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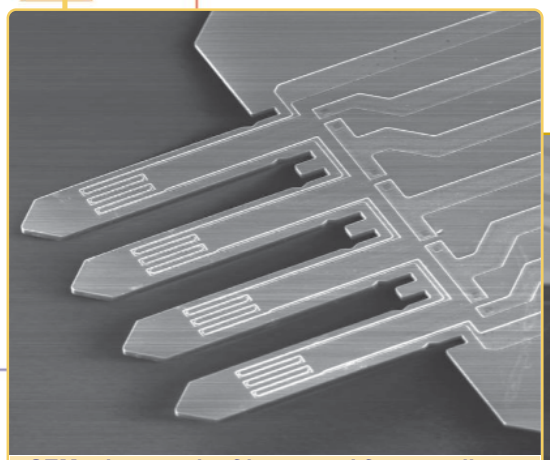
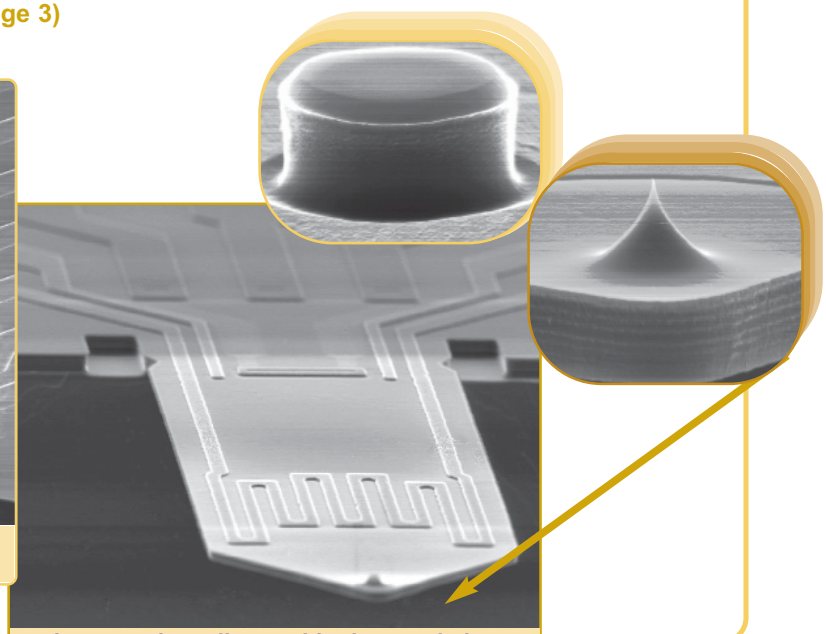
Topics in this issue:

MEMS manufacturing in Nano ToolShop Ltd. company, Bulgaria
(see details on page 3)



SEM micrograph of integrated four-cantilever MEMS cell for bio-chemical application.



Integrated cantilever with piezo-resistive readout and bimorph thermo actuator;

Edited by:
National Institute for Research and Development in Microtechnologies
(IMT-Bucharest, www.imt.ro)
Ministry of Education and Research, Romania

Previous issues on web*: www.imt.ro/mnt*

Design for Micro & Nano Manufacture (DfMM) News

web page: http://www.patent-dfmm.org

The NoE Patent-DfMM aims to establish a collaborative team to provide European industry with support in the field of "design for micro nano manufacture" to ensure that problems affecting the manufacture and reliability of products based on micro nano technologies (MNT) can be addressed before prototype and pre-production.

"Embedded Test Solutions" and "Package Engineering" Tutorials at DTIP 2008, 8 Apr 2008, Nice, Fr

PATENT-DfMM is organising 2 tutorials addressing "Embedded Test Solutions" and "Package Engineering" for Micro Nano Technology (MNT)-based systems to be held in conjunction with the DTIP symposium (9-11 Apr) http://tima.imag.fr/conferences/dtip/.

The Embedded Test Solutions tutorial will explore the need and potential solutions for manufacturing and on-line test of Micro Nano Technology (MNT)-based systems. Specific focus will be put into electrical only methods for implementing both Built-in-Test and Health Monitoring of MEMS based systems.

The Package Engineering tutorial will introduce the various levels of packaging used within the Micro & Nano Systems world with examples and explore reliability issues including typical defects, parametric, evolving and hard physical manufacturing faults and the impact of the packaging process on micro & nano scale MEMS components.

Speakers: Prof. **Andrew Richardson** (Lancaster Univ), Dr. **Srikanth Lavu** (Heriot-Watt Univ), Prof. **Alain Bosseboeuf** (University of Paris-Sud).

The Venue: Hotel Boscolo in Nice, Côte d'Azur, France. Registration fees: €150

Please register through the DTIP registration http://cmp.imag.fr/conferences/dtip2008/registration.php

For additional information, please contact either: **Prof. Marta Rencz (rencz@eet.bme.hu)**, Budapest Univ of Technology and Economics, Hungary, or **Patric Salomon (patric.salomon@4m2c.com)**, 4M2C PATRIC SALOMON GmbH-enabling MNT, Germany, More information is available at **www.patent-dfmm.org**.

EUMIREL, the European Microsystems Reliability Service Cluster, secures its first Contract

The European Microsystems Reliability Service Cluster – **EUMIREL** has recently been developed out of the "DfMM–PATENT" network and is offering a wide range of reliability services to the European Microsystems industry:

Reliability analysis: • Application-depending accelerated reliability tests of MEMS, especially for harsh environment; • Quantitative Accelerated Life Testing of MEMS for calculating reliability indicators; • Functional testing in different environments: temperatures, pressure, gasses, humidity, vibration, etc.; • Electrical and environmental reliability testing including statistical data processing where possible; • Failure analysis including multi-physics modelling; • Design of dedicated test structures for reliability monitoring; • Research-based services on MEMS reliability;

Consultancy: • Advice on MEMS reliability including material, processing and packaging related issues; • Development of reliability test plans; • FMEA studies; • Advice on test instrumentation and set-up and reliability methodology;

Information about reliability issues: • Access to databases on material issues, test structures, test equipment availability and MEMS failure mechanisms,…and a wide range of Training Courses on all aspects of MEMS reliability.

EUMIREL has now secured its first contract on the modelling of charging effects for improved MEMS reliability. The project is aimed at improving the understanding of failure mechanisms leading to improved reliability in products (design for reliability) and predicting device failure likelihood associated with charging. More information: **Patric Salomon**, E-Mail: **services@patent-dfmm.org.**

Hermeticity Testing of Microsystems, a Questionnaire from Heriot-Watt University

Due to problems associated with the standard helium leak test when applied to microsystems, novel hermeticity test methods are being researched and developed at MISEC, Heriot-Watt University. To ensure the techniques are relevant to industry, we have prepared a brief market survey which aims to help us understand how the hermeticity of devices is currently tested. All contributors will receive a summary of the survey. ***Link to survey:*** **http://www.patent-dfmm.org/site/events/questionnaire.htm**

iSLI and Cadence Design Systems join forces to help start-ups

The Institute for System Level Integration (iSLI) has announced an agreement with Cadence Design Systems Ltd. to help advance new businesses by giving them easy access to chip design software and methodology services. Providing access to software design tools and methodology services will enable new companies who may not have the finance or resources available, to accelerate their product development processes allowing them to become successful in the shortest possible time. The complete press release is available at **www.sliinstitute.ac.uk/pdf/news/iSLIandCadenceJoinForcesPR.pdf**

Call for papers: The 13th Commercialization of Micro and Nano Systems Conference (COMS), Puerto Vallarta, Mexico, 31 Aug - 4 Sep 2008

Deadline for submissions: 30 Apr 2008

Organized by MANCEF, COECYTJAL, FUMEC and CMM Microsystemas, COMS 2008 is an ideal location to network with leading representatives from the entire micro-nano community. It fosters the commercialization of micro and nano technologies and addresses commercialization issues unique to these emerging and disruptive technologies and it will bring together key personnel from all over the world and from every sector of the supply chain, including government representatives, top researchers in the field, educators, relevant publication sources, equipment suppliers, end users, and financial experts. The small tech community gathers at COMS conferences to learn from others, share their own knowledge, discuss and debate points of view – all of which contribute to the advancement of this emerging field. COMS is the oldest and most widely attended international conference on the commercialization of these enabling technologies.

