C03

10:00 – 13:30 Short Course I
Fine Beam Induced Processing

Author
Dr. Hans W. P. Koops
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Abstract
For focused ion beam processing FIBIP, as well as focused electron beam processing FEBIP, the past and the present is described. Basics of particle sources and matter interaction for ions and electrons is reviewed. For both fields precursors in use and characteristics of deposits and etching processes are reviewed. Early and todays rapid prototyping for mechanical, optical and electronic nanostructured devices is presented.

CV
Hans W. P. Koops is a doctor in physics and former chief scientist of NaWoTec GmbH, Rossdorf, Germany, who developed electron beam photomask repair. Dr. Koops research interest is among projection e-beam lithography also miniaturized electron optics especially electron beam induced processes for electronics and optics. He has written over 160 scientific papers including 58 patent applications and several book chapters. He is member of the committee of the International Vacuum Nanoelectronics Conference IVNC, the German Physical Society DPG, and of the German Engineers VDE.

C04

10:00 – 13:30 Short Course IV
Optical and X-ray lithography for MEMS applications

Author
Dr. Jost Goettert
Director of Microfabrication
Associate Professor – Research
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Abstract
The tutorial is addressing the topic of lithography and its importance in the field of Microsystems Technology (MST). The discussion will focus around optical and x-ray lithography and how to make small and precise structures needed for many MST applications.

The presentation will begin with a brief historical review on lithography and the importance of the process for microelectronics to cost-effectively patterning Integrated Circuits and then address in detail the use of lithographic techniques for MST applications where the focus is not only on making extremely small pattern but also on making complex, 3D shapes with very tall feature sizes. The tutorial will address two main techniques – UV and X-ray lithography – and will cover process and material fundamentals as well as illustrate current topics of interest and latest patterning results.

Audience
Intended for researchers using or planning to use lithographic techniques for their MST applications.

CV
Jost Goettert is directing the Microfabrication Program at Louisiana State University's (LSU) Center for Advanced Microstructures and Devices (CAMD) - the only university-operated and state-funded Synchrotron Radiation Research Facility in the US entertaining an active LIGA program. Under his direction his team of researchers and students has established key capabilities in LIGA and supports about half a dozen of SME companies in their efforts to develop prototype devices utilizing high aspect ratio LIGA metal and polymer structures.

C03

13:30 – 17:00 Short Course II
Lithography Modeling:
Optical/EUV projection and selected other techniques

Author
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Abstract
An overview on modeling techniques for optical and EUV lithography is given. This includes the rigorous simulation of light diffraction by masks, the image formation in high numerical aperture projection systems, and models for the description of physical and chemical effects during the processing of photo resists. Lithography simulation is applied to understand and optimize various resolution enhancements such as phase shift masks, off-axis illumination, source and mask optimization and double patterning. Other examples demonstrate the application of simulation for the evaluation of the impact of optical aberrations, mask defects and other imperfections on the lithographic process performance. Finally, selected applications of lithography simulation to alternative exposure techniques and applications beyond semiconductor fabrication are presented.

CV
Andreas Erdmann has been head of lithography simulation at Fraunhofer Institute of Integrated Systems and Device Technology (IISB) for since 1999. His current responsibilities include the model and software development for optical and EUV lithography and the application of these models for the evaluation and optimization of lithographic processes for semiconductor fabrication. Dr Erdmann's fields of research include simulation of optical lithography, computational electrodynamics, microelectronic process technology, and modern optics. He is co-author of SOLID-E and of Dr.LiTHO, the Fraunhofer IISB development and research lithography simulator. As a mentor of the Erlangen Graduate School of Advanced Optical Technologies he holds lectures on "Lithography: technology, physical effects, and modeling". Prior to joining Fraunhofer IISB, Dr. Erdmann was staff member of the Fraunhofer Institute ISiT, Erlangen, Germany and scientific assistant at the universities of Jena and Osnabrück.

19:00 – 21:00 Welcome Reception

C04

13:30 – 17:00 Short Course III
Nanoimprint Lithography

Author
Prof. Dr. Hella-Christin Scheer
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Abstract
The course introduces the techniques summarized as "Nanoimprint" or "Nanoimprint Lithography" (T- NIL, UV-NIL, microcontact printing and derivatives thereof) and addresses process specific issues as well as ideas for their solution or avoidance by taking examples. Important aspects that are common to these contact lithography techniques are treated in detail, such as suitable materials and their required properties, material transport during the imprint phase and its impact in respect of process limitations, relevance of surface properties as well as preparation and durability of anti-sticking layers.

CV
Prof. Scheer and her group work in the field of nanoimprint since 1996, concentrating on technological issues of this technique. As an electrical engineer she started from device physics and shifted her interests towards technology for device preparation. After more than 10 years of research in the field of dry etching and plasma technology with the Fraunhofer Institute for Silicon Technology she joined University of Wuppertal in 1995 and took up the new topic of nanoimprint, an attractive idea just emerging at that time. Beyond basic courses in Electrical Engineering her regular lectures address device physics and the respective technology for device preparation, ranging from solar cells over microelectronics to MEMS.

Tuesday 20 September

MNE BERLIN 2011

08:30 – 09:00 Welcome address, MNE Fellow Award Ceremony

09:00 – 10:20 Plenary Session 1 – Session Room: Plenary Hall C01

Session Chairs:
Gabi Grützner, micro resist technology GmbH, Berlin/Germany; Dieter P. Kern, University of Tübingen/Germany

09:00 Plenary

O-PLEN-01

Semiconductors: core of a sustainable amazing world

Luc Van den hove, imec, Leuven/Belgium

Cheap-person centric nomadic communication where virtual communities are experienced as real life, remote health monitoring systems, improved diagnostics and personalized medicines, smart grid, sustainable mobility … All these smart systems will play an essential role in finding solutions for the grand challenges today's society is facing. Tomorrow's smart systems will require extreme computation and storage capabilities, orders of magnitude above what the processors and memories of today can deliver. Thus there is a need to keep on scaling, pushing technology to its extreme.

For more than 10 years now, transistor scaling is considered to have reached its limits. But we have always found new solutions. To get to ultra-small dimensions beyond 10nm, we have to use new materials with high electron mobility such as germanium, III-V materials or graphene. And we have to look to new transistor architectures such as TunnelFETs with heterojunctions. And a lot is expected from the third dimension, which allows even more functionality, compute power and memory on a chip. Also new memory concepts such as resistive RAM, floating-body RAM and vertical Flash memory are coming up to further reduce the cost and maximizing the memory density as required by the emerging high-end applications.

Looking at the lithography landscape, there are three persisting trends. One is that EUV lithography is slowly maturing towards production-ready tools, not expected to take over the main role before 2014. The issues that are holding back EUV are well known: the light source, which is being improved steadily, mask inspection and defects, and last, but not a real showstopper, resists. Luckily, 193nm immersion lithography is inching, nanometer per nanometer, past all limits that we thought insurmountable just a few years ago. It will most probably allow us to maintain the scaling pace until EUV is ready. The name of the game now is computational lithography, a basket of powerful computational tools that allow printing ever finer details, linked to ever more powerful scanner knobs. In combination with double patterning, computational lithography will allow us to print 22nm half pitch layouts.

And last and less prominent, there are a few alternative techniques for 193nm and EUV lithography. These, however, are unable to catch up with EUV, and currently trend towards their own niche: mask writing for maskless e-beam lithography, hard drive lithography for nano-imprint.

These three developments have their own dynamics, but they are bound together and driven by the scaling roadmap.

09:40 Plenary

O-PLEN-02

MENS/NEMS for Nano and Bio Technologies

Hiroyuki Fujita, CIRMM, IIS, University of Tokyo/Japan

The author and his colleagues have intensively investigated MEMS (micro electro mechanical system) design, fabrication and its application to nano and bio technologies. Nano scientific research using MEMS devices covers the electro-mechano-thermal characterization of nano contacts in transmission electron microscope (TEM) for in situ atomic level observation of its shape and dimensions, and MEMS tweezers for capturing, handling and characterizing DNA and other linear molecules. MEMS for bio technology includes micromachined fL-chambers and heaters to allow single-molecular level enzymology, and the integration of bio molecular motors in MEMS for direct sorting and transportation of specific sample molecules. In this talk, I will focus on two topics, nano tensile testing in TEM and a nano transportation device driven by bio molecular motors.

We designed MEMS opposing tips for the experiments under TEM observation and investigated the formation-loading-fracture process of silicon and gold nano contacts. MEMS devices can provide higher and more precise control over long time (hours or even days) and better temperature stability than conventional piezoelectric actuators. Furthermore, the integration of thermal sensors and heaters enables temperature control of MEMS devices that can fit in the narrow space in TEM. We have developed a characterization system that is capable of simultaneous TEM visualization and electro-mechano-thermal measurement of a nano object manipulated by a MEMS device. We have observed extraordinarily large (2000 %) elongation of a silicon nano wire under mechanical tensile stress while gold contact showed thinning but little elongation. We also succeeded in observing the frictional deformation in a silver contact and measuring its shear force simultaneously [6].

The conveyance of bio molecules in cells is conducted by the microtubule network on which vesicles, filled with target molecules and coated with kinesin, move around. We have studied the device that imitates the intracellular nanotransport system, kinesin coated beads were used as carriers moving along microtubules placed on a glass substrate. We have developed a novel method to build a rail system based on single microtubule capturing and relocation by using silicon micro tweezers under a high-resolution fluorescent microscope. The relocated microtubules act as a nano monorail for kinesin-coated beads. The beads moved along the artificial network of microtubules towards predetermined directions. This technique is useful for engineering purposes such as a nano-scale molecular sorter.

10:20 – 10:50 Coffee break

10:50 – 12:50

IMPRINT 1

Session Room: Plenary Hall C01

Session Chairs: Stephen Chou, Princeton University – U.S.A.; Helmut Schift, Paul Scherrer Institut – Switzerland

NANOELECTRONIC DEVICES

Session Room: Hall 1 B08-B09

Session Chairs: Olaf Krüger, FBH Berlin – Germany; Veronica Savu, EPFL – Switzerland

MEMS/NEMS 1

Session Room: Hall 2 B05-B07

Session Chairs: Anja B. Boisen, Technical University of Denmark; Martin Hoffmann, TU Ilmenau – Germany

10:50

O-LITH-01

Digital Planar Holograms fabricated by Step and Repeat UV nanoimprint lithography

Stefano Cabrini [1]

[1] Molecular Foundry, Lawrence Berkeley National Lab, Berkeley/United States

We demonstrate for the first time the replication of digital holograms by UV Nanoimprint Lithography (UV-NIL) technology. Our novel Step&Repeat UV-NIL process on pre-spin coated resist films allows imprinting sub-15 nm patterns with very high fidelity. The fine control of the residual layers thickness allows an easy pattern transfer by plasma etching of some of the smallest feature sizes reported in the literature. The process has been successfully used to fabricate our nanophotonic DPH chips.

O-NANO-01

Energy Harvesting with Antenna Coupled MIM Diodes

Filiz Yesilkoy [1]

[1] University of Maryland, College Park, MD/United States

Antenna coupled MIM tunnel junctions are studied for the application of IR energy harvesting. Main challenges of this topic, such as high-resolution nano-patterning, efficient coupling of the antenna to the detector, and the development of easy and cheap process techniques are considered in the design. A special geometry is developed to enable the rectification without any bias applied. In addition, a novel saline water oxidation process is used to create a thin and durable tunnel barrier.

O-MEMS-01

Piezoelectrically Actuated and Sensed Silicon Carbide Ring MEMS Resonators

Boris Svilicic [1], Enrico Mastropaolo [1], Brian Flynn [1], Tao Chen [1], Rebecca Cheung [1]

[1] Institute for Integrated Micro and Nano Systems, University of Edinburgh, Edinburgh/United Kingdom

We present the design, fabrication and testing of 3C-SiC flexural ring resonators integrated with lead zirconium titanate (PZT) electrodes for MEMS filters applications. Piezoelectric transduction has been used for structure actuation and resonance detection. Rings fabricated with radius between 60µm and 200µm and hole radius of 5µm and 10µm have been shown to resonate in the range 600kHz – 3.7MHz. The measured and predicted frequencies along with the effect of internal stress will be discussed.

11:10

O-LITH-02

Structuring graphene using UV-NIL

Iris Bergmair [1]

[1] Functional Surfaces and Nanostructures, Profactor GmbH, Steyr-Gleink/Austria

In this work we demonstrate the structuring of exfoliated and chemical vapor deposited graphene using UV-based Nanoimprint Lithography (UV-NIL) in the ìm as well as nm regime down to 20 nm linewidth. The progress towards large area structured graphene will have a deep impact in using graphene for industrial applications like graphene-based electronics for high frequency applications.

O-NANO-02

CMOS compatible fabrication of cupric oxide nanowire devices

Stephan Steinhauer [1], Elise Brunet [1], Thomas Maier [1], Giorgio Cataldo Mutinati [1], Anton Köck [1], Oliver Freudenberg [2], Christian Gspan [3], Gerald Kothleitner [3]

[1] AIT Austrian Institute of Technology GmbH, Vienna/Austria, [2] Siemens AG, Munich/Germany, [3] Institute for Electron Microscopy and Fine Structure Research, Graz Centre for Electron Microscopy, Graz/Austria

Cupric oxide (CuO) is known as a narrow band-gap p-type semiconductor with numerous potential applications like gas sensors, high critical temperature superconductors, photovoltaics, field emitting devices and catalysts. A simple and cheap thermal oxidation process of electroplated copper microstructures is used for the on-chip synthesis of CuO nanowires. Due to the CMOS compatibility of the described nanowire devices new possibilities for integrated smart gas sensing may arise.

O-MEMS-02

Design, fabrication and surface treatment of a micropaddle resonator for ultra low mass detection

Sahand Chitsaz Charandabi [1], Majid Malboubi [1], Carl Anthony [1], Jon Preece [1], Philip D Prewett [1]

[1] The University of Birmingham, Birmingham/United Kingdom

In this paper the design, fabrication 3D reconstruction and surface treatment of a micro resonant sensor have been discussed. Micro resonant sensors have many applications in the health, security and defense sectors. The proposed paddle is formed from a 200 nm thick membrane of silicon nitride. The surface of the paddle is 3D reconstructed using SEM stereoscopic technique. Oxygen plasma treatment has been used to increase the hydrophilicity of the surface which enhances the sensor effectiveness.

11:30

O-LITH-03

Preparation of random stamps for thermal nanoimprint

Si Wang [1], Khalid Dhima [1], Andre Mayer [1], Saskia Moellenbeck [1], Hella-Christin Scheer [1]

[1] University of Wuppertal, Wuppertal/Germany

Random stamps for thermal nanoimprint were prepared from Si by dry etching in SF6/O2, making use of contamination lithography. The stamps feature smooth truncated ridges well suited to imprint thin layers without print-through holes, when the layer thickness is adequately chosen. The stamp height can be tuned by tuning the etch process, without changing their relative shape. Optical characterisation of the stamps reveals a decrease of the reflectance by a factor of 20 compared to blank Si.

O-NANO-03

Improved electrical properties of charge trap flash memories having a patterned surface in a Si3N4 trap layer

Ho-Myoung An [1]

[1] Korea University, Seoul/Republic of Korea

A novel charge trap flash (CTF) memory structure having the abundantly trap densities is proposed by the nanosphere lithography (NSL) process. The polystyrene (PS) bead of 500 nm-diameter were used as mask to make patterns in the etching process with CF4 as the gas source. As a result, the CTF devices by adopting a roughened surface on Si3N4 trap layer show the enhancement of memory window and improved program properties, compared to those with flat surface on the Si3N4 layer.

