison with traditional vis-à-vis training modules when dealing with the above-mentioned aspects.

Remote training concepts face typical organisational barriers for the further education of employees, although on the other hand they need to respond to several challenges. Typically, technically based education fields need to comprise not only theoretical knowledge and scientific background, but also practical learning units. Therefore, the barriers of industrial companies against in-house training can be seen in the acquisition of expensive training equipment for tests and experiment, as well as in the absence of employees from work. The basic conditions mentioned above clearly show why industry in some cases needs or intends to avoid traditional further education. Hence, it is necessary to take into account the motivation of participating in further education when e-learning and blended learning concepts are developed. Beside the technical aspects of those concepts, the didactic issue is another challenge. Solutions so far seem not to be very popular, since the didactic background for realisation is not appropriate (see BIBB Informationsdienst 3/2003).

Another aspect for publishing this topic is to report on new strategies in micro-nano technology (MNT) against the background of the skills shortage on the national and international level in the industrial area. Therefore, the article mainly focuses on new in-house concepts to realise training and education and other kinds of simulations and process engineering in different ways.

In Germany the agenda for the development of e-learning or blended learning concepts in Microsystems Technology was defined in 2002, when the contest for training and educational networks was carried out. The four articles from Germany (pro-mst, learn-mst, MunichMicronet and mstbildung) refer to specific concepts that have been developed for academic or vocational training in Microsystems Technologies.

The rationale behind targeting consumer-oriented training concepts, most notably in blended or e-learning format, can be seen in different

Figure: The dynamic process of technological development requires permanent appropriate qualification to run the process of ongoing diffusion smoothly

barriers to the process of technology transfer to industrial use. In the awareness that technological evolution and its transfer to application fields causes a lack of appropriate skilled employees first on an academic and finally on a non-academic level, which on the other hand indicates the delay of technological diffusion, solutions were requested to preserve the economy from a shortage of skills and a lack of appropriately educated employees.

In order to set up a system of training concepts it is necessary to understand the knowledge requested from the application fields. Concerning Microsystems Technology, relevant skills are precise work in microstructures, often under clean-room conditions. Technical equipment and clean-room conditions must be available to teach and exercise those skills and it is necessary to have a prequalification in the behaviour under clean-room conditions. Besides the question of available clean rooms for training courses, expenses for such training facilities are a relevant factor for offer and participation. In general, clean-room facilities require maintenance to maintain conditions for production processes. Hence, each training unit will be an incident to them.

Absence from work is the other important factor for the neglect of further education and training. Especially SMEs, the major structure of Microsystems Technology companies, lack human and capital resources to substitute their employees during training courses. Therefore, in Germany only 71 percent of companies with 10 up to 49 employees participate in further education while 87 percent of companies with 50 up to 249 employees attend training courses and 98 percent of larger companies (at least 250 employees) take part in training units. Still, the readiness of German companies to allow participation in or offer further training and education is better than the European average of 62 percent. The number of employees participating in training and education across Europe is 47 percent while in Germany only 36 percent of employees have the chance to participate in further education (see BIBB: Betriebliche Weiterbildung in Europa, 2003).

The analysis of BIBB shows that the proportion of in-house training in the industrial sector (NACE G: 0.9) is nearly as small as that for the public sector (NACE O: 0.8). Only manufacturing industry (NACE D: 1.3) provides a little more in-house training. In contrast to the sectors of services (NACE K: 2.6), facility and insurance (NACE J: 2.5) are more active in in-house training (see above BIBB, 2003). Participation in in-house training for the manufacturing and the industrial sectors (NACE D and NACE G) is minor compared to that for services and facility and insurance (NACE K and NACE). Regarding the dynamics in technology transfer and its barriers, like shortage of skills and lack of appropriate skilled employees, the results sound alarming.

In summary it can be stated that the rationale behind the reduced activity in the field of further training and education of industry might be an awareness of cost-benefit ratios, a critical level of manpower in the companies and a lack of opportunities to attend training courses in Microsystems Technology. Therefore, e-learning and blended learning concepts seem to be the crucial option to maintain requested training, esp. for research entities and SMEs. Those training concepts enable them to attend training courses much more easily than before. They can maintain their competitiveness and moreover they are enabled to attract researchers as future employees. New training concepts could contain features for e.g. simulation and tests or theoretical background with a certain portion of practical exercises. They give researchers and engineers the option to share brand-new knowledge within their working process. The gap between research and application could be minimised. This option would lead to a better competitiveness of entities that have been disadvantaged so far.

