Nano-surface metrology

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Micronora, which first opened its doors almost 40 years ago, has become Europe’s biggest microtechnology and high-precision trade fair on the strength of its unique concept and content.

At a time when many industrial sectors are hedging their bets on the smallest, most accurate, most intelligent techniques, visitors will find scores of innovations on the 900 exhibitors’ stands, not to mention evidence how this high added-value market is growing.

Micronora has been giving nanotechnology an excellent deal since the last show in 2006.

The 2008 nanotechnology pavilion will play host to some twenty exhibitors including: Acxys Technologies, Cedrat Technologies, CSM Instruments, Polyrise, Schaefer Techniques, Saint-Gobain PPL Asti, Suss Microtec, Veeco Instruments.

Micronora has set out to step up a gear with each succeeding show it organises.

A series of conferences is tabled to take place over two days - 24 and 25 September - while this “nano pavilion” is running – organised in partnership with FEMTO-ST, the research centre, on the following topics: micro- and nanomanufacturing, nano-characterisation and nanometry, nanomaterials and surface treatments.

Each conference will start with a keynote speech given by an internationally renowned specialist.

We will also be hosting the 6th “micro- and nanotechnology” European technology brokerage event supported by the brand new “Enterprise Europe Network”, launched last February in Brussels by the European Commission.

Following Nanomatch in Frankfurt and Nanotec in Venice, this technology brokerage event will bring actors together at Micronora on 25 and 26 September 2008.

Micronora will use this occasion to highlight the industrialisation potential of nanotechnology and its many derived applications, because nanotechnology is no longer the exclusive province of research, but has already made in-roads into the industrial world.

Make an appointment in your diary to join us in Besançon this September and discover how this burgeoning global market is shaping up. For further details and to obtain your free visitor badge, visit: www.micronora.com
Measure in 2D, visualise in 3D surface conditions whatever

The arrival of the international standard ISO 25178 is confirmation that characterisation of 3D surface
However research is moving fast and 4D is already on the way, offering the prospect of describing
and also with respect to temperature, pressure, magnetic field and other dimensions. This has

In 1941, Taylor Hobson of the UK developed "TalySurf 1", the first true profilometer. This instrument measured surface geometry in 2D, i.e. profile z according to position x. Nowadays most industrial surface texture measurements are made in 2D, using laboratory profilometers and also workshop diamond-tipped roughness testers providing roughness parameters (Ra).

In the 1980s, progress in electronics and more especially in IT opened up a third dimension, leading to 3D surface analysis. This entailed a transition from profile z = f(x) to surface or topography z = f (x,y) measurement. The surface becomes visible with 3D, which puts the 3D profilometer at the point where profilometry and microscopy meet. More recently, firms like Digital Surf and Insidix have started measuring surface characteristics in 4D, measuring z = f (t,x,y) that develop static surface descriptions into dynamic descriptions against time, temperature, or any other variable constraint imposed on the surface.

Today’s industries could not manage without surface condition analysis!

Christophe Mignot, Digital Surf’s founding director, says, “In almost all industrial sectors including aeronautics, car manufacturing,
and understand in 4D — state they are in!

conditions has reached maturity.

the dynamic behaviour of surfaces over time...

ramifications for the entire industrial world!

medical devices, MEMS, electronics, metal-
lurgy, plastics, paper and printing and cos-
metics there is no getting away from surface
analysis.” Automobile iron has to adhere
to strict microrelief definition constraints.
It requires such precision that Sidmar
(now Arcelor-Mittal) has developed a
highly accurate, electron beam texturing
(EBT) system to engrave 3D patterns on
rolls. The paper industry also needs highly
accurate surface parameter inspection,
for example to avoid banknotes jamming
in ATMs.

The electronics industry is another major
consumer of micro-surface measurement.
At the front-end it is used to inspect
etchings on silicon, while at the back-end
it is used to inspect packages, connectors
(coplanarity), welding (BGA), and the
thickness of printed circuit traces.

In plastics, the finish of telephones, dash-
boards and computer screen casings,
depends largely on the texturing applied
to the injection mould used in their
manufacture. Wear on the mould after
a certain number of injection cycles,
necessitates texture replacement or
renewal.

Two micro-scale
profilometer groups

There are two major highly complemen-
tary families of profilometer - single-point
sensor “scanning” appliances, and “matrix”
appliances.

The former use a sensor to measure the
z relief at one single point at a time. The
profile (2D) or surface (3D) is obtained
by scanning the area along horizontal
axes X and Y. This type includes con-
ventional 2D diamond-tipped roughness
testers (Mahr, Ametek-Taylor-Hobson,
Hommel-Etamic, Mitutoyo, Zeiss, etc.).
It also includes non-contact scanning
topography devices (nanoJura, Taylor
Hobson, Altimet, etc.) that are primarily
based on chromatic coded confocal sen-
sor technology.

In contrast matrix devices measure
images in a single sweep using a CCD
camera. The relief is not given directly
by the image but is generally limited to
contour lines, which are then scanned
along the z axis to reproduce the full
relief. This group of devices includes white
light interferometry profilometers (Zygo,
Veeco, Fogale Nanotech), and confocal
microscope profilometers (NanoFocus,
Sensofar).

Conventional 2D profilometry
is still in widespread use

2D profilometry is covered by many
national and international standards.
ISO 12085 and ISO 13565 define parame-
ters used for the functional characterisa-
tion of mechanical surfaces, widely used in
car manufacturing.

Continued on page 4
Recent progress has led to the introduction of new types of filtering, primarily to distinguish roughness from waviness. However, the use of 2D profilometry, that only measures one profile of surface texture at a time, is really limited to “isotropic” surfaces... which are hardly ubiquitous in industry!

Anisotropic surfaces generally require transition to 3D profilometry, which also provides much more information on the functional properties expected of the surface. The newly published ISO 25178 standard specifies 3D parameters and also inspection procedures using non-contact processes. As a result, non-contact and 3D systems have been standardised at the same time.

3D to 4D...
like 3D in motion!

According to Christophe Mignot, 3D surface analysis reached its maturity in 2007, with the arrival of the long-awaited international ISO 25178 standard. "The newly-defined analysis parameters enable us to characterise texture geometry (amplitude, slope, directionality, etc.) and also predict surface behaviour. One common application for 2D is running-in and lubrication estimation for functional engine surfaces. Now the method has been updated and considerably improved with 3D in the ISO 25178 standard. Today, the transition from 2D to 3D in industry is usually accompanied by switching from contact (diamond) sensors to non-contact (optical) sensors".

4D opens up new possibilities, going further than 3D, by analysing how a surface will change. Altitude z is a function of position x,y, and a fourth dimension, t, which tends to be time, but could equally be temperature, pressure, magnetic field, or any physical constraint to which you might subject an item or surface, to analyse its response. "3D visualisation tools enabled us to take a virtual flight over a nanosurface in 3 dimensions with flight simulator-type real-time 3D visualisation. 4D is even more spectacular!

You can not only fly over the surface in 3D, but also, the surface changes during the flight..." In addition to the spectacular and entertaining aspects of 4D visualisation, Mountains v.5 provides real tools for handling and quantifying 4D surface series where z = f(t,x,y). (see page 6, provided by Digital Surf).

"To get to 4D, we started by including ergonomic handling of 4D data in our software. All the topography images are combined into one animated 3D sequence instead of having N unconnected images when examining surface wear. Furthermore, in Mountains v.5 over and above handling and visualisation tools, we have real computing and analysis tools, such as the Karhunen-Loeve transform (KLT)".

Potential applications of 4D in all industrial sectors

Measure to visualise and understand, we said... The potential applications include monitoring surface deterioration - corrosion, depolymerisation of composite surface epoxies due to UV rays, surface treatment (galvanizing, paint, varnish, etc.) thinning, fabric fibre wear, dissolution or scraping of barrier layers... or, conversely, surfaces that improve through "local intelligence" - self-assembling nanostructures, self-repairing surfaces.

We should also mention measuring stress-induced deformations, which could be due to thermal (shape memory alloys), pressure (pressure sensor, membrane, etc.) or mechanical stress (dynamic study of micro-system or an operating MEMS).

Insidix’s TDM solution, the first real French-developed 4D measurement system, can be used, for instance, to build a protocol for monitoring an electronic package that distorts as temperature changes.
Insidix, which specialises in high-resolution non-destructive inspection, uses several techniques: 2D/3D X-rays (micrometer resolution), acoustic microscopy (separating power of a few micrometers), high resolution infrared thermography and topography and deformation measurements under thermomechanical stress (TDM). This company, based at Seyssins, near Grenoble, has two main activities. It provides services and analyses on customer parts, and also sells machines tailored to the needs of sectors where defects cause safety hazards or could result in significant financial risk (micro-electronics, automotive, aeronautics, aerospace electronics, etc.).

The TDM (Topography and Deformation Measurement) machine developed and patented by Insidix, is used when heating parts to monitor any deformations during temperature rise and fall (usually -40°C to 260°C) with a camera.

In electronics, printed circuit boards and BGAs tend to be made of a combination of several assembled materials and interconnections. When the temperature is raised for assembly, the various thermal expansion factors will cause distortions that can damage the product’s materials and interfaces. The TDM approach has potential applications in automotive electronics and onboard electronics, be it in aeronautics, satellites, oil drilling or any other industry where assembling involves brazing, splicing, depositing, mechanical clamping, pressurised components, batteries, or optics subject to thermal cycles.

"Manufacturers contact us when their products are subjected to (normal or accidental) thermal constraints and have deteriorated". Jean-Claude Lecomte, Insidix’s director, notes that when customers send in a sample, they want to understand why the part is defective. "We can subject the part to thermal and mechanical stresses and observe how this stress affects z and xy topography. What sets us apart from the rest of the market with this patented TDM machine is that while everybody is talking about topography, Insidix talks about “topography + deformation”. What this means is that with our tool we can create a specific stress (thermal, electrical, mechanical) and at the same time, measure the topographical changes in the assembled parts in relation to each other and individually at any time, to resolutions of a few μm (including a time-stress correlation) i.e. z and xy deformations. Hence, the customer obtains dynamic images of deformations and an interpretation of the images and amplitudes". When the request comes at design stage, Jean-Claude Lecomte talks of a comprehensive predictive approach to defects. In these cases, Insidix can combine non-destructive techniques - TDM, infrared, acoustic microscopy and X-ray – to achieve a fuller, more accurate diagnosis of how deformation will affect the entire assembled part.

Jean-Yves Catherin
Digital Surf

Digital Surf's MountainsMap® surface analysis software is used to visualize and characterize nano-surfaces measured using scanning probe microscopes (SPMs). The software will be presented at Micronora Hall A2 - Allée 3 - Stand 322.

Nanosciences and nanotechnology study and exploit nanoscopic phenomena. One of the tasks of nanometrology is to measure and analyse the dimensions and characteristics of nanosurfaces. Examples are thin film dimensions in semiconductor electronics and grain (particle or island) size and distribution in nanomaterials.

Scanning probe microscopes (SPM) are typically used to measure nano-surfaces. The most common types are scanning tunnelling microscopes (STM), atomic force microscopes (AFM) and scanning near-field optical microscopes (SNOM).

Software is required to visualise and analyse SPM measurement data. This is where software based on Digital Surf’s Mountains Technology for surface analysis comes in.