O-MEMS-03

A wide-range frequency tunable nanomechanical resonator with parametric resonance characteristics

Shin'ichi Warisawa [1], Shunjiro Nishi [1], Reo Kometani [1], Sunao Ishihara [1]

[1] The University of Tokyo, Tokyo/Japan

We fabricated a nanomechanical resonator by FIB-CVD and wet etching processes. Its resonance frequency tuning capability was observed with a 573 % increase at natural frequencies from 107 kHz to 782 kHz by adding DC bias voltages which induces a increase of restoring force of the vibration. The parametric resonance was also observed by adding AC drive voltages with three vibration modes: 1st bending, 2nd bending and 1st torsional modes.

11:50

O-LITH-04

Fabricating Nanodot Array Mold with Ultrahigh Recording Density of 2 Tbit/inch2 and Nanoimprint of Metallic Glass

Yasuyuki Fukuda [1], Yasunori Saotome [2], Nobuyuki Nishiyama [3], Kana Takenaka [3], Noriko Saidoh [3], Eiichi Makabe [4], Akihisa Inoue [1]

[1] Tohoku University, BMG Co., Ltd., Sendai/Japan, [2] Tohoku university, Himeji/Japan, [3] The Materials process Technology Center, Sendai/Japan, [4] BMG Co., Ltd., sendai/Japan

A bit-patterned media is a promising next-generation magnetic recording technique with recording densities of over 2 Tbit/inch2. We aim to fabricate molds having nanodot arrays with a ultrafine pitch of 18 nm by Pt- mask patterning with focused ion beam assisted chemical vapor deposition and reactive ion etching. The metallic glass is a nanoimprintable amorphous alloy that has excellent functional properties, and we investigated nanoformability of metallic glass by using the fabricated molds.

O-NANO-04

Directed Scanning Probe Nanomanufacturing of Lateral Ti-TiO¬2-Ti Junctions for Low Capacitance MIM Rectenna Diodes

David Ricketts [1], Weihua Hu [1], Jason Gu [1], Zacharias George [1]

[1] Carnegie Mellon University, Pittsburgh/United States

This research explores the potential for using lateral Ti-TiO2-Ti junctions for MIM diodes in applications such as rectennas, where the capacitance of the diode significantly impacts performance at target frequencies of 0.1-100 THz. We fabricated several lateral Ti-TiO2-Ti junctions, i.e. MIM diodes, and compare measurement results with theory. We then estimate frequency limits through capacitance calculations and measured differential resistance to show the potential for operation above 1THz.

O-MEMS-04

3D Micro patterning on a concave substrate for the replica of PDMS cylindrical stamp

Jongho Park [1], Nobuyuki Takama [1], Beomjoon Kim [1]

[1] CIRMM, IIS, The University of Tokyo, Tokyo/Japan

We have developed an alternative, non-photolithographic set of microfabrication methods, optical softlithography, for patterning on a concave substrate as well as the fabrication of micro patterned PDMS cylindrical stamp. Firstly, we fabricated SU-8 micro patterns on a concave glass substrate using optical softlithography. Then, PDMS cylindrical stamp with a minimum pattern size of 5~10 micron was fabricated easily, fast and repeatedly using SU-8 micro patterns on a concave mold.

12:10

O-LITH-05

Anisotropic re-mastering for reducing feature sizes on UV-NIL replica stamps

Elisabeth Lausecker [1], Martyna Grydlik [1], Moritz Brehm [1], Iris Bergmair [2], Michael Mühlberger [2], Thomas Fromherz [1], Günther Bauer [1]

[1] University of Linz, Linz/Austria, [2] Functional Surfaces and Nanostructures, Profactor GmbH, Steyr-Gleink/Austria

We present an approach that uses existing nanoimprint stamps and reduces the size of the out-coming features via a re-mastering process utilizing the anisotropic etchant Tetramethylammoniumhydroxide (TMAH) and a stamp casting process. We show that by imprinting with such a 2.5-dimensional replica stamp, the width at the base and the apex of the imprinted pyramids and V-grooves differs by a factor f = 4.7 and 7.2, respectively.

O-NANO-05

Silicon nanowire device fabrication by advanced electron beam lithography

Jens Bolten [1], Thorsten Wahlbrink [1], Mathias Schmidt [1], Birger Berghoff [2], Heinrich Kurz [1]

[1] AMO GmbH, Aachen/Germany, [2] RWTH Aachen University, Aachen/Germany

Here, we report on final fabrication steps and frist characterization experiments for test devices designed to study charge transport in highly confined channels of field effect devices composed of ultimately scaled silicon nanowires. In addition to fabrication-related information such as a lithographic process combining HSQ and UVN 30 in a single etch mask results of both an optical and an electrial characterization of the devices is presented.

O-MEMS-05

Sub micrometer ceramic structures fabricated by molding a polymer-derived ceramic

Jonas Grossenbacher [1]

[1] EPFL, Lausanne/Switzerland

We present a novel method to fabricate sub-micrometer ceramic structures. The approach consists in copying high resolution silicon structures into polydimethylsiloxane. This negative copy will be used for replication by micro/nano molding with a liquid polymer-derived ceramic precursor. Using this technique, tips with radii of 120 nm could be successfully replicated in ceramic. The presented process may open new possibilities for M/NEMS applications in high temperature and in harsh environments.

12:30

O-LITH-06

Development of ultra-hard stamps for titanium patterning

Ali Z. Khokhar [1], P. Monica Tsimbouri [1], Matthew J. Dalby [1], **Nikolaj Gadegaard** [1]

[1] University of Glasgow, Glasgow/United Kingdom

In the presented work, we have made imprint stamps of diamond, sapphire and silicon carbide with the purpose of using them to directly pattern titanium surfaces by embossing. We will demonstrate stamps with features down to 50 nm and their corresponding success in patterning titanium. The patterned titanium substrates have then used to investigate the stem cell response. We have seen that the cells responded positively to the nanopatterns.

O-NANO-06

Conduction mechanisms in tungsten-polyoxometalate self-assembled molecular junctions

Dimitrios Velessiotis [1], Antonios M. Douvas [1], Panagiotis Dimitrakis [1], Panagiotis Argitis [1], Nikos Glezos [1]

[1] Institute of Microelectronics – NCSR Demokritos, Aghia Paraskevi – Athens/Greece

The redox properties of polyoxometallate (POM) self-assembled layers can be exploited in two terminal memory elements or in planar nanotransistors. Here, we investigate the transport mechanisms involved in planar molecular junctions, where single and double W POM layers were used as molecular material, by measuring the I-V characteristics of the junctions in various temperatures. It was deduced that hopping prevails in higher temperatures (>220K), while a tunneling regime exists below 220K.

O-MEMS-06

Analysing Nanobombs for Potential Drug Release

Tassilo Kaule [1], Anika Hamberger [1], Yi Zhang [1], Katharina Landfester [1], Hans-Jürgen Butt [1], Rüdiger Berger [1]

[1] Max Planck Institute for Polymer Research, Mainz/ Germany

Nanobombs, nanocapsules containing explosive materials are potential carriers that can be triggered for the release of drugs. The mode of the release mechanism was investigated by heatable scanning force microscope cantilevers. The decomposition temperatures of single nanocapsules containing silveroxalates was measured to be 180 °C using nano-thermogravimetric analysis. Nanoscale heating and scanning probe microscopy of individual capsules showed that the capsule was ruptured at one position.

12:50 – 14:20 Lunch

14:20 – 15:50

MICROSYSTEMS 1

Session Room: Plenary Hall C01

Session Chairs: Hans W. P. Koops, HaWilKo Consutling – Germany; Massimo De Vittorio, Universitá del Salento – Italy

BEAMS 1

Session Room: Hall 1 B08-B09

Session Chairs: Peter Hahmann, Vistec Electron Beam GmbH – Germany; Johann-Peter Reithmaier, University of Kassel – Germany

MICROFLUIDICS 1

Session Room: Hall 2 B05-B07

Session Chairs: Gilgueng Hwang, LPN-CNRS Marcoussis – France; Martin Stelzle, NMI Reutlingen – Germany

14:20

O-MEMS-07

INVITED

Magnetic Bead Nanoactuator

Julian Hartbaum [1], Peter-Jürgen Jakobs [1], Jonas Wohlgemuth [1], Matthias Franzreb [1], Manfred Kohl [1]

[1] Karlsruhe Institute of Technology (KIT), IMT, Eggenstein-Leopoldshafen/Germany

This paper presents the development of nanoactuators of free-standing Ti beam cantilevers with integrated superparamagnetic beads at their front end that allow a controlled deflection by an external magnetic field gradient. We investigated a process flow consisting of two-step electron-beam lithography and reactive ion etching combined with the deposition of functionalized beads. The lateral dimensions can be adjusted over a wide range down to critical dimensions of 100 nm.

O-LITH-07

INVITED

Scanning helium ion beam lithography: approaching and understanding the limits

Emile van der Drift [1], Anja van Langen [1], Paul Alkemade [1], Emile van Veldhoven [2], Diederik Maas [2]

[1] Delft University of Technology, Delft/Netherlands, [2] TNO Science and Industry, Delft/Netherlands

The recent introduction of a sub-nm helium ion beam has revitalized ion beam lithography. In this work the performance (resolution, sensitivity and proximity effects) of helium ion beam lithography has been studied for HSQ and PMMA. Also, we have constructed a model for resolution and sensitivity. The best resolution obtained so far is 5 nm, but the model predicts an ultimate limit of 2 nm. Helium beam lithography might become the technique for high-density and high-resolution nanostructures.

O-LIFE-01

INVITED

Pressure assisted selective preconcentration of biomolecules within a micro-nanofluidic device

Ane-Marie Haghiri-Gosnet [1], **Anne-Claire Louër** [1]

[1] LPN CNRS, Marcoussis/France

A new method has been investigated to monitor the preconcentration focusing regimes within a glass fluidic device that integrates a nanoslit. Preconcentration occurs either in the anodic reservoir at nanoslit entrance for opposite directions of pressure and electrical field, or in the cathodic reservoir if pressure and electric field are applied in the same direction. We demonstrate the stability of these two regimes in the range 1mg/mL-10µg/mL for BSA biomolecules.

14:50

O-MEMS-08

Patterned super-hydrophobic sensor windows for food monitoring

Stijn van Pelt [1], Jeroen Eggermont [1], Arjan Frijns [1], Andreas Dietzel [2]

[1] Eindhoven University of Technology, Eindhoven/Netherlands, [2] Holst Center/TNO, TU/e, Eindhoven/Netherlands

For application in food monitoring, we present a gas sensor window. This window isolates the sensor surface from non-target gasses and water. This way the low selectivity and sensitivity to water of current electro-chemical polymer-based sensors can be overcome. We show a method to locally pattern super-hydrophobic spots on a high-permeability polymer using excimer laser ablation. Addionally, we will present permeability characterization of the manufactured sensor windows.

O-LITH-08

Electron-Beam-Induced Deposition of 3.5 nm Half-Pitch Dense Patterns on Bulk Silicon

Cornelis Wouter Hagen [1], Jules C. van Oven [1], Frans Berwald [1], Pieter Kruit [1], Karl K. Berggren [2]

[1] Delft University of Technology, Delft/Netherlands, [2] MIT, Cambridge/United States

Using Electron-Beam-Induced Deposition we deposited and imaged 3.5 nm half-pitch dense patterns on bulk Si in an SEM. This required synchronization of the writing sequence with the 50Hz line frequency, as well as a careful choice of the dwell time per pixel, number of passes, and waiting time between passes.

O-LIFE-02

Hollow cantilever-based density sensors with embedded microfluidic channel

M Faheem Khan [1], Silvan Schmid [1], Zachary J. Davis [1], Anja Boisen [1]

[1] DTU Nanotech, Kongens Lyngby/Denmark

A hollow cantilever with 4 x 4 µm2 microfluidic channel makes it possible to pass small volumes (~2µl) of liquid samples through the channel which results in changes in overall mass of the cantilever. The change in mass changes the resonant frequency of the cantilever. Information about the density of the fluid or presence of particles in the fluid can be extracted from the measured change of resonance frequency of the cantilever.

15:10

O-MEMS-09

High performance uncooled THz sensing structures based on antenna-coupled air-bridges

Andreas Ihring [1], Ernst Kessler [1], Ulrich Dillner [1], Frank Haenschke [1], Uwe Schinkel [1], Marco Schubert [1], Robert Haehle [1], Hans-Georg Meyer [1]

[1] Institute of Photonic Technology, Jena/Germany

A high performance uncooled thermoelectric THz sensing structure based on antenna-coupled air-bridges is presented.The first configuration level is a 2-D array, which consists of 2 x 4 pixels.Thereby, each pixel comprises 8 thermocouples of a highly effective BiSb-Sb thermocouple materials combination.For the surface micromachining fabrication of the air-bridges a sacrificial layer of polyimide has been used.The NEP of a sensing structure was established to be 18 pW/Hz^1/2.

O-LITH-09

Measurement of surface potential distribution of a resist film irradiated by electron beam

Masatoshi Kotera [1], Akira Osada [1]

[1] Osaka Institute of Technology, Osaka/Japan

We measure lateral distributions of electric potential of a resist irradiated by EB using a newly developed electrostatic force microscope, built in an ordinary SEM. The irradiated area shows a higher potential than its outside, but if the dose is high, the distribution shows a negative dip at around 50 um away from the edge. We speculate that this negative value may be due to fogging electrons in the SEM specimen chamber. Further, we find that the distribution decays as a function of time.

O-LIFE-03

Anisotropic Wetting Phenomena on Polymer Foils as a Function of Topography and Surface Chemistry

Sonja Neuhaus [1], Nicholas D. Spencer [2], **Celestino Padeste** [1]

[1] Paul Scherrer Institut, Villigen PSI/Switzerland, [2] ETH Zurich, Zürich/Switzerland

We present a versatile platform suitable to systematically vary the surface topography of fluoropolymer foils by hot embossing and, in a further step, to adapt their surface chemistry by surface grafting of polymer brushes. Anisotropies in wetting were observed for surfaces with periodic groove or square structures, in particular when the surfaces were moderately hydrophilic. Both, very high and very low hydrophilicity led to much less anisotropy in the wetting behavior.

15:30

O-MEMS-10

Linear and rotation thermal micro-stepper

Ali Khiat [1]

[1] Delft University of Technology, Delft/Netherlands

A novel thermal micro-stepper based on friction principle has been developed. Its objective is to move, align and adjust micro-objects with nanometer precision. The principle had been validated in the macro scale. In this study, the miniaturization challenges are presented, such as design of individual microactuators, microfabrication and insertion method of an external object to the micro-stepper to be moved. The first experimental results will be presented and compared to the analytical ones.

O-LITH-10

Local ion irradiation of thin graphene films grown on SiC substrates

Jacques Gierak [1], Brigitte Prevel [2], Jean Michel Benoit [2], Laurent Bardotti [2], Patrice Mélinon [2], Abdelkarim Ouerghi [3], Damien Lucot [1], Eric Bourhis [1]

[1] LPN-CNRS, Marcoussis/France, [2] LPMCN, Villeurbanne/France, [3] LPN-CNRS, Villeurbanne/France

This work is aiming at investigating the structural modifications of the local properties of a graphene monolayer grown on a SiC substrate irradiated by highly focused Ga+ ions. Using Atomic Force Microscopy and Raman spectroscopy measurements we investigate the nature and the importance of the modifications induced . The morphology and the electronic properties of the created nanodots that exhibit a progressive and local amorphization will be thoroughly presented and discussed.