The articles published in this issue present a wide range of facets of what the concerns of blended and e-learning are or can be. Blended game-based learning introduces what is called a serious game. Mission mst-3 combines playing and learning in the field of micro production. The training modules launched by learn-mst are an autodidactic system and thus make it possible to broaden or accomplish MST knowledge for already appropriately qualified employees. The internet-based "Teaching-Learning Environments" from mstbildung deals with work tasks of microtechnologists with a high relevance for application. Due to a didactic concept behind the platform, users can design their own work plan. The training and educational foundry pro-mst developed a highly efficient blended learning system that addresses the benefit of high-tech education for moderate expenditures in combination with state-of-the-art clean-room equipment and is completed with a virtual technology lab for preparatory training. The topic of virtual presentations in blended sales training in order to shorten the way from R&D to sales and thus save money is introduced by NanoSPRINT.

Contact:
Sabine Globisch
VDI/VDE-IT + Technik GmbH
E-Mail: Globisch@vdivde-it.de

Innovative Strategies of Qualification in Microsystem Technology

Robin Sandvoß

Focusing on Microsystem Technology, this article presents an approach to fulfil the demand for qualification and Lifelong Learning by using innovative, net-based strategies of teaching and learning. The teaching/learning materials are provided via an open source Learning Management System (LMS) ILIAS, which was installed on a server of the L3S Research Center and is easily accessible. This article elucidates how to qualify with these materials and strategies in the highly innovative field of MST.

Qualification in MST – a Challenge for Vocational Education

The translation of Microsystem Technologies from development into application and (mass) production requires not only engineers, but also skilled workers with a specific vocational training. Staff members have to deal with microstructures and they need to be experienced in clean rooms, new materials and basic scientific methods. For

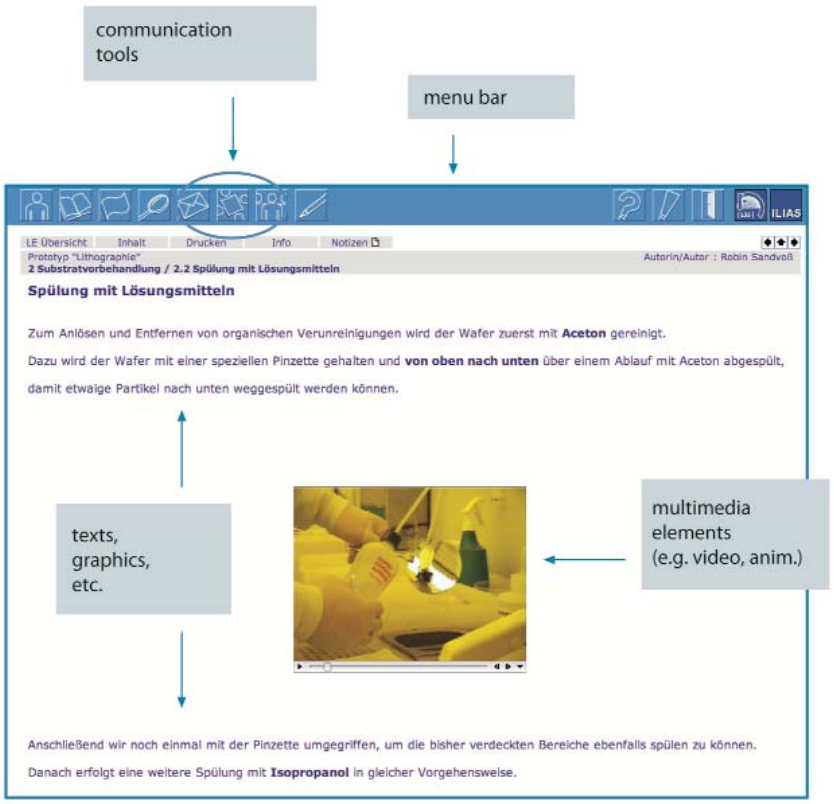


Figure 1: Essential LMS features.

this reason, in 1998 the new profession 'Certified Microtechnologist' [1] was established to fulfil the demand for qualification of the industry. Within Germany approx. 70 companies offer this vocational training [2].

