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The enablingMNT reviews analyse the critical issues encountered during the creation process of MNT-based products and provide guidance with regards to the approaches taken to overcome barriers and challenges. All reviews include a comprehensive listing of services offered in the field (including current contact information). The emphasis is on the provision and availability of fully commercial services, infrastructure, and suppliers considered to be essential for the commercial realisation of MNT-based products. It is expected that enablingMNT industry reviews will motivate new applications for MNT, enhance confidence in the technology as well as help identify funding sources for research and development. They highlight trends from the facts and the prospects and provide a wealth of intelligence for assessment and strategic decision-making. Supported by significant players in the field, the reviews are produced and edited by the enablingMNT team.

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- Test and Measurement Equipment and Services for MST/MEMS – worldwide, Dec 2004 (€280)  
100 pages, which include 14 tables, 9 figures and 48 company profiles
- Suppliers of Materials for MST/MEMS Production – worldwide, Sep 2004 (€280)  
100 pages, which include 16 tables, 10 figures and 58 company profiles
- MNT Web Directories and On-line Communication Channels – worldwide, Aug 2004 (€280)  
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- Equipment Suppliers for Nanofabrication – worldwide, Apr 2004 (€280)  
90 pages, which include 10 tables, 13 figures, and 44 company profiles
- Back-End Manufacturing Equipment Suppliers for MST/MEMS – worldwide, Nov 2003 (€280)  
100 pages, which include 12 tables, 13 figures, and 64 company profiles
- Front-End Manufacturing Equipment Suppliers for MST/MEMS – worldwide, Nov 2003 (€280)  
90 pages, which include 24 tables, 9 figures, and 45 company profiles
- Packaging and Assembly Services for MST/MEMS – worldwide, Oct 2003 (€280)  
95 pages, which include 10 tables, 10 figures, and 46 company profiles

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- Design, Modelling and Simulation Tools for MNT – worldwide
- Packaging and Assembly Services for MST/MEMS – UPDATE 2008

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## MST/MEMS Activities in China - Industry and Key Research Centres

August 2007

Given the magnificent growth, over the past few years, of the Chinese industry in electronics manufacturing, it is no surprise that the breadth of the MST/MEMS activities in China is also experiencing a dramatic rise. enablingMNT's assessment of the developments in China indicate that the Chinese MST/MEMS industry is in the first place aiming at: the semiconductors, automotive and telecommunications markets, but effort to penetrate the medical, industrial and consumer markets are also evident.

**The enablingMNT analysis of this developing Chinese MST/MEMS industry** demonstrates that there are two strong forces behind the Chinese MEMS industry, namely: (1) foreign companies starting joint ventures or subsidiaries and (2) national and regional government investment. The major areas of interest to those investing companies are in two main areas; manufacturing equipment and components/sensor fabrication. In the later group tire pressure sensors are especially of interest, given the size of the automotive market. The enablingMNT review will provide readers with a detailed overview of this growing segment of the MST/MEMS community with profiles of the most important stakeholders in this exciting new market opportunity.

The enablingMNT industry review on MST/MEMS Activities in China has more than 100 pages, which include 7 tables, 10 figures, and 62 company profiles.

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## Design and Engineering Companies for MST/MEMS

January 2007

**The enablingMNT Review on Design and Engineering Companies for MST/MEMS** analyses the current state of design houses in the context of microsystems markets and development trends. It provides an assessment for the various types of design houses in terms of the facilities and the capabilities on offer and their position within the product development chain and its lifecycle. With over 75 organisations studied and compared, the state of design houses across the world has been evaluated.

The study has established that design houses have, of late, become more evident, as the potential advantages of microsystems-based components and (sub) systems materialised for many varied applications (automotive, IT and medical).

Design houses appear to offer the multi-disciplinary approach necessary to fully understand and exploit the potential of the technology, due to their having a more flexible access to a wider range of capabilities and expertise than either a foundry or a specialised industry will have. In addition, the design houses claim to provide an ideal gateway to small- and medium-sized enterprises (SMEs) for accessing the technology that, generally, would be prohibitively expensive to undertake. In essence, the proliferation of design houses is becoming a vital element for the realisation of the predicted future market potential.

The enablingMNT industry review on Design and Engineering Companies for MST/MEMS has more than 115 pages, which include 9 tables, 10 figures, and 77 company profiles.

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## Foundries for MST/MEMS

November 2005

**The enablingMNT Review on Foundries for MST/MEMS** is a complete update of the previous Foundries review. It analyses the status of foundries across the world. The analysis was undertaken in light of the technologies underpinning the microsystems (MST/MEMS) development processes and market opportunities. It has confirmed a number of perspectives and views associated with the survivability of foundries vis-à-vis products, quality and market sizes. The study also revealed how viability of this business is deeply linked to the overall supply chain and the product lifecycle.