An exhibition of equipment suppliers, product & service providers and consultants will be held in conjunction with COMS 2008. COMS addresses the issues related to building successful MNT firms, regions and educational programs:

Global Overview of Small Technologies

More information: **www.mancef-coms2008.org**

Contact PATENT-DfMM Coordinator:
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The publication of this page is supported by the ***network of excellence PATENT - DfMM***

MEMS manufacturing in company of Nano ToolShop Ltd.

Nano ToolShop (NTS) is a developer of ***novel MEMS (Micro Electro-Mechanical Systems)*** devices along with corresponding operating methods and technologies. NTS's goal is to develop a viable technology for multi-probe nano-scale devices and assist the design and development process of relevant equipment, based on such devices.

Two most promising applications are:

• ***high-throughput/high-complexity Scanning Probe Microscopy (SPM) and • sensors for chemical and bio-chemical recognition*** *(**e-NOSE**, etc.).*

NTS focuses on being:

• a high-tech subcontractor to SPM system OEMs

• a supplier of high-tech consumables (nano-probes) to end users of SPM systems

NTS does not a high-volume manufacturer but rather focuses on custom development, rapid prototyping and small-to-medium production runs.

Strategic approach: The company has three key strengths:

– Access to highly trained and experienced personnel

– Manufacturing facilities that are specifically optimized for producing nano-probes.

– Since the area of needed expertise is quite wide, a very close and trustable co-operation with different companies and Institutes of Bulgarian Academy of Science, having similar or complimentary know-how, was set up for years. As a result, this is a prerequisite permitting NTS to focus on emerging applications.

Products:

- **SPM probes: An integrated cantilever sensor** *(see the front cover, picture on the right)* is an example, demonstrating company capability to design and manufacture various kinds of advanced custom-tailored MEMS devices. This particular sensor, consisting of thin silicon cantilever with piezoresistor and bimorph actuator, provides nano-Newton / nano-meter resolution. Different-in-shape tips or other sensing elements, could be integrated on the cantilever.

- **Sensors for bio-chemical recognition and life science**

Since November 2005 NTS company is a **coordinator** of R&D project (NIF No IF-02-20/24.10.2005) aimed to develop **e-NOSE.** Within the project, a novel piezoresistive MEMS cell *(see the front cover, picture on the left)* was developed. According to specific application requirements, the cell could be modified and/or multiplied as many times, as required. Additionally, because of the integrated bimorph thermo actuator, this device could operate without any extra components. Mirror-smooth cantilever back side allows dual kind of detection, laser and/or piezo resistive used, simultaneously/ complimentary.

History: Nano ToolShop Ltd. was established in 2003 as a JV between Bulgarian and EU partners.

Fig. 1. High temperature furnace.

Fig. 2. Photo-lithography aligner.

Integrated MEMS sensor for chemical and bio-chemical applications

Future of analytical and manufacturing methods based on micro-mechanical cantilevers, depends critically on the ability to implement parallel operation and fast signal processing. There are two main reasons: high throughput requirement and complexity (multidimensionality) of analyzed value. In order to get parallel function, any single device should be simultaneously: recognizable, autonomously actuated and independently accessible for readout. Devices, fulfilling these requirements, are suffering from a substantial increase in complexity of both: layout and manufacturing technology.

As a part of e-NOSE (Nanotechnology Olfactory SEnsor) application project, a novel piezoresistive cell, shown in Fig. 2 was developed and manufactured. It consists of four cantilevers of different length and each of them is having a single piezoresistor for displacement detection. Each cantilever is, in fact, microbalance made of silicon beam coated with specific analyte-sensitive layer. When the cantilever along with the deposited active layer vibrates, its resonance frequency f depends on effective mass of the system: cantilever with active layer. If molecules from the environment adsorb on the cantilever surface, the mass changes involved can be detected by recording the shift in resonance frequency. Cantilevers of different length and resonance frequency allow identification of the individual cantilevers during measurements and minimization of the mechanical cross talk. In order to get an autonomously operating device, bimorph thermo-actuator was integrated on the cantilever, additionally.

The new micro-machined cell, as a micro-balance, is suitable for chemical and biological recognition. Sensor's pads are wire-bonded on sensor-carriers, made of standard double-side PCB with metallized vias. Sensor-to-carrier wires are epoxy coated, in order to protect them and prevent leakages.

A dedicated electronic modules, one of them shown in Fig. 3, have been developed by our partner from Bulgarian Academy of Science - Institute of Solid State Physics. Using advanced hardware and software solutions, systems with embedded four-cantilever sensors, demonstrate picogram/ sub-picogram resolution.

Every single cantilever cell is fully characterized at manufacturer fab. Measured parameters, application specific data and dedicated hardware are available, at request - see contact data.

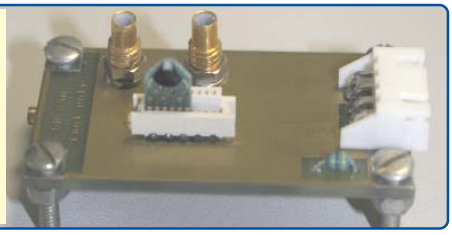


Fig. 3. Optical photo of cantilever cell measuring amplifier.

Contact: **(Mr.) Vladimir Stavrov, Nano ToolShop Ltd Manager; email: vts@nanotoolshop.com.**
Address: Microelectronica Industrial Zone, 2140 Botevgrad. GSM: **(+359) 888 700 216,** Office phone**: (+359) 723 66134**

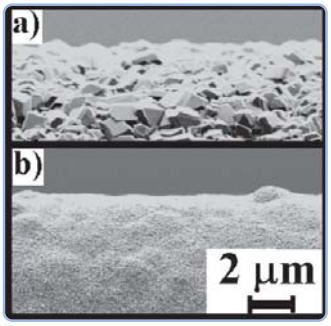
The publication of this page is supported by the ***MINOS-EURONET*** project (EC Contract No 015704)

Slovak Diamond Group

Department of Microelectronics,
Faculty of Electrical Engineering and Information Technology,
Slovak University of Technology in Bratislava

Slovak Diamond Group *is a R&D team working in Vacuum Technology and Electronics Section of the Slovak University of Technology in Bratislava, exactly at Faculty of Electrical Engineering and Information Technology, Department of Microelectronics. We are primarily interested in diamond thin films, Diamond-like Carbon (DLC), Carbon Nitride (CN_x) layers and Carbon Nanotubes (CNT). We are able to perform (selective) CVD growth of homogenous polycrystalline and nanocrystalline diamond and above mentioned thin films for large range of mechanical, electrical, optical and particular biological applications.*

Micro- and Nano-crystalline Diamond Thin Films for Mechanical Applications.

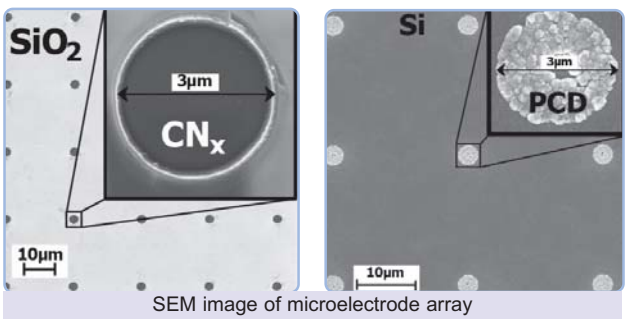


PCD and NCD films on WC-Co cutting tool

We have used Hot Filament CVD technology with Double Bias Enhanced Nucleation developed at our Department to produce smooth and homogenous nanocrystalline (NCD) and polycrystalline (PCD) multilayer diamond thin films with low roughness and high adhesion on standard WC-Co cutting inserts. The NCD and PCD multilayer thin films were deposited layer by layer through regulating both substrate bias and methane concentration. The structure of diamond layers was ranged from high phase purity PCD to NCD containing amorphous carbon component and one layer was successfully grown over the previous one. Substrate bias voltage was demonstrated to be the tool for changing the deposited layer grain size.

Nano-crystalline Diamond Thin Films and CNx Layers for Electrical Applications.