In Germany, technical education is carried out within a dual system. The trainees work in their companies on three or four days per week to learn their trade on the job. During the remaining days, they go to special vocational schools to deepen their theoretical knowledge. In most technological professions, the technical education usually requires 3.5 years.

Compared to other professions, qualification in MST poses a challenge to vocational education because of many difficulties, e.g. high innovation potential, continuous improvement of production processes, ever-changing curricula and lack of transparency of working methods, technologies and company organizations. That's why it is very difficult to convey theoretical content to trainees in a practical and action-oriented way [3].

Furthermore, the technical equipment is very complex and expensive and cannot be used in vocational schools. Action-oriented instruction is consequently only possible with external partners. All these special features of MST complicate education and qualification in MST.

Therefore, the German Federal Ministry of Education and Research (BMBF) promotes educational networks with the objective of co-operating and building up training facilities.

One of the aims of mstbildung, the 'Educational Network to promote Microsystem Technology in Lower Saxony', is to develop highly innovative, net-based strategies for the qualification in MST. Institutes, companies and a vocational school thus co-operate to assure a complete and high-quality education for microtechnologists [4]. The L3S Research Center is responsible for innovative teaching/learning strategies and materials as described in this article. For this purpose, a Learning Management System is used. The LMS is faced with the following essential tasks:

- Provision of the needed materials
- Presentation of technical topics (multi-medial).
- Medium of communication (e-mail, forum, chat).
- Administrative functions

The open source LMS 'ILIAS' was installed on a server of the L3S Research Center and is accessible to all participants in this project (fig. 1) [5]. With the help of 'profession-typical Teaching-Learning Environments', trainees learn to solve everyday problems in a real working environment.

These internet-based 'Teaching-Learning Environments' deal with typical work tasks of microtechnologists of high relevance to applica-

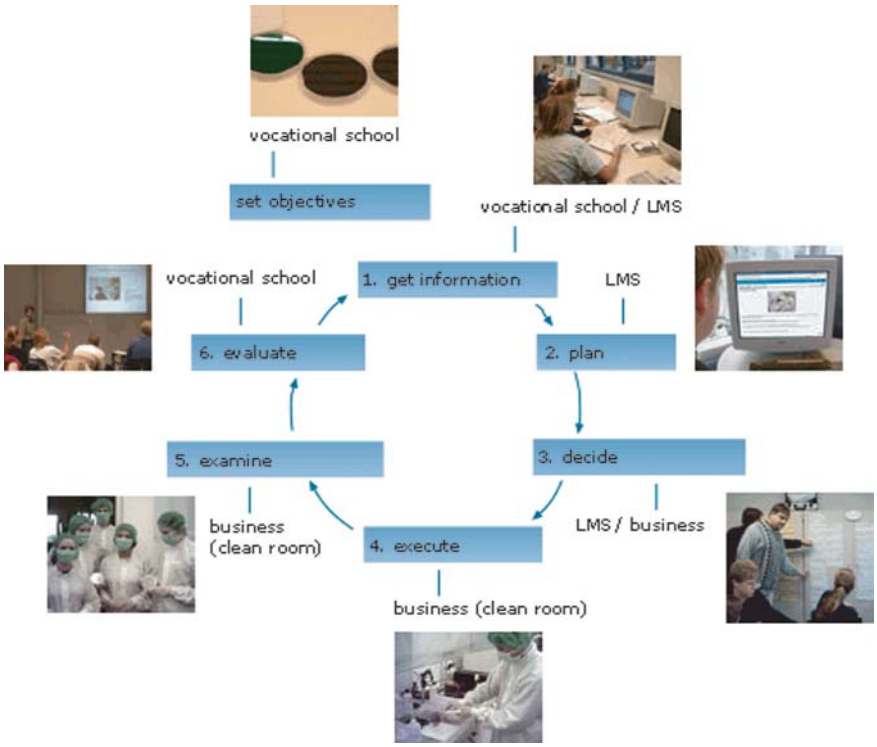


Figure 2: Principle of Complete Action.

tion. Special attention through the choice of the work tasks for the LMS is paid to a close connection with professional practice and a realistic representation of the work process. This is supposed to enable trainees to set up a work plan and to perform the described activities autonomously after having dealt with the tasks on the LMS. Therefore, domain-specific contents, e.g. operation of profession-typical plants and handling of special means of labour, were created and presented multi-medially (video, etc.).