The results provide a useful insight into the potential opportunities available for investment and the pitfalls necessary to be avoided. Clearly, such decisions will need to be addressed and balanced against the ensuing economic climate and the overall financial trends. Finally, the report includes sufficient levels of classification and categorisation for various aspects of the technologies, and the industry, in general, to provide particularly useful insights into the activities and the developments in this market. With over 40 organisations studied and assessed, this comprehensive report provides an up to date account of the state of this business and its future potential.

The enablingMNT industry review on Foundries for MST/MEMS has more than 90 pages, which include 9 tables, 19 figures, and 43 company profiles.

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## Processing Service Suppliers for MST/MEMS

May 2005

Time to market and achieving the right levels of quality and price are the most challenging aspects of MST/MEMS industrialisation. Subcontractors are key, and often underestimated, elements in the commercialisation process. Specialised suppliers, delivering optimised processing services are the subject of this report.

The **enablingMNT Industry Review on Processing Service Suppliers for MST/MEMS** provides an overview of technologies, company information and general trends and background. This study has confirmed that there is a healthy supply of replication services as well as services offering glass processing as a prime capability for optical or fluidic products. These services seem to be more prevalent in Europe as the USA appears to be concentrating more on the conventional thin film technologies.

Most of the service suppliers offer a range of more or less similar technologies, although the traditional separation between front and back end processing remains well defined. The geographically-based preferences between the USA and Europe stems from the source of the developments, where in the USA developments were spurred by the semiconductor industry which started activities to support this industry by supplying technology services. In Europe, on the other hand, companies were started by university based researchers and their evolving aims to commercialise the technologies from within those establishments. In addition to the traditional MEMS technologies, enablingMNT has studied services in the following areas and included in the report:

- LIGA and alternatives like SU-8 and HARMST
- Optical/MOEMS production
- Laser and mechanical precision machining and engineering
- Micro sandblasting
- Powder-blasting

The enablingMNT Industry Review on Processing Service Suppliers for MST/MEMS has 130 pages including 16 Tables and 11 Figures, and 77 company profiles.

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## **Test and Measurement Equipment and Services for MST/MEMS**

December 2004

MNT devices require precise measurement of multi domain and inter-related parameters. In the case of mechanical microsystems, the static and dynamic behaviour must be investigated in such a way that the measurement does not interfere with the performance of the device. Optoelectronic devices need simultaneous measurement of electrical and optical signals often with extreme demands on accuracy and resolution, whilst in fluidic devices the systems require the measurement of well defined flow rates of fluids with accurate composition. Thus, testing MNT products is much more complex than testing standard electronic components.

There is a huge potential for suppliers of specific equipment for MNT testing. Whilst this market growing and transforming itself from R&D to production, testing has been a neglected area. The current scarcity of suitable equipment suppliers is underpinned by the fact that in many companies the test equipment is built in-house.

The **enablingMNT Review on Test and Measurement Equipment and Services for MST/MEMS** provides an in-depth analysis of the state-of-the-art in MST/MEMS test and measurement technologies ranging from in situ probing of electrical and mechanical properties to the testing of functional devices, such as inertial sensors. The report includes outlined descriptions of the basic underlying techniques and technologies and detailed information on the suppliers from across the world. The enablingMNT team has analysed the markets of equipment suppliers and companies supplying test and measurement specific equipment and services for the MST/MEMS industry. The research culminated in this review, which incorporates an outline of the technologies and markets for MNT, a description of testing techniques and profiles of around 50 selected suppliers.

The enablingMNT industry review on Test and Measurement Equipment and Services for MST/MEMS is over 100 pages including 14 Tables and 9 Figures, and 48 company profiles.

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## Suppliers of Materials for MST/MEMS Production

September 2004

Although still considered to be the smallest of MST/MEMS markets, the demand for specific materials (substrates, resist, etc) is growing. Equally relevant is the fact that users are operating in a fast changing and diverse environment, forcing the suppliers to develop and sustain a range of application specific products.

**The enablingMNT Review on Suppliers of Materials for MST/MEMS Production** shows that a multitude of companies ranging from small start-ups to the chemical and plastics giants are supplying the MST/MEMS community. Having noted the neglect by the suppliers of large quantities for the high volume electronic industries, small companies started to developed customised material solutions for the MST/MEMS market: where, for example, high aspect ratio resist as well as thin resist for nanoimprinting are offered by relatively small companies.