One application in this field, which we are dealing with, is a sensor based on polycrystalline diamond (PCD) and carbon nitride (CN_x) microelectrode array (MEA) for detecting Pb^{2+}. Electrochemical stripping voltammetry method offers a simple, quick and cheap way of detecting trace metals such as (Pb, Cu, Cd, Mn, Ag) in water. The minimum measurable current response to Pb^{2+} concentration on PCD was $1x10^{-4}$ mol/l, and on CN_x $5x10^{-6}$ mol/l. We are interested also in another electrical application of CVD diamond layers such as Schottky rectifying diodes, or electrochemical sensors for pharmaceutical and automotive industry.



SEM image of microelectrode array

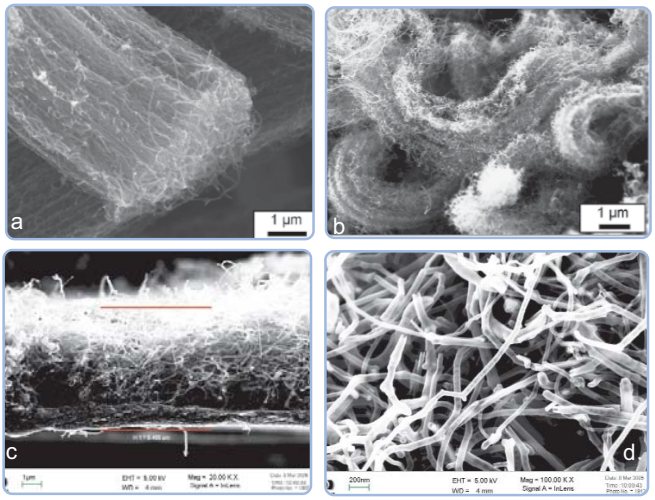
DLC and CNx Thin Films for Biological Applications.

We are producing smooth and homogenous DLC and CN_x thin films on hip replacement joints made of standard titanium alloy Ti–6Al–4V. For deposition of DLCs and CN_x we are using an UVNIPA-1-001 vacuum system with three sources (gas ion source for cleaning, electric arc source for non-magnetic metal sputtering and pulse arc carbon source for DLC deposition). Low deposition temperature opens the new window for many cheaper applications in medicine such as cover layers of hip replacement joints, nails, or cover microscopic glass for research of DNA or any biological tissue growth.

Optical image of CNx layer on hip replacement joints

Carbon Nanotubes.

Our CNTs are produced by HFCVD method on various substrates (Si, sapphire, glass, etc.) with various catalysts. Recently, we are finalizing two apparatus based on Arc-Discharge and Laser Ablation methods for CNT preparation. We have analyzed their electrical and optical properties such as emission, electrical conductance, influence of various gas concentration or behavior under different ambient condition primary for sensor applications.



(a)CNT bundles on sapphire substrate. (b) Bundles of carbon nanotubes on amorphous glass. (c) CNT array on Cu substrate. (d) CNTs on Si with Ni catalyst


Arc discharge UVNIPA-1-001 sputtering system

Contact: Dr. Marian Vesely, marian.vesely@stuba.sk, FEI STU, Slovak Republic

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The 7th edition of the Nanoscience and Nanotechnologies National Seminar,

20th of March 2008,

Romanian Academy, Bucharest, Romania

This seminar is continuing a series of events organised in the frame of FP 6 European project ROMNET-ERA (**http://www.romnet.net/**) even the project ended in 2007. Romanian Academy and IMT-Bucharest the coordinator of the project and organised the 7th edition which was dedicated to promoting the Romanian scientific results, resources and activities in micro- nano and bio technologies domain. Speakers presented in their papers at the oral session the latest results from Romanian scientific community, the newest equipments acquisitioned trough the national or international infrastructure research projects and the educational opportunities for young researchers or students.

Prof. Ion Mihailescu, INFLPR, Bucharest Romania

The Seminar included sessions for oral presentations of scientific papers (18 papers presented), debates and poster sessions (28 posters displayed). The debates offered an opportunity for the people attending the event to consult the speakers and discuss various interpretations of the results and applications presented.

Poster Session

85 participants attended the event, the majority coming from national R&D research institutes but also participants from universities and industry.

The extended version of the papers presented at the 7th seminar edition will be published in "Micro and Nanoengineering" series (edited by the Publishing House of the Romanian Academy).

.This MNT Bulletin edition presents the paper „Nanostructured biomaterial thin films synthesized by pulsed laser technologies: new applications to implantology" by Prof. Ion Mihailescu, INFLPR, Bucharest Romania.

Nanostructured biomaterial thin films synthesized by pulsed laser technologies: new applications to implantology (I)

Ion N. Mihailescu, Carmen Ristoscu, Felix Sima, Gabriel Socol, Marimona Miroiu, *National Institute for Lasers, Plasma and Radiation Physics*, PO Box MG-54, RO-77125, Bucharest-Magurele, Romania

Gabrielle Charlotte Chitanu, *"Petru Poni" Institute of Macromolecular Chemistry*, Iasi, Romania

Gabriela Negroiu, Livia Sima, *Institute of Biochemistry, Romanian Academy*, Splaiul Independentei 296, Bucharest, Romania

Roxana Piticescu, Madalina Popescu, National R&D Institute for Nonferrous and Rare Metals, 102 Biruintei Blvd., Pantelimon-Ilfov, Romania

Laser-Surface-Plasma Interactions (LSPI) Laboratory (*http://lspi.inflpr.ro*), Lasers Department, National Institute for Lasers, Plasma and Radiation Physics has more than 35 years of experience in the field of laser generated plasmas, laser-surface interactions, and material processing with lasers. *The permanent staff of the Laboratory consists of one university professor, 7 PhDs, 8 PhD students and 5 graduate students.*

Our current researches are focused on: biocompatible and bioactive thin films synthesis and characterization, nanostructured films for gas- and bio-sensing, new thin films for spintronics, laser transfer of delicate complex molecules of polymers and living cells, and the kinetics of interfacial layer growth during pulsed laser deposition of thin films on various substrates.

Recent research activities of LSPI laboratory were focused on obtaining biomimetic coatings for advanced metallic medical implants. They involve new composite thin films and fabrication technologies. We analyze the potential of biocompatible, bioactive thin layers for specific applications in orthopedic and dental surgery and implantology.

To overcome the major drawback of the second correction surgeries caused by the incomplete biocompatibility of the metallic implants, it was developed the solution to cover the metallic implants with biomimetic layers of excellent biocompatibility and high bioactivity. Pulsed Laser Deposition (PLD) proved in this respect a versatile technique to grow

Fig. 1: Pulsed Laser Deposition facility in operation in LSPI Laboratory

thin films, with important significant advantages. PLD presents the unique ability to obtain a large variety of coatings morphology, from amorphous to crystalline, dense to porous or from rough to uniform. The complex stoichiometry of almost any biomaterial is preserved during pulsed laser experiments as demonstrated in our studies after 2000 [1, 2].

One restriction of the method is deriving from the physical mechanisms of the laser ablation: in case of delicate organic or biological molecules, the laser irradiation provokes an irreversible damage of the chemical bonds and thus a compositional change in the deposited film.

Nanostructured biomaterial thin films synthesized by pulsed laser technologies: new applications to implantology (II)

This limit was surpassed by new deposition technologies, i. e. Matrix Assisted Pulsed Laser Evaporation (MAPLE) and Matrix Assisted Pulsed Laser Evaporation - Direct Writing (MAPLE DW), able to successfully transfer organic and biological materials from cryogenic targets [3,4]. In Romania these techniques were developed for the first time by LSPI laboratory, after 2003.