The project courses follow the principle of 'complete action' (fig.2). The individual phases are performed by the trainees at different learning places [6]:

At the vocational school the trainees are introduced to the work task itself (0,1). In the companies (business) where the trainees are learning and at home they can acquire the necessary knowledge for planning and performing the task and set up the work plan (2,3). Therefore, the trainees use the learning units, which are presented in a virtual classroom on the LMS. In the laboratory (companies) the trainees perform the work task and check the result (4,5). At the vocational school they finally reflect on the process of solving and discuss possibilities for improvements (6,0). In order to support information and communication of the trainees, a closed user group was established on the LMS. Within this group the trainees have access to all relevant information and work sheets necessary for planning and performing the work tasks. The learning units are created and put on the LMS by the tutor before the start of the projects. They contain general physical as well as plant-specific information (e.g. about operation systems, processes) relevant for performing the work task. Information is available in the form of texts, photos, videos, graphics, animations and data sheets.

The evaluations of these projects show:
With the help of the net-based Teaching-Learning Environment all participants acquire new and important technical knowledge in an action-oriented way [7]. The trainees can set up the work plan with the help of the information given on the Learning Management System without further support. They are also able to perform the profession-specific tasks correctly. Materials can be easily adapted to changes in technology and processes.

Thus net-based strategies of teaching and learning fulfil the demand for qualification and Lifelong Learning. They offer the opportunity to support trainees in their adoption of action competence in the rapid changing field of MST.

References:

[1]Bundesinstitut für Berufsbildung: Mikrotechnologe/Mikrotechnologin, Berlin, Germany, 1998
[2]Globisch, Sabine: The Importance of Education, mst news 5/03, VDI/VDE, Teltow, Germany, November 2003
[3]Brandt, Michael K.; Schmidt, Ulrich: Ausbildung in der Mikrotechnologie – Eine berufspädagogische Herausforderung, lernen & lehren (l&l) 73, 2004
[4]mstbildung, Official web page of the project, http://www.mst-bildung.de, L3S, Hanover, Germany
[5]ILIAS, Learning Management System, http://www.ilias.uni-koeln.de, University of Cologne, Germany
[6]Sandvoß, Robin; Weiner, Andreas: Netzbasierte Lernformen in der Ausbildung von Mikrotechnologen. In: Pangalos, Joseph u.a. (Hrsg.): Informatisierung von Arbeit, Technik und Bildung, Münster: Lit Verlag, 2005
[7]Sandvoß, Robin: Net based strategies of qualification in Microsystem technology, TESI 2005, Training, Education and Simulation International, Maastricht, NL, 2005

Contact:

Robin Sandvoß
L3S Research Center
Leibniz University of Hanover, Germany
E-Mail: sandvoss@l3s.de

Blended Game-based Learning

Carolin Dehne, Frederic Adler and Norbert Schwesinger

The institute for the physics of electrotechnology at the Munich University of Technology is conducting research in the field of Microstructured mechatronical systems, exploring the potentials and implications for university teaching: A Blended Learning environment is under development that connects traditional knowledge transfer (e.g. lecture, exercises, tutorials, and hands-on training) with game playing elements (Game-based Learning) in a coherent way. The project it part of the network for further education of Microsystems engineering, which is called MunichMicronet and is financially supported by the Ministry of Education and Research (BMBF).

In cooperation with the University of Augsburg (Professur für Medienpädagogik, Prof. Dr. Gabi Reinmann), the MunichMicronet is developing a "learning game" and a Blended Learning Concept, which is intended to convey the complex contents of Microsystems engineering to engineering students. The game is to stimulate the introduction of more forms of innovative multimedia for teaching and learning at the university.