O-LIFE-04

EWOD-driven stirring in lab-on-chips: dependence on the electrodes' geometry

Rachid Malk [1], **Johannes Theisen** [2], Yves Fouillet [3], Laurent Davoust [4]

[1] CEA-LETI, Grenoble/France, [2] Grenoble-INP/LEGI, Grenoble cedex 9/France, [3] CEA/LETI, Grenoble/France, [4] Grenoble-INP/SIMAP-EPM, St Martin d'Hères/France

Electro-Wetting (EW) is used in micro-systems (lab-on-chips, optical lenses, displays). This paper deals with stirring flow in sessile droplets actuated by oscillating EW with applications in lab-on-chips. Depending on chip design (circular vs square electrodes), EW-induced flow pattern switches from toroidal to quadripolar flows. Design guidelines can be formulated for end-users of EW chips (flow-focusing of biomaterial, functionnalization of supports, bio-fouling, mixing).

15:50 – 18:30 Poster session 1 – Posters with **odd** number

Wednesday 21 September

mne BERLIN 2011

08:30 – 09:50 Plenary Session 2 – Session Room: Plenary Hall C01

Session Chair:
Massimo Gentili, Innovation & Technology Management, Milan/Italy

08:30 Plenary

O-PLEN-03

Micro and nanostructures for multichannel imaging – small lenses go big

Andres Tünnermann, Fraunhofer Institute IOF, Jena/Germany

The application of miniaturized camera systems for portable devices (e.g. mobile phones) and ultra-compact close-up imaging sensors demands not only the shrinking of opto-electronic and electronic but also of optical components. The basic requirements to achieve that goal are (1) a short focal length and (2) an optical system with low complexity. However, the on going miniaturization of the image sensor size also causes a demand for a higher image resolution and light sensitivity. Wafer-level fabrication techniques for camera lenses and modules turned out to be promising candidates for the high-volume production in the low cost regime. The existing concepts for wafer-level optics (WLO) apply complex aspherical lens profiles and vertical integration techniques which put limits to the process yield so far.

We realized new types of multi-aperture imaging systems which capture different portions of the object field of view within separated optical channels. These different partial images are joined together digitally to form a total image of the full field of view in case of the camera application whereas for the close-up imaging sensor the partial images are optically stitched within the optical system without any scanning motion.

The segmentation of the full field of view partly decouples focal length from the size of the field of view. Therefore, a short total track length is realized for each optical channel. On the other hand, simple optical components such as reflow microlenses with small sags can be applied due to the short focal length and small size of field per channel. These may be fabricated with well-established microoptical fabrication techniques such as UV-lithography, reflow and UV-molding which show sub-µm precision and are cost-efficient due to wafer-level manufacturing. Alignment and assembly may at least partially be done on wafer-level reducing the production costs.

09:10 Plenary

O-PLEN-04

Atomically Precise Silicon Devices in all Three Dimensions

Michelle Y. Simmons, Centre of Excellence for Quantum Computation and Communication Technology, School of Physics, University of New South Wales/Australia

Over the past five years we have developed a radical new strategy for the fabrication of atomic-scale devices in silicon using scanning probe microscopy in combination with molecular beam epitaxy. Using registration markers etched into the substrate we have been able to make electrical contact to buried, STM-patterned dopant atoms and perform both direct transport measurements and now spin based measurements of the donor states.

We have also developed hydrogen resist lithography to image, place with atomic-precision accuracy and encapsulate single phosphorus atoms in silicon for the realisation of atomic-scale qubit devices. Using this unique strategy we have demonstrated conducting nanoscale wires with widths down to ~1.5nm, tunnel junctions, and all epitaxial single electron transistors down to the single donor level. We will present atomic-scale images and electronic characteristics of atomically precise devices fabricated and demonstrate the impact of strong vertical and lateral confinement on electron transport.

We will also highlight some of the opportunities ahead for atomic-scale quantum computing architectures and some of the challenges to achieving truly atomically precise devices in all three spatial dimensions.

09:50 – 10:20 Coffee

10:20 – 12:30

IMPRINT 2

Session Room: Plenary Hall C01

Session Chairs: Iris Bergmair, Profactor GmbH – Austria; Santos Merino, Fundación Tekniker – Spain

PHOTONICS & PHOTOVOLTAICS

Session Room: Hall 1 B08-B09

Session Chairs: Goncal Badenes, ICFO – Spain; Uwe D. Zeitner, FhG-IOF Jena – Germany

NOVEL FABRICATON 1

Session Room: Hall 2 B05-B07

Session Chairs: Falco C. M. van Delft, Philips Innovation Services – Netherlands; Jeroen van Kan, National University of Singapore – Singapore

10:20

O-LITH-11

INVITED

Replication of hybrid 3-D structures using flexible polymer molds and roll-to-plate UV-nanoimprint lithography

Helmut Schift [1], Arne Schleunitz [1], Christian Spreu [1], JaeJong Lee [2]

[1] Paul Scherrer Institut, Villigen PSI/Switzerland, [2] Korean Institute of Machinery & Materials, Daejeon/Republic of Korea

We report on our research towards mass fabrication of complex 3-D micro- and nanostructures. A process was developed to transfer the pattern into a working stamp made of PUA casted onto a PC foil. The patterned PUA layer exhibits both, a strong chemical adhesion to the PC and a sufficient mechanical flexibility. The final replication was accomplished using a roll-to-plate (R2P) embossing setup which makes the 3-D structures also available in other materials as needed for direct applications.

O-PHOT-01

INVITED

Focused ion beam technology for the creation of photonic and plasmonic structures

Hans Mulders [1], Ernst Jan Vesseur [2], Albert Polman [2]

[1] FEI Electron Optics, Eindhoven/Netherlands, [2] AMOLF, Amsterdam/Netherlands

A Focused Ion Beam (FIB) with Ga+ ions can be used for the direct, top down creation of three dimensional photonic and plasmonic structures. The FIB is efficient for this rapid prototyping, allowing a quick research-scan of the relevant optical parameter space. Examples of these structures at sub-wavelength scale will be given, in combination with the related optical properties. Boundary conditions and practical limits as well as the influence of implanted ions will be discussed.

O-NANO-07

INVITED

Self Perfection of Nanostructures– A New Frontier in Nanofabrication

Stephen Chou [1]

[1] Princeton University, Princeton/United States

Rather than abonding current nanofabrication method, we are taking a drastically different approach, which accepts the defects/ weakness of a given nanofabrication but perfects the nanostructures after original fabrication. The perfection not only removes the fabrication detects in the initial fabrication, but also makes the final structure better than a perfect initial structures (e.g make them narrower or smaller in lateral dimensions and a higher in vertical dimension).

10:50

O-LITH-12

Fabrication and Characterization of Sub-500 nm Organic Field Effect Transistor using UV Nanoimprint Lithography with Opaque Molds

Lichao Teng [1], Kirchner Robert [1]

[1] Technische Universität Dresden, Dresden/Germany

A new technique using cheap Si-molds, called non-transparent UV-nanoimprint lithography, was reported to pattern sub-500 nm channels for OFETs. The resolution of NT-UV-NIL should not be restricted by the wavelength of the exposure light. The fabricated OFET works successfully and shows a proportional dependence of the current density on the W/L ratio, which corresponds with the theory very well.

O-PHOT-02

A dedicated multilayer technology for the fabrication of three-dimensional metallic nanoparticles

Christian Helgert [1], Kay Dietrich [1], Dennis Lehr [1], Thomas Käsebier [1], Thomas Pertsch [1], Ernst-Bernhard Kley [1]

[1] Friedrich-Schiller-Universität Jena, Jena/Germany

We address the further miniaturization of three-dimensional metallic nanoparticles at the example of a loop-wire structure. Thus we describe for the first time how genuine three-dimensional, periodically arranged, metallic nanoparticles, which are not just stacked planar layers, can be fabricated by a dedicated technology based on electron-beam lithography. Concerning light-matter interaction, we show that the fabricated structures exhibit a record-breaking optical activity.

O-NANO-08

VCSEL, LED, thin-film PV production by Substrate Conformal Imprint Lithography

Marc Verschuuren [1], Remco van Brakel [2], Robert van de Laar [2], Ran Ji [3], Michael Hornung [3]

[1] Philips Research, Eindhoven/Netherlands, [2] Philips Innovation Services, Eindhoven/Netherlands, [3] SUSS MicroTec Lithography GmbH, Garching/Germany

Substrate Conformal Imprint Lithography combines the low cost, flexibility and robustness of PDMS working stamps with the resolution and low pattern deformation of small rigid stamps. The process forms silicon-oxide layers in one minute with sub-10 nm resolution over 150 mm wafers. We demonstrate the robustness and flexibility by producing photonic crystal LEDs & ultra-thin plasmonic a-Si:H solar cells. SCIL is already used for two years in the mass production of polarization stabilized VCSELs.

11:10

O-LITH-13

Thermal Nanoimprint Resist for the Fabrication of High-Aspect-Ratio Patterns

Martin Messerschmidt [1], Marko Vogler [1], Freimut Reuther [1], Thomas Werner [2], Andreas Bertz [2], Gabi Grützner [1]

[1] micro resist technology GmbH, Berlin/Germany, [2] Fraunhofer-Institut für Elektronische Nanosysteme ENAS, Chemnitz/Germany

A new thermal nanoimprint resist for the fabrication of high-aspect-ratio patterns via a bilayer approach is presented. Crucial material properties were tailored by chosing specific comonomers and adequate free radical polymerization conditions. The resist revealed excellent imprint and demoulding characteristics as well as a high oxygen RIE resistance demonstrating its suitability as a masking layer material in pattern transfer.

O-PHOT-03

Design and fabrication of plasmonic gratings for bulk Silicon solar cell light harvesting enhancement

Davide Sammito [1], Gabriele Zacco [2], Pierfrancesco Zilio [3], Valentina Giorgis [1], Alessandro Martucci [4], Julius Janusonis [5], Filippo Romanato [6]

[1] IOM CNR, Tasc National Laboratory, Basovizza (Trieste)/Italy, [2] Physics Department, Padova University, Padova/Italy, [3] LaNN Laboratory for Nanofabrication of Nanodevices, Padova/Italy, [4] Dipartimento di Ingegneria Meccanica, Padova University, Padova/Italy, [5] MET Modernios E-Technologijos, Vilnius/Lithuania, [6] Veneto Nanotech – LaNN Laboratory, Padova/Italy

This work investigates the potentialities of subwavelength Silver 1D gratings with square wave profile as a light trapping system on top of bulk Silicon solar cells. We demonstrated that a nanofabrication process based on Laser Interference Lithography patterning is able to realize such submicrometer features over the large areas of solar cells.

O-NANO-09

Design and Fabrication of a Miniaturized Gas Ionization Chamber for Production of High Quality Ion Beams

David Jun [1], Vladimir Kutchoukov [1], Pieter Kruit [1]

[1] Delft University of Technology, Delft/Netherlands

We are currently developing a next generation ion source suitable for both high resolution focused ion beam milling and imaging applications. Our source relies on electron impact gas ionization and consists of a sub-micron sized gas chamber and a Schottky electron gun. The gas chamber is prepared through several lithographic fabrication steps and is designed to provide a variety of ion beams with high brightness and low energy spread.

11:30

O-LITH-14

Ferroelectric PZT Film Domain Patterning by Nano-embossing Technology

Zhenkui Shen [1], qian Lu [1], xinping qu [1], Yifang Chen [2], **ran Liu** [1]

[1] Fudan University, Shanghai/China, [2] Rutherford Appleton Laboratory, Didcot/United Kingdom

Understanding ferroelectric domain configurations in submicron dimension is essential to both nanoferroelectrics research and ferroelectrics-based applications such as ultra-high density data storage devices, biology assembling, and nonlinear optics devices. In this paper, we studied domain pattern formation in nano-embossed Pb(Zr0.3,Ti0.7)O3 (PZT) nanostructures and demonstrated a new approach for the domain engineering in polycrystalline ferroelectric films.

O-PHOT-04

High aspect ratio deep UV wire grid polarizer fabricated by double patterning

Thomas Weber [1], Thomas Käsebier [2], Adriana Szeghalmi [1], Mato Knez [1], Ernst-Bernhard Kley [1], Andreas Tünnermann [3]

[1] Friedrich-Schiller-University Jena, Jena/Germany, [2] FSU Institute of Applied Physics, Jena/Germany, [3] Fraunhofer Institute IOF, Jena/Germany

In this work we present the fabrication of a wire grid polarizer by double patterning based on ultra fast electron beam lithography and sophisticated deposition techniques. For an application in the deep UV spectral range a grating period of 100 nm and an aspect ratio of about 1:5 is essential. Different grating materials and deposition techniques were applied and compared. Furthermore, the optical function of the elements is determined in a large spectral range.

O-NANO-10

Extremely thin planarization of an embedded grating for sub-diffraction limit (100nm) far-field imaging of living cell membranes

Andrea Cattoni [1], **Anne Talneau** [1], Ane-Marie Haghiri-Gosnet [2], Jules Girard [3], Anne Sentenac [3]

[1] CNRS/LPN, Marcoussis/France, [2] LPN CNRS, Marcoussis/France, [3] Institut Fresnel, Marseille/France

Far-field optical imaging of living cells at the highest resolution can be obtained through illuminating the cells deposited on a periodically nanostructured substrate. The substrate has to be flat in order not to distort for the plasmic membrane. A Degassing Assisted Patterning allows embedding the grating with a very thin (10nm) cover layer. The Moiré pattern obtained when depositing a thin layer of fluorescent dyes on the flat surface evidences the proper behavior of the embedded grating.

11:50

O-LITH-15

Nano-patterned Fluorinated Diamond-Like Carbon thin films used as UV-NanoImprint Lithography templates

Maxime Bossard [1], Boris Le Drogoff [1], Mohamed Chaker [1], Jumana Boussey [2]

[1] INRS-EMT, Varennes/Canada, [2] LTM-CNRS, Grenoble/France

In this paper, we present results on the use of Fluorinated Diamond-Like Carbon (F-DLC) thin films as release layers for UV-NIL molds. Nanopatterned DLC and F-DLC thin films were microfabricated and tested through nanoimprint processes after characterization. F-DLC films confirm their potential as good candidates for UV-NIL applications, as 50 nm patterns could be successfully imprinted on a UV-NIL resist.

O-PHOT-05

Nanoporous liquid core dye laser

Mads Brøkner Christiansen [1], Jeffrey Peterson [1], Kaushal Sagar [1], Nimi Gopalakrishnan [1], Anders Kristensen [2]

[1] Technical University of Denmark, Kgs. Lyngby/Denmark, [2] DTU Nanotech, Copenhagen/Denmark

We present a dye doped nanoporous polymer ring laser, where the cavity is formed from liquid core waveguides. To the authors' knowledge, this is the first realization of a nanoporous polymer laser. The laser contain seprately a solid state gain medium and an aqeous analyte inside the porous cavity, which is an important step towards sensitive optofluidic intra-cavity laser sensors.