The quality and properties of materials are essential for the successful development, commercialisation and operation of any MST/MEMS product and the choice of appropriate materials must be seriously addressed during the design phase. Demand for MST/MEMS specific materials (substrates, resist, etc) is growing, but the leading driver in this market is application specificity. There is, as a result, a limit to the extent of uptake of new materials where, in general, production engineers are very reluctant to change base materials in their line, especially if such materials are critical to the process.

As the position of materials is changing from just a commodity to an enabling factor, suppliers of "only" standard materials need also to change their business model. They, in turn, should adapt to market forces in order not to lose market share to the numerous specialty suppliers.

The enablingMNT industry review on Suppliers of Materials for MST/MEMS Production has more than 100 pages, which includes 16 tables, 10 figures and 58 company profiles.

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## Web Directories and On-line Communication Channels

August 2004

The **enablingMNT Review on Web Directories and On-line Communication Channels** incorporates the results of an in-depth investigation into web sites and electronic newsletters that are MNT-focused. The report also includes outline descriptions of the MNT technologies and markets and an in-depth analysis of web-based directories and information sources.

Electronic information as provided by web-directories and web sites offers a potentially simple means of accessing a very wide audience with little effort and very small marginal/additional costs. There is an increasing reliance on web-based directories for both dissemination and information gathering. This type of information platform is preferred for novel technologies such as that of micro nano technologies (MNT). Nevertheless, due to the large number of web sites available, users are often disconcerted as to the usefulness and the ability of the sites to fulfil their specific needs.

To address this issue, enablingMNT has carried-out research into over 100 web-based directories and newsletters, which focus on MNT. The research has revealed that the stakeholders (technology providers and users) are both driving the impetus in this field. The objectives, although diverse, have one common goal: to encourage the uptake of the technology. Unlike the well established technologies (e.g. semiconductors), web-based directories for MNT are, currently, fairly generic in their content and target audience. This is due to the fact that MNT needs to be publicised to a new community of potential users.

In addition to an overview of the MNT market, the review contains an analysis of the world wide web as a means of dissemination and information gathering, as well as a discussion on the characteristics of web sites. Finally, a summary of trends with regard to web directories and profiles of around 40 selected web sites is incorporated in the review.

The enablingMNT Review on Web Directories and On-line Communication Channels has more than 68 pages, which includes 8 figures and 40 company profiles.

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## **Equipment Suppliers for Nanofabrication**

April 2004

**The enablingMNT review on Equipment Suppliers for Nanofabrication** classifies the production equipment used for nanotechnology-based products into four subgroups: top down, bottom up, nanoparticle processing and nanotube production. The top down and bottom up approaches are mainly equipment oriented, whilst, Molecular Self Assembly, nanoparticle and nanotube production are process oriented. In this context, the top-down and bottom-up nanotechnology equipment was found to have benefited from the available equipment infrastructure which is extensively used for semiconductor lithography and deposition as well as the ample availability of Scanning Probe Microscopes. The development of processes for the production of nanoparticles is, to date, mainly carried-out in-house as there is limited equipment availability on the market, although this field benefits from the experience derived from the chemical/physical process equipment market.

The investigation has also found that with six main contenders offering capabilities in nanoimprinting, this section of the market is well covered. Additionally, it is concluded in the enablingMNT review that the most promising application for dip-pen technology will be for the deposition of bioactive materials, which cannot be deposited or structured using the harsh techniques of thin film processing. In contrast, bottom up nanotechnology is the least developed area of nanotechnology. To benefit commercially from the ability to manipulate atoms and molecules at the atomic scale, a basic understanding of the processes at such a scale is needed. Bottom up technology is also struggling with the needed combination of nanoscale precision and volume demand. This difficulty is clearly seen with Scanning Probe Microscopy, when used as nano-manipulation tools.

Regarding nano-particles or fullerenes, the current core enabler was found by the reviewers to be the process. Thus, process knowledge and not equipment is, currently, the most important differentiator among suppliers. In this context, the major differentiator between the suppliers will be the ownership of equipment and processes, which are used to produce large quantities of nanotubes at low cost and with high purity.

The enablingMNT industry review on equipment suppliers for nanofabrication has more than 90 pages, which include 10 tables, 13 figures, and 44 company profiles.