The initial point was and still is the fascination of computer games and the firm conviction to use computer games for learning. At its most basic level, our research in interested in how learners can be motivated by computer games, how computer games are able to spark interest and curiosity, and how to engage this fascination in learning. This area gives priority to the problems of a rising generation of scientists specializing in technology. The emotional-motivational concepts of computer games are informed by "legitimate" theoretical perspectives on learning and educational research: Computer games are shown as demonstrative, interactive, and complex learning media.

In our project we argue that computer games cannot only be used as a motivational tool, or as an intensive activity mediated by electronic objects, but can also function as ambitious, complex, and effective learning media. The two main foci of the project are the development of a Game-based Learning environment and the integration of the game-playing elements in a blended learning environment for the higher education of Microsystems engineering. The purpose is to create a playful, highly motivating learning medium that allows the active application and absorption of teaching content without losing the close connection with essential content.

Blended learning was introduced because experience with e-learning shows that a total substitution of common learning and teaching methods is not reasonable. At the Munich University of Technology, there are two lectures, each accompanied by exercise courses and a project course in the institute's clean room. In the future, the

courses and lectures will be accompanied by a learning game. This learning game is meant to facilitate the active application of the content knowledge. It can also be used as a tool for visualization and experimentation both in the more passive knowledge gained through lectures and in the more active courses. In that way, it works as an integrating element. In addition to its instructional function, it also aims to support the social aspects of learning.

Computer players are expert communicators and exchangers of information about the games they play. We use this fact to catalyze the exchange of students and lecturers. The learning game should be systematically adopted in the exercise courses to improve the communication of students and lecturers. This arrangement of game-based learning encourages students' cooperation and social skills by combining real and virtual tasks, real projects and different learning, teaching and social interaction.

Grounded on theoretical considerations concerning the combination of learning and playing, the game is intended to have a motivational effect and make room for the neglected emotions that always accompany learning. Recent scientific discussions centre more and more around the relationship between learning and playing and the opportunities of using games for learning. The importance of play for children's learning is well documented in the field of developmental psychology. Recent research on learning and teaching is more and more concerned with the constitutive role of emotions. This is important because play often provides more positive emotions than rote learning does. A new approach in the field of learning with media is game-based learning. This approach uses computer games for learning. Game-based learning is generally suitable for learners who

- have to deal with technical and more difficult to understand matters as well as complex problems
- are difficult to reach with specific matters and tend to be unmotivated and
- are both experienced and apt at playing computer games.

There is new generation of learners who are different in that they have grown up with computers and video games. This has changed their way of dealing with new information and learning. The old ways of learning won't satisfy these learners.

In our project, we take these changes into consideration. We also believe that computer games fuel motivation and intensive engagement. We show that computer games are superior, complex, and especially effective learning media. A big advantage of computer games is that they allow learners to interact and to visualize complex material. Strategy games and economic simulations, for example, show that computer games not only engage the emotions (especially fun), but also have cognitive advantages. Computer games are very similar to visualizations used in education, to business games and simulations, and to scientific and technical simulations. Additionally, they are more motivating.

Therefore, computer games can help learners to understand difficult matters better because they support learning with fun.

In the game, the students take on real tasks surrounded by motivating computer game elements. To begin with, they have to reconstruct/rebuild simple micro systems. At a higher level they also must develop the design of the micro system and decide how to produce it with given processes and materials. In the end, they can use all processes and materials mapped in the game to produce their own micro system to solve real problems given in the project course. The game always allows learners a chance to try out solutions and to see what happens. The game could also be used to visualize processes described in the lectures and exercise courses and to facilitate discussion.

The learning game delivers problems and tasks very similar to those in the real production of micro systems. So the students must apply and reflect on the knowledge gathered in their courses. The game (see figure) allows them to design a production process for micro systems and to see the result of each step. This is realized trough several buildings and a dynamic visualization of the process. One can link these buildings, which represent different processes, in producing micro systems and apply different materials to the buildings. Clicking on a building one can choose a selected process. If several buildings are linked, a click on every building shows what happens to the micro system in the building.

Figure: Screenshot of the game

The tasks in the game range over all important processes and materials used for micro systems. The simulation part of the game is enriched by typical computer game elements: Gathering resources (materials), searching for important machine parts and developing a narrative framework. Players always gets short, precise information on processes, materials, and machine parts as well as a detailed feedback trough high scores and explanations during and after each level.