O-NANO-11

A novel technique for metallic porous microtubes by rolling from anodic aluminum oxide as templates

Zhaoqian Liu [1], Yongfeng Mei [1], Yifang Chen [2], ran Liu [1]

[1] Fudan University, Shanghai/China, [2] Rutherford Appleton Laboratory, Didcot/United Kingdom

We report our recently developed 3D pattern conversion technique to produce porous microtubes by rolling of a metallic film from anodic aluminum oxide. The novel structure of this specially designed microtube shall have properties different from those of the ordinary micro-/nano-tubes with uniform tube walls, and thus can be advantageously used in optics, biology microfluidic system, lab on chip, etc.

12:10

O-LITH-16

Fabrication of Large Area Seamless Roller Mold using Fast EB Lithography (rEBL) for R2R Process

Masayuki Abe [1]

[1] Asahi Kasei Engineering Co., LTD., Fuji/Japan

Many companies are developing flexible electronics devices and optical devices. An important feature of flexible electronics is low cost, which is enabled through manufacturing by R2R process. However, this R2R process requires a large-area seamless roller mold (SRM) which has not been easy to achive. We have succeeded in the development to enable the achievement of such an SRM. This SRM's diameter is 100mm, and roller width is 50 nm. On its surface, there are 300nm line patterns in 20mm width.

O-PHOT-06

Lasing properties of Anderson localized modes in planar random photonic crystals

Seiji Takeda [1], Romain Peretti [2], Thanh-Phong Vo [2], Segolene Callard [2], Christian Seassal [2], Xavier Letartre [2], Pierre Viktorovitch [2], Minoru Obara [1]

[1] Keio University, Yokohama/Japan, [2] Ecole Centrale de Lyon, Lyon/France

We present the first demonstration of two-dimensional Anderon localization of light in a planar random (disordered) photonic crystal laser, with direct near-field imaging by use of Scanning Near-field Optical Microscope (SNOM). We exhibit that extended Slow Bloch Mode is Anderson localized by moderately randomized bandgap scattering. We furthermore confirm that the observed mode profiles are consistent with theoretically predicted ones by FDTD (Finite-Difference Time-Domain) computations.

O-NANO-12

In-situ UHV four-point-probe characterization of near-surface δ-doping profiles in silicon

Craig Polley [1], Michelle Simmons [1], Jill Miwa [1], Warrick Clarke [1]

[1] University of New South Wales, Sydney/Australia

We use a UHV four-point-probe scanning tunneling microscope to create and electrically characterize atomically thin and abrupt phosphorus δ-doping profiles in silicon at depths as shallow as 1nm from the silicon-vacuum interface. We demonstrate that our room temperature measurements are not influenced by leakage through the substrate, and due to the degenerate doping density we obtain the lowest sheet resistances for sub-5nm silicon doping profiles reported to date.

12:30 – 14:00 Lunch

14:00 – 15:50

BIOMEMS 1

Session Room: Plenary Hall C01

Session Chairs: Klaus Stefan Drese, Institut für Mikrotechnik Mainz – Germany; Harry Heinzelmann, CSEM SA – Swoitzerland

PATTERN TRANSFER 1

Session Room: Hall 1 B08-B09

Session Chairs: John Randall, Zyvex Labs – U.S.A.; Monika Fleischer, University of Tübingen – Germany

SELFASSEMBLY

Session Room: Hall 2 B05-B07

Session Chairs: Jens Gobrecht, Paul Scherrer Institute – Switzerland; J. Alexander Liddle, Center for Nanoscale Science and Technology, Gaithersburg – U.S.A.

14:00

O-LIFE-05

INVITED

Control of molecular motors-driven nano-level motion on thermo-chips

Dan Nicolau [1], Harm van Zalinge [1]

[1] University of Liverpool, Liverpool/United Kingdom

A combinatorial chip was fabricated which contained areas that provided different levels of electric heating. The effects of an electric current flowing through this chip were simulated and tested using a kinesin/ microtubule molecular motor system. It is shown that the velocity of the microtubules increases as a function of the current flowing through a particular junction.

O-MEMS-11

INVITED

Soft lithography method for the integration of surface structures into polymer devices

Tobias Senn [1], Christian Weniger [1], Juan Pablo Esquivel [1], Daniel Schondelmaier [1], Neus Sabaté [1], Bernd Löchel [1]

[1] Helmholtz Zentrum Berlin für Materialien und Energie GmbH, Berlin/Germany

In this paper a soft lithography method is used for the integration of surface structures into polymer devices. A 3D structured master is fabricated using a thermoforming process. In this process a prepatterned foil is used as a substrate which is structured by UV-NIL. From this master a PDMS stamp is produced which is applied to a replica molding process for the fabrication of 3D structured polymer parts. This method can be used for the fabrication of functionalized polymer devices.

O-LITH-17

INVITED

Directed self-assembly of ultrahigh density patterns by controlled solvent annealing of cage silsesquioxane-containing block copolymer

Hiroshi Yoshida [1], Yasuhiko Tada [1], Yoshihito Ishida [2], Teruaki Hayakawa [2], Mikihito Takenaka [3], Hirokazu Hasegawa [3]

[1] Hitachi Ltd., Hitachi/Japan, [2] Tokyo Institute of Technology, Tokyo/Japan, [3] Kyoto University, Kyoto/Japan

We report directed self-assembly with density multiplication of strongly segregating polyhedral oligomeric silsesquioxan containing diblock copolymer employing controlled solvent annealing on templates with sparse chemical contrast patterns. Hexagonally closed packed pattern with >4Tdot/inch2 was demonstrated with improved fidelity by applying a solvent neutral to both of the blocks, and optimizing degree of swelling in solvent annealing process.

14:30

O-LIFE-06

Plasmonic Nano-cavity Antenna Arrays Integrated in Fluidic Systems for >20X Enhancement of Single DNA Molecule Detection

Chao Wang [1], Ruoming Peng [1], Wendi Li [1], Stephen Chou [1]

[1] Princeton University, Princeton/United States

We present a highly sensitive, high-absorbing, yet simple-to-fabricate plasmonic structure and a novel method of integrating it into fluidic channels based on nanoimprint lithography and multiple resist layer etching. Enhanced fluorescence detection (up to 20X) of DNA molecules (YOYO-1 dye labeled) was observed, demonstrating its potential in fast and real-time biochemical sensing. The method could be extended to high-throughput fabrication of complex nano-patterns in many other applications.

O-MEMS-12

Biomimetic soft lithography on curved nanostructured surfaces

Vaida Auzelyte [1], **Valentin Flauraud** [1], Victor J. Cadarso [2], Thomas Kiefer [1], Jürgen Brugger [1]

[1] École Polytechnique Fédérale de Lausanne (EPFL), Lausanne/Switzerland, [2] Microsystems Laboratory, EPFL, Lausanne/Switzerland

We have demonstrated a simple and cost-efficient soft lithography based pattern transfer technique from curved to flat surfaces having micro and nano-patterns by using a bio-mimetic template. The results obtained using this bio-inspired technique proved that the proposed technology can be used for pattern tansfer of complex functional surfaces, such as microoptical systems.

O-LITH-18

Locally controlling the morphology of Self-Assembled Block Copolymer Patterns by Templating

Amir Tavakkoli K. G. [1], Adam F. Hannon [1], Kevin W. Gotrik [1], Caroline A. Ross [1], **Karl K. Berggren** [1]

[1] MIT, Cambridge/United States

This study shows that by using an array of functionalized posts, it is possible to locally control the morphology of a Block Copolymer (BCP) and thus achieve several morphologies on a single substrate. The resulting period of the final pattern was less than the original BCP period, i.e. the final pattern resolution was increased. Also, this method achieved a square lattice in the case of dots, as well as doubled the spatial frequency of the patterns. Also, 3-dimensional simulations were done.

14:50

O-LIFE-07

SOI-based Nanowire Field Effect Transistor Arrays for Sensing Applications

Kristine Bedner [1], Vitaliy A. Guzenko [1], Oren Knopfmacher [2], Alexey Tarasov [2], Mathias Wipf [2], David Just [2], Wangyang Fu [2], Michel Calame [2], Christian David [1], Jens Gobrecht [1], Christian Schönenberger [2]

[1] Paul Scherrer Institut, Villigen PSI/Switzerland, [2] University of Basel, Basel/Switzerland

We develop a silicon nanowire field effect transistor (SiNW-FET) for pH and biosensing applications. The sensor is made from a Silicon-On-Insulator wafer in a top-down approach. The nanowires have different widths ranging from 100nm to 1µm. The detected signal is a change in the conductance. Due to implanted contacts the operating range is enlarged. In pH measurements its sensitivity is about 56mV/pH. The dependence of the sensitivity on the nanowire width is currently investigated.

O-MEMS-13

New placement templates for DNA Nanostructures on surfaces lithographically patterned and the use of the Origami as etch mask

Rossella Giardi [1]

[1] Polytechnic of Turin, Bussoleno/Italy

We describe the use of plasma etch processing to position DNA nanostructures on substrates compatible with semiconductor manufacturing. Electron beam and optical lithography are used to create the patterns. When combined with ion milling or a CF4 etch followed by an oxygen etch, the topographic templates control the placement of DNA origami on SiO2. We also describe experiments using the origami itself as an etch mask for pattern transfer into oxide and nitride surfaces using a CF4 etch process.

O-LITH-19

Pattern multiplication in guided self-assembly of PS-b-PMMA block co-polymers by surface chemical modification

Lorea Oria [1], Alaitz Ruiz de Luzuriaga [2], Juan Antonio Alduncin [2], Francesc Perez-Murano [1]

[1] Instituto de Microelectronica de Barcelona IMB-CNM (CSIC), Bellaterra (Barcelona)/Spain, [2] CIDETEC – IK4, Donostia/San Sebastián/Spain

We present a new process of guiding the self-assembly of PS/PMMA block co-polymers relaxing the pre-pattern resolution in the lithography step. It consists in creating different wetabilities on a polymer brush with a pattern pitch of multiple times the polymer chain length. The influence of the pattern width, the oxygen plasma intensity and the annealing conditions are presented. We show that this method simplifies the block co-polymer self-assembly by chemical epitaxy for the 22nm hp and below.

15:10

O-LIFE-08

Efficient fluorescence suppression by large area gold-based surface enhanced Raman scattering device

Gobind Das [1], Niranjan Patra [1], Anisha Gopalakrishnan [1], Remo Proietti [1], Andrea Toma [1], Sanjay Thorat [1], Enzo Difabrizio [1], Alberto Diaspro [1], Marco Salerno [1]

[1] Italian Institute of Technology, Genova/Italy

APA substrates,hexagonal periodicity, were fabricated with different protocols, which allowed us to obtain different pore diameters (160–15 nm) and pore wall thicknesses (104–36 nm). Novelty of this SERS work is that we are able to achieve reproducible SERS substrates with the wall thickness and pore diameter down to 15 and 36 nm, respectively.The enhancement factor is estimated to be around 10^7.The reported samples are the the trade between the high fabrication are and the enhancement factor.

O-MEMS-14

Hybrid Inlays for Injection Moulding

John Stormonth-Darling [1], Bill Monaghan [1], Nikolaj Gadegaard [1]

[1] University of Glasgow, Glasgow/United Kingdom

A novel method for rapid protoyping of inlays for injection moulding of 2D and 3D nanopatterned surfaces is presented. Inlays were fabricated by nanoimprint and photolithography on polymeric substrates and facilitated superior pattern filling by polycarbonate to geometrically similar nickel inlays. Flexible inlays were placed on top of others such that the topograpies of both layers were superimposed in the final moulded part. Inlays show no measurable sign of wear after over 500 cycles.

O-LITH-20

Formation of Three Dimensional Nanopattern Via Nanosphere Lithography and Soft Lithography

Ali Mohammadkhani [1], **Hany Hassanin** [1], **Carl Anthony** [1], **Kyle Jiang** [1]

[1] The University of Birmingham, Birmingham/United Kingdom

In this research, a combination of Nanosphere Lithography and Soft Lithography technique is applied to create three dimensional (3D) nanostructure arrays with gold nanoparticle on its triangular tips.

15:30

O-LIFE-09

Design, Fabrication and testing of a biosensor using Plasmonic Gratings

Mauro Perino [1], Tommaso Ongarello [2], Pierfrancesco Zilio [3], Elisabetta Pasqualotto [4], Matteo Scaramuzza [4], Alessandro De Toni [4], **Filippo Romanato** [5]

[1] Department of Physics, University of Padova, Farra d'Alpago/Italy, [2] LaNN, Padova/Italy, [3] LaNN Laboratory for Nanofabrication of Nanodevices, Padova/Italy, [4] Department of Information Engineering University of Padova, Padova/Italy, [5] Veneto Nanotech – LaNN Laboratory, Padova/Italy

In this work we consider the architecture based on a silicon photodetector designed to detect the light collected in extraordinary transmission through an array of plasmonic gratings. The final device will act as an effective multi array biosensor. The incoming laser light will sense the functionalization layer around the gold. The information of this refractive index will be transmitted as far field radiation and then register as electrical current produced by the photodiode.

O-MEMS-15

Fabrication of nickel micro-parts using liquid-crystal-display projection lithography and newly developed image-reverse process

Toshiyuki Horiuchi [1], Sho Shiratori [1]

[1] Tokyo Denki University, Tokyo/Japan

Projection lithography using a liquid-crystal-display (LCD) panel in place of a reticle is expected as simple and low-cost technology. However, it has not been applied to fabricating thick SU-8 mould patterns for electroplating, because LCD panels have no transmittance for ultra-violet light to sensitize SU-8. Here, image reverse process to transfer 1-μm thick g-line resist patterns to 100-μm SU-8 patterns was newly developed, and nickel micro-gears were successfully fabricated.

O-LITH-21

Directed Assembly of Horizontal Suspended Carbon Nanotubes for NEMS Applications

Hari Pathangi [1], Guido Groeseneken [1], Ann Witvrouw [2]

[1] IMEC/KU Leuven, Heverlee/Belgium, [2] IMEC, Leuven/Belgium

We have presented a wafer-scale technique to assemble horizontally aligned and suspended single-walled carbon nanotubes at well defined on-chip locations in a parallel manner with a very low thermal budget. Given the scalability of this process, arrays of such devices could be of interest for instance as gas or chemical sensors.

15:50 – 18:00 Poster session 2 – Posters with **even** number

18:30 – 19:00 Conference Dinner Reception

19:00 Conference Dinner

Thursday 22 September

mne BERLIN 2011

09:00 – 10:20 Plenary Session 3 – Session Room: Plenary Hall C01

Session Chair:
Christophe Vieu, University of Toulouse , LAAS-CNRS/France

09:00 Plenary

O-PLEN-05

The Race to Higher Resolution: It's not over yet!

C. Grant Willson, University of Texas, Austin, Department of Chemical Engineering, Texas/U. S. A.

During the last half century scientists and engineers have devised the methods and materials that enable manufacturing of the incredibly small and ever shrinking structures that are the basis of the microelectronics industry. The ability to manufacture such structures and the devices derived from them is a tribute to the ingenuity of man. It is an accomplishment that has changed society in remarkable ways. This achievement has required advances in many areas including optics and imaging materials chemistry. Classical photolithography, the process that has enabled this process has now reached physical limits. Efforts to push that technology to provide still higher resolution by the historical paths of wave length reduction, increase in numerical aperture and reduction in the Raleigh constant have been abandoned. Is this the end? Can scaling continue??