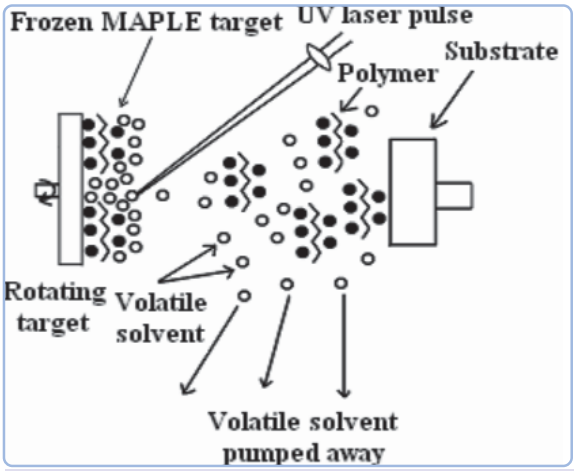

Fig. 2 Schematic representation of MAPLE process

In MAPLE (Fig 2), the simultaneous evaporation of the frozen target and ejection of the organic or biologic material are initiated. The photon energy absorbed by the solvent is converted to thermal energy that causes the organic or biological material be expulsed under the protection of frozen solvent, which is gradually vaporized and evacuated by pumping. The delicate material molecules reach sufficient kinetic energy by collective collisions with the evaporating solvent molecules, to be transferred in gas phase.

Recent literature data predicted that MAPLE and MAPLE-DW will be indispensable in the development of next generation microfluidic biosensors and biochips, coating drug particles with functional polymers, microneedle coatings for various therapeutic applications (DNA vaccines, gene therapy) or biocompatible coatings for medical implants.

In our experiments, the radiation generated by a KrF* excimer laser source (λ=248 nm, T=25 ns, v=(1-50)Hz) was focused onto the cryogenic composite target surface.

Very recently, we succeeded to synthesize by MAPLE new inorganic-organic (ceramic-polymer) hybrid thin films, directly onto the surface of the metal implants.

The composite material prevalently contained (80% w. p.) hydroxyapatite, the main component of the bone tissues.

A synthetic organic polymer (maleic anhydride copolymer) was added (20% w. p.) to induce the coating surface functionalization and improve mechanical properties.

All deposited samples were subjected to physical investigations (XRD, SEM, FTIR) and in vitro biological characterizations. The results indicated that the optimum deposition regime for an appropriate stoichiometric and functional transfer was obtained for 0.55 J/cm^2 laser fluence, 30 °C substrate temperature, 26 Pa N_2 and 3 cm target-substrate separation distance.

In vitro tests demonstrated that Ti coated with hybrid HA-polymer exhibit excellent biocompatible behaviour. Fluorescence microscopy studies of human embryonic kidney (HEK293) cells grown on HA-polymer coatings show a surface occupancy comparable to the control (Fig 3).

The hybrid biomaterials films proved a better biocompatibility than simple HA films, enhancing even more the adhesion and

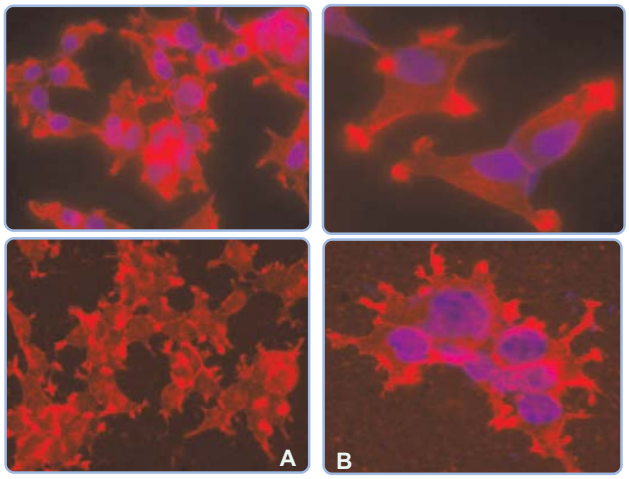

Fig. 3: Fluorescence microscopy images of Hek293 cells grown on HA - maleic anhydride copolymer thin film (A) and on standard glass material (B), respectively;

proliferation performances of implant surface (Fig 4). The cells presented normal morphology, good adhesion, and, spreading as it is evidenced by actin filament organization, cell-cell contacts and uniform covering of the substrate.

In vivo biological studies of the new structures are in progress.

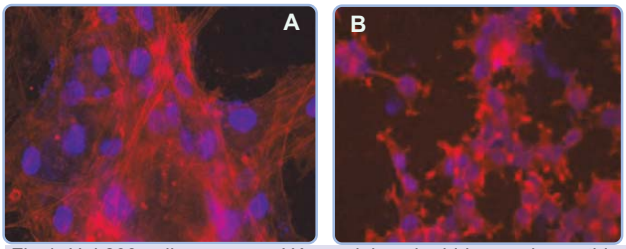

Fig.4: Hek293 cells grown on HA - maleic anhydride copolymer thin film (a), and on simple HA thin film (b)

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3. "Laser deposition of polymer and biomaterial films" D.B. Chrisey, A. Pique, RA McGill, JS Horwitz, Chem. Rev. 103 (2), (2003) 553-576;

4. "Pulsed Laser Deposition of Biocompatible Polymers: a comparative study in case of Pullulan" R. Cristescu, I. Stamatin, D. E. Mihaiescu, C. Ghica, M. Albulescu, I. N. Mihailescu, D. B. Chrisey Thin Solid Films 453-454 (2004), 262-268.

IT Girls – Great careers for great women

European Commission initiative in Information and Communication Technologies (ICT) domain.

"IT Girls – Great Careers for Great Women" is an important initiative taken by the *European Commission* to convey the message that rewarding career opportunities in the ever-growing domain of *Information and Communication Technologies (ICT)* exist for both men and women. *To encourage young girls to choose a career in the ICT sector, the European Commission coordinated the organization of* ***Shadowing Days in ICT*** *companies and institutions.*

Delia Dogaru, Adina Corbu, Irina Damascan and Luiza Cicone, from the **"Tudor Vianu" National College**, shadowed four female engineers throughout the day as they carried out their regular professional commitments. They spent the day seeing the seniors in action in some of the main departments of IMT and visited the main technological facilities, including the clean room:

- **Carmen Moldovan** – Wafer Processing
- **Gabriela Dragan** – Mask Fabrication
- **Monica Simion** – NanoBioLab
- **Raluca Gavrila** – Atomic Force Microscopy
- **Oana Nedelcu** – CAD Design & Simulation

Within IMT, 40% of the researchers are women proving exceptional qualities for research and development in nanotechnology area. The event was a great experience for the IMT's researcher women and for the young girls spending a full working day inside the microfabrication facility and trying to use the new software programmes or new equipments. The girls were very impressed by the activities within IMT, and declared that research is, from now, a domain to think about when choosing their future careers.

A few impressions of the four young students:

Delia Dogaru: "I witnessed the beginning process of microchips used in microsensors to determine the compensation of a certain substance. These tiny things create the bridge between technology and environment. I do find the R&D work quite appealing and I take this in consideration for a future job."

Adina Corbu: "I could observe the deformation the material had when it was tested under extreme temperatures and pressures."

Irina Damascan: "I had the most interesting day here at IMT. I started to understand how new technology works in the field of creating masks."

Luiza Cicone: "I discovered how we can find out the rugosity of some materials at nanoscale level with a special microscope."

Irina Damascan (left) and Gabriela Dragan (right) - Mask Fabrication Shop

The ***IMT's activity*** is devoted to *"Development of research activities in the field of micro/nano-technologies, with strong impact on the development and competitiveness of the Romanian Industry"* **www.imt.ro**. With unique research facilities in Romania, IMT is a major player in the area of micro and nanotechnologies for ***MEMS/MOEMS, RF-MEMS, bioMEMS*** with *applications in industry, automotive, communications, biomedical and environment monitoring*.

As an innovative, leading edge research institute, *IMT is interested in attracting new, young people (students, PhD students) in the micro and nanotechnology field.* This is why this event was a nice opportunity for us to meet young girls, interested in a technical career.

INTERDISCIPLINARY PLATFORM FOR MASTER PROGRAMME IN NANOSCIENCE *AT UNIVERSITY OF BUCHAREST*

The programme ***"Master in Nanoscience"*** will be jointly developed by three faculties from **University of Bucharest: Physics, Biology and Chemistry** and by partnership with many specialised laboratories from Research & Development institutes and industry from Bucharest and country. The development of a new Curriculum in a performing and modern domain (as concerning human resources and equipment) was possible only by infrastructure enhancement at Univ. of Bucharest and by applying a modern methodology and an educational strategy capable to guarantee the formation of specialists, as well as competitiveness on "European educational market".