Overall, such games promote knowledge application or knowledge transfer to an intense, active, and emotionally positive level, thereby leading to further discussion and supporting social processes.

For mastering complex, ambitious content, there is no "quick and easy" way. It will always be necessary to spar longer and more intensely with the content; however, computer games can be a very effective way of facilitating this process. In the game, the teaching content is prepared as a computer game that resemble a "mental game", in which a given problem must be solved cognitively and in which a solution problem can be realised and checked experimentally. This increases the attraction for the target group by integrating content in an exciting story. The (analogous) close-to-reality way of the problem makes the application and reflection of the provided contents (e.g. by lecture) necessary.

From an educational/psychological point of view, the following goals are pursued: a) An increase in motivation and success in learning in the study of Microsystem engineering as a result of the learning game and Blended Learning arrangements. b) Gaining knowledge and experience in the processes of successfully integration this learning game into university teaching. c) Gaining knowledge and experience in the opportunities and boarders of Game-based Learning for beginning engineering students.

Different modules of the game are currently being technically converted. At the same time, a textbook for Microsystems engineering for the university is being developed. The textbook is being worked out didactically and serves to mediate basic knowledge while simultaneously supporting the game software.

Contact:
Technische Universität München
Fakultät für Elektrotechnik und Informationstechnik
Fachgebiet Mikrostrukturierte Mechatronische Systeme
Carolin Dehne, Frederic Adler and Norbert Schwesinger
Theresienstr. 90
D-80290 München, Germany
Phone: +49 89 289 23111
E-Mail:
dehne@tep.ei.tum.de
frederic.adler@phil.uni-augsburg.de
schwesinger@tum.de

Modules and an Interactive CD – an Autodidactic System in Microsystem Technology

A. Kaprolat

The fascinating area of microsystem technology inspires everyone who knows about Gauss, Leibnitz and Humboldt or, in other words, about curiosity and interest in science. With a growth rate of over 20 p.c. per year, microsystem technology is one of the fastest growing branches of technology. The world market for MST devices was valued at over 4 billion Euros in 2005. Expectations for the future are even higher. Such innovative technologies also require quite a potential of well and specifically trained and qualified employers. Right now great efforts are being made to train microtechnologists, as the profession is officially called in Germany. Since 1990 developments in microsystem technology have been supported through projects of the Federal Ministry of Education and Research. Under the framework project in the aid programme called Microsystems 2004 to 2009 six regional networks for training and further education in microsystem technology (AWNET) have been supported since the end of 2002. One of these further education networks is learn-mst. The main subject of this network, coordinated by the "Berufsförderungszentrum (Bfz)" in Essen, is the development of didactic materials in microsystem technology.

The didactic material formerly used in training is more of an academic kind with complex mathematical deviations. There has been no corresponding material for qualified workers and operators. This led to a concept that pursued the aim of presenting contents in microsystem technology in an easy way without losing the special information, thus being suitable for qualified workers.
The main subjects have been divided into modules. Prof. Dr. Lilienhof and his team of Fachhochschule Gelsenkirchen attached the given concept. The result is a number of modules that are treated in didactic sessions, or one can work with autodidactically at home. The translation into English is done by a specialist of microsystem technology, Jörg Müller. According to the training schedule for microtechnologists, there are 9 modules:
Material science, clean room technology and yield, lithography, additive techniques, doping techniques, assembly and packaging, material characterization, microfabrication, microsystems. Each module contains 1 to 4 submodules according to the complexity of each module, 18 all in all.

The target to be reached can be tested in two ways. First by repetitive questions referring to the contents of the module, which aim at a pure reproductive achievement. Then there are further questions that can only be answered with acquired knowledge of an advanced level. Here a transfer of knowledge is required.

The time given to work on a module is 1 to 2 weeks. The 18 modules have been worked on by two groups of retraining based on the trainee concept (12 months of training in a training centre and a further 12 months of practice in the microsystem technology industry).