Nano-surface analysis
Mountains was already the leading software for the analysis of surface topography, integrated by most 2D/3D profiler manufacturers. A strategic investment in the development of innovative SPM features over the last five years led to the integration Mountains-based software by a leading SPM manufacturer in 2007, increasing Digital Surf’s penetration of the growing SPM market.

New features include tools for the simultaneous manipulation of the multiple layers of data that are generated by an SPM. For example it is possible to zoom in on a feature in the topography layer and switch to the same feature in another layer (for example phase, current or deflection) at the same zoom level. In addition, any non-topographical layer can be overlaid on a 3D image of the topography layer.

Powerful tools facilitate the correction of aberrant scan lines, a common problem with SPM measurements. In addition Mountains has gone 4D. 3D surfaces can be visualised as they change over time, temperature, pressure or another physical dimension.

Other features appreciated by SPM users are the fruit of Digital Surf’s nineteen years as a surface analysis technology leader. For example, a sub-surface can be extracted and analysed in exactly the same way as a full surface. Ease of use is also of great importance. Reports are built as you work and productivity features include the ability to automatically generate reports on batches of measurement data.

Application in Advanced Materials Research
ICMAB-CSIC (Institut de Ciéncia de Materials de Barcelona, Consejo Superior de Investigaciones Científicas), located on the campus of the autonomous university of Barcelona, has been carrying out advanced materials research since its foundation in 1989. The institute uses several SPMs, including AFMs, and MountainsMap surface analysis software from Digital Surf.

ICMAB-CSIC has pioneered an innovative strategy that uses chemical solution deposition (CSD) techniques for the generation and tuning of large scale self-assembling and self-organising epitaxial nanostructures. There are numerous potential applications for this strategy. They include the nanostructuring of thin film superconductors, all-oxide electronics, the growth of quantum dot arrays for optoelectronics applications, and the self-assembly of ferroelectric nanocrystals.

Nanostructures are visualised and analysed using MountainsMap software.
**The InfiniteFocus glosses over depth of field!**

Alicona’s InfiniteFocus is a contact-free optical 3D topographical measurement device in the micro and nano range that provides all surface dimensional measurement, analysis and characterisation functions. It offers vertical resolution of up to 10 nm!

"Any photographer who has ever tried to achieve the same sharp focus on their spouse’s face and the Parthenon in the background can understand that..." Pierre Rolland, the Alicona-Alprimage engineer continues in a more serious vein to introduce us to his InfiniteFocus surface topography system: "When a sample’s topography is higher than the depth of field, it is only the part of the object inside the focal plane that is clear. The system acquires a series of colour images at different heights between the two levels where the image is completely out of focus. Each image contains pixels that are more or less in focus depending on the height at which the information was captured. The software processes the set of several hundred images to determine the maximum focus for each pixel. It then creates complementary data: the surface topography image and the microscope image where each pixel is at its maximum focus. The altitude variations can be analysed in their visual context by combining the two data items".

A sample needs to present a surface with 10 nm of surface microroughness if it is to be analysed. The InfiniteFocus’ capacity to measure steep-sided flanks (>80 degrees) or major irregularities with a vertical resolution of up to 10 nm (regardless of the luminous contrast) makes it the ideal tool for homogenous or composite material studies.

Pierre Rolland suggests potential applications such as metallurgy (microtopography of friction surfaces, fractures, sandblasted or corroded surfaces, rolled sheet metal, plasma deposition), electronics (welds, components and contacts) and composites in general.

The best of the profilometer and the best of the SEM!

Christophe Vincent, doctor-engineer at the ENSMM Surface Microanalyses Laboratory at FEMTO-ST, has written a thesis on surface texturing (scratches) by laser machining on lamellar graphite iron to reduce the friction with lubricated contact. He first used a diamond-tipped profilometer-roughness tester to characterise the surfaces obtained. A software routine is used to construct 3D images from the acquisition of several profiles. "However there are some issues about the texturing profile measurement on occasion I have measured the sensor angle as opposed to the real texturing angle, without ever knowing whether I was getting to the bottom of the scratches". A few trials on a Scanning Electron Microscope (SEM) gave good results for viewing the machining quality, but poorer dimensional results. During the 2005 STIF2C Conference at Besançon, Christophe Vincent met Pierre Rolland who was presenting the Alicona InfiniteFocus system and gave him a sample. "When I saw the results, I had a clear vision of the machining quality and the dimensional measurements into the bargain, as if the appliance was giving me the best of the SEM and the best of the profilometer".

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Yann Clavel
The LNE gathering nanodimensional metrology expertise for national requirements

Nanosciences and nanotechnology are a fast-growing, highly competitive strategic research sector, with substantial untapped economic development potential. The LNE, in conjunction with ENSAM, are working on developing dimensional metrology reference tools traceable to the national standard of length.

The Agence Nationale de la Recherche set up an "Instrumentation and Metrology" section in the 2007 PNANO programme. This field is clearly crucial to nanoscience and nanotechnology development. The LNE claims that metrology has been the subject of 7% of all documents published on nanotechnology over the past decade. Like most of the major NMLs (National Metrology Laboratories), work on nanometrology started in the late 90s. According to Sébastien Ducourtieux, the French NML's aims in 2000-2001 were "to develop the reference dimensional measurement facilities capable of satisfying the main (present and future) industrial needs, primarily by harnessing nanotechnology, for linking standard lengths or specific objects for the purpose of developing the future standards and reference frames, to offer guidance and transfer to the industrial context".

The ultra high-precision 300-mm instrument

In 2001, the nanometrology project initially set out to develop a new ultra high-precision measuring machine to satisfy the microelectronics industry’s needs as a whole and laying special emphasis on designing a system with development potential for future dimensional metrology needs. This measuring machine known as the "300-mm instrument" comprises a displacement generator capable of positioning a sample in the space under an interchangeable sensor (mechanical sensor, optic sensor, interferometer, AFM, etc.). This machine has roughly 500 constituent parts with a volume of 4 m³ for a mass of 2 tonnes of steel, invar and aluminium. Furthermore the whole device is traceable to the national standard of length. The displacements covered are 300 mm in xy and 50 µm in z. The expected uncertainties for a 10 mm displacement are 10 nm (xy) and a few nm (z), and 30 nm (xy) and 10 nm (z) for a 300 mm displacement. The "rough" (millimetric) displacements are generated by a commercially available motorised table (Aerotech) and the "fine" (sub-micrometric) displacements by a hexapod with piezoelectric actuators (Physik Instrument). Measurement of the xy position is provided by eight Renishaw interferometers – four measure the xy position and the remaining four the real-time compensation of air index variations. Four Heidenhain 2D coders provide redundancy on the xy measurement and measure rotation Rz. Four Fogale Nanotech capacitive sensors are required to measure the position along z and rotations Rx and Ry. The air index variation compensation calculations, mirror straightness and orthogonality defect assessment in xy have been completed to calibrate the instrument. Innovative procedures are being developed for calibrating along the z axis.

"An update on the performance levels achieved along the xy axes will be given in 2008. The first applications will be developed on rule calibration and 2D coders (Heidenhain type)".
The LNE is hoping very shortly to transfer the instrumentation required for calibrating the reference standard for the z axis of flatness on to the machine.

**The LNE’s Metrology Atomic Force Microscope (AFM)**

The LNE nanometrology activity’s second string is the metrology atomic force microscope (AFM), the instrument that has been adopted for calibrating periodic grids. Benoît Poyet, an LNE doctorate candidate, explains that "the ideal metrology AFM would comprise an AFM tip whose end would be measured by calibrated sensors, but as it stands today this solution is technically unfeasible. Accordingly, all the design work is focussed on finding solutions for minimising measurement result degradation arising from the distance of the sensors compared to this ideal configuration". Several metrology AFMs have been developed across the globe (including PTB in Germany, METAS in Switzerland, NPL in the United Kingdom, NMIJ in Japan, NIST in the United States) on the basis of two design methods adopted: one modifies a commercially available AFM by adding calibrated displacement sensors, the other involves total instrument development. The LNE has opted for this second method (as have Japan and the United States) to obtain a compromise that optimises the instrument from the metrology standpoint. The specifications drawn up by the LNE entail developing a short travel AFM with 100 µm displacement capacity for the xy axes and 10 µm for the z axis, with an uncertainty surrounding position measuring relative to the tip as compared to the sample of approx. 1 nm.

The provisional uncertainty budget has been sufficient to slant the design choices in line with the parameters producing the highest degradation on the measuring results. If the only example to be retained were thermal dilation of materials, we note that every cm of aluminium dilates 238 nm per degree. In the light of the 1 nm requirement criterion, it is clear that the choice of materials is extremely important. That explains why zerodur (dilating 0.5 nm per degree per cm of material) has been selected for constructing the instrument’s metrology chain. The current state of progress is such that metrology concepts have been applied to design the instrument’s geometry (CAD development of the AFM metrology and structural chain and development of a dual-axis translation plate).

"There is outstanding work to be done on developing the z flexible blade translation stage, building the instrument, integrating the sensor, building the automatic controls and piloting, calibrating the AFM and drawing up the uncertainty statement… We have 2 years to go!"

Jean-Yves Catherin
Surface characterisation at the ENSAM Laboratory
of metallurgy physics and materials engineering.
Source: Ingrid Serre
Nanotechnologies in 2007: towards larger commercialization

While Europe is still the world’s largest public investor in nanotechnology, with €1.8 billion (less than €1.4 billion in the US), amounting to one third of the total public funding, the US are still leading the commercialization of nanotech products, with over 50%.

According to the inventory made by the Project on Emerging Nanotechnologies, there are currently about 600 consumer products using nanotechnology. In 2005, consumer goods using nanotechnologies represented a market of over €20 billion and strong growth is expected in the coming years, up to several trillion euros in 10 years.

Numerous activities in the nano world

Nanotechnology is clearly a worldwide research business, with the funding and opening in 2007 of several research centres and national institutes (IIT Bombay in India, seven facilities in Quebec, Nottingham nanotechnology and Nanoscience Centre, National Institute for Nanotechnology in Canada,…). This fad for nanotechnologies is also demonstrated by the numerous conferences and exhibitions dealing with this topic.

As for example, nano tech Japan is the international exhibition on nanotechnologies, gathering close to 50,000 people in 3 days in Tokyo in February 2008.

Nanotechnologies dedicated to environmental preservation

A strong focus has been made in 2007 on the link between nanotechnologies and environmental preservation. Many nanotechnology products have been developed to protect the environment and to reduce human toxic emissions. In this context, we can quote the following examples:

- The Japanese convenience store am/pm Japan Co. is now using plastic shopping bags that are thinner but as strong as standard plastic bags, using nanotechnology to disperse a strengthening agent. The store estimates that these bags can lower carbon dioxide emissions by 3000 tons annually.
- Mazda has used nanotechnology to create a catalyst material structure which substantially reduces the amount of precious metals used, such as platinum and palladium, by 70 to 90%.
- Researchers from the University of Queensland have developed a CNT membrane to reduce largescale greenhouse gas emissions caused by coal mining and power generation.
- VeruTEK Technologies launched its green nanotech solutions for environmental clean-up, from environmental contamination from petroleum, chlorinated solvents, pesticides, herbicides, PCB, dioxin and other toxic chemicals.