Of course it can! It is not over yet! Various incredibly tricks have been devised to extend photolithography, some of which are already in use in full scale manufacturing. However, these tricks add complexity to the patterning process and carry an associated increase it cost. The high cost of these clever, but complex processes and the even higher cost of the EUV alternative threaten to change the economics of the semiconductor manufacturing industry. We will review some of these resolution extension tricks including advances in materials for directed self assembly and a new pitch doubling technique that requires no extra processing steps. Finally, Step and Flash Imprint lithography, a potentially disruptive, much lower cost, high resolution patterning technology has emerged as a potential adjunct to photolithography. This process has demonstrated great potential, but concern of some about limitations in throughput and potential for defectivity has delayed maturation of the process. We will briefly examine the state of this interesting alternative path to continued scaling.

09:40 Plenary

O-PLEN-06

How Cells Exploit the Nanomechanics of Proteins

Viola Vogel, Department of Materials, ETH Zürich/Switzerland

How do cells sense the mechanical properties of synthetic materials? In their very initial response after getting in contact with a synthetic material, they adhere and then pull on the substrate. In this process, cells stretch those proteins that connect the contractile cytoskeleton with the exterior. Yet, most of the structure-function relationships that are known today for proteins have been derived under equilibrium conditions. Recent research reveals that cells exploit proteins as nanoscale switches that convert mechanical forces into biochemical signals which they can read, ultimately leading to a cellular response. While such mechanotransduction processes regulate many cell functions, first underpinning mechanisms are only recently emerging. Deciphering how proteins can serve as mechano-chemical signalling switches is thus not only essential to learn how cells probe and respond to their environments, but it has also far reaching implications in tissue engineering, systems biology and medicine. Stretching of extracellular matrix fibers can also destroy bacterial binding sites, for example the epitopes that Staphylococcus aureus or the lime disease-causing bacterium B. Burgdoferi utilize to specifically bind to extracellular matrix. Insights into the mechanical designs might also stimulate new thoughts how to engineer switches or integrated devices at the nanoscale.

10:20 – 10:50 Coffee

10:50 – 13:00

PATTERN TRANSFER 2

Session Room: Plenary Hall C01

Session Chairs: Michel Despont, IBM Research Laboratory, Zurich – Switzerland; Emile van der Drift, Delft University of Technology – Netherlands

LAB ON CHIP

Session Room: Hall 1 B08-B09

Session Chairs: Stefano Cabrini, LBL Molecular Foundry – U.S.A.; Evangelos Gogolides, NCSR Demokritos – Greece

LITHO MATERIALS & SYSTEMS

Session Room: Hall 2 B05-B07

Session Chairs: Michael Hornung, Suss MicroTec Lithography GmbH – Germany; Alex P.G. Robinson, University of Birmingham – United Kingdom

10:50

O-MEMS-16

INVITED

Realizing advanced surface nano-structuring by utilizing porous anodic alumina membranes: breaking the limits

Stefan Ostendorp [1], Yong Lei [1], Gerhard Wilde [1]

[1] Institute of Materials Physics/WWU Münster, Münster/Germany

Here we present our latest results concerning the extension of known limitations of the surface nano-structuring technique based on porous anodic alumina membranes (PAAMs). By using an advanced anodization cell it was possible to realize anodizations in the mild anodization regime with a wide range of voltages applied and to obtain regular pore growth, what has not been reported in the literature before. As proof of concept the fabricated PAAMs have been used to create various nano-structures.

O-LIFE-10

INVITED

A modular micro-valve suitable for lab-on-foil

Allwyn Boustheen [1], Erik Homburg [1], Andreas Dietzel [2]

[1] Eindhoven University of Technology, Eindhoven/Netherlands, [2] Holst Center/TNO, TU/e, Eindhoven/Netherlands

We present a novel polymeric microvalve employing thermal phase change actuation. A layer based platform is chosen. Individual functional components: actuator, interfacing membrane, and the fluidic channels are isolated and structured only in their respective layer. Moreover for the microvalve, most structures will be limited to structuring from one side only. This reduces the complexity of the design and manufacturing processes. Different manufacturing processes may be used for each layer.

O-LITH-22

INVITED

High Resolution Dry Development

Deirdre Olynick [1], Dimas G. de Oteyza [1], Martin Schmidt [1], Pradeep Perera [1], Scott Dhuey [1], Bruce Harteneck [1], R. Martin Falch [1], Adam Schwartzberg [1], P. James Schuck [1], Stefano Cabrini [1]

[1] Lawrence Berkeley Lab/The Molecular Foundry, Berkeley/United States

We have developed a high resolution dry development method using resists, (e.g. calixarenes) that during exposure undergo an optical absorption change to allow selective laser ablation. With electron beam lithography followed by development using a CW 532 nm laser (spot size ~300 nm) we reveal 10 nm features in a film 120 nm thick, with pitch resolution down to 30 nm and aspect ratios of ~4:1. We have identified mechanisms and functional groups responsible for the optical absorption change.

11:20

O-MEMS-17

Metallic nanocones for surface enhanced Raman spectroscopy

Andreas Horrer [1], Christian Schäfer [1], Dominik Gollmer [1], Katharina Broch [1], Frank Schreiber [1], Dieter Kern [1], **Monika Fleischer** [1]

[1] University of Tübingen/Institute of Applied Physics, Tübingen/Germany

Plasmonic nanostructures can greatly increase the low cross-section of Raman spectroscopy. Variations of a fabrication process for plasmonic nanocones based on thin film evaporation, local masking by e-beam lithography or self-assembly of colloidal crystals, and ion milling are shown. Regular arrays of cones are applied as advantageous sensor surfaces for surface enhanced Raman spectroscopy. Strong intensity enhancement of the characteristic Raman peaks of a thin pentacene film is observed.

O-LIFE-11

Integrated micropillar liquid chromatography-electrospray ionization microchip

Lauri Sainiemi [1], Teemu Nissilä [1], Risto Kostiainen [1], Raimo Ketola [1], Sami Franssila [2]

[1] University of Helsinki, Helsinki/Finland, [2] Aalto Universtiy, Helsinki/Finland

In this work we present fabrication of a novel monolithically integrated silicon/glass microchip for liquid chromatography (LC) and electrospray ionization (ESI). Isotropic etching is utilized in novel manner to create three-dimensionally sharp ESI-tip out of glass. The fabricated microchip is coupled to a mass spectrometer and separation and mass spectrometric analysis of four drugs are demonstrated.

O-LITH-23

Strength analysis of EUV-exposed photo resists by AFM at 40nm half pitch and below

Gustaf Winroth [1], Roel Gronheid [1], Tae-Gon Kim [1], Paul Mertens [1]

[1] IMEC, Leuven/Belgium

We present an AFM-based method to measure collapse forces in EUV-resists. The technique which has been proven at larger dimensions is here extended with some modifications to EUV-exposed resist features at 40 nm half pitch and below. It is shown that the method can discriminate forces between photo resist width variations of less than 2 nm. A square dependence is furthermore demonstrated, which is used to derive specific strength coefficients for a series of commercially available EUV resists.

11:40

O-MEMS-18

Fabrication of Single Crystal Silicon Micro-/ Nanowires and transferring them to Felxible Substrates

Ravinder Dahiya [1], Andrea Adami [1], Leandro Lorenzelli [2]

[1] Fondazione Bruno Kessler, Trento/Italy, [2] FBK-CMM Center for Materials and Microsystems, Trento/Italy

This work describes the method to fabricate micro-structured single-crystal Si wires and ribbons from silicon-on-insulator (SOI) wafers using top-down fabrication strategy. The ordered wires of lengths ranging from 30 µm – 5000 µm and widths ranging from 4 µm – 50 µm have been successfully transferred to flexible PDMS substrates. The result presented here is an important milestone in the direction of obtaining electronic circuits over large and flexible substrates.

O-LIFE-12

The Quadrupole Microelecrode Design of Multilayer Biochip

Siti Noorjannah Ibrahim [1]

[1] ECE Department, University Of Canterbury, Christchurch/New Zealand

The new quadrupole microelectrode was developed to cater mass trapping of single cell on biochip using Dielectrophoretic (DEP) force. Study of DEP force profiles were done using Comsol 3.5a software whilst assesment on microelectrode functionality were conducted using polystyrene microbeads and Ishikawa cancer cells. The promising results offer possibilities to study single cell intracellular activities using high resolution analytical instruments such as atomic force microscopy (AFM).

O-LITH-24

Self-aligned Multiple Patterning: How Far Can It Go?

Yijian Chen [1]

[1] Peking University Shenzhen Graduate School, Shenzhen/ China

Self-aligned multiple patterning (SAMP), combined with immersion or EUV lithography, can drive IC resolution down to 5nm half pitch. By designing mandrel patterns which further define the route of the second/third spacers, SAMP techniques can significantly increase the device density. We shall analyze several competitive issues of SAMP techniques: resolution, complexity & overlay, and performance; and discuss how to reduce process complexity using fewer masks and allow 2-D design flexibility.

12:00

O-MEMS-19

Microcantilevers encapsulated in fluid wells for sensing in liquids

Warner Venstra [1], Wim Wien [2], Lina Sarro [2], Jan Eijk [3]

[1] Kavli Institute of Nanoscience, Delft/Netherlands, [2] DIMES, Electronic Components, Technology and Materials Laboratory, Delft/Netherlands, [3] Precision and Microsystems Engineering, Delft/Netherlands

We fabricated arrays of cantilever sensors suspended deep inside fluid wells. To eliminate critical alignment and assembling steps during encapsulation of the cantilevers, these 3-D MEMS devices are realized in a single-side, single-wafer process. SiN cantilevers with varying geometries are suspended 100 µm below the wafer surface, and a structured gold layer is patterned on top. The cantilevers are calibrated and the formation of a DNA monolayer on the cantilever surface is detected.

O-LIFE-13

Extraction of intact DNA from single metaphase chromosomes

Rodolphe Marie [1], Payton Marshall [1], Anil H. Thilsted [1], Johan Eriksen [1], Kristian H. Rasmussen [1], Christopher J. Lüscher [1], Lars B. Nielsen [1], Jacob M. Lange [1], Peter Szabo [1], Winnie E. Svendsen [1], Kalim U. Mir [2], Anders Kristensen [3]

[1] Technical University of Denmark, Kongens Lyngby/Denmark, [2] Oxford University, Oxford/United Kingdom, [3] DTU Nanotech, Copenhagen/Denmark

We present three different routes to extract genomic length DNA from single metaphase chromosomes by proteolysis. One in the absence of mechanical stress, one in presence of shear stress and a third one embedding the chromosome in a hydrogel activated by light induced local heating.

O-LITH-25

Phenyl-bridged polysilsesquioxane positive and negative resist for electron beam lithography

Laura Brigo [1], Vaida Auzelyte [2], Kevin Lister [2], Jürgen Brugger [2], Giovanna Brusatin [1]

[1] University of Padova, Mechanical Engineering Department – Materials Sector, Padova/Italy, [2] École Polytechnique Fédérale de Lausanne (EPFL), Lausanne/ Switzerland

We have developed an organosilicate material synthesized by acid catalyzed sol-gel process of phenyl-bridged polysilsesquioxane precursors, and evaluated its performance as new high resolution resist for EBL at 100 kV. Bridged polysilsesquioxane-based sol-gel materials have not previously been exploited for high resolution patterning with EBL. One interesting feature of this resist is the possibility to switch the tone behaviour from negative to positive by applying a post exposure bake.

12:20

O-MEMS-20

Single-step heterogeneous material micro-transfer by inkjet printed mould filling

Victor J. Cadarso [1], Grégoire Smolik [1], Vaida Auzelyte [1], Loïc Jacot-Descombes [1], Jürgen Brugger [1]

[1] École Polytechnique Fédérale de Lausanne (EPFL), Lausanne/ Switzerland

In this work we propose to combine Micro-transfer molding, a soft lithography technique, and inkjet printing into a new technology labeled as IJP assisted soft-lithography, which benefits from the advantages of both techniques. Using this simple, low material consuming and cost-efficient fabrication method it will be possible the development of heterogeneous micro-structures in a myriad of applications in which the simultaneous use of several materials is needed.

O-LIFE-14

Simple photolithograph rapid prototyping of microfluidic chips

James Hoyland [1], Casper Kunstmann-Olsen [1], Horst-Günter Rubahn [1]

[1] Syddansk Universitet, Sønderborg/Denmark

We present a simple method for producing molds for casting PDMS microfluidic chips using photolithography with 35mm photographic negatives as masks. We have optimized this procedure to create very good quality planar lab-on-chip structures and with this method can go from design to finished device in a few hours.

O-LITH-26

Ultra thick epoxy-based dry-film resist for high-aspect-ratios

Nicolai Wangler [1], Sebastian Beck [2], Gisela Ahrens [2], Anja Voigt [2], Gabi Grützner [2], Claas Müller [1], Holger Reinecke [1]

[1] University of Freiburg – IMTEK, Freiburg/Germany, [2] micro resist technology GmbH, Berlin/Germany

We present a new lamination able high resolution epoxy based dry film resist for the fabrication of large scaled polymer structures. The 360 µm thick dry film resist can be structured by standard i-line UV lithography. Thereby, the new solvent free resist allows for large scaled structures and aspect ratios of up to 12:1 (height:width) with an extreme low angle deviation of a < 1.5° at the edges.

12:40

O-MEMS-21

High Aspect Ratio X-Ray Optical Components for Improved X-Ray Imaging

Jürgen Mohr [1], T. Grund [1], J. Kenntner [1], A. Last [1], V. Nazmov [1], M. Simon [1], J. Leuthold [1]

[1] Karlsruhe Institute of Technology, Karlsruhe/Germany

We report on the fabrication of high aspect ratio X-ray optical components (compound refractive lenses, gratings for Talbot interferometry) and their X-ray optical performance First results on their applications in X-ray optical imaging are presented to demonstrate the potential of the new imaging methods in medical applications and material analysis. These X-ray optical components require microstructures with micrometer dimensions and an aspect ratio of more than 100, which can be achieved using X-ray lithography and a negative epoxy based resist material (mr-L).

O-LIFE-15

A platform combining activable magnetic tweezers and biphasic fluidic plugs for ultra low volume and high throughput bioassay

Laurent Malaquin [1], **Anaïs Ali-Cherif** [1]

[1] Institut Curie, Paris/France

We developed a novel capillary based analysis platform with integrated magnetic tweezers enabling fast and robust bead-based bioassays in confined droplets. All the basic functions required for a bioassay namely washing, dilution, and incubation were performed. This strategy was applied to an immunoassay for neonatal diagnosis of congenital hypothyroidism. The analysis is performed in less than 18min in sub-100nL volume sample against 2h30 and 200 µL for conventional colorimeteric ELISA.

O-LITH-27

Super-Resolution Single-Molecule Fluorescence Microscopy: Measurement of Acid Diffusion in a Model Chemically Amplified Resist

Adam Berro [1], **J. Alexander Liddle** [1], Andrew Berglund [1]

[1] Center for Nanoscale Science and Technology, Gaithersburg/United States

The acid image and latent images from e-beam patterned reisit are investigated using inverse PhotoActivation Localization Microscopy (PALM) employing a novel acid-and photo-switchable fluorophore.