The process was tested by the university of Essen, a partner, and 2 teachers. The test and its results led to optimized options:

- Build-up of a computer-based glossary;
- Inventing forum on a didactic platform to exchange information. Each group gets its own forum, where teachers and authors also take part;
- An interactive CD is planned as a so-called "didactic clip" by the FH Gelsenkirchen. The advanced questions appear in three modules first.

The interactive CD is nearly complete and is being tested right now. Different groups such as retraining, students and autodidacts test the CD with regard to its function and use. The example is the manufacture of a flow sensor for controlling mixtures in a car. Each subject is supported by images, short movies and animations in Flash so the user gets the picture. Each page has a notice function where further information can be written down. This CD is an addition to the modules and can be used in networks.

With the help of these didactic materials and additional lab practice at partners such as RAG BILDUNG and the FH Gelsenkirchen, a trainee can develop into a highly qualified worker in a fascinating profession with a future career. By the way, you can get each module in English, so they can be used on the international market.

Contact:
Alex Kaprolat
E-Mail: kaprolat@bfz-essen.de

Cover-layout example in German

Adopting the Foundry Concept of Semiconductor Fabrication on Educational Schemes and the Virtual Technology Lab (VTL)

A. Picard, P. Kämper, A. Schütze, D. Wallach and Th. Walter

Teaching high technologies like MNT or other modern topics as e.g. bioengineering has to tackle such frequent problems as the high cost of state-of-the-art lab infrastructure and equipment. In general, hands-on training with appropriate tools is limited to very few examples. Moreover, even if state-of-the-art lab equipment were available, the complexity of modern equipment would not allow students the freedom of real experimental experiences. Instead, students have to follow rather restricted operating instructions without any possibility of exploring the features of the fabrication tools. The training and educational foundry pro-mst has developed a highly efficient blended learning system that addresses the above problems of high-tech education: pro-mst offers other educational institutions access to MST training facilities at moderate costs with state-of-the-art equipment in a clean room. This is complemented with an efficient method of preparatory training with the Virtual Technology Lab (VTL).

Introduction

Micro- and Nanotechnologies (MNT) are regarded as key technologies and essential for the competitiveness of highly industrialized countries. MNT comprise rapidly developing high technologies, are very interdisciplinary and cover a wide variety of applications. "High tech" in an educational context also means that you have to deal with very expensive and complex machineries. The affix "rapidly developing" intensifies the difficulties in keeping educational equipment up-to-date. Multidisciplinarity and the variety of applications on the other hand imply that it is difficult to handle every aspect of MNT on every educational site. Educational institutions have to decide on a clear profile and to focus their resources on their individual strengths.

As an example, the number of educational institutions offering study courses in MST has been rapidly increasing since 1995, but only very few can offer appropriate hands-on courses on the fundamental process technologies within an up-to-date clean room environment. It is a simple fact that the enormous investment and running costs of a training clean room are beyond the budgets. Actually, in certain cases clean rooms for advanced R&D or production purposes are available – but clean room managers are very reluctant to give

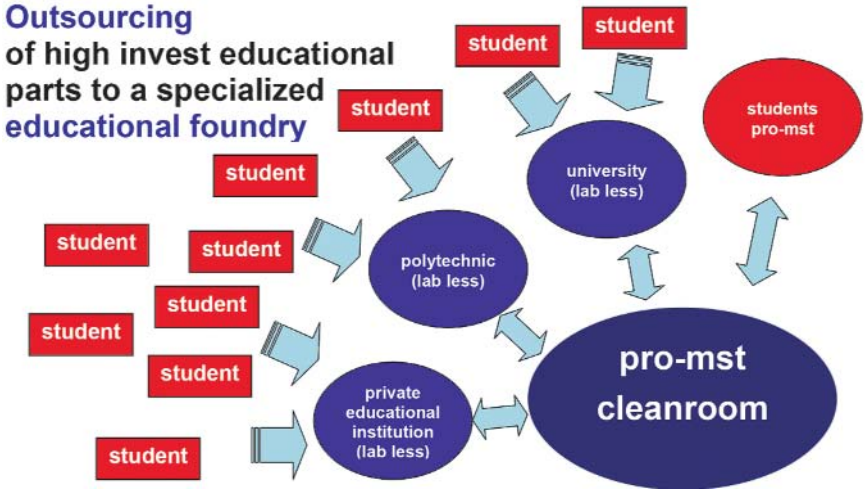


Figure 1: Adopted foundry concept within high-tech education.

access to inexperienced students. High-tech machineries and production lines are very sensitive to maloperation. Even a minor mistake within a process line can cause severe problems in yield or postpone the success of R&D projects for months.