Automotive and aerospace are key markets driving the development of nanotechnology products

In automotive, nanotech coatings have existed for several years, offering higher scratch resistance and coating gloss to car paints. Nano Chemical Systems unveiled its automotive “sunscreen”, made with TiO2. In 2007 developments resulted also in the use of carbon nanotubes in transparent electrically conductive coatings on windshields to avoid fogging. Moreover, Yokohama unveiled an eco-friendly tire that combines citrus oil with natural rubber to reduce the use of petroleum products in tires by 80 percent. Ford also announced the acceleration of its nanotech work into lightweight metals, in collaboration with Northwestern University, to develop stronger and lighter structural materials and increase fuel efficiency. In aerospace, nanomaterials can help the development of new composites and also enable real-time diagnostics and onsite repair of stress-induced cracks in a composite structure.

In the meantime, more fundamental research is still on-going in nanotechnology. This ranges from the development of new or improved nanomaterials to the integration of nanotechnology into applications such as electronics. In particular carbon nanotubes are being tested to create pressure sensors, ultra small radios, to enhance heat flow in computer chips and to potentially replace copper interconnects. Objectives in the development of new nanomaterials are the creation of improved materials to achieve higher performance as well as to create totally new devices.

Strong focus on carbon nanotubes

Though nanosilver is the most used nanomaterial in current nanotech products, carbon nanotubes are triggering researchers’ interest and are the material experiencing the most innovative research. In 2007, scientists from the University of Cincinnati announced the growth of the longest carbon nanotubes ever syn-
thesized, reaching 2 cm long, i.e. 900,000 times longer than their diameter. In the meantime, industrial production of carbon nanotubes is becoming established, with Bayer Material Science announcing a 60 ton annual capacity (cf figure 2: Carbon nanotubes suppliers). New production methods are being investigated and CVD and plasma technologies have shown promising results. The stakes lie in the compatibility of these processes with large scale production while maintaining a high level of purity. Prices have dramatically decreased and one can currently buy 95 wt% pure multi wall carbon nanotubes for less than € 700, in kg quantities. For ton quantities the price of this same material drops down to € 170 per kg. Single wall carbon nanotubes are much more expensive: for 90% pure SWNT, one gram costs around € 100 or € 50,000 per kg. Current carbon nanotubes market is estimated at less than 100 M$, but 600% growth in volume is expected for MWCNT from 2007 to 2012, together with a continuing price decrease (cf figure3 : Carbon nanotubes market forecasts 2007-2012). Carbon nanotubes are interesting for both mechanical reinforcement and electrical performance. For example, researchers from the University of Pennsylvania and Rice University have developed a nylon polymer composite fortified by single-walled carbon nanotubes, resulting in greater strength and toughness. While very few applications are currently commercialized, material research is booming, with potential uses in various industrial fields, such as the development of bullet-proof jackets with carbon nanotubes by researchers from the University of Sydney and new lightweight and strong textiles by Nanocomp Technologies. The commercialization of carbon nanotubes into consumer goods started especially with high end sport goods. Now we see more industrial applications, as the plastic transport drum from Schütz GmbH & Co. KGaA to be made electrically conductive by Baytubes® carbon nanotubes.

Conclusion

Health and Safety issues regarding the use of nanotechnology remain a critical issue concerning large commercialization of nanotech products. This is highlighted by the numerous workshops, conferences and expert groups dealing with this subject. However the community still needs experience in the assessment of long term effects, as well as in vivo toxicological tests, requiring the validation of a standard set of nanoparticles by laboratories for benchmarking purposes. Nanotechnologies remain a hot topic, but issues need to be tackled to ensure broadening of high volume applications.

YOLE DEVELOPPEMENT
Barbara Jeol-Pieters
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NanoStrand to "point the way" for R&D in nanotechnology and its exploitation

Development in nanotechnology is fast-moving and is making in-roads into all fields. NanoStrand’s stated goal is to identify nanotechnology development and exploitation needs and define its pre-normative research priorities.

The European Commission adopted a communication entitled "Towards a European strategy for Nanotechnology" in May 2004, which recommended a safe, integrated and responsible approach. Since then a number of initiatives have taken shape and been funded under the auspices of FP6 and FP7, including 14 R&D projects to the tune of 32 million euros. A further 47 million euros of national funding by the various Member States is being invested in 92 additional projects.

Standardisation in nanotechnology R&D

Peripheral to this research work, the NanoStrand project, "Standardisation relating to nanotechnology research and development" set out to identify existing barriers to the development and exploitation of nanotechnology and the requirements for new measurement tools, technologies and standards to support nanotechnology development. A further aim was to define priorities for nanoscience and nanotechnology measurement tool development and pre-normative research.

The French National Metrology and Test Laboratory (LNE-FR) was commissioned along with four other partners to work on this project. All in all there were two French and British national metrology laboratories, LNE and NPL, the DIN standards body (Germany), the CTU University of Technology (Czech Republic) and Optimat Ltd, consultants (England). It ran from August 2006 until the end of January 2008. A consultative committee comprising the respective chairmen of the "Nanotechnology" CEN TC 352 and ISO TC 229 committees and a pool of international experts validated and approved their findings, which are due to be published very shortly.

Roadmaps to define nanotechnology development

These findings rank the future requirements and work that should contribute to sustainable nanotechnology development and yet satisfy society’s expectations and take the form of roadmaps for standardisation and relevant pre-normative research. According to Jean-Marc Aublant, of the LNE, the main lessons to be drawn from this work are "the need for specific nanotechnology vocabulary and nomenclature standards, and standards for measuring and nanomaterial characterisation techniques, chiefly in dimensional (3D) and chemical characterisation of nano-particles. Pre-normative research into measuring and characterising nanomaterials is governed by the overriding case for society’s environmental, health and safety requirements. Reliable scientific bases backed by suitable measuring, toxicological and eco-toxicological testing methods must be used for nanotechnology-related risk assessment and management. The study highlights the technological breakthroughs made by nanotechnology and its potential multi-disciplinary capabilities especially in the area of measuring instrumentation. It demonstrates the need for certified reference materials for existing and forthcoming techniques and facilities for ensuring traceability to the international system of units (SI). Lastly, it underpins the need for demonstrating the inter-comparability of reference measuring techniques, relying mainly on atomic force microscopy (AFM)."

Jean-Yves Catherin

Although chips are still part of "microelectronics", they are now at the heart of the "nano" universe as 32 nanometre chips are expected to be marketed from 2009. Source: CEA
Regional cooperation to reinforce innovation

The INTERREG IV France — Switzerland cooperation programme, which covers the period from 2007 to 2013, has been built around the key objectives of innovation and sustainable development. In particular, it will support cross-border projects in the areas of the economy, research and education.

It will provide help to companies within the cooperation area by supporting coordination and communication action, link up existing services in a network and create new cross-border services (monitoring of the economic, competitive and technology environment and ICT services etc.), particularly in the high-potential industries in the area of cooperation. It will encourage technology partnerships aimed at transferring the results of research to businesses. For example, the programme will cover cross-border projects for competitiveness clusters, collaborative projects between laboratories and/or transfer centres and companies and closer relations between transfer centres.

Understanding the minute to have a wider view of things

With nanotechnologies, Franche-Comté is going beyond the borders of microtechniques. With Interreg, cooperation is going beyond the border with Switzerland. The two sister regions are pioneers in working on the very small, and have come together to take a wider view of things and the issues relating to these technologies. That will be a future industrial revolution, a challenge and a chance for Europe.

Nanotechnology is one of the most innovative technologies, as it relates to the structure and behaviour of material at the molecular and atomic levels. It is in its infancy, but is sure to produce enormous practical and economic effects in all areas. For Daniel Courjon Vice President of the Associated European Laboratory in Microtechniques, "their application, for example in nanomaterials, will be comparable to the move from animal hides to weaving techniques".

Associated European Laboratories are laboratories without walls, organisations through which teams from several European countries share their resources to carry out a joint research programme. The French-Swiss laboratory benefits from the legacy of cross-border programmes Interreg I, II and III. The last of these particularly made it possible to make a smart microcapsule that travels in blood vessels.

Interreg has also brought out the need for a lasting basis for cooperation, which survives the changes in the budgets of contractual agreements. That is the approach that gave rise to the Associated European Laboratory for Microtechniques, which was a large project of Interreg III, with the same partners — the two universities of Franche-Comté (Besançon and Belfort-Montbéliard), the National School for Mechanical Engineering and Microtechniques and the Microtechniques Transfer Centre in France, and the University of Neuchâtel, the Federal Polytechnic School of Lausanne and the Swiss Centre for Electronics and Microtechniques in Switzerland.

The objective is three fold — heightening the awareness of shared interests in the Jura area, supporting scientific projects between the adjacent regions and lastly encouraging initiatives such as the Arc-et-Senans workshops (annual meetings of researchers, PhD students and industry) or the Highlights in Microtechnology summer school (international top-level school for PhD students, doctors and engineers). The eight scientific projects selected (Syncope, SAIRI, Mosgam, Prommod, Medima, Micropuce, Crislar and Nanotool) cover all the areas of microtechniques — micromanufacturing, microrobotics, nanotools and nano-optics — and their applications range from electron microscopes to the manipulation of egg cells and cover micro-factories and insect robots.

Total cost: € 1,799,000
EU contribution: € 396,800
(FEDER European fund for regional development)

With Trod Medical, INTERREG supports new medical devices to treat cancer

Trod Medical is developing a new device for the mini-invasive treatment of prostate cancer. Innovation by the company relies on a new way to use a therapeutic means that is already known and used in medical treatment, namely radiofrequency. The new device makes it possible to contain and control the area of destruction, which spares surrounding organs such as the rectum, bladder and nerve networks. In Europe and the USA, prostate cancer affects nearly 500,000 more people every year.

The development of a new medical device that has been funded by INTERREG was the result of collaboration between the University of Franche-Comté and the Federal Polytechnic School of Lausanne. Out of a total cost of € 460,000 of the development, European funding was € 194,000.
Organised by the newly launched Enterprise Europe Network, represented in Franche-Comté by the Regional Chamber of Commerce and Industry, the brokerage event is designed for companies that are looking for novel solutions to innovate, improve their products and processes, to develop their activities or access new markets. Micro & nanotechnology opportunities will be accessible on line to potential users of technologies, through a catalog of profiles. Requests of meetings with companies or research laboratories will be based on these profile selections.

The 6th edition is a real opportunity to
- discuss product development, manufacturing, licensing or similar technological partnerships,
- find partners to build a solid base from which to approach new markets,
- make international contacts to promote innovative technologies and know-how,
- become informed about the latest technological trends and research activities,
- initiate technology transfer.

One of the network’s expertises is the organisation of targeted brokerage events. Over time, companies or research laboratories that succeed to engage cooperation after that kind of event, increased in size. “Lovalite is the designer of a new generation of optical microcomponents. During this event, we not only met customers but also development partners”. Lovalite “Our company usually attends brokerage events organised by the network. We have forged several partnerships with foreign companies to integrate new technologies or to manufacture and put on the market new biomedical products”. Statice Santé “Attendance enabled us to make a successful bid for a Femto Innovation tender by combining our expertise with that of Venfroid”. Vegatec
This Federal Ministry of Economics and Technology initiative brings together about 116 networks from nine areas of innovation. Organised for ten years, the brokerage event has acquired an international dimension. Supported by the Nano and Micro sector group, it has followed the same path: it is co-organised by partners from different countries involved in Micro and Nanotechnologies as Belgium, Germany, Greece, Italy, Spain, Sweden, Switzerland… That’s the real added value of the event. In 2006, 54% of the participants came from abroad and 11 countries were represented. This really increases the trans-national potential of cooperations.