The development of the interdisciplinary platform by enlargement of existing experimental facilities and the development of this new Master programme by using TUNING methodology will offer the best solution for success.

A consortium of 4 research centres from the Faculties of Physics, Chemistry and Biology in Univ. of Bucharest was successful in the competition organized by Romanian Ministry of Education, Research and Youth, in 2006, for projects of infrastructure development as interdisciplinary platforms for research and formation.

The organization of the interdisciplinary Platform at Univ. of Bucharest for "Master Programme in Nanoscience" will allow the development of a research master programme based on a high performance equipment basis. The existing equipment in the departments involved in accomplishing the programme ***"Master in Nanoscience"*** was enlarged by new and specific instruments for studies, at nanometer scale, of materials and structures important for applications in electronics, new sources of energy, medicine and environment. The faculties are cooperating for Curriculum design and development and for the accomplishment of all activities. The Master programme is based on modules: intensive teaching periods (theoretical and laboratory courses mainly in university) and practical stages (of min 3 months) in specialised laboratories from university and partner institutions. The main characteristics are: *interdisciplinarity and flexibility* (66% of total 120 ECTS being optional).

The 2 years "Master programme in Nanoscience" will start in the academic year 2008/2009. By developing this new, modern and interdisciplinary programme of study, the educational offer at University of Bucharest will be enriched and also the enhancement of student recruitment for the second and third cycles is envisaged.

Contact: Laura Tugulea (laura.tugulea@g.unibuc.ro), Faculty of Physics, Univ Bucharest, P.O.Box MG-11, Magurele, RO 077125, www.unibuc.ro

DELILA - Development of Lithography Technology for Nanoscale Structuring of Materials Using Laser Beam Interference

Overview: The project "Development of Lithography Technology for Nanoscale Structuring of Materials Using Laser Beam Interference (DELILA)" focuses on researching and developing a new production technology for fabrication of 2D and 3D nano structures and devices. In particular, DELILA will enable low cost and large volume production of surface structures and patterns with a feature size better than 40nm. DELILA is a specific targeted research project (STREP), funded by the European Commission under the 6th Framework Programme (FP6). The consortium consists of 5 partners: the Manufacturing Engineering Centre (MEC) of Cardiff Univ in the UK (coord), the Optoelectronics Research Centre (ORC) of Tampere Univ of Technology in Finland, SILIOS Technologies SA (SILIOS) in France, the Institute of Applied Physics (IAP) of Russian Academy of Sciences, and the Dept. of Microelectronics, Centro de Estudios e Investigaciones Técnicas de Gipuzkoa (CEIT) in Spain.

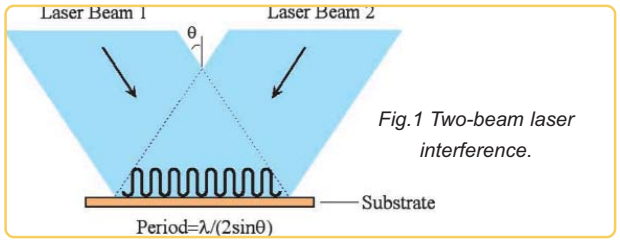


Fig.1 Two-beam laser interference.

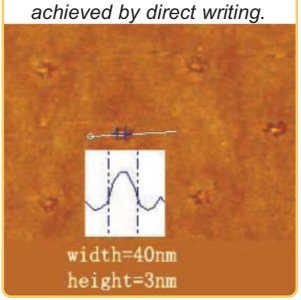
Laser interference lithography: Laser interference lithography (LIL) is concerned with the use of interference patterns generated from two or several coherent beams of laser radiation for the structuring of materials. The interference patterns can be arrays or matrices of laser beam lines or dots. The pattern period is basically governed by as shown in Fig. 1. The intensity distribution of the interference patterns exposes materials with a pitch of sub-wavelength of the interfering light. When using such radiation to interact with materials, feature sizes down to a fraction of the laser wavelength can be created. This technology provides a way for nano patterning periodic and quasi-periodic patterns that are spatially coherent over large areas. LIL is highly innovative in nanolithography due to the facts that its high efficiency, large working areas and low cost in nanoscale structuring of materials as compared to the ion beam lithography (IBL) or electron beam lithography (EBL) technology. With respect to the scanning probe lithography (SPL) technology the advantage of LIL is the non-contacting projection mode with a large working distance and extremely efficient fabrication which are two decisive advantages with respect to emerging nanotechnology production requirements.

In general, LIL has the following advantages compared with other nanolithography technologies: (1) Very high throughput (1 pattern/pulse in ~10ns); (2) low cost; (3) programme controlled re-configurable patterns (with different periods, feature sizes and pattern shapes); (4) surface contamination-free; (5) creation of structures on large areas (up to hundreds of mm in diameter); (6) long working distance (flexible within coherence lengths and modification energy thresholds of materials); and (7) environment friendly.

System architecture: The scheme of a multi-beam laser interference lithography system for formation of laser interference patterns consists of nine parts: laser radiation, beam shaping, beam splitting, phase control, interference control, polarization control, beam monitoring, sample positioning and system control. The role of laser radiation is to supply coherent light with an appropriate wavelength, power and coherence length. As for almost all lasers, the intensity of laser beam is Gaussian distribution, and it must be transformed into a flat-top distribution before interference so that a uniform pattern can be produced. Beam splitting is needed to obtain several coherent beams for a laser interference nanolithography system. Phase control is significant for a laser interference nanolithography system, as it is related to pattern orientation or localization of a pattern. Interference control is concerned with the arrangement of the coherent beams to form required interference patterns. Polarization control is related to the arrangement of the polarization states of interfering beams to form required interference patterns. Beam monitoring is concerned with the monitoring of a multi-beam interference nanolithography process. Sample positioning is related to the positioning of samples (x, y, z), repeated patterning of large samples (x, y), changing of the incident angles of the laser beams and the periods to keep the sample in a position for patterning (z) and rotation of the angle between the sample and the incoming beams to have more flexibility to the shape of patterns that can be defined.

Technological potential: The technological potential of the multiple beam laser interference lithography technology is closely related to the following parameters: writing mode – both direct writing and indirect writing, pattern feature size – a feature size down to ~λ/10, pattern period – a period of ~ λ/2 (without interpolation), pattern type – gratings (2-beam interference) or arrays of dots/holes (multi-beam interference), pattern size – up to hundreds of millimetres in diameter, exposure mode – single or multiple pulses, exposure duration – ~ 10ns, exposure repetition – ~ 10Hz, depth of focus – large (flexible), and throughput – high (1 pattern/pulse).

Fig. 2 A feature size of ~40nm achieved by direct writing.



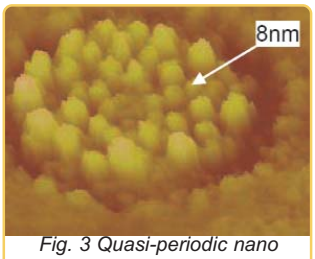


Fig. 3 Quasi-periodic nano islands or features down to around 8nm induced by pulsed laser interference patterns.

Fig.2 shows a surface pattern with a feature size of ~40nm achieved by direct writing and Fig.3 shows quasi-periodic nano islands or features down to around 8nm induced by pulsed laser interference patterns.

Contact: **Project coordinator: MEC/Cardiff University (Dr Zuobin Wang, Email: WangZ@cf.ac.uk.); Phone: +44 29 20876374; For further information, visit www.delila.cf.ac.uk.**

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ASSEMIC
Advanced Methods and Tools for Handling & Assembly in Microtechnology

ASSEMIC ANNUAL REPORT 2007- Science (I)

Edited by Ana Almansa, ASSEMIC Science Manager

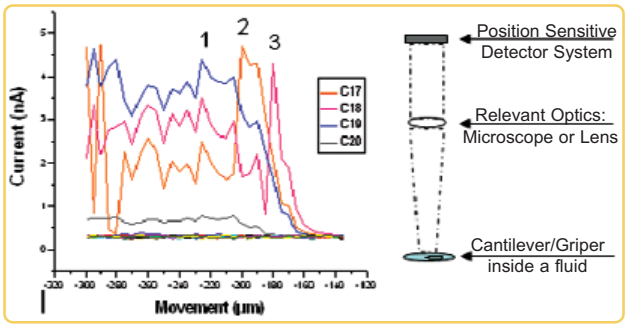
MARIE CURIE ACTIONS

ASSEMIC "Advanced Methods and Tools for Handling and Assembly in Microtechnology" (MRTN-504826, 2003-2007) is a Marie Curie Research Training Network devoted to training and research in handling and assembly in the microdimension, involving advanced methods and tools and providing a multidisciplinary, complementary approach.