Many other new fields like nanotechnology or bioengineering, but also classical disciplines like RF electronics or hydraulic engineering, face a similar key problem: up-to-date practical experience for students during their university education is very limited, resulting in suboptimal education results.

One way to address this situation is cost sharing within a scheme that we have termed education and training foundry.

An Education and Training Foundry: pro-mst

pro-mst is a network of several universities and partners from industry and R&D institutes as well. pro-mst acts as an education and training foundry while offering hands-on MST courses in a 300 m² training clean room at the campus Zweibrücken of the Kaiserslautern University of Applied Sciences. The fully equipped clean room, various measurement tools and a small assembly facility allow the fabrication of complete silicon sensors within a state-of-the-art semi-professional environment.

The concept of the training foundry resembles the very successful business concept of production foundries within microelectronics and MST fabrication. A foundry is specialized on fabrication processes and collects orders from different fab-less operating companies. This results in a very high degree of cost efficiency and productivity on both sides, i.e. foundry and orderer. The foundry can achieve an optimum rate of utilization (e.g. of a CMOS process line) and the orderer can concentrate on his specific profile and offers his own clients a lean but complete service (e.g. customer-specific ICs)

Fig. 1 shows how pro-mst adopted the foundry concept for high-tech MST education. Different "lab-less" educational institutions do offer cost-intensive educational study courses as MST to their clients, i.e. students. The part of the very expensive clean room training is sourced out to the training foundry. Lab-less, of course, only refers to a specific clean room lab for general educational purposes. It does not mean that there should be no laboratory at all. As an example, the University of Saarbrücken runs a very sophisticated clean room for advanced R&D projects, but they use the training facilities of pro-mst for the general practical education within the study course mechatronics/MST. Within only one week of intensive training students can build their own silicon sensor as shown in Fig. 2.

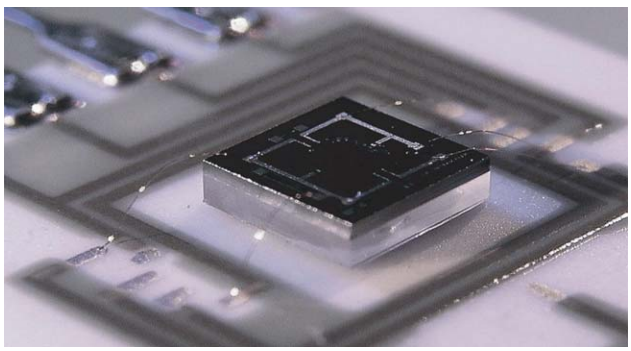


Figure 2: A simple, but fully operational silicon pressure sensor, manufactured by students from Aachen within a one-week excursion to the pro-mst clean room in Zweibrücken.

A proper preparation of the students is an indispensable prerequisite for such an intensive and ambitious lab course with real hands-on experience. Severe operating errors must be avoided since they might be dangerous for both the operator and the equipment. On the other hand, it would not be appropriate if the students just watched how professional operators handle the expensive equipment!

Moreover, in many cases modern high- tech equipment gives access to the processes only via computer panels, and the process itself is hidden in a closed process or vacuum chamber. This makes a direct experience of process fundamentals extremely difficult even if the students could operate the machinery by themselves.

pro-mst tackles the two problems of proper preparation and the "hidden processes" within modern equipment by a Virtual Technology Lab (VTL).

Virtual Technology Lab (VTL)

The Virtual Technology Lab is an essential part of the blended learning concept of pro-mst and comprises a set of interactive computer simulations, process animations, and illustrative videos.

- **Simulations** are employed for complex machines, which are controlled either by computer via a GUI or a machine control panel. The simulations resemble the user interface of the machines and respond interactively very much like their real counterparts at the training foundry
- **Animations** are used in those cases where only limited interaction occurs between the machine and the user. Animations are also advanta-

Continuation on page 35