The industrial environment of Micronora trade-fair is a real key of success. Some of Enterprise Europe Network partners will not only attend the brokerage event but will also take part to the exhibition, as it is the case for Berlin-Brandenburg, Thuringia… The conditions are excellent for SMEs and larger companies to meet European partners and to find the technologies they are looking for. It is the place to present micro & nanotechnologies offers, requests and R&D partner searches.

**Micro & nanotechnologies as competitiveness and innovation boosters**

Micronora is a multi-technology trade-fair and the brokerage event is a real opportunity to present latest developments and innovations to potential partners. From micro to nanotechnologies, the topics of the brokerage event cover various technologies (materials and coatings, high resolution manufacturing processes, micro-systems and components design, characterisation and microscopy), various industrial sectors (biomedical, automotive, optics, watchmaking industry, energy, measurement…). Industrial applications of micro & nanotechnologies are wide enough to allow companies to design together their future products in close cooperation with research laboratories (micro fuel cells, microsystems and micromachines, new functional and aesthetic coatings, bio-chips,…). Every industrial sector has to deal with micro & nanotechnologies. Take advantage in meeting your future partners and Open Up possibilities with micro & nanotechnologies…

Registration is mandatory. To register and access to the updated catalog: **[www.micro-nano-event.eu](http://www.micro-nano-event.eu)**
Winning the innovation battle with the microtechnology cluster

Seventy-five businesses have now joined the microtechnology cluster.
If the research laboratories and associated partners are added, it has 109 members and supports 50 accredited innovative technology-centred projects.

The word microtechnique was coined in the Eighties, on Micronora’s behest, when former watch-making businesses took a new lease on life in precision techniques by combining their expertise with microelectronic advances. At the time, the change of focus and pinpointing new markets likely to use miniaturisation and precision techniques were crucial to their survival. The companies targeted electrical equipment, aeronautics, automotive, biomedical and other sectors and their diversification into microtechnology enabled them to enter both the subcontractor and service provider markets, while in the larger groups they became more integrated in microsystems.

The microtechnology cluster officially inaugurated in July 2005 was the formal embodiment of Franche-Comté’s drive to enhance research by creating innovating companies.

The microtechnology cluster has singled out three scientific themes that could give rise to new industrial developments, on the basis of the technological expertise in Franche-Comté — metrology, time-frequency solutions and microsystems on silicon.

Lovalite, a tenant of the business incubation centre, was spawned by a technology transfer from the Troyes Technology University. The technology uses a photosensitive polymer solution to manufacture micropoints at the end of an optical fibre. Source: Lovalite

Lovalite technology makes highly-efficient light manipulation possible at microscopic scale. Source: Lovalite

The microtechnology cluster officially inaugurated in July 2005 was the formal embodiment of Franche-Comté’s drive to enhance research by creating innovating companies.

It should be remembered that historically one of the cluster’s technology project strategies was to redouble the microtechnology-targeted R&D efforts and define and push the original technology development lines to their micro- and nanotechnology limits.

Furthermore, innovation was required to enable companies acting together in the microtechnology sector to overhaul their practices radically in the medium term. What is the state of play today? We asked the cluster’s director, Jean-Michel Paris, to outline the current driving forces.

Three scientific themes to win the innovation battle

"We had 18 projects in the initial application or cluster contract. By the end of 2006, we had embarked on over 30, and by the end of the summer of 2007, we were up to 50 projects. While these figures speak for themselves, this increase attests to diligent efforts that were indispensable.

This is because the constraining consequences of globalisation intensify as each day passes and it is now commonly held that certain FMCG industry sectors, that rely heavily on assembly work with only a small amount of technology input, have been permanently lost to low-cost countries. Our industrial skills are under daily threat.

This obviously goes for France as a whole, but is particularly true of Franche-Comté where automotive subcontracting is experiencing hard times. Against this backdrop, the microtechnology cluster has a mission — to win the innovation battle, and a responsibility - to put forward alternative solutions. The only real dilemma is how to develop the acumen for homing in on high added-value products".

Lovalite technology makes highly-efficient light manipulation possible at microscopic scale. Source: Lovalite

Lovalite, a tenant of the business incubation centre, was spawned by a technology transfer from the Troyes Technology University. The technology uses a photosensitive polymer solution to manufacture micropoints at the end of an optical fibre. Source: Lovalite

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From time-frequency to metrology

Besançon’s three time-frequency laboratories (The Observatory, LPMO and FEMTO-ST’s LCEP) share three caesium beam clocks and a hydrogen maser that cover their joint short- and medium term frequency stability requirements. Additionally the LPMO and Besançon Observatory laboratories cooperate with the French National Metrology Bureau and are accredited by COFRAC to conduct time-frequency calibrations.

"Although time-frequency does not offer openings in medium run markets as it stands, the stakes in micro-clocks are huge. The Swiss are ahead of us, but development is not linear in this field, as every technology leap acts as a multiplying factor generating new solutions that take us towards increasingly complex materials and intelligent materials that incorporate sensors."

At the same time, a feature of Franche-Comté’s watch-making past is the web of relationships it has woven around the measurement of time. The ENSMM was first the Institute and then became the Ecole de Chronométrie, the chronometry school.

“One of the directions we are drawn to is nanotechnology, because this metrology expertise is essential for moving on from micromechanical to nanotechnology precision levels. This is particularly true of machining, because we cannot control machines without measuring displacements, especially as nanometric accuracy is demanded of them nowadays”.

Digital Surf, NanoJura and Mecasem (which has taken over a Cetehor metrology unit) are already working in these nanometric precision levels and many SMEs could work in niche metrology markets. “Once again, it is up to us to guide them, because the cluster has this initiating and facilitating mission. We must be ready for the day when the manufacturing job creating potential comes along.”

A natural shift towards microsystems

Franche-Comté has recognised capacity for designing and building microsystems for electromagnetic applications, sensors micro-actuators, micromechanisms, and so forth on the strength of the Centre de Transfert des Micro et Nanotechnologies (CTMN) and FEMTO-ST laboratories.

“These systems are obtained by processes that are highly similar to those used in microelectronics (batch production) but differ from them by the absence of transistors. They comprise pseudo-mechanical devices (sensors), with, for example, a beam that moves in line with an electromechanical type of external stress. Photline emerges from another orientation altogether, with microsystems that transform electric waves in a piezo-electric type material into acoustic-mechanical vibration. Senseor, for its part, has developed a gravimetric surface acoustic wave (SAW) sensor to detect chemical and biological substances. “In actual fact the cluster’s three orientations are not as divergent as they might seem. We realise that metrology and time-frequency have enabled us to move towards microsystems which are part and parcel of the industrial application fields that generate the production of commercial devices”.

Jean-Yves Catherin

MICRO-TEP was the national jury’s choice at the French National Competition for Aid in creating innovating technology enterprises for its high-performance PET (Positron Emission Tomography) instrument development and marketing project for functional exploration of the brain. The apparatus presents a raft of advantages over the existing competing PET units in clinics as a result of its new detection device, which is a quantum technological leap. Given the detector’s capacity to operate in high magnetic fields, this innovation also paves the way for the construction of dual-mode PET-MRI apparatus, which the experts welcome with open arms.
The regional policy of the European Union

Between 2000 and 2006, European Structural Funds invested about €10.5 thousand million in Research, with 97% of that aid provided by the European Regional Development Fund (FEDER). In the course of the period from 2007 to 2013, the regional policy of the EU and the structural funds is aimed at increasing and improving investment in research and innovation and reinforcing synergies with other community policies and instruments.

The regional policy of the European Union is primarily focussed on:
• Increasing and improving investment in the area of R&D in order to create a European knowledge area,
• Promoting innovation in all its forms.

Good European Practices for innovation in Franche-Comté

Technological development of the spectacle trade in 2007-2009

The programme is aimed at providing the French spectacle trade with the know-how, skills and technologies required to adapt to, anticipate and lead technological changes in the area.

First of all, the future needs for technical competencies of the industry need to be identified to prevent recruitment difficulties in the key employment areas of tomorrow. Appropriate training programmes and conferences must be prepared so that the employment market is able to fulfil the identified needs.

Similarly, steps must be taken to anticipate the needs of the industry in terms of technical processes. In particular, they must make it possible to identify the new materials that could be used to make frames of a new type.

Europe and the economic dynamic in Franche-Comté

European programmes are part of regional competitiveness initiatives in Franche-Comté. The action taken stresses development and research, the technology development of businesses, specialised activity zones and education.

In figures:
€339 million for 2007 to 2013
Including €201 million for regional competitiveness and cooperation

As a reference, in the 2000 – 2006 period
5254 aided projects With over 3000 applications supported for economic and employment development
Nearly 13,500 jobs created or maintained with the support of FEDER.

The European Union commits itself in favour of innovation in Franche-Comté

In order to pursue an ambitious regional policy that is even more focussed on the achievement of growth and employment goals, the European Union is looking to foster knowledge and innovation by increasing investment in research and facilitating innovation. For a large number of regions, research and innovation have been identified as enablers of development, growth and therefore prosperity for the European Economic Area.
The regional policy of the European Union commits itself to research and innovation. Between 2000 and 2006, European Structural Funds invested about €10.5 thousand million in Research, Technological Development and Innovation (RDTI). 97% of that aid was provided by the European Regional Development Fund (FEDER).

In the course of the period from 2007 to 2013, the regional policy of the EU and the structural funds is aimed at increasing and improving investment in research and innovation and reinforcing synergies with other community policies and instruments.

The action programme concerns 40 companies in Franche-Comté. With a total cost of a little over €1.1 million, it ought to provide businesses with effective technology monitoring and enable them to acquire the processes that are currently indispensable for the spectacle making trade. It will improve organisation within the industry by supplying better integrated communication resources than those in place today.

The programme devised for the spectacle industry of Franche-Comté will span a period of two years because of the large number of Research & Development measures it includes and because of the fact that they are highly technical in nature and their timescales are therefore not as controllable.

A budget of €1.1 million, with x provided by European Funds

TEMIS SCIENCES, a flagship project for research and innovation in microtechniques

TEMIS Sciences is designed to bring together all the departments of FEMTO-ST in and around Besançon in a single geographical location within the microtechniques and science park. Near the departments that are already present there, TEMIS Sciences makes up a consistent, visible and effective whole covering optics, electronics, time-frequency and microsystems, the administration of FEMTO-ST, exploitation and information resources. With the Pierre Vernier Institute, which is a regional technology transfer centre, the same site will now be home to all the research and innovation in micro and nanotechnology and engineering sciences, from pure research to the setting up of businesses.

The total cost of this ambitious project is over €34 million; FEDER funds will contribute a little over €15 million (or about 40%).
Innovation, a source of growth for SILMACH and Power MEMS

This aided project is aimed at developing ultra-deep silicon engraving processes in the area of MEMS. The applications relate to watch movements, smart locks, micro drones and micro power sources to replace lithium cells with gas micro turbines on silicon. When that is achieved, power densities will be ten times those of current cells.

To carry out the project, it is necessary to develop new processes for the ultra-deep engraving of silicon, up to 1 mm. Current systems using reactive plasma do not exceed a few dozens of microns with sufficient engraving quality. The process has been developed by a new type of DRIE (Deep Reactive Ionic Engraving) machine.