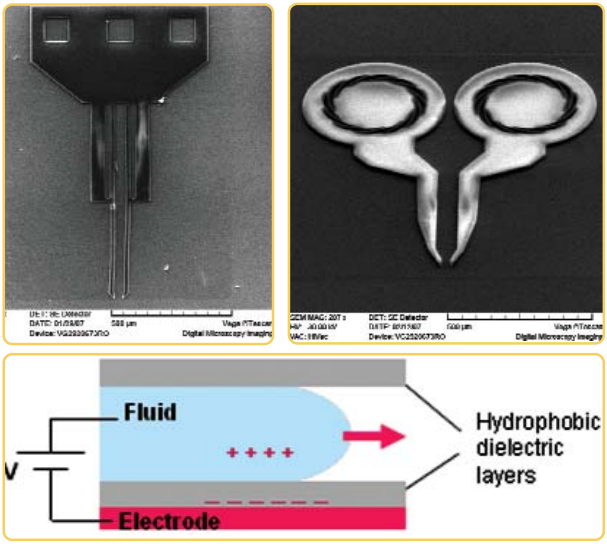
Consortium: 14 partners from 10 countries: **TU Vienna / ISAS, Austria; SSSA, Italy; FORTH IESL, Greece ; PROFACTOR Research and Solutions GmbH; IMT-Bucharest, Romania; PW WUT, Poland; Nascatec, Uni-OL, FhG/ILT, Germany; CCLRC-RAL, United Kingdom; Progenika, ROBOTIKA Spain; UNINOVA, Portugal; FSRM, Switzerland.**

Work within **Workpackage II-** Microhandling focused on finalization of the task in progress, with special focus on Task II.5 haptic human interfaces and Task III.6 operation in special environment and conditions. With regard to the last task, special mention deserves the successful experimental results of Uninova reported by ESR **Javier Contreras**, *in cooperation with Nascatec*. They used Uninova's position sensors and Nascatec's setup with the portable PSD-XDAS system in order to detect the movement of micro-cantilevers under a fluid.

Additional remarkable results were achieved by **IMT-Bucharest** on computational fluid dynamics, modelling and simulation for fluid micro-handling, performing mathematical model of a micropump actuated using the electrocapillarity effect and computer simulations of the device using the software programme Coventor 2006 **(Irina Codreanu).** In addition, *IMT also simulated and partially manufactured* (by means of SU-8) two types of grippers, applicable for micromanipulation of micro-objects including cells in liquids, medical and assembly applications **(Rodica Voicu)**.



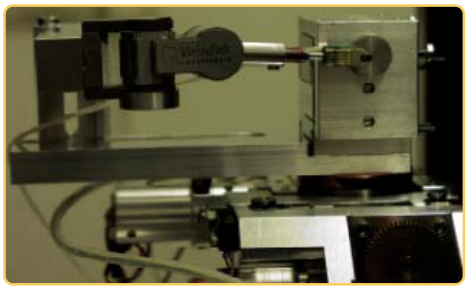
Measurement of the movement of microcantilevers under a fluid with Uninova's PSD-XDAs system



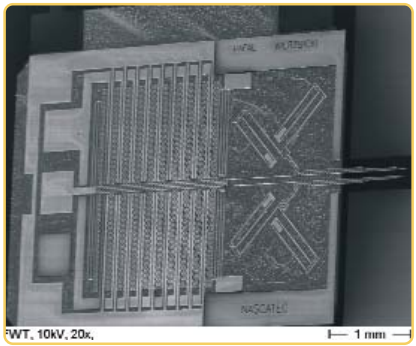
Micropump and microgrippers developed at IMT

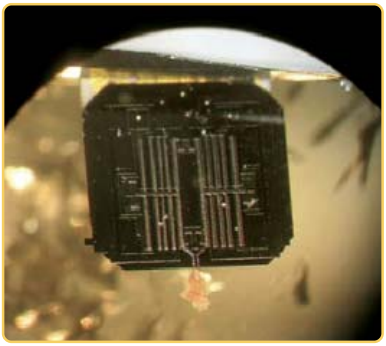
Concerning Task II.5 Human Hap tic Interfaces, SSSA developed haptic tweezers for grasping of micro-objects with fore feedback (used with sensorized tools). A teleoperation system based on LabView for micro-manipulation was also implemented by ESR Keith Houston, as well as the electronics for system control -and overall integration of the station set-up. A key contribution to this task was delivered by Oldenburg ESR, who built and implemented a software haptic interface allowing the coupling of an available haptic device, a SensAble Desktop PHANTOM [2], in the already existing control loop structure of AMiR's lab setup, in order to allow manual force feedback-enabled teleoperated control of micro- and nanomanipulators in complex tasks in two specific areas of research: carbon nanotubes (CNTs) and biological specimens.

Additional activities where reported by **Javier Contreras (Uninovas ESR)** and **Samuel Serra (RAL ESR)**:use of dynamic optical sensors for detection of microgrippers and system integration of Uninova's a 128 position sensitive detector. ESR Rafal Wierzbicki - Nascatec developed silicon electrostatically actuated microgripper, which has been designed and prototyped, and tested in a variety of applications, in cooperation with Robotiker. Work reported includes development of low-voltage silicon microgripper and blood-vessel microgripper, piezoresistive cantilever resonance frequency calibration system, capacitive position and force feedback, among others.



System architecture of the haptic interface software and its application for manipulation of nanotubes

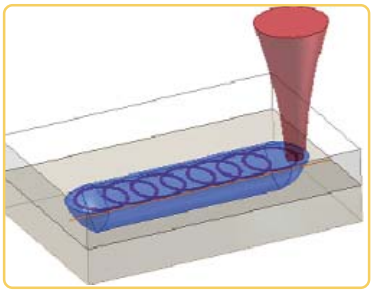


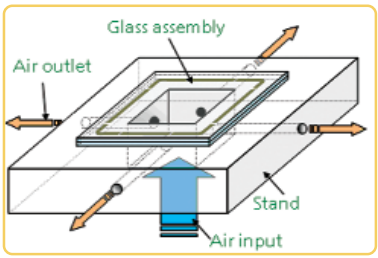


Nascatec low voltage microgripper and blood vessel manipulation device

The publication of this page is supported by the ***MINOS-EURONET*** project (EC Contract No 015704)

ASSEMIC ANNUAL REPORT 2007- Science (II)



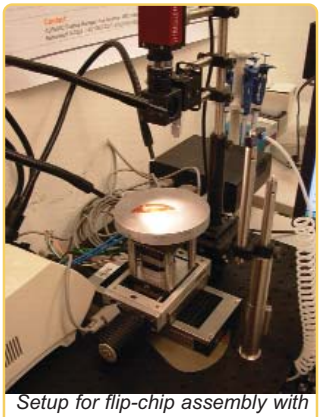


Two new methods for laser bonding developed, implemented and tested at ILT (left, TWIST, right, glass soldering for package applications)

Workpackage III. Microassembly is devoted to advanced tools and systems for microassembly applications, involving also joining and bonding issues.

WUT's reported a comparative study on advantages of integrated monolithic versus hybrid Microsystems, delivered by **ER Marius Pustan** and **Prof Rymuza**. The conclusion seems clear: if monolithic alternative technologies are available, the solution tends to be considerably more cost efficient, unless in some cases with very small manufacturing volume. Some ASSEMIC partners have demonstrated interesting and promising approaches: the photodiode fabrication-integration with polymeric waveguide (SU-8, PMMA) researched by **ER Irina Bineva** at **IMT**. or the alternative packaging solution described below.