13:00 – 14:10 Lunch

14:10 – 16:00

MICROSYSTEMS 2

Session Room: Plenary Hall C01

Session Chairs: Francesc Perez-Murano, CNM-IMB, CSIC Barcelona – Spain; Ivo W. Rangelow, TU Ilmenau – Germany

PHOTOLITHOGRAPHY

Session Room: Hall 1 B08-B09

Session Chairs: Andreas Erdmann, Fraunhofer Institute IISB – Germany; Kurt Ronse, imec – Belgium

CARBON MATERIALS

Session Room: Hall 2 B05-B07

Session Chairs: Rebecca Cheung, University of Edinburgh – United Kingdom; Zahid Durrani, Imperial College London – United Kingdom

14:10

O-MEMS-22

INVITED

Stretched organic transistors maintain mobility on flexible substrates

Katrin Sidler [1], **Veronica Savu** [1], Nenad V. Cvetkovic [1], Dimitrios Tsamados [1], Adrian Ionescu [1], Jürgen Brugger [1]

[1] Ecole Polytechnique Federale de Lausanne, Lausanne/Switzerland

Pentacene organic transistors are fabricated using stencil lithography on flexible polyimide substrates. All the devices have the same 20 um short channels and are differently orientated with respect to the stretching axis. Their mobility is monitored during straining, decreasing to 73% of its initial value for 2.6% strain, bur recovering to 81% when back in a relaxed state. Their high functionality during and after stretching is a step forward for miniaturized flexible organic electronics.

O-LITH-28

INVITED

High resolution periodic and quasiperiodic patterning using EUV interference lithography

Birgit Päivänranta [1], Andreas Langner [1], Eugenie Kirk [1], Bernd Terhalle [1], Christian David [1], Jens Gobrecht [1], Yasin Ekinci [1]

[1] Paul Scherrer Institut, Villigen PSI/Switzerland

Extreme ultraviolet interference lithography (EUV-IL) is a powerful tool for academic and industrial research. Using EUV-IL together with optimized processing steps we show line/space patterns down to 8 nm, which marks the record value for photon-based lithography. Furthermore, we present generation of 2D quasiperiodic nanostructures with 5- and 8-fold symmetries and feature sizes down to 50 nm. Such unique long-range aperiodical structures are of interest, e. g. for optical applications.

O-NANO-13

INVITED

1 nm thick functional carbon nanomembranes (CNMs): New opportunities for Nanoengineering and Nanobiotechnology

Armin Gölzhäuser [1]

[1] University of Bielefeld, Bielefeld/Germany

1 nm thick, mechanically stable carbon nanomembranes (CNMs) are made by e-beam induced cross-linking of self-assembled monolayers released from their surface. CNMs can be made in sizes from nm2 to cm2. CNMs can be spanned over openings and pores, perforated by lithography and transformed into graphene. Their surfaces can be functionalized with polymers and proteins. CNMs are thus functional hybride materials for filters and transducers in lab-on-a-chip and NEMS devices.

14:40

O-MEMS-23

Metal based micro-feature fabrication using biomachining process

Jos Istiyanto [1], Tae Jo Ko [1]

[1] Yeungnam University, Gyeongsan-si/Republic of Korea

Biomachining process that use microorganisms as the tool to remove metal from a workpiece may have environmental advantages. The innovative use of this process will be an alternative technology. The objective of this study is to investigate the possibility of biomachining process in fabricating micro-size features on pure copper. This paper presents the biomachining processes of pure copper using Acidithiobacillus ferrooxidans and their results in producing several complex features.

O-LITH-29

Mask roughness impact on EUV and 193 nm immersion lithography

Konstantinos Garidis [1], Alessandro Vaglio Pret [1], Roel Gronheid [1]

[1] IMEC, Leuven/Belgium

The contribution of mask absorber LER on printed resist lines is studied for EUV and 193nm immersion lithography. A programmed roughness mask was designed. Correlated and anti-correlated roughness on 88nm pitch structures were considered by varying roughness amplitude and spatial frequency. PSD analysis was performed on top down SEM images with the LERDEMO software. Taking into account the different conditions explored, we could evaluate the mask absorber-to-wafer roughness transfer mechanism.

O-NANO-14

Vertically Aligned Carbon Nanotube Arrays as Vertical Comb Structures for Electrostatic Torsional Actuator

Jungwook Choi [1], **Youngkee Eun** [1], Soonjae Pyo [1], Jaesam Sim [1], Jongbaeg Kim [1]

[1] Yonsei University, Seoul/Republic of Korea

We have demonstrated an electrostatic torsional actuator with vertically aligned carbon nanotube (VACNT) arrays as interdigitated vertical comb structures. The torsional actuator was batch-fabricated on a silicon-on-insulator wafer, and the VACNT arrays were selectively synthesized on stator comb sets to create structural height mismatch between stator and rotor comb fingers. The robustness of the VACNT comb structures were verified throughout the long-term operation test of 4.4×10^7 cycles.

15:00

O-MEMS-24

Bio-inspired Multifunctional Nanostructured Surface

Hyungryul Choi [1], Kyoo-Chul Park [1], Chih-Hao Chang [1], Robert Cohen [1], Gareth McKinley [2], George Barbastathis [3]

[1] MIT, Cambridge/United States, [2] MIT, Acton/United States, [3] MIT, Boston/United States

We fabricate high aspect ratio (>5) nanocone structures possessing highly robust superhydrophobicity or enhanced structural superhydrophilicity, as well as broadband omnidirectional anti-reflectance, and near-lossless transparency. By texturing a square array of nanocones on both sides and modifying the surface energy of the substrate, we have shown that it is possible to combine multifucntionality on a single glass substrate: self-cleaning, anti-fogging, and anti-reflectivity (anti-glare).

O-LITH-30

Revisiting Maskless EUV Lithography as Moore's Law Meets NEMS

Yijian Chen [1]

[1] Peking University Shenzhen Graduate School, Shenzhen/China

We present an emerging research opportunity across two fields: IC and NEMS. It is shown the NEMS mirror based maskless approach is one path to cost-effective EUV lithography. Our research focus is to optimize the existing nanomirror process and scale down the mirror size from several ums to sub-um. The NEMS device scaling and fabrication results of high density vertical-comb actuation structures (tens-of-nm half pitch, defined by self-aligned double patterning) will be reported.

O-NANO-15

Electric field induced p-n tunnel junction in bilayer graphene

Hisao Miyazaki [1], Michael Lee [1], Song-Lin Li [1], Akinobu Kanda [2], Kazuhito Tsukagoshi [1]

[1] MANA, NIMS, Tsukuba/Japan, [2] Univ. of Tsukuba, Tsukuba/Japan

We report a fabrication and tunneling properties formed at p-n junction generated by gate electric field in bilayer graphene (BLG). To make the p-n junction we applied spatially modulated gate electric field using a stepped top gate structure. Band-gap is opened in the BLG under a high electric field, generating a insulating barrier at the p-n junction. A tunneling current tuned by the band gap opening was characterized for understanding the properties of band-gap in the in-plane system.

15:20

O-MEMS-25

Parallel Force Spectroscopy for Applications in Cell based R&D

Mélanie Favre [1], Gilles Weder [1], Joanna Bitterli [1], Réal Ischer [1], Sebastian Gautsch [2], André Meister [1], **Harry Heinzelmann** [1]

[1] CSEM SA, Neuchâtel/Switzerland, [2] EPFL, Neuchâtel/Switzerland

We report on the development of a parallel force spectroscopy setup, that allows to measure the mechanical properties and the adhesion properties of many different cells in parallel. This concept allows to measure the adhesion properties of e.g. cancerous cells as a function of the intercellular evironment, with sufficient statistics and in useful time frames for screening purposes. Details of the system are discussed and first results will be demonstrated.

O-LITH-31

A New Photolithography Technology for Large Area Photonic Patterning

Harun Solak [1]

[1] Eulitha AG, Villigen PSI/Switzerland

The recently introduced Displacement Talbot Lithography technique enables fabrication of photonic patterns such as 2D photonic crystals or linear gratings over large areas. Periodic patterns with feature sizes as small as 100nm are easily printed in a proximity photo-lithography setup that would ordinarily have a resolution of only about 1um. Potential applications include LED light extraction layers, wiregrid polarizers and nanostructured solar cell architectures.

O-NANO-16

Direct Sub-Micrometer Patterning of Bifunctional Organic Resists

Markus Kaiser [1], Alexander Kuehne [2], Andre Joppich [1], Jonas Kremer [1], Klaus Meerholz [1]

[1] University of Cologne; Departement of Chemistry, Cologne/Germany, [2] Harvard University, School of Engineering and Applied Sciences, Cambridge/United States

Very thin active layers used in organic solar cells (OSCs) show weak absorption. In organic lasing devices, the integration of an external resonator is necessary to supply feedback and amplify the flourescence by stimulated emission. Crosslinkable and functional organic materials allow for direct implementation of diffraction gratings in the thin organic devices to overcome these problems. In this work, this is done by means of electron beam lithography.

15:40

O-MEMS-26

Xerogel polymeric absorbance micro-filters for its integration into photonic lab-on-a-chip

Ester Carregal-Romero [1], César Fernández-Sánchez [1], Stefanie Demming [2], Stephanus Büttgenbach [2], Andreu Llobera [3]

[1] IMB-CNM (CSIC), Cerdanyola del Vallés/Spain, [2] Institut für Mikrotechnik, Technische Universität Braunschweig, Braunschweig/Germany, [3] Institut de Microelectrònica de Barcelona (IMB-CNM, CSIC), Bellaterra/Spain

This work reports on the design, fabrication and characterization of 128 different absorption micro-filters based on a xerogel-like hybrid organic-inorganic polymeric material doped with four different dyes. Filtering microstructures were fabricated in PDMS by standard master-replica molding. Filtering capacity as a function of dye concentration and filter width was studied and revealed a linear dependence with both parameters. Relatively sharp stop-band regions, from 50 to 80 nm, were achieved.

O-LITH-32

An Embedded Method using Physical Lithography Simulation for OPC and Verification on Full Chip Scale

Seongbo Shim [1]

[1] Samsung Electronics Co., Gyongi-Do, Hwasung-City/Republic of Korea

We have demonstrated the rigorous verification and OPC technology by embedding rigorous simulation into the verification and the OPC flow. We are able to overcome the inefficiently long TAT and greatly improve the detection accuracy of defects, which has been confirmed by wafer results. The integration of physical lithography simulation in OPC and verification flows slightly increases computation time, but significantly reduces the need for manual work and engineering time.

O-NANO-17

Fabrication of Silicon-based single spin quantum devices using Hydrogen silsesquioxane electron beam resist

Muhammad Khaled Husain [1], Yun Peng Lin [1], Feras Alkhalil [1], Harold Chong [2], Yoshishige Tsuchiya [1], Nicholas Lambert [3], Andrew Ferguson [3], Hiroshi Mizuta [4]

[1] University of Southampton, Southampton/United Kingdom, [2] Nano Research Group, Southampton/United Kingdom, [3] University of Cambridge, Cambridge/United Kingdom, [4] JAIST, Ishikawa/Japan

Electron spins in Si quantum dots provide an attractive alternative to GaAs conterparts for application in quantum information processing due to their much longer spin relaxation times. We realise a pair of Silicon-on-insulator-based double quantum dot transistors facing each other with only a 60 nm separation via electron beam lithography using high resolution HSQ resist. A VLSI compatible fabrication process is implemented allowing for future scalability in quantum systems.

16:00 – 16:30 Coffee

16:30 – 18:20

IMPRINT 3

Session Room: Plenary Hall C01

Session Chairs: Ran Liu, Fudan University – China; Hella C. Scheer, University of Wuppertal – Germany

CELL INTERFACES

Session Room: Hall 1 B08-B09

Session Chairs: Hubert Brückl, AIT ATn Institute of Technology – Austria; Leandro Lorenzelli, FBK – Centre for Materials and Microsystems (CMM) – Italy

MEMS/NEMS 2

Session Room: Hall 2 B05-B07

Session Chairs: Philip Prewett, University of Birmingham – United Kingdom; Sandra Wolff, TU Kaiserslautern – Germany

16:30

O-LITH-33

INVITED

Industrial Entry Points for UV Nanoimprint in Optical Applications

Christian Moormann [1], Namil Koo [1], Jung Wuk Kim [1], Ulrich Plachetka [1], Florian Schlachter [1], Christoph Nowak [1], Heinrich Kurz [1]

[1] AMO GmbH, Aachen/Germany

Nanoimprint Lithography offers a huge potential for applications where the unique properties of nanoimprint are an essential perquisite. We will give an overview on key entry points for industrial applications. Special emphasis will be put on novel concepts in imprint processing that might extend the range of possible application areas in optics beyond the current limitation given by thin film processing.

O-LIFE-16

INVITED

SERS Analysis On Exosomes Using Super Hydrophobic Surfaces

Luca Tirinato [1]

[1] University Magna Graecia Of Catanzaro, Catanzaro/Italy

Exosomes were analyzed exploiting the combined effects of micro textured, superhydrophobic surfaces (SHSs) and biophotonic devices. SHSs comprise a regular array or pattern of micro sized pillars, and, on account of these, the surfaces would exhibit an extremely low friction coefficient. If this active site is decorated with nano optics based structures, then Surface Enhanced Raman Scattering (SERS) are induced and few (at the limit a single) molecules can be recognized.

O-MEMS-27

INVITED

Micromachining of Scanning Probe Devices

Thomas Michels [1], Elshad Guliyev [1], Manuel Hofer [1], Ute Wenzel [1], Marcus Kästner [1], Michal Klukowski [1], Yanko Sarov [1], Tzvetan Ivanov [1], Burkhard Volland [1], Jens-Peter Zöllner [1], Ivo Rangelow [1]

[1] Ilmenau University of Technology, Ilmenau/Germany

The fast development of scanning probe techniques and their use as a tool in nanotechnology created a need for specialized tips and intelligent cantilevers. Based on MEMS technology we developed more then 30 different scanning probes. Here we will demonstrate high speed passive and active scanning probes. Theoretical calculations, finite element (FEM) simulation, and electrical measurements are done to characterize and optimize the mechanical as well as the thermal properties of the devices.

17:00

O-LITH-34

Characterisation of the Geometrical Properties of Multilayer Nano-Imprint-Lithography Molds for Optical Applications

Andreas Finn [1], René Hensel [2], Falk Hagemann [3], Robert Kirchner [4], Andreas Jahn [1], Wolf-Joachim Fischer [4]

[1] Institute of Semiconductors and Microsystems Technology, Dresden/Germany, [2] Leibniz Institute of Polymer Research Dresden, Dresden/Germany, [3] SAW components GmbH, Dresden/Germany, [4] Fraunhofer Institute for Photonic Microsystems, Dresden/Germany

A production method for multilayer Nano-Imprint-Lithography molds is shown in this paper. The molds consist of silicon due to its mechanical properties and processability. Wafer stepper exposure was used for lithography. 300 nm half-pitch structures with an aspect ratio of up to 5 have been patterned. Alignment accuracy, lateral und vertical resolution have been investigated. Polymer working stamps have been successfully casted from the master and consecutively imprinted into UV-curable resist.

O-LIFE-17

Growth and characterisation of carbon nanotube microelectrodes for neuronal recording

Boris Stamm [1], Kerstin Schneider [2], Thoralf Herrmann [1], Claus Burkhardt [1], Wilfried Nisch [1], Monika Fleischer [2], Dieter Kern [2], Alfred Stett [1]

[1] NMI Natural and Medical Sciences Institute at the University of Tuebingen, Reutlingen/Germany, [2] University of Tübingen/ Institute of Applied Physics, Tuebingen/Germany

Due to their outstanding properties like low interface impedance, high charge transfer capacity and chemical inertness, carbon nanotube (CNT) electrodes are of great interest for in vitro and in vivo neuronal applications. A new developed substrate system based on fused quartz and the integration of CNT-microelectrodes onto a regular array of 59 microelectrodes (MEA) and its characterisation and suitability test with dissociated cortical neurons from rats will be presented.