In addition to the control of this emerging technology, the work is aimed at:

- Optimising the selectivity of masks, achieving uniform engraving speeds and increasing the rate of engraving of standard and SOI wafers,
- Developing active MEMS that are economically competitive, for micro-mechanical applications that are potentially very numerous,
- In a subsequent stage, making micro power sources.

This Power MEMS project executed by SILMACH in collaboration with the University of Franche-Comté and the Federal Polytechnic School of Lausanne represents a major investment – in addition to the purchase of the machine, two engineers must be allocated to the development for two years.

The European aid granted to SILMACH as part of measures for research, technology development and innovation using the FEDER funds is € 100,000.
The fuel cell in its walls...

The small and medium businesses of northern Franche-Comté are exposed to the very great changes taking place in the automotive market. Their independence hinges on a diversified base of customers and products and the addition of more value, and therefore requires considerable efforts in the area of innovation. Equipment projects co-funded by the European Union, the State and regional authorities are part of the collective action taken for the benefit of these companies.

The projects are part of the VEHICLE OF THE FUTURE COMPETITIVENESS CLUSTER approach, and particularly the work on clean vehicles, smart vehicles and new materials and surface treatments. Extensive investment has already been funded jointly by the European Union in the Technology University of Belfort-Montbéliard for several projects relating to research, and also the transfer of technology to SMEs. The extension of the building of the University for fuel cells will be supported again.

The fuel cell project is a structuring project that looks to reinforce northern Franche-Comté in the area of alternative energy, such as hydrogen, for land transport. The FC-Lab was founded in 2006 and is devoted to work on fuel cells. The project is co-funded by FEDER funds and is aimed at giving the laboratory efficient resources and equipment. An extension of the current building, which houses several cells and prototypes, is planned in order to provide the space and the conditions required for its future development.

The laboratory, which has the CEA as one of its governing bodies, has the task of developing the systems aspect of fuel cells. The originality of the project lies in the fact that it is resolutely complementary with the activity of CEA in Grenoble. That organisation is involved in the improvement of the core of the cell, whereas Franche-Comté is more concerned about the relations between the cell and the outside world.

These issues have not been studied in great detail, even though they play an important part in the premature ageing of fuel cells. The stakes for sustainable development are considerable.

Out of a total amount of €5.7 million for the project, European funds will provide €1 million. ■
Glass fracturing observed at nanometric scale

In order to understand the fracturing mechanisms of materials, we must have access to their intimate structure. The CEA has created an experimental device to study crack propagation in glass that uses an atomic force microscope to monitor that propagation.

We now have a good grasp of how stresses are concentrated in cracks tips, primarily by using Linear Elastic Fracture Mechanics (LEFM), which assesses the mechanical energy flow at the crack tip. However this leaves many unresolved questions about how cracks extend in response to this flow. Elisabeth Bouchaud, Research Director at CEA Saclay, is interested in the mechanical properties of materials at scales at which they cannot be considered as homogenous. Her more specific focus examines the fracturing properties of fused silica.

Glass appears to be homogenous even under a magnifying glass. In order to see that its amorphous structure renders it heterogeneous, you have to drop to a few tens of nanometres or even down to nanometric scale. "Because we are limited by wavelength, optical microscopy is ineffective at these scales and this also holds true for scanning electron microscopy, leaving us no option but to find alternative techniques to observe and understand what is happening".

Near-field microscopy is inescapable when you get down to “nano” scale

Scanning Probe Microscopes (SPMs) are the only near-field microscopes capable of scanning the surface at nanometric scale. There are two main types of SPM - atomic force microscopes (AFMs) and tunnel effect microscopes (STMs). Both use techniques involving surface scanning with a tip.

The AFM comprises a very fine tip (curvature ray of about ten nanometres) placed at the end of a lever (cantilever). This tip follows the changes in surface level in contact mode, bending the lever. This deflection is amplified by a laser that reflects it onto a mirror incorporated into the AFM tip before it is forwarded to a photodiode. The amplification serves to measure minor variations of about one Angstrom (0.1 nm) with lateral resolution of 1-5 nm.

STM microscopes also have a tip, but their mechanism is very different in that there is no contact with the surface. Instead of measuring the mechanical deflections of a stem, they measure the quantum effect of a current (the tunnel current) that passes from atom to atom from the surface to the microscope tip. Thus it is the current that is measured for an imposed bias potential and that interprets the topographical and chemical variations at the surface.

The glass study entailed monitoring the propagation of a crack tip with an AFM. Specific conditions had to be set up to ensure that the propagation progress was very slow, by using a "stress corrosion" mechanism. "Real-time monitoring enabled us to understand that the crack front advances as the result of the growth and coalescence of nanometric damaged cavities as opposed to regularly and steadily as we previously believed". This study could be used to develop more stress corrosion-resistant glasses. It is precisely this type of corrosion that turns the impact of a flying stone on a windscreen into a crack that gradually works its way across it.

Jean-Yves Catherin
Lovalite’s optical micropoints reconnoitre matter

Lovalite’s points produced at the tip of an optical fibre offer unmatched transmission capabilities and access to highly effective light manipulation at nanoscopic scale.

In September 2005, Lovalite came away from the Opto show with a bronze Photon for its micropoint mounted on Perfos microstructured fibre. The startup was founded in the Aube in 2004 as a result of a technology transfer from the Troyes Technology University. It employed 4 people and later established its base in the Franche-Comté Microtechnology Centre in 2007. It was selected to collaborate in an ANR-financed three-year nanoantenna programme with a FEMTO-ST team that kicked off in 2008 to develop new, improved components for analysing light at nanometric scale.

A high quality clean signal for surface characterisation

The technology harnessed by Lovalite for manufacturing micropoints at the end of an optical fibre is based on the use of a photosensitive polymer solution. One drop of this compound is deposited at the tip of an optical fibre and is then polymerised into a 3-µm diameter point by a laser beam guided by the fibre. These micropoints are chiefly used in near-field optical microscopy because of their exceptional reliability, symmetry and light transmission properties. They are characterised by very high optical transmission (>80%) and perfect symmetry (<0.1 dB polarisation-dependent losses). The maximum rating they can withstand is 50 mW for a numerical aperture in the 0.5-0.8 range. Lovalite offers a choice of points on different fibres with a tip curvature ray of approximately 200 nm. These points, for near-field microscopy, tend to be metallic (aluminium or gold-plated) with a 50-nm opening pierced at the tip. Other points, which come in 1 µm, 2 µm and 30 µm curvature rays, are mounted on SNF28e fibre for use in optical telecommunications coupling applications.

Scores of potential microscopy and micro-optics applications

Brahim Dahmani, the company’s founder-director explains that the products developed using Lovalite technology give access to highly efficient light manipulation at microscopic scale. “Our products target the biomedical research and industrial near-field microscopy markets and also the optical interconnections market for telecommunications in high-integration complex components. They are also found in high-resolution spatial spectroscopy and coupling in integrated optical components”. Lovalite’s is also the only technology suitable for complex fibres (holey fibre, photonic crystal fibre, etc.). “Our customers appreciate three facets of our skills - firstly the manufacture and sale of micropoints (consumables) and coupling microcomponents in boxed sets. Secondly, they come to us for optical and micro-optical system modelling software and lastly for our consultancy and R&D services in joint development projects. Lovalite distributes microscopy instruments (near-field scanning optical microscopy) using these micropoints as consumables and software programmes explaining light behaviour at this scale”.

Lovalite’s has mainly developed internationally and its distribution network that initially focussed on Asia now extends as far as Italy, Great Britain and the United States.
AcXys Technologies is an innovative leader in the area of atmospheric plasma surface preparation solutions. The French manufacturer, located in Grenoble, offers technologies for enhancing materials surfaces properties before process operations like gluing, painting, printing or varnishing. Nearly all materials can be treated: polymers, metals, glass, rubber, wood, leather. Plasma treaters fit all kind of surfaces geometries like films, flat products, web materials, non-woven materials, profiles, foams or 3-D objects.

The first technology, called ULS, is a small nozzle producing high energy gas for fast cleaning and surface preparation before gluing or coating. The nozzle works with compressed air and electricity. It is thus very handy and money-saving. The treatment area is a 2 cm spot. For wide surface treatment, it is recommended to move the source around the surface or to use a multiple sources configuration.

The second technology, called ULD, is a linear plasma source which produces a gas curtain. It is very convenient for treating wide surfaces because source length can be chosen from 6 cm to 50 cm (a 1 meter source prototype is currently being manufactured). For wider surfaces, several sources have to be mounted together. ULD technology works with nitrogen based gas mixtures. It is devoted to activation treatments, i.e. treatments enhancing adhesion and wettability on materials. A good point of mixing gases is to be able to adjust gas mixtures nature so as to optimize the surface treatment, depending on the material and the following process operation.

Both technologies can be adapted to products geometry and customer’s needs. Standard products are used for making special equipments on request. Beyond plasma technology, specific functions can be added: equipment mounting, products handling, automation and computer interface. Customization is made by AcXys Technologies, a turnkey solutions provider.

Beyond simple activation or cleaning, plasma can also be mixed with chemicals in order to make thin film coatings. An mixing equipment is available from AcXys Technologies and used in several laboratories in the world. AcXys Technologies has a strong experience in silicon oxide coatings.

The company, established in 2001, is a spin-off. When being created, the first task was to convert a lab technology into an industrial products, while promoting it among different industrial fields.

At first, plasma equipments were sold to public and industrial R&D labs. Now, they are also being used for mass production by several customers. Our commitment to high quality and customer satisfaction has lead to new purchases from existing customers.

AcXys Technologies plays a role among different markets: automotive, cosmetics, electronics and micro-electronics, composites, aerospace, screen-printing, optics. The company is also involved into European projects for biological and textile applications.

AcXys Technologies is active in France and in many other countries or regions in the world, including: USA, Japan, India, Taiwan, Italy, Benelux.
In the world of the machining process, the holy grail is high speed, high precision and high quality at the same time taking into account the cost factor as low as possible. While the precision is related to the quality, the speed always represents the limitation in providing high precision during the machining process and so a problem to lead to high quality of the machining parts. This trade-off between speed and precision or speed and quality is even harder to cope with especially if the machining parts are of complex shape.

In order to keep pace with the demand of high quality and speed machining process coming from many industries (optics and automotive), Cedrat Technologies SA (CEDRAT), a French company involved in mechatronic engineering and components manufacturing, developed a novel and versatile Servo Piezo Tool, so called SPT400MML.

The SPT400MML is a fast tool servo driven by piezoelectric actuator for high speed and precise diamond turning and Lathe machining. The SPT is particularly used in applications where unsymmetrical surfaces have to be machined such as oval piston and non-spherical optics. The SPT400MML uses the patented Amplified Piezo Actuators (APA) from CEDRAT because of their high stiffness (in the transverse and actuation axes) and then high achievable bandwidth and acceleration to get a fast motion of the diamond tool with long stroke. The APA is used in a new counter-balanced configuration to limit the impact of the vibrations during the machining process, to improve the accuracy of the tooling system and to obtain a high quality surface.

To overcome the inherent hysteretic and drift nonlinearity effects while keeping the powerful performances of the piezoelectric actuator, a closed-loop control system is established using position feedback based on a high resolution Eddy current sensor integrated in the casing, which has compact structure and avoid any interference in the machining.