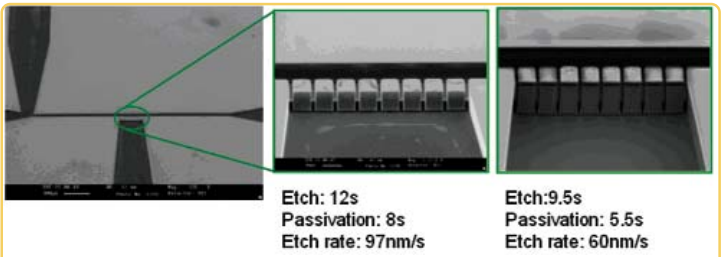
The work reported by Fraunhofer ILT focused on two different technologies, ER Cedric Chaminade developed laser-based glass soldering from MEMS Packaging, whereas two glass plates are soldered using diode laser, providing an innovative packaging/integration solution. On the other hand, **ESR Andrei Boglea** developed the novel processing approach TWIST for joining of polymers with seam width < 100 μm. This innovative concept, standing for Transmission Welding Incremental Scanning Technology, is based on the implementation of highly dynamic circular movement combined with linear feed of the fiber laser beam.The process optimization and experimental results have demonstrated its reliability as a promising novel technology, whose potential is to be further explored after the end of ASSEMIC.



Setup for flip-chip assembly with beamsplitter developed by Zybszek Rozynek and Domnita Fratila

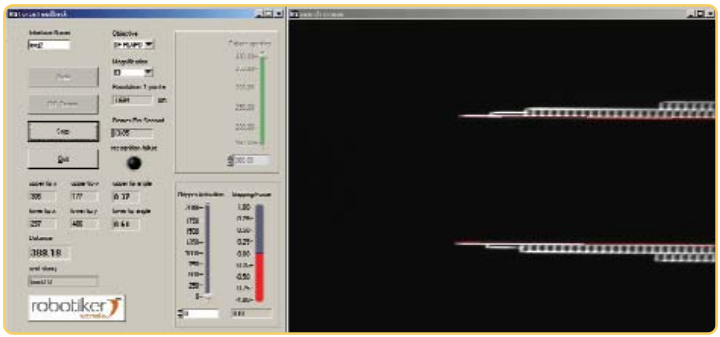
ESRs Gergely Perlaky and **Samuel Serra (RAL)** presented successful results on deep silicon etching using an STS deep etcher as alternative technology for the development of Microsystems. In order to solve the reproducibility and reliability problems which appeared in a previously reported work when developing SU-8 microfluidic chips by UV lithography and adhesive bonding, a new approach was implemented, consisting of fabrication of silicon on glass microfluidic devices by deep reactive ion etching (DRIE) and anodic bonding.

ESR Zbyszek Rozynek at **Profactor (formerly ARC)** enhanced the setup for mounting of silicon force sensor with dedicated vision alignment system, by integrating (hardware and software) a heating plate for bonding and rotation stage in the substrate positioning system.

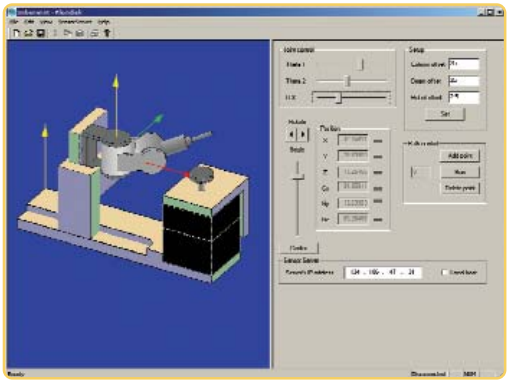


Results of experiments for optimization of RIE process done at RAL

Wok package IV. Automation of industrial micro-assembly was focuses on two different aspects: automated handling and assembly with intelligent control techniques is being explored. WP leader **Robotiker** cooperated with **Nascatec** for machine vision procedures applied to imatge calibration, object identification and handling **ER Cedric Ada** implemented an application of micropositioning using reinforcement learning. **Cedric Ada** reported simulation tests using various algorithms and various action sets, with tests on Robotiker microrobotic platform to be performed.



Cooperation between Robotiker and NAscatec: calibration of microgripper



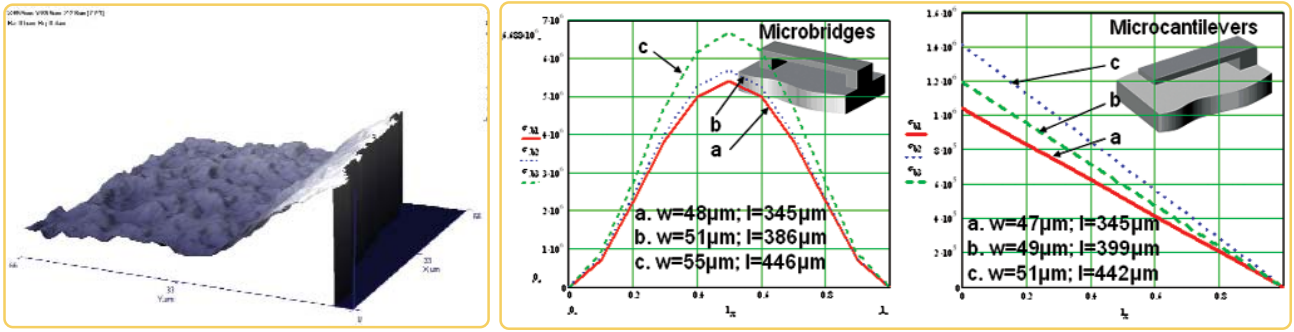
Screenshot of Oldenburgs software

Oldenburg's ER Marek Idzikowski reported work on visualization of the manipulator and the workspace with efficient 3D rendering, simulation of the Kleindiek manipulator and testing.

The publication of this page is supported by the ***MINOS-EURONET*** project (EC Contract No 015704)

ASSEMIC ANNUAL REPORT 2007- Science (III)

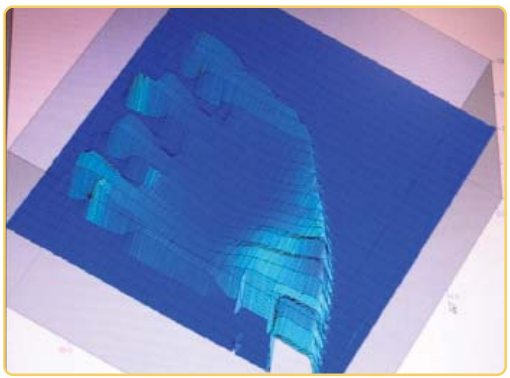
Moreover, **Profactor's ESR Luis Rubio** presented a new concept for handling of chips for self-assembly applications by implementing intelligent capabilities by means of adaptive control techniques on a vacuum gripper. The strategy consists on developing a control technique able to recognize on-line the current state of the pick and self-assembly placement process, and automatically adapt the control strategy, taking into account all forces which play a role in the process, such as capillary forces between the chip and the gripper and between the chip and the substrate.



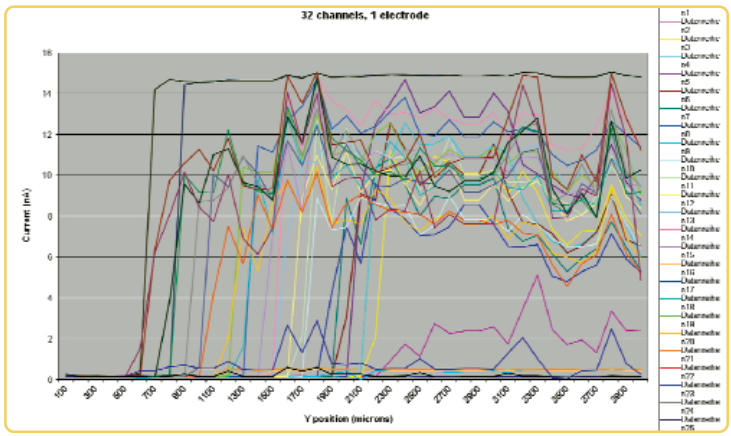
Deformation of a cantilever during experimental testing after nanoindentation, and variation bending stresses for differente geometric dimensions (WUT)

A second part of this Workpackage concerns test and characterization of assembled Microsystems. An outstanding result of this task is the work on characterization of mechanical properties of MEMS with movable components done in WUT (theoretical and experimental tests on cantilever and bridge structures), as well as evaluation and comparative analysis of testing methods, such as SEM, STM, AFM and Nanoindentation by triboscope. WUT's work has led to the published book "Mechanical and Tribological Characterization of MEMS Structures" by **M. Pustan** (since the end of his appointment back in TU Cluj-Napoca) and **Prof. Z. Rymuza**.