O-MEMS-28

Manufacturing of cavities with monocrystalline silicon membranes for pressure sensors using annealing forming gas procedures

Remigius Poloczek [1], Paul Filusch [1], Klaus Kallis [1]

[1] TU Dortmund, Dortmund/Germany

Based on silicon on insulator (SOI) substrate and annealing forming gas procedures, a new realization technology for sealed off cavities is presented. Instead of the conventional deposition and removing of a sacrificial silicon layer or a heated potassium hydroxide etching the buried oxide of a SOI substrate is removed through nanoscale holes in the silicon top layer which are closed afterwards by hydrogen annealing.

17:20

O-LITH-35

Roll 2 Roll imprint for light management structure used in printed electronics

Peter Giesen [1], Pascale Maury [2], Niki Stroeks [1], Sami Sabik [1], Merijn Wijnen [1], Iryna Yakimets [1], Stephan Harkema [1], Joris de Riet [1], Erwin Meinders [1]

[1] TNO – Holst Centre, Eindhoven/Netherlands, [2] ASML, Veldhoven/Netherlands

The market for printed electronics is growing. Applications like flexible displays, smart packaging, flexible OLED will hit the market in the coming years. A roll to roll imprint apparatus is developed to investigate the imprint process for printed electronics, including multi-level imprint technology to make functional structures in foil. The R2R imprint tool will be described in detail. Also the imprint concept and the latest results of light management structures will be presented.

O-LIFE-18

Elucidation of the role of carbon nanotubes patterns on the development of cultured neural cells

Amélie Béduer [1], Florent Seichepine [1], Emmanuel Flahaut [1], Christophe Vieu [1]

[1] LAAS-CNRS, Toulouse/France

In the area of biomaterials, nanoscale features are used to influence the growth of cells. Especially, carbon nanotubes (CNTs) appear to be excellent candidates for providing best coupling between artificial devices and neural tissues. However, the exact effect of CNTs on neurons is still unclear. We created CNTs micropatterns and observed a strong selective effect of the CNTs on neural cells influencing their morphology as well. We show that CNTs act as a sponge for culture medium components.

O-MEMS-29

Development of Silicon Electret Condenser Microphone with SiO2/Si3N4 electret

Masahide Goto [1], Kei Hagiwara [1], Toshifumi Tajima [1], Yoshinobu Yasuno [1], Hidekazu Kodama [1], Kenichi Kidokoro [1], Yoshinori Iguchi [1]

[1] NHK Science and Technology Research Laboratories, Tokyo/Japan

We developed a silicon electret condenser microphone (ECM) fabricated with the micro-electro-mechanical systems (MEMS) process. The ECM has a SiO2/Si3N4 inorganic electret on the backplate. We fabricated a prototype ECM operated at 3 V and confirmed a high sensitivity and wide frequency range. We also confirmed that the charged electret has excellent heat and humidity resistance. These results show that it is feasible to use such low-voltage high-performance ECM for a wide range of applications.

17:40

O-LITH-36

Stamp-and-Repeat UV-Imprinting of Spin-Coated Films: Pre-Exposure and Imprint Defects

Robert Kirchner [1], Lutz Nueske [1], Andreas Finn [2], Bo Lu [1], Wolf-Joachim Fischer [1]

[1] Fraunhofer Institute for Photonic Microsystems, Dresden/Germany, [2] Institute of Semiconductors and Microsystems Technology, Dresden/Germany

Stamp-and-repeat UV-nanoimprint lithography (SR-UV-NIL) ensures homogeneous residual layers by repeating a single imprint mold step-by-step over a substrate and does not require a layout dependent resist dispense-pattern optimization. SR-UV-NIL in spin-coated films revealed a clear influence of adjacent imprint sites due to UV-pre-exposure. Lower imprint-site densities ensured successful imprints. Imprints on thick spin-coated films had a higher yield than imprints on dispensed resist patterns.

O-LIFE-19

Micro-beams with tunable stiffness and curvature for mechano-sensitive cell culture substrates

Mattia Marelli [1], Neha Gadhari [1], Matthias Chiquet [1], Jürgen Brugger [1]

[1] EPFL, Lausanne/Switzerland

We present the complete fabrication of 3D microenvironments for single-cell culture. They are based on SiO2 cantilevers bending out-of-plane with radii as small as 20 um. By engineering the intrinsic stress of SiO2 thin films, we were able to tune the radii and the spring constant of cantilevers. Moreover micrometric Au dots were deposited onto the cantilevers, and functionalized in order to localize focal adhesions (FA). Mouse fibroblasts were finally cultured and developed FAs on Au dots only.

O-MEMS-30

Thick Silicon-On-Insulation Vibrating Body FET Resonator

Marion Hermersdorf [1]

[1] EPFL, Lausanne/Switzerland

This work reports of a flexural mode vibrating body field effect transistor (VB-FET) resonator designed for a fundamental frequency of about 2.2MHz. The resonator is implemented in thick silicon-on-substrate (SOI) with a 3um device layer. The fabrication challenge was the submicron wide gap at the gate for improving the device performance. Characterization of the resonator in the frequency domain showed a quality factor of more than 10000.

18:00

O-LITH-37

Nanoimprinted complementary organic inverters and self-aligned transistors

Thomas Rothländer [1], Ursula Palfinger [1], Barbara Stadlober [1], Christoph Auner [1], Anja Haase [1], Herbert Gold [1], Thomas Haber [2], Meltem Sezen [2], Werner Grogger [2], Gerhard Domann [3], Christian Palfinger [1], Johanna Kraxner [1], Georg Jakopic [1], Paul Hartmann [1]

[1] Joanneum Research Forschungsgesellschaft mbH/MATERIALS, Weiz/Austria, [2] Institute for Electron Microscopy, Graz University of Technology, Graz/Austria, [3] Fraunhofer-Institut für Silicatforschung ISC, Würzburg/Germany

Organic electronics has received considerable attention during the last decades. For future applications on the market, high switching speeds are essential, which can only be achieved by reducing the transistor dimensions to the nanometer regime. We report flexible, complementary organic inverters with transistor channel lengths of 900 nm fabricated by NIL. We also propose a r2r compatible NIL self-alignment process, resulting in p-type and n-type transistors with switching speeds up to 400 kHz.

O-LIFE-20

Water soluble nanosponges for drug delivery and molecular sieving applications

Francesco de Angelis [1]

[1] Istituto Italiano di Tecnologia, Genova/Italy

We propose a biodegradable nanoporous nanoparticle as an efficient tool for drug delivery and molecular sieving applications. The nanoparticles have a controllable diameter in the range from 30 to 500 nm and internal porous structures of 2-5 nm. They are obtained from a porous silicon film by means of ultrasonication. Through a set of experiments we show that the proposed nanosponges exhibit many appealing properties such as biodegradability (in water), high payload, and multivalent loading.

O-MEMS-31

Fabrication of Au Nano-Aperture on the Pyramid Using Electron Beam Exposure

Seong Soo Choi [1], Tokutaro Yamaguchi [1], Myoung Jin Park [2]

[1] SunMoon University, Ahsan/Republic of Korea, [2] Korea Military Academy, Seoul/Republic of Korea

A plasmonic probe on the apex of a pyramidal array with ~2.4 nm diameter is microfabricated to control speed of DNA translocation with optical force. The nanoflowered Au probe with a 15 nm diameter was reduced to ~ 2.4 nm diameter using electron beam annealing. Optical measurments presents the exceptional transmission, which can be utilized as single molecule translocation and characterization device.

Friday 23 September

mne BERLIN 2011

08:30 – 10:20

MICROFLUIDICS 2

Session Room: Plenary Hall C01

Session Chairs: Allwyn Boustheen, Eindhoven university of technology – Netherlands; Olivier Fuchs, CEA-Leti Minatec – France

METROLOGY

Session Room: Hall 1 B08-B09

Session Chairs: Hiroyuki Ito, Hitachi High-Technologies Corporation, Japan; Urs Staufer, Delft University of Technology – Netherlands

PLASMONICS

Session Room: Hall 2 B05-B07

Session Chairs: Annamaria Gerardino, CNR-IFN, Rome – Italy; Manfred Kohl, Karlsruhe Institute of Technology, Karlsruhe – Germany

08:30

O-LIFE-21

INVITED

Remotely powered floating microswimmers as colloidal microparticle manipulators

Gilgueng Hwang [1], Ioan Alexandru Ivan [2], Joël Agnus [2], Micky Rakotondrabe [2], Edgar Leon Perez [1], Stamboul Myriam [1], Hugo Salmon [3], Sinan Haliyo [3], Nicolas Chaillet [2], Stéphane Régnier [3], Ane-Marie Haghiri-Gosnet [1]

[1] LPN-CNRS, Marcoussis/France, [2] FEMTO-ST, Besancon/France, [3] ISIR-UPMC, Paris/France

Remote propulsion of microswimmers has great potential as wireless manipulation tools for smaller scale objects. In this paper, the propulsion of floating microswimmers is proposed to demonstrate the cargo transport of colloidal micro particles. These floating mobile microswimmers are advantageous because they can trap and release the massive amounts of colloidal particles in parallel. Therefore the proposed microswimmers can be applied to long distance wireless liquid manipulation tools.

O-MEMS-32

INVITED

Imaging and analysis with the Helium ion microscope

Peter Gnauck [1], Diederik Maas [2], Emile van Veldhoven [2]

[1] Carl Zeiss NTS, Oberkochen/Germany, [2] TNO Science and Industry, Delft/Netherlands

A new microscope has been developed that uses a beam of helium ions which is focused and scanned across the sample. The helium ion source offers high brightness and a small energy spread, and hence allows the beam to be focused into very small probe sizes. The helium beam generates secondary electrons, backscattered helium, and other detectable particles from which high resolution images can be generated or analysis can be performed.

O-PHOT-07

INVITED

Hyperspectral Nanoscale Imaging with optical antennae on Scanning Probe Tips

Alexander Weber-Bargioni [1], Wei Bao [1], Francesca Intonti [2], Vito Matarazzo [2], Francesco Riboli [2], Diederik Wiersma [2], P. James Schuck [1], Stefano Cabrini [1]

[1] Molecular Foundry, Lawrence Berkeley National Lab, Berkeley/United States, [2] LENS, Sesto Fiorentino (FI)/Italy

Imaging matter optically with a spatial resolution below 20nm enables unique insights into material properties. We use various coupled optical antennae geometries, fabricated reproducibly on Scanning Probe Tip apexes to investigate matter optically via hyperspectral Raman and photo luminescence spectroscopy. Our novel bell tower like “campanile” tip geometry allows the exciting and collecting through the optical fiber with high efficiency, precluding the need for a transparent substrate.

09:00

O-LIFE-22

A nanoreactor for dielectrophoretic manipulation and imaging in a SEM

Sander den Hoedt [1], Daan van Oosten Slingeland [1], Nalan Liv [1], Christiaan Zonnevylle [1], Vladimir Kutchoukov [1], Carel Heerkens [1], Pieter Kruit [1], **Jacob Hoogenboom** [1]

[1] Delft University of Technology, Delft/Netherlands

The use of thin electron-transparent membranes has enabled electron microscopy of nanoparticles and biological cells in a liquid environment. We present a liquid enclosure wherein the membrane is patterned with electrodes that allow us to guide suspended materials to the membrane by dielectrophoresis. We demonstrate trapping and SEM imaging of silica particles in water. Microfluidics is presented for connecting the nanobioreactor to several reservoirs outside the SEM vacuum chamber.

O-MEMS-33

Development of Charge-up Measurement Method using Mirror Electrons for Scanning Electron Microscope

Minoru Yamazaki [1]

[1] Hitachi High-technologies corp., Hitachinaka Ibaraki/Japan

SEM (Scanning Electron Microscope) is widely used as an in-situ measurement/inspection apparatus for nano devices. However, in case of observing an insulator specimen such as photoresist, charge-up in specimen occures and causes SEM image distortion, image drift, defocus and so on. Therefore, we thought it is important to measure charge-up voltage and control it. In this work, we developed a charge-up measurement method using mirror electrons, which doesn't affect charge-up state.

O-PHOT-08

Ultra-High-Enhancement and Wafer-Scale Uniform Plasmonic Sensors Using Fully Optimized Designs and Fabrication of Nanoimprint, Self-Assembly, and Self-Alignment

Stephen Chou [1]

[1] Princeton University, Princeton/United States

Here we present a new SERS architecture and a new nanofabrication method that have solved both problems and can significantly improve other plasmonic systems design, fabrication and performances.

09:20

O-LIFE-23

Three-dimensional cellular focusing utilizing negative dielectrophoretic force generated by insulating microstructures

Ching-Te Huang [1], Cheng-Hsin Weng [1], **Chun-Ping Jen** [1]

[1] Department of Mechanical Engineering, National Chung Cheng University, Chia-Yi/Taiwan

The main purpose of this paper was to design microdevices with 3D focusing of cells by employing combination of insulator-based and metallic dielectrophoresis. The dielectrophoretic force was employed to confine the cells. Four insulating structures squeezed the electric field in a conducting solution to generate high-electric-field regions. The electrodes were designed as three different patterns: planar, dual-planar and 3D electrodes. The 3D focusing was also successfully achieved.

O-MEMS-34

TiN scanning probes for electrical profiling of nanoelectronics device structures

Thomas Hantschel [1], Andreas Schulze [1], Umberto Celano [1], Kai Arstila [1], Pierre Eyben [1], Bivragh Majeed [1], Deniz Tezcan [1], Cindy Demeulemeester [1], Wilfried Vandervorst [1]

[1] Imec, Leuven/Belgium

TiN scanning probe tips are demonstrated for nanoscopic electrical measurements using atomic force microscopy (AFM) methods such as scanning spreading resistance microscopy (SSRM) and conductive AFM (c-AFM). The TiN tips are fixed to Ni cantilevers and are made in 200-mm Si wafer technology. We show SSRM (e. g. Ge staircase structures, carbon nanotube (CNT) interconnects structures, III-V) and c-AFM (e. g. high-k oxides) measurements.

O-PHOT-09

Fabrication and characterization of plasmonic structures with sub-10-nm gaps

Huigao Duan [1], Michel Bosman [1], Karthik Kumar [1], Joel Yang [1]

[1] Insitute of Materials Research and Engineering, A*STAR, Singapore/Singapore

Nanoscale gaps between metal structures are of great interest because of the strong electric fields generated in the gap region due to the excited surface plasmons. In this work, we present several methods based on high-resolution electron-beam lithography to fabricate plasmonic structures with sub-10-nm gaps reliably. With the structures that we fabricated, we systematically studied the plasmon resonance behavior of gold nanostructures at the sub-10-nm scale.

09:40

O-LIFE-24

Fabrication of 30 nm nanochannels integrated with bowtie nanoantenna

Irene Fernández-Cuesta [1], Anna Laura Palmarelli [2], Xiaogan Liang [2], Scott Dhuey [2], Deirdre Olynick [2], Gabi Grützner [3], Stefano Cabrini [2]

[1] Technical University of Denmark, Copenhaguen/Denmark, [2] Lawrence Berkeley Lab/The Molecular Foundry, Berkeley/United States, [3] micro resist technology GmbH, Berlin/Germany

We present a fabrication approach, for the fabrication of micro and nano (30 nm) fluidic channels. The process is based on UV-NIL, and the multilevel 3D device is defined by just one single step. We also fabricate gold bowtie nanoantenna aligned to match the antenna gap with the nanochannel, by focused electron beam mask induced deposition and sputtering. We will show flow test and the potential use for biosensing.