The UC75 controller includes a National Instrument Core based on Compact RIO@NI (based on native parallelism of the FPGA component) and the power of the Labview@NI Libraries (based on simple graphic code) to control any system with fast ticks and deterministic time. This real-time controller with fast sampling rate up to 100kS/s permits to tune the regulator to obtain a high bandwidth and high accuracy control of the tool holder with a robust regulator relying on the classic PID topology. As a consequence, the UC75 allows the SPT400MML to follow the complex trajectory motion in oval piston machining and complicated free form surfaces in optics machining.

Various tests were performed, including some trials to assess its performances when coupled with standard lathes, on aspheric and elliptical form machining. The surface roughness obtained with a “Contour fine tooling” diamond tool is 10 nm rms. The SPT400MML prototype was developed under the FP6 MasMicro project.

### References

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</tbody>
</table>

Notes: Temperature 25°C
(a) < 100Hz; 200μm@200Hz, 100μm@400Hz
(b) -3dB small signal
(c) Bandwidth DC-500Hz
(d) at 100Hz
Leader in advanced mechanical characterization

Nanotechnology, thin films and coatings are becoming incontrovertible in many different industrial applications. In order to simulate the service life of a particular system and to improve efficiency, the characterization of materials properties is important.

The value of any instrument is based on the reproducibility of those measurements, independently of the human operation. A variety of different instruments, techniques and methods are here presented for the characterization of the surface mechanical properties: Indentation, scratch and tribological instrumentation.

Hardness and Elastic Modulus by instrumented indentation

Hardness is measured by pressing an indenter, usually a diamond, of known geometry into the test surface. During this indentation, penetration depth and applied load are monitored both during the insertion and withdrawal of the indenter.

Using such a method, material hardness, elastic modulus, strain-hardening exponent, fracture toughness and viscoelastic properties can be determined.

The interest of using an instrumented indentation technique over traditional methods is that much greater when characterizing thin films. To avoid the influence of the substrate on the measurements, one must take into account the interface stress field. As such penetration depths for the indentation should be kept below 10% of the overall film thickness. With low penetration depths, the uncertainties in the optical observation of the residual imprint, lead to very high errors in the hardness values. Instrumented indentation then becomes incontrovertible.

Nanoindentation Tester Xpress

The Nanoindentation Tester (NHX) is the perfect low-cost solution for measuring HARDNESS and ELASTIC Modulus in accordance with ISO 14577 and ASTM 2806. Using our extensive experience – gained during 30 years – we have developed the NHX specifically designed for industrial Quality Control (QC).

The NHX is a robust, tried-and-tested instrument which is designed for ease of use to characterize the mechanical properties of the real surface with depth down to few nanometers.

Scratch testing is a versatile tool to evaluate the adherence, stress and strain between a coating and a substrate as a diamond stylus is passed over the surface with some normal load applied. The mechanical response can be measured by simultaneously recording friction transients, acoustic emissions and changes in surface morphology whilst this scratch on the test surface is applied. Examples of fields include the thin DLC overcoats used in the magnetic hard disk industry and varnish clearcoats used in the automobile industry, etc.

Tribology

Friction and wear lead to study the interaction of two surfaces through a sliding motion. A flat or a sphere tip is loaded on to the test sample with a precisely known force. The tip is mounted on a stiff lever. As the disk is rotated, resulting frictional forces acting between the tip and the disk are measured by small deflections of the lever. Wear coefficients for both the tip and sample are calculated from the volume of material lost. We can then study the behavior of almost every solid state material combination, with varying time, contact pressure, velocity, temperature (from 20°C to 1000°C), humidity, lubrication, etc.
Dou Yee Technologies (DYT), a subsidiary of Dou Yee Group, has been providing Ceramic Injection Moulding, Metal Injection Moulding & Plastic Injection Moulding solutions to customers worldwide since its inception in 1996. From its design centre to manufacturing plant, the Company is equipped with state-of-the-art machinery and manufacturing capabilities that enable it to provide an extensive suite of products and solutions. Together with a team of experienced and dedicated personnel, the Company is committed to provide innovative solutions – from the initial design phase to the final volume production stage – in the most cost-effective and timely manner. DYT is certified with ISO 9001:2000 and ISO 13485:2003. In addition to an extensive range of in-house products, the Company specialises in customising injection moulding design solutions and managing projects with short lead times. Since its incorporation, DYT has manufactured precision ceramic, metal & plastic parts for the automotive, dental & medical, hard disk, telecommunications and consumer electronics industries.

**Situation**

In recent years, the orthodontics industry has an increased demand for aesthetic brackets, in particular translucent ceramic brackets. Engineering ceramic is known to be the second hardest material after diamond. The conventional method of manufacturing ceramic brackets is through CNC machining from translucent ceramic blanks. Some major pitfalls through this method include design limitation, long manufacturing cycle times and low yield rate in resulting in higher production costs.

**Challenge**

Ceramic Injection Moulding (CIM) technique is an ideal method for producing translucent ceramic brackets as the process is known to be excellent for producing small complex parts with high volume, yet offers consistently high quality products. CIM also offers the designer flexibility of designing near net-shape products with better functional features. Brackets are injected instead of machined, allowing smooth contours in a bracket profile as compared to sharp edges in a machined bracket. Economies of scale in production can also be achieved, offering a much more competitively priced bracket than a machined bracket.

The key challenges faced in the CIM process for the production of translucent ceramic brackets include more intricate process steps, complex process control, stringent mold maintenance and possible contamination issues which may greatly affect the aesthetic of the final product. Selection of the correct raw material in conjunction with our binder system is also important especially when sintering temperatures of 2000°C and clean room methods are utilized.

**Solution**

The team has done a DOE to carefully solve all process issues and perform all experiments in clean room with strict discipline. Extensive trials and tests have been carried out. DYT now uses nano-powder from a specialized manufacturer with much success.

**Result**

The team is able to manufacture a final product which offers the customer a satisfactory translucent ceramic bracket. Key challenges faced have been resolved through relentless efforts in maintaining consistent & stringent process controls. Through economies of scale in production, the final product offers the customer a lower cost bracket compared to a CNC machined bracket.
Eolite Systems develops and manufactures High Power Pulsed Fiber Lasers for a variety of fine-technology micro-machining applications, including cutting, engraving, ablation, drilling, annealing, printing, scribing, patterning, LIBS …

Boreas and Mistral offer power levels up to 150W, 1 nanosecond pulses and $M^2<1.5$ at 1030nm, and harmonics at 515nm and 343nm.

Eolite offers 2 types of fiber based Lasers:
- Q-Switch models: Boreas
- MOPA model: Mistral

Eolite Systems Lasers principal advantages to micro-machining are better quality in marking and deep-engraving (thanks to short pulse duration minimizing thermal effects) and faster speed processing with high peak power pulses.

Located in Bordeaux area, the company is working in close relationships with Bordeaux University and TUT, Tempere (Finland).

**Products**

Boreas and Mistral combine very good beam quality (<1.5), high average power (up to 100W) and short pulses (<10ns) and are de facto non-sensitive to back-scattering beams.

**Boreas**

Boreas product range is offered into 3 wavelengths model range:
- **Boreas IR30 and Boreas IR60**: 1030nm, 30W and 60W, pulse duration < 10ns, 1mJ, to 200kHz, $M^2<1.5$
- **Boreas G15 and Boreas G30**: 515nm, 15W and 30W, pulse duration < 10ns, 0.5mJ, 10 to 200kHz, $M^2<1.5$
- **Boreas UV10**: 515nm, 10W, pulse duration < 10ns, pulse energy 0.25mJ, 10 to 200kHz, $M^2<1.5$

**Mistral**

Mistral combines short pulse (1 ns), good beam quality (<1.5) and high peak power (up to 300kW).

Mistral product range is offered into 3 wavelength model range:
- **Mistral IR5**: 1064nm, 5W, pulse duration $\approx$ 1ns, up to 20kHz, $M^2<1.5$
- **Mistral G2.2**: 532nm, 2.2W, pulse duration $\approx$ 1ns, up to 20kHz, $M^2<1.5$
- **Mistral UV1.2**: 343nm, 1.2W, pulse duration $\approx$ 1ns, up to 20kHz, $M^2<1.5$

**Applications**

Photo-voltaic Industry: Edge Isolation, front surface contacts, via drilling, wafer marking, Thin Film patterning, scribing ...

IC Industry: microvia drilling, ceramic processing, PCB drilling

Silicon Industry: scribing, via drilling, dicing, cutting ...

Diamond Processing: Jewelry, LED heat sink dicing ...

Marking/Coding industry: metal marking, metal deep-engraving, texturing ...

Materials: plastics, polyimide, PET, ceramics, glass, copper, aluminum, gold, brass, ruby, silver ...

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**Eolite Systems**

www.eolite.com
New activity for Optec Industries: Silicon for the watch market

Optec Industries adds to its core business the deep ion etching of silicon to provide to luxury watch manufacturers an innovative offer opening new technical and aesthetic opportunities.

The Silicon

The creation of technical and aesthetic pieces like the dials is executed with a great accuracy. The flatness of the wafers, the sharpness of etching and the complexity free design capability improve the technical results of manufacture of pieces of movement. Micro pieces up to 500microns thick can be manufactured with this technique. Chemical Vapour Deposition applied to Silicon allows a variety of colors extended by adjusting the thickness of the deposited layer.

Other features like anti abrasion coatings, optical effects can be also proposed. Please contact us for further details.

The offer includes the dial made of silicon until watch pieces.

Optec Industries’ core business: automatic testing and control equipements

Optec Industry invites you to discover at the Micronora 08’s fair our surface defects analysis system TactEye® on FPGA base and mounted on a robotic arm. TactEye ® analyses in full field and without contact the profile and surface state of a single piece of any shape. An application is presented at the fair for the complete control of large plastic parts for automotive market. Other successful integration has been performed on pieces for Luxe market.

The line of products presented by Optec Industries

Automatic optical systems to replace manual control:
- TactEye® : full field non contact system for analysis of profile and surface state of a piece of any shape
- FlatEye® : competitive compact measurement of flatness of microtech and watch pieces
- RapidEye® high frame rate acquisition system for vibrating or fast response time analysis
- ProfilEye® : line LED profilometer for high sensitivity inline profile analysis
- FlashEye® : Free PC programmable Directional lighting system equipped with its own power supply to reveal surface defects (stripes)

Testing equipement for measurements of watches pieces or assemblies aging:
- Palpeur force-distance: Device for measuring force and position simultaneously (tensile and compressive)
- Palpeur couple: semi-automatic measurement of micro couples subassemblies watch in static or dynamic mode
- Watches barrels spring torque measurement with mechanical study of the temperature dependency

Optec Industries

www.optec-industries.com

The FlatEye®
Polyrise is a French SME specialized in the design, development and production of highly functional technical products (nanomaterials, thin films coatings) which can address a large panel of applications and substrates.

Intensive R&D efforts led to the development of a unique and original process of preparation of nanomaterials and allow the presence of Polyrise on new markets and businesses: Polyrise has integrated the production of high added value coatings. Polyrise offers two portfolios of products for aeronautics, automotive, microelectronics, optics, composites, technical textiles...

Hybrid Nanomaterials

- Polyrise develops hybrid nanomaterials based on the combination of a nano-sized inorganic core (silica, titanium dioxide...) with an organic polymer shell
- Patented technology
- Products (acrylate, methacrylate, epoxy, fluorinated...) and new sample resulting from Polyrise R&D are available on demand
- Polyrise’s nanomaterials can be used as a filler, an additive or a binder resin
- Polyrise’s nanomaterials take advantages of a large panel of final properties (residual stress lowering, abrasion resistance, impact resistance, dielectric properties, thermal and chemical resistance...)