Other contributions to this task are among others, the studies on the effect of baking conditions on the stress of SU8 cantilevers (**ER Sotiria Psoma**), fabrication of bimorph cantilevers and bridges to be mechanically tested by WUT (**ESR Samuel Serra** and **ESR GErgely Perlaky**),

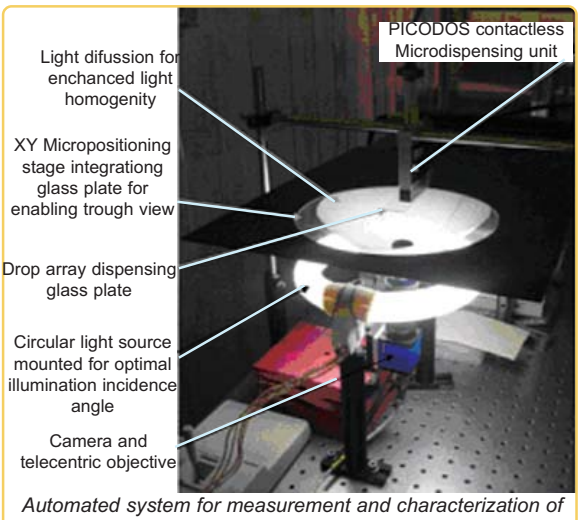


Performance assessment of position sensitive device



The contribution of **Uninova** to the task of ***Test and Characterization*** was focused on system performance assessement. Two software applications were developed by **ESR Javier Contreras** from **Uninova**, with the help of **ER Marek Idzikowski in Oldenburg** (a 3D simulation platform able to represent 3D profiles of objects scanned by Uninova's 3D sensor in real time, as well as a 3D simulation software application for tracking the movement of micro objects within the detecting area of the 3D sensor itself).

ESR Silvia Bou with support of **ESR Zbyszek Rozynek** at **Profactor (former ARC)** did considerable progress and finalized the development of an automated system for measurement and characterization of microdispensed drops by means of image processing.



Automated system for measurement and characterization of microdispensed drops

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Schedule for UK Road Shows, 15th May-16th May 2008. Activity organised in the frame of MINOS-EURONET project (**www.minoseuro.net**) by Tim Harper, Cientifica Ltd, partner in this project.

The roadshow will consist of a series of presentations given by eastern partners at key western institutions. The aim is to select the key eastern expertise that the institutes may find useful, and present this in an internal seminar. This activity is organised in the frame of the MINOS-EURONET project (**www.minoseuro.net**)

Wednesday 15th May

- **Morning**: ***Arrival and travel to Cambridge***

- **Afternoon**: ***University of Cambridge Nanoscience Centre*** (**http://www.nanoscience.cam.ac.uk/**) The Cambridge centre was the first to open in the UK and its head, Prof Mark Welland was recently appointed chief scientist to the Ministry of Defence. The centre is also home to the new Nokia Nanolectronics research centre which launched the 'Morph" phone concept in February this year (**http://www.admin.cam.ac.uk/news/dp/2008022501**). Cambridge is constantly in the top three universities worldwide, and has global research collaborations.

Thursday 16th May

Morning: University of Sheffield, home of the new Kroto Research Institute and Centre for Nanoscience and Technology (**http://www.shef.ac.uk/northcampus/**) hosted by Prof Richard Jones who is also chief nanoscience advisor to the EPRSC (the UK national academic funding body). Since its inception, the new Sheffield/Leeds research hub has become one of the UKs fastest growing nanoscience centres, with an emphasis on polymers and the life sciences. Richard Jones is also the author of one of the best written and most entertaining nanoscience books published so far, Soft Machines.

Afternoon: University of Oxford Begbroke Science Park (**http://www.begbroke.ox.ac.uk/research/nanotechnology.php**), also home to two Interdisciplinary Research Collaboration (IRC) centres -Quantum Information Processing (QIP) and Bio-nanotechnology. We'll be hosted by Prof Pete Dobson, founder of Oxonica and a number of other nano related spin offs, who has been the director of Begbroke Nano since its inception.

New World Record in High-Aspect Ratio Microstructure Measurement!

Press Release from 4M Network of Excellence: **A new record has been achieved for the aspect ratio measurement of micro structures.** Working in conjunction with a major equipment manufacturer, ***Prof. Lars Mattsson (KTH, Stockholm, Sweden, larsm@iip.kth.se)***, leader of the Metrology Division of the 4M Network of Excellence, reports that a new aspect ratio of 50:1 was recently achieved in laboratory measurements following the optimisation of an existing optical metrology system.

Prof. Mattsson, who is Chair of Industrial Metrology and Optics at KTH, Stockholm in Sweden, has benefitted from his membership of the 4M Network to visit other laboratories and audit their metrology facilities, comparing the performance of various systems using X-ray lithography manufactured artefacts made within the Network's own Polymer Division.

"There are currently no suitable standards in high aspect ratio micro-metrology, and it is an issue that will impact on many of the growth areas in micro-manufacturing" said Mattsson. "Different equipment developed by a variety of companies and being used by operators in a number of ways inevitably leads to uncertainty in the measurements provided. And strangely enough the worst measurement errors were discovered in the horizontal x-y plane at the top of deep microstructures. This was a complete surprise for the instrument manufacturers as well."

"In 4M I have been able to observe different equipment being operated in different environments on standard test pieces. This has enabled me to establish the measurement limitations of today's equipment, and take this information to metrology equipment manufacturers as useful information for future instrument development."

This has recently lead to Prof. Mattsson working with one major equipment manufacturer and, in collaboration with them, improving the performance of their optical measurement system such that it was able to achieve measurements of a star shaped microstructure with an aspect ratio of 50:1, the actual dimensions being 400 μm : 8 μm.

The 4M Network of Excellence will soon become the **4M Association**, with membership open to all (see: **www.4m-net.org/4MAssociation**,contact **Chris Matthews**, **matthewscw@cf.ac.uk**). The 4M NoE is a Knowledge Community in Multi-Material Micro Manufacture, ***comprising over 150 researchers*** from ***30 partner institutions***, and ***supported by over 80, mainly industrial, affiliates***. Funded by the EC, the Network seeks to develop Micro- and Nano- Technology (MNT) for the batch-manufacture of microcomponents and devices in a variety of materials for future microsystems products. The Network acts as a knowledge resource to both the research community and industry in the development of microsystems devices that provide increased functionality in tiny packages, integrating micro and nano scale features and properties into products and systems.

Micro and NanoTechnology Bulletin is published quarterly by IMT-Bucharest, Romania (**www.imt.ro**). This Bulletin, originally intended to publish **results of Romanian researchers in the micro and nanotechnology (MNT) field,** is extending its coverage since 2004 to Eastern Europe. The purpose is to contribute to a *better communication of MNT scientific communities from Eastern Europe to the rest of the world*. MNT Bulletin is distributed free of charge to interested organisations and individuals.

Editor-in-Chief: ***Dan Dascalu (IMT-Bucharest)***. The Bulletin is also available on the web page: **www.imt.ro/mnt.**

IMT-Bucharest it is also the coordinator of three SSA projects (***MINOS-EURONET***) with *support and dissemination activities* through *web pages, e-newsletter, flash news and online databases:*

- **E-newsletters and flash news:** ***MINOS-EURONET project***: **http://www.minos-euro.net;**
- **Online Databases: http://www.minos-euro.net**

MINOS-EURONET **Coordinator :** Prof. Dan Dascalu **(dascalu@imt.ro).** ***MINOS-EURONET Team*** **(minos@nano-link.net)**

Contributions and correspondence for MNT Bulletin may be sent to **mnt@imt.ro**.