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## **Back-End Manufacturing Equipment Suppliers for MST/MEMS**

November 2003

### **The enablingMNT review on Back-End Manufacturing Equipment Suppliers for MST/MEMS**

provides an in-depth analysis of the state-of-the-art in MST/MEMS equipment such as those for precision position/manipulation, wafer thinning, microgrippers etc. The report provides outline descriptions for the basic underlying techniques and technologies backed up by detailed information on the suppliers from across the world. Using information from an extensive database of equipment suppliers and companies supplying Back End-specific equipment for the MST/MEMS industry, the report provides a wealth of intelligence for assessment and strategic decision-making. This review has focused on the processes adopted by manufacturers that cater specifically for back-end production of MST/MEMS and, possibly, MNT based products. The review has assessed the processes in the context of commercial availability and accessibility. This review compliments other publications in the series produced by enablingMNT, which address the various facets of the commercialisation business. In this investigation of the markets for back-end services it is noticed that there is a tendency to return to the benefits of the semiconductor industry by making use of (adapted) standard processing. Standardisation is, however, still at its infancy for most if not all of this range of equipment. Some effort in this field is, none the less, in progress, the most notable of which is the work undertaken by the ISMG group of the Semi organisation. For customers and suppliers alike, this will be a great help to enhance the quality of the products.

This study confirms that the MST/MEMS industry is, indeed, based on a strong infrastructure of equipment suppliers and service providers. The market opportunities on offer will, it is believed, be attained and exploited. Furthermore, the study establishes a definitive move by equipment makers towards addressing the growing demand specific to the MST/MEMS community.

The enablingMNT industry review on Back-End manufacturing equipment suppliers for MST/MEMS has more than 100 pages, which include 12 tables, 13 figures, and 64 company profiles.

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## Front-End Manufacturing Equipment Suppliers for MST/MEMS

November 2003

### **The enablingMNT review on Front-End Manufacturing Equipment Suppliers for MST/MEMS**

provides an in-depth analysis of the state-of-the-art in MST/MEMS equipment such as wafer bonders, backside aligners etc. The report provides outline descriptions for the basic underlying techniques and technologies backed up by detailed information on the suppliers from across the world.

Using information from an extensive database of equipment suppliers and companies supplying Front End-specific equipment for the MST/MEMS industry, the report provides a wealth of intelligence for assessment and strategic decision-making.

Although based on similar thin film technologies, the manufacturing of semiconductors and MST/MEMS have, in reality, drifted apart. Guided by customer demand and neglected by the IC industry, the MST/MEMS industry started to develop its own processes and equipment. Entrepreneurs have built a solid position on this market with specialised products. In general the smaller companies tend to be, initially, more active when compared to the larger ones and MST/MEMS Front-End processing has over the years become more widely available. This applies equally to the specialised equipment market, as it does for the more general process equipment scenario. The processing functions of waferbonding, backside alignment and Deep Reactive Ion Etching of silicon are well established and there is ample choice of equipment and, generally, a good supply of services. Initially, semiconductor process equipment suppliers were hesitant to step into this market due to its relative restrictions and lack of standardisation, but alongside their natural customer base of IC manufacturers, these industries are gradually beginning to enter this new field. With this influx, a new emphasis on IC compatibility and standardisation is beginning to emerge.

The enablingMNT industry review on Front-End manufacturing equipment suppliers for MST/MEMS has more than 90 pages, which include 24 tables, 9 figures, and 45 company profiles.

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## Packaging and Assembly Suppliers for MST/MEMS

October 2003

The infrastructure for MST/MEMS development and production is growing fast: Many foundries and design houses have been established over the past few years which cover most, if not, the whole range of the required technologies for commercialising micro- (and nano-) technology. Packaging, however, still remains a bottleneck introduced, belatedly, at the end of the design cycle, and often delaying or even preventing industrialisation and commercialisation.

In this context, **the enablingMNT review on Packaging and Assembly Suppliers for MST/MEMS** has confirmed that many of the small and medium sized enterprises (SME) often lack both the expertise and the infrastructure for full wafer level packaging, leading to high-volume, cost intensive solutions. The existence of professional suppliers of MST/MEMS packaging and assembly is therefore an essential element in the supply chain and critical for the industrialisation and commercialisation of MST/MEMS products. Over 40 organisations that offer packaging and assembly services for MST/MEMS have been identified, studied and assessed and the results are presented in this report.

The companies described here range from small start-ups, offering very specialised services, to large semiconductor packaging companies, with production lines set up specifically for microsystems-based products. In addition, the report provides an assessment of the major trends and technologies in this field. Finally, the intricate interactions that exist between microsystems-based users and/or die manufacturers (foundries) and the service suppliers of packaging and assembly is also addressed.

The enablingMNT industry review on Packaging and Assembly Suppliers for MST/MEMS has more than 95 pages, which include 10 tables, 10 figures, and 46 company profiles.

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<b>Processing Service Suppliers for MST/MEMS</b> May 2005, Personal copy as PDF Version, sent as E-mail Attachment	280 €		
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