- Due to their polymer shells, Polyrise’s nanomaterials are not concerned by dispersion problems and improve in a significant manner the rheological behavior of materials in which they are dispersed (thermoplastics, resins...)
- Polyrise’s nanomaterials are transparent and available in viscous or solid form as well as pre-diluted solution

Technical multifunctional coatings for industry

- Polyrise proposes SOL GEL and UV curable coatings
- Polyrise solutions are innovative, easy and quick to implement
- They adapt to a large number of substrates (plastics, glass, metals, textiles...)
- Main properties of Polyrise’s technical coatings are: abrasion resistance, anti-fingerprint property, chemical resistance, barrier effect, anti-fire property, electric properties (electric capacity, resistivity, dielectric properties...)

Polyrise leads its customers and partners to more innovation and added value. Beside range of products, Polyrise is skilled to develop tailor-made products which, for example, will be characterized by the combination of different or antagonist properties (like anti-fingerprint property associated with barrier effect). One of strongest Polyrise commitment is to adapt to each of your needs. Polyrise assists its customers along all the steps of the partnerships from definition of technical specifications, through manufacturing of coating formulations to final deposition onto desired substrate surface.

UV curable anti-fingerprint coating
To meet the growing need for surfaces and materials characterization, the Schaefer Group offers a comprehensive set of solutions which provide measurement of morphological, physical and mechanical properties from macro-scale to nano-scale.

We want to focus here on two innovative instruments: Universal Materials Tester called UMT and MicroPhase, a module for 3D optical microscopy.

**Universal Materials Tester: more than a simple tribometer**

**CETR** (Center for Tribology, California) has developed a flexible instrument called UMT for testing tribological and mechanical properties of materials and lubricants.

The unique modular design provides the capability of fast switching between multiple testing modes such as micro- and nano-scratch, indentation, wear, indentation, friction, fatigue, AFM imaging... by simply swapping the easily-replaceable drive stages and sensors.

The UMT can perform synchronized multi-axial linear and rotary tests, including fast oscillations, with speeds from 0.001 (0.1 µ/s) to 5,000 rpm (25 m/s).

The extremely reproducible servo-controlled loads can be programmed to be constant or variable in several ranges from 0.1 mN (10 nN with Nanohead) to 1 kN. Ultra-accurate strain-gauge sensors perform simultaneous measurements of forces and torques in two to six axes.

All tribological parameters are monitored and recorded in-situ: normal load and wear depth, friction force, torques, acoustic emission, electrical resistance, humidity and temperature. In addition various chambers for heating / cooling, humidity and gases, vacuum and other conditions allow the user to perform tests under controlled environment.

Over the years, CETR has developed its three main interchangeable configurations:

- Universal Micro+Nano Materials Testing UNMT with nano-indenter, AFM microscope and other nanotechnology modules for studies of nanocoatings and nanostructured materials
- Universal Microtribometer UMT-2 for the complete micromechanical characterization of coatings and bulk materials
- Universal Macrotribometer UMT-3 for all commons tests of lubricants including ball / pin- on-disk, disk-on-disk, block-on-ring, 4-balls, piston/ring-on-cylinder and many other modes.

CETR makes also a specialized tester for chemical-mechanical polishing of semiconductor wafers.

**MicroPhase: an easy way to 3D optical microscopy**

**PhaseView** (French company, Massy) provides the simplest method available in the field of optics instrumentation for quantitative 3D surface imaging. By using standard video equipment and a powerful digital image processing, this innovative and user-friendly technology provides a 3D visualization of your sample (no more need for complex and expensive system or optics). From images of a conventional optical microscope, Digital Phase Technology® builds the 3D shape of an object.

Based on Maxwell differential equations solving, PhaseView has patented a technology that decouples the spatial variation of the electromagnetic power and the 3D shape of the object under study.

On this principle PhaseView has developed the MICROPHASE® instrument which is a very simple device. This is a module compatible with any microscope equipped with a video port. It fits to the standard C-mount and does not require any additional accessories. Your microscope is turned into a 2D vision and 3D metrology system. Acquisition and processing times are extremely fast (less than 10 seconds) and the measurement accuracy covers the micro-and nano-ranges.
SILMACH is a "fabless" MEMS company which is deeply involved in silicon-based micromechanics. The company provides engineering and design services to both institutional and industrial groups of watch industry, aeronautics, automotive and defense. The R&D staff has direct access to clean room facilities located in Switzerland and France. SILMACH investigates and prototypes new generations of products such as high-torque MEMS micromotors ("PMS" technology) and fully autonomous wireless mechanical sensors ("CHRONOMEMS" technology). SILMACH engineers master a wide range of MEMS-based micronanotechnologies at both micrometer and nanometer scales. The company delivers innovative MEMS solutions from several units up to small/medium series. In addition to MEMS micronanotechnologies, SILMACH engineers also master conventional machining techniques. The company's know-how allows the development of innovative products designed through hybridization of both conventional tool machining and MEMS technology.

The "PMS" Technology
Pioneer in the field of MEMS-based actuation of nomadic devices, SILMACH holds 4 patent families dealing with the so called "PMS" disruptive technology. The company currently develops with CEA/LITEN - Grenoble new motorization chips which combine on a same silicon substrate complex mechanical systems and MEMS-based high voltage solid electrolyte batteries. According to massively parallel MEMS production, hundreds to thousands motorization chips are manufactured simultaneously on a 6 inches silicon wafer. "PMS" technology already provides new MEMS solutions for actuation of a wide range of products such as quartz watches and racks of retractile obstacles for active flow control. SILMACH solutions today include integrated high voltage ASICs.

The "CHRONOMEMS" Technology
SILMACH develops wireless mechanical sensors dedicated to health monitoring of structures. The "CHRONOMEMS" technology allows mechanical and thermal parasitic events to be passively detected and recorded without the need of energy and electronics. CHRONOMEMS sensors can store a wide range of cyclic events such as impacts, mechanical vibrations and thermal expansion. Every type of quasi-static loadings such as traction, compression and flexion loading of structures can also be stored mechanically within periods of a to a few tens years.

"CHRONOMEMS" is a cost-effective and reliable technology which is patented by SILMACH and DGA. According to its miniaturized size, CHRONOMEMS can be easily distributed within arrays so as to improve the information collected on structures subjected to parasitic mechanical events.
Created in 1986, 40-30 based in Grenoble ensures the maintenance of high technology systems: vacuum technologies (leak detectors, metrology of low pressures, pumps…), electronics (automatism, temperature control, equipment and industrial radio frequencies transfer), controls and non-destructive tests, ultra clean activities. 40-30 is present in all industrial sectors (micro-electronics, aeronautics, agro alimentary, automobile, chemistry, pharmacy, photovoltaic…) and scientific research.

The company proposes 3 improvement targets: maintenance, trainings, engineering.

Our department “cleaning” proposes services of decontamination for all ceramic, metal and polymeric materials usually used in industry:

- Alumina
- Quartz, silica
- Carburize silicon
- Graphite
- Anodic aluminium
- Aluminium (any alloys)
- Stainless steels
- Technical metal alloys (HastelloyTM, KovarTM…)
- Polyethylene
- Polypropylene
- VespelTM, HalarTM

Cleannings are carried out in clean environment, if necessary. Beyond the visual contamination, we develop specific cleanings process adapted to your needs guaranteeing the withdrawal of the submicronic particles (> 0,1 µm) such as metals traces of or ionic species (nitrates, sodium…).

A large range of technical solutions is proposed:

- CO2 blasting
- Skat blast or sand spreaders
- Ultrasounds baths (with various frequencies of cleaning) with a great capacity
- Solvants baths
- Chemical baths
- High temperature furnaces

To help you to define your requirements in cleaning and to develop your functional and technical specifications, a team of engineers in research and development, expert in ultra clean activities, is at your disposal.

Jemi France

JEMI France (Joint Equipment Manufacturers Initiative France), a non profit association was created in 1989 to assist French companies working with microelectronics manufacturers (Integrated circuits and discrete) : equipment manufacturers, materials suppliers (gases, chemical products, liquids…) and service providers to collaborate with their customers.

JEMI France later enlarged its scope of action to include the fields of micro-and nano-object manufacturing within several national and european programs, such as those of the ANR, the MinEFE, the EUREKA clusters (CATRENE, EURIPIDES) and EUROGIA, the European Commission R&D program (PCRD7).

The association covers all the manufacturing process :

- Buildings and clean-rooms
- Facilities (distribution : electricity, liquids, gases, vacuum…)
- Equipment and manufacturing processes (Front End and Back End)
- Control equipment (mechanics, optics, electronics)
- Materials (solids, gases and liquids)

The association represents more than 40 companies. Over ¾ are SMEs. There are also 5 major laboratories working in manufacturing.

For several years, JEMI France has been progressing in its assistance to members by means of federative booths in major well-known exhibitions in Europe, North America and Asia, and by organizing B2B meetings with major companies in each area. In this way, JEMI France has brought together up to 20 companies, laboratories and development agencies in certain exhibitions. This new way of promoting its members is progressing every year and now represents half of the association budget. For 2008, we have targeted the Microelectronics field with exhibitions in Singapore, San Francisco and Stuttgart while in Photovoltaics, an exhibition is planned in Valence (Spain) and San Francisco.

Key figures for the 34 companies of JEMI France:

- Total turnover of 1 222 M€
- A total of 4 222 employees (410 dedicated to R&D)
- Export percentage of 73 %

Among these 34 companies, 26 represent :

- Total turnover of 1 111 M€
- 1 361 employees (143 dedicated to R&D)
- Export percentage of 57 %
Saint-Gobain PPL Asti

Polymer Solutions and Systems for Micro-electronics and Micro-technique

Saint-Gobain Polymer Products as a part of Saint-Gobain group is a wide range of Polymer Materials and solutions. Our mission is to provide superior engineered polymer solutions for demanding component applications using our high performance polymer expertise and our diverse in-house polymer manufacturing capabilities.

On Microelectronics manufacturing flow management, Saint-Gobain Polymer Products is providing a full range of full polymer pumps, valves, manifolds, fittings and tubing. A new improved full high purity polymer pump line, Astipure 2 pumps benefit all design improvements developed and validated during the last years. Astipure pumps are a leading pump system for aggressive media, slurry and chemical, in semiconductor applications. They are specifically designed without any metal component for non contamination. Astipure 2 shows better performance in flow and durability for an improved cost of ownership for the semiconductor fabs.

Meldin 7000 Polyimide material presents one of the highest performances that can be offered by a polymer material. Various applications are referenced in automotive, aeronautics and Micro-electronics. Saint-Gobain Polymer Products propose manufacturing processes according parts specifications and quantities.

S.E.T.

S.E.T., Smart Equipment Technology is a world leading supplier of High Accuracy Die-to-Die and Die-to-Wafer bonding solutions. With more than 250 Device Bonder installed worldwide, S.E.T. is globally renowned for the unsurpassed placement accuracy and the high flexibility of its Flip Chip Bonder. From the KADETT semi-automated R&D Device Bonder, through the automated FC150 and FC300 to the Production FC250, S.E.T. offers a continuous process path from research to production. S.E.T. bonders cover most bonding technologies and offer the unique ability to handle and bond both fragile and small components onto substrates up to 300 mm.

Thanks to over 25 years experience into High Accuracy Placement Systems, S.E.T. has introduced a new generation of Nanoimprint Lithography solutions for the replication of sub-20 geometries on large substrates. The Nanoimprint Stepper NPS300 is a cutting-edge lithography solution that combines advantages of E-Beam-Resolution with high throughput and low cost of ownership.

The NPS300 is optimized for the cost-effective replication of micro or nanometer scale structures using two different processes, Step & Stamp Imprinting for Hot Embossing is an innovative method that has been demonstrated at the VTT Technical Research Centre of Finland. This method consists of transferring the stamp pattern into a thermoplastic material by controlling heat and pressure. Step & Cure combine accurate in-situ material dispensing with UV curing, for the application of the UV-NIL process.

This innovative technology is a very promising solution for replacing standard UV-lithography systems when sub-100nm resolution or three-dimensional structures are required.

Features and Benefits of the NPS300:
- Combining Hot Embossing and UV-NIL on wafer
- Step & Repeat mode optimize the mold (stamp) cost
- Inert gas for faster print in UV-NIL process
- Automatic stamp pick-up
- Air bearing technology and granite structure ensure long-term stability and reliability

NPS300 Applications:
- Integrated optics devices, High precision micro-optical arrays and gratings
- CMOS-MEMS integration
- High density HDD’s for mobile storage
- Biomedical, lab on chip
- High resolution OLED displays
- Other emerging techniques
SUSS MicroTec

The best in Micro/Nano-Replication
Specialist from 60 years now of Photolithography for Microelectronics, it is natural that Suss MicroTec today is the best partner for the Imprinting technology.
For its wide installation base in the R&D labs and institutes, Suss MicroTec is proposing today a New UV-NIL Toolset, easily field installed on Suss MA6/MA8 mask aligners.
This innovative proposal enables you to build structures with features at the nanoscale level.
The easy and fast switching between UV-Lithography and nanoimprint lithography gives you a straightforward upgrade path to enter the nano world.

SUSS MicroTec …
… is a global player in the semiconductor industry
… is the only European producer of Step & Stamp Nanoimprint Lithography and competes in the worldwide imprinting market
… is offering a complete toolset which enables UV-NIL nm resolution
… benefits through membership in an international Nanotechnology knowledge network
… is the only supplier of a truly versatile and multi-process tool adapted to R&D requirement and scalable to production
… will be successful in NANO as we have an established global application, marketing and sales force.

Veeco

The Innova’s high-end functionality, compact footprint, and moderate cost make it one of the best value SPMs available today.

Dektak 150 - Stylus Profiler

The Dektak 150 Surface Profiler boasts the industry’s best performance, best repeatability, and largest standard scanning range for research and production environments. Combining over three decades of stylus profiler technology innovation, the Dektak 150 offers a variety of configurations to best match your application requirements. The cast aluminum frame and rigid support elements dramatically improve repeatability and reduce the noise floor. Dektak system software provides comprehensive analysis functions via an easy-to-use Windows® XP interface. One-button load-and-go testing and point-and-click operation make characterization highly intuitive and repeatable. Advanced capabilities and features are available via specific imaging packages.

NT9100 - Optical Profiler

The new bench-top Wyko NT9100 Optical Profiling System shares many of the performance attributes of the larger ninth-generation NT9000 systems, including: easy measurement setup, fast data acquisition, comprehensive and extensible data analysis, and angstrom-level repeatability. A data stitching option adds a motorized stage and support software to scan larger surface areas, and an optional X-Y stage automation option brings programmability to the NT9100, a first for a Wyko tabletop profiler. Industry-leading Wyko Vision software provides over 200 built-in analyses as well as automated measurement sequences (recipes), data logging, and pass-fail criteria for real-time process feedback and SPC.
nanoJura to manufacture and commercialise ultra-high precision surface profilometers for measuring surface texture based on French National Metrology Institute know-how.

Paris and Besançon, France, 22 February 2008. The French National Metrology Institute (LNE) and nanoJura, manufacturer of standard and customised surface profilometers, announced an agreement whereby nanoJura will manufacture and commercialise ultra-high precision surface profilometers based on French National Metrology Institute know-how. The profilometers increase the precision of 2D profile and 3D surface texture measurements by a factor of 10 to 100 depending on the application.

The LNE has installed an ultra-high precision profilometer to calibrate ISO 5436-1 roughness standards. These standards are used in turn to calibrate and guarantee the traceability of the results of high precision surface measurement systems. The ultra-high precision profilometer has nanometric resolution. It achieves an uncertainty of 16 nanometers on Ra=1 micrometre, where Ra is the arithmetic mean deviation of an assessed profile.

Standard components in the LNE’s profilometer include a moving sample table with a ZERODUR® glass flat base. A laser interferometer measures the displacement of this table in the X (and Y) direction. The profile is recorded with a contact inductive stylus (range 2.5 mm, radius 2 µm, angle 90°). A laser interferometer measures the relative displacement in Z between the arm holding the stylus and the moving table. Measuring this relative displacement means that both repeatable errors (for example the ones introduced by the profilometer’s mechanics) and random errors (for example those due to mechanical perturbations like vibrations) can be corrected in real time using technology patented by surface metrology solutions provider Digital Surf. In addition, all measurement axes, given by the laser beams, cross at one point: the contact point on the surface and the tip of the stylus. This satisfies Abbe’s principle and reduces errors due to the imperfect movement of the X and Y tables (pitch and yaw) during measurement.

The incorporation of additional sensors, which provide information on the position of the measurement sensor with respect to the object being measured, guarantees a closed metrological loop and reduces measurement uncertainties. The architecture allows in situ calibration of the probe against a laser interferometer, respecting the Abbe principle. This feature, which is not available on conventional profilometers, provides direct traceability to the unit of length and avoids the use of step height standards, calibration blocks or gauge blocks, which need to be calibrated by other means, and are not easy to use because of their imperfect geometry. It follows that this feature is perfectly adapted for exploitation by a national metrology institute.

nanoJura manufactures 2D and 3D ultra-high precision profilometers based on Digital Surf’s proven Volcanyon® modular control technology. The profilometers are available with both inductive contact gauges and chromatic confocal non-contact measurement gauges. Surface analysis is carried out using state of the art MountainsMap® software. The ultra-high precision profilometers can be used for any application where ultra-high precision is required. For example, they...
can be used to measure flatness, waviness and small features like craters on surfaces of 100 mm, which cannot be measured by conventional profilometers without significant measurement uncertainties.

“We welcome the addition of profilometers based on French National Metrology Institute know-how to nanoJura’s product line,” stated Anne Calvez, managing director of nanoJura. “This means that nanoJura is in the unique position of being able to offer standard and customized ultra-high precision surface profilometers for measuring surface texture to customers worldwide. The ultra-high precision profilometers complement our existing line of high precision profilometers.”

French National Metrology Institute

The French National Metrology Institute (LNE) is the national reference laboratory in metrology for French industry, pursuing scientific and technological development in order to anticipate new measurement and testing requirements created by advances in technology and society’s new expectations in the spheres of safety, health, quality and environmental protection. It provides state authorities and key economic players with the technical assistance they require to draft new regulations and standards at national, European and international level, develop new test methods and carry out market surveillance. Applying its multidisciplinary technical expertise, the Institute provides companies with metrology services in the numerous fields and offers a full range of technical conformity services, from calibration and testing to technical assistance and training. The Institute is also a certification body, providing companies with the technical solutions they need to ensure the quality and conformity of their products and enhance them on markets worldwide. It has centres in France, Asia and the United States.

For more information, visit: http://www.lne.eu

nanoJura develops, manufactures and commercialises both standard and customised high precision and ultra-high precision 2D/3D surface metrology instruments for micro and nanotechnology applications. In addition, it retrofits third party systems. The company works closely with the LNE (French National Metrology Institute) and integrates proven technologies developed by surface metrology solutions provider Digital Surf. nanoJura’s high precision instruments are sold through an international distribution network.

For more information, visit: http://www.nanojura.com

> NanoSEE 2008 Report

**UNIQUE ANALYSIS DESCRIBING NANO MATERIAL WORLD**

This report is designed to present the opportunities offered by nanomaterials to potential industrial users as well as the different nano-objects, the players involved and market data. It highlights the technical functions made possible by nanomaterials to create our daily nanoproducts.

**NanoSEE 08: Nanomaterials Industrial Status and Expected Evolution**

This report answers to:

> What are the benefits of nanomaterials?
> Who are the key players?
> How is the industry organized?
> What is the market for nanomaterials (2007 – 2012)?

**Contents of the report**

> Nano object description with special focus on nanoparticles and carbon nanotubes
> Main players and industry organization
> Market data

**Who should buy this report?**

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TEMIS: research, innovation and businesses build up their networks

Synonymous with high precision, Greater Besançon is staking everything on innovation. Microtechnologies and nanotechnologies are today at the heart of its approach to economic development. Researchers, companies, training organisations and local authorities in the Besançon area have chosen to work together to meet the challenge of the 21st century: to find a place on world high technology markets, relying on the region’s considerable resources in terms of skilled labour and grey matter.

TEMIS, economic development in action

The main tool at the service of innovative technological businesses is TEMIS. France’s only Technopole dedicated to microtechnologies, it was initiated and financed by the local authorities. It holds the Technopole label awarded by Retis, the French relay of the IASP (International Association of Science Parks).

The attraction of TEMIS is that it brings together on a ZAC (joint development zone) covering 75 hectares, 27 of which are still available, numerous resources in the microtechnology sector. And more widely, innovative businesses in general. Its philosophy is economic development in action at the service of the urban area and its promotion. In concrete terms it relies on constantly progressing technological markets, which are liable to provide lasting jobs. The Technopole offers research professionals, companies and training bodies the chance to work in networks. By pooling their resources and skills, TEMIS encourages cross fertilisation and increases the attractiveness of the Greater Besançon area.

The dynamics of innovation, a lever for companies’ competitiveness

Investing in the knowledge and innovation economy is the main aim of TEMIS and TEMIS SANTE. The Technopole therefore supports the companies that set up there and contributes to the synergy between research, industry and training. This policy enables it to attract new investors. And to do this, it has several advantages:

- The Microtechnologies cluster: based at TEMIS, the cluster has already validated 53 development projects for an investment budget of 40 M€. Its high visibility should further contribute to the attractiveness of the Technopole.
- TEMISciences. This flagship project is a logical follow-up to the other facilities on the site. It will soon bring together on the Technopole the major players in the microtechnologies and engineering sciences. The project will include the FEMTO-ST research unit (European-scale micro-manufacturing facility holder of one of the 20 first Institut Carnot labels), a higher education and research institute, the National Higher Institute of Mechanical Engineering and Microtechnologies (ENSMM), as well as structures to foster the application and transfer of technologies.

The economic strength of Greater Besançon

At a now more sustained pace, new activities are developing or opening up at TEMIS. This is the case for the R&D departments of PSP Peugeot and the Cheval Laser’s IMI holding. SOPHYSA, one of the world leaders in neurological implants, opened its site last year. ERG, one of the big names in ticketing, is also extending its business there. TROD MEDICAL is developing a new non-invasive surgical procedure for the treatment of cancer… At the Maison des Microtechniques, which is now full up, some fifteen incubated projects or companies based in the nursery are working on innovative activities of the future.
The microtechnology cluster: strategic for Europe

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