O-MEMS-35

Quantification of Order in Self-Assembled Block Co-Polymer Films

Timothy Kehoe [1], Nikolaos Kehagias [1], Dipu Borah [2], Michael Morris [2], Worawut Khunsin [3], Andreas Amann [4], Clivia Sotomayor Torres [1]

[1] Catalan Institute of Nanotechnology, Bellaterra/Spain, [2] University College Cork, Cork/Ireland, [3] Max-Planck-Institut für Festkörperforschung, Stuttgart/Germany, [4] Tyndall National Institute, Cork/Ireland

Self-assembly of block copolymers has been used to form periodic arrays on the scale of 5 – 50 nm. There is a lack of metrology techniques which are capable of quantifying the order of assembled structures, thereby enabling reliable comparisons between different processes and alignment methods. We demonstrate the use of an image analysis technique to quantify order in hexagonal arrays of block copolymers, based on a statistical summation of all correctly positioned elements in an AFM image.

O-PHOT-10

Elucidating effects of nanoscale structural variations on local plasmonic modes via photon localization microscopy

Alex McLeod [1], Alexander Weber-Bargioni [1], Zhaoyu Zhang [1], Scott Dhuey [1], Bruce Harteneck [1], Jeffrey Neaton [1], Stefano Cabrini [1], **P. James Schuck** [1]

[1] Molecular Foundry, Lawrence Berkeley National Lab, Berkeley/United States

Using the non-perturbative superresolution capabilities of photon localization microscopy, it is observed that localized modes in plasmonic devices are significantly impacted by small structural variations on the nanometer scale. This is important because many such devices are now engineered to concentrate light down to ~ 10 nm length scales, but fabrication and placement limitations at the same scale are currently unavoidable, thus restricting application.

10:00

O-LIFE-25

Injection molded device with nanoslits for the elongation of dsDNA

Peter Friis Østergaard [1], Marco Matteucci [1], Anders Kristensen [2], Rafael Josef Taboryski [1], Rodolphe Marie [3]

[1] DTU-Nanotech, Kongens Lyngby/Denmark, [2] DTU Nanotech, Copenhagen/Denmark, [3] Technical University of Denmark, Kongens Lyngby/Denmark

Single use systems for elongation of dsDNA in 100nm tall nanoslits are produced as cheap, all polymer devices in an injection molder. To produce the injection molded parts, a nickel shim is fabricated through a series of standard LIGA processes. The process can easily be transferred to commercial industries, where large scale production is performed. The sealing of the system through plasma enhanced thermal bonding is investigated in order to ensure the functionality of the systems.

O-MEMS-36

FIB milling characterization of nanoporous materials

Sahand Chitsaz Charandabi [1], Hossein Ostadi [1], Aydin Sabouri [1], Carl Anthony [1], Philip D Prewett [1]

[1] The University of Birmingham, Birmingham/United Kingdom

This paper reports a study of the FIB sputtering yield of Ga+ on nanoporous CL based on analytical calculations, simulation and SEM stereo imaging experiments.

O-PHOT-11

Fabrication and characterization of nanoantenna-ehnanced Raman Scattering device for ultrasensitive spectroscopic applications

Andrea Toma [1], Gobind Das [1], Anwer Saeed [1], Remo Proietti [1], Luca Razzari [1], Marco Leoncini [1], Carlo Liberale [1], Francesco de Angelis [1], Enzo Di Fabrizio [1]

[1] Italian Institute of Technology, Genova/Italy

We report on the fabrication, by means of Electron Beam Lithography, of laterally ordered arrays of gold nanoantennas supported on dielectric substrates. A tunable near-field interparticle coupling has been demonstrated exploring different geometrical configurations (i.e. dimers, long-chains, radial arrays). The localization and amplification of electromagnetic fields in the close proximity of the nanoantenna gaps has been assessed by means of Raman-active molecular vibrations.

10:20 – 10:50 Coffee

10:50 – 13:00

NOVEL FABRICATON 2

Session Room: Plenary Hall C01

Session Chairs: Shinji Matsui, University of Hyogo – Japan; Andris Šternberg, University of Latvia – Latvia

BEAMS 2

Session Room: Hall 1 B08-B09

Session Chairs: Lars Bruchhaus, Raith GmbH – Germany; Ralf Steingrüber, Fraunhofer-Institute for Telecommunications – Germany

BIOMEMS 2

Session Room: Hall 2 B05-B07

Session Chairs: Zoran Djuric , IHTM – Institute for Chemistry, Technology and Metallurgy, Belgrade – Serbia; Dan Nicolau, University of Liverpool – United Kingdom

10:50

O-NANO-18

INVITED

Vertically-Stacked Si Nanowire FETs with sub-µm Gate-All-Around polysilicon gates patterned by nanostencil lithography

Davide Sacchetto [1], Shenqi Xie [1], Veronica Savu [1], Michael Zervas [1], Giovanni De Micheli [1], Jürgen Brugger [1], Yusuf Leblebici [1]

[1] Ecole Polytechnique Federale de Lausanne, Lausanne/Switzerland

We report on the fabrication of vertically-stacked SiNW GAA FETs by means of DRIE and nanostencil lithography. The nanostencil is used to form sub-µm GAA gates over NW arrays channels. Electrical measurements confirm the results obtained from similar devices fabricated with a standard lithography method while achieving higher density, larger reproducibility and yield, maintaining the performance improvement related with scaling.

O-LITH-38

INVITED

Direct Write 3-Dimensional Nanopatterning Using Probes

Michel Despont [1], Armin Knoll [2], Philip Paul [2], Urs Duerig [2], Felix Holzner [2], James Hedrick [3]

[1] IBM Research Laboratory, Rueschlikon/Switzerland, [2] IBM Research, Zürich/Switzerland, [3] IBM Research – Almaden/United States

A novel probe patterning method based on the local evaporation of organic resist materials has been developed. A three dimensional relief pattern is written directly into the resist without the need for a development step. 15nm resolution and 2µs per pixel patterning speed have been achieved. The structuring capability in the third dimension adds an entirely new feature to the lithography landscape enabling, for example, template designs featuring shape recognition properties for self assembly.

O-LIFE-26

INVITED

FIB carving of nanopores into suspended monolayer graphene films

Jacques Gierak [1], Alan Morin [1], Gilles Patriarche [1], Eric Bourhis [1], Ali Madouri [1], Juan Pelta [2], Loic Auvray [3], Ralf Jede [4], Lars Bruchhaus [4]

[1] LPN-CNRS, Marcoussis/France, [2] LAMBE, Evry/France, [3] Matière et Systèmes Complexes, UMR 7057, Paris/France, [4] Raith GmbH, Dortmund/Germany

We investigate the potential of a highly focused beam of gallium ions for drilling nanopores into suspended monolayer graphene films. We detail our methodology for preparing, manipulating and finally engraving nanometer-sized holes in a graphene monolayer exfoliated from natural HOPG. FIB fabricated graphene nanopores having diameters about 10 nm are presented. Minimum sizes were obtained for a surprisingly high dose of about 105 ions we will discuss.

11:20

O-NANO-19

Lithography-Free Fabrication of Single Crystalline Silicon Tubular Nanostructures on Wafer-Scale

Hak-kyun Jung [1], Hyungjoo Na [1], Min-Ook Kim [1], Dae-sung Kwon [1], Jeong-Jin Kang [2], Jongbaeg Kim [1]

[1] Yonsei University, Seoul/Republic of Korea, [2] Korea Institute of Industrial Technology, Gyeonggi-do/Republic of Korea

A novel method to fabricate vertically arranged single-crystalline silicon tubular nanostructures on wafer-scale have been developed utilizing the etching selectivity between silicon substrate, metal mask and silicide layer. This is cost effective and facile process without the necessity of nanopatterning. The typical dimension of fabricated tubular nanostructures is in the range of 1 µm in length, 300 nm in diameter, 100 nm in wall-thickness and 350 nm in hollow-depth.

O-LITH-39

Scanning Probe Nanolithography on ultra-thin Calixarene-based Molecular Resist

Marcus Kaestner [1], Ivo W. Rangelow [1]

[1] Ilmenau, University of Technology, Ilmenau/Germany

Within this study we have demonstrated a novel maskless nanoscale lithography method based on patterning of a ultra-thin sub-10nm spin-coated molecular resist material, especially calix[4]resorcinarene, by spatially extreme confined electric-field-induced interactions. The high, nonuniform electric fields created between biased nanoprobe and sample leads to a localized Fowler-Nordheim current and in-situ remova /extraction of resist material, whereby no additional development steps are required.

O-LIFE-27

Gold nanoparticles by soft UVNIL technology for ultrasensitive biochemical sensing based on surface enhanced spectroscopy (SERS)

Nathalie Lidgi-Guigui [1], Frederic Hamouda [2], Maximilien Cottat [3], Philippe Gogol [1], Abdelhanin Aassim [1], Marie-Paule Planté [2], Jean-Michel Lourtioz [2], Bernard Bartenlian [2], Marc Lamy de la Chapelle [1]

[1] CNRS – University Paris 13, Bobigny/France, [2] Univ. Paris Sud, Orsay/France, [3] CNRS, Orsay/France

We propose to exploit soft UVNIL lithography for the development of reproducible, large-size highly-sensitive substrates for Surface Enhanced Raman Scattering (SERS) detection. The technique has been proved to be a very effective molecules analytical tool. We describe the nanodisks fabrication root as well as their functionnalization with biotin molecules. Eventually, we discuss the detection of avidin in SERS experiments.

11:40

O-NANO-20

Top down fabricated silicon nanowire networks for thermoelectric applications

Massimo Totaro [1], Giovanni Pennelli [1], Paolo Bruschi [1]

[1] University of Pisa, Pisa/Italy

SiNWs shows very interesting thermoelectric properties. However, for a practical employment of SiNW based thermoelectric generators a technique for a massive production of very long SiNWs must be developed. This work shows a top down technique for the fabrication of a well organized network of SiNWs. The very reliable network is composed by a large amount (10^5 SiNWs per mm^2) of narrow SiNWs and it is equivalent to many parallel, millimeter long, SiNWs. Electrical characterization is reported.

O-LITH-40

Optimization of the 3D Proximity Effect Correction Algorithms for the Grayscale Electron Beam Lithography

Vitaliy A. Guzenko [1], Nikola Belic [2], Christoph Sambale [2], Arne Schleunitz [1], Christian David [1]

[1] Paul Scherrer Institut, Villigen PSI/Switzerland, [2] GenISys GmbH, Taufkirchen/Germany

The resist development is an isotropic etching process. The lateral development at the border between the regions with different development rates is not taken into account at the 3D PEC algorithm. As a result, deviations of the critical dimensions of the 3D structures are observed. In this work, the 3D PEC was extended to correct for the "lateral development effect" by simultaneously optimizing both the exposure dose and the structure size, or by inserting gaps acting as development stoppers.

O-LIFE-28

Tailored Ag Nanoparticles/Nanoporous Superhydrophobic Surfaces Hybrid Devices for the Detection of Single Molecules

Francesco Gentile [1], Maria Laura Coluccio [1], Angelo Accardo [2], Giovanni Marinaro [3], Eliana Rondanina [1], Stefania Santoriello [1], Andrea Toma [1], **Francesco de Angelis** [1], Luca Tirinato [3], Gerardo Perozziello [3], Patrizio Candeloro [3], Enzo Di Fabrizio [1]

[1] Italian Institute of Technology, Genova/Italy, [2] ESRF, Grenoble/France, [3] BioNEM – University Magna Graecia (Cz), Catanzaro/Italy

Here, a novel, hierarchical platform integrates three different structures into one, that are, (i) a superhydrophobic surface; (ii) a NPSi film and (iii) a randomly distributed cluster of silver nanoparticles that partially loads the nanopores. The combination of these units would allow the concentration, harvesting and SERS detection of few molecules with unprecedented accuracy.

12:00

O-NANO-21

Using intruded gold nanoclusters as highly active catalysts to fabricate silicon nanostalactite structures exhibiting excellent field emission property

Shao-Chin Tseng [1]

[1] National Taiwan University/Department of Materials Science and Engineering, Taipei/Taiwan

In this study, we employed the intruded Au nanocluster (INC) technique to prepare highly uniform, "atomic-scale" Au nanoclusters as highly active catalysts within Si wafers. Employing the Au nanoclusters allowed us to prepare, unique Si nano-stalactite (SNS) structures possessed superior light trapping capability and excellent field emission property.

O-LITH-41

Development behavior of hydrogen silsesquioxane resist at sub-5-nm length scales

Huigao Duan [1], Vitor Manfrinato [2], Karl K. Berggren [2], Joel Yang [1]

[1] Insitute of Materials Research and Engineering, A*STAR, Singapore/Singapore, [2] MIT, Cambridge/United States

In this work, we studied the development behavior of hydrogen silsesquioxane resist at the sub-5-nm length scales. We found that the resolution of HSQ is limited to ~ 9-nm pitch (4.5 nm half pitch), regardless of the broad range of process parameters and EBL systems investigated. However, for sparse HSQ structures, we could obtain sub-2-nm features. We used an "aggregation" concept to understand the development behavior at this scale length.

O-LIFE-29

Automated nanoimprint lithography of transmission-mode SPR structures on plastic substrates

Keith Morton [1]

[1] National Research Council Canada, Boucherville/Canada

We show automated, cassette to cassette, fabrication of nanostructures on plastic for transmission-mode SPR applications. Functional topologies were fabricated simply, by direct-imprint, using working stamps to emboss low-cost, all-polymer substrates. When gold coated, the tailored nanostructures show sensitivity to bulk refractive index change and protein surface binding

12:20

O-NANO-22

Nanostructured Silicon for Ge Nanoheteroepitaxy

Joachim Bauer [1]

[1] IHP, Frankfurt (Oder)/Germany

Selective epitaxial growth of Ge on Si has a high potential for electronic, optoelectronic and photovoltaic applications. The main difficulty with Ge heteroepitaxy on Si is the lattice mismatch of 4.2 % which results in misfit dislocations (MD). The MDs can be reduced by introducing elastic deformation in Si using nanoheteroepitaxy. In this work, a fabrication process was developed for Si nanopillars to realize Si NPs with <100 nm width and >100 nm height as template for Ge heteroepitaxy.

O-LITH-42

Recent progress in Tip-based Nanolithography: Nanoengineering for optics, advanced materials, biosensors and cell biology

Robert Stokes [1]

[1] Nanoink Inc., Skokie/United States

Recent advances in tip-based nanolithography has resulted in the ability to directly print biologically relevant materials, including proteins and DNA, on to a variety of surfaces under ambient conditions. This has great potential for utilization in the fields of cell biology and biosensors. The same direct deposition methodology has opened up many potential applications in nanochemistry, nanofabrication, advanced optical and electronic materials. Recent progress will be presented in each area.

O-LIFE-30

On-chip vacuum generation by phase transition in micro chamber

Kiyotaka Sugiyama [1]

[1] Japan Advanced Institute of Science and Technology, Nomi/United Kingdom

We propose on-chip vacuum generation system using gas-liquid phase transition of filled fluids in micro chamber to develop miniaturized mass spectrometer. We investigated the dependence of pressure on material of fluids and the effect of degassing in the chamber. This micro vacuum pump performed that the lowest pressure reached at 8.5kPa from atmospheric pressure. Vacuum less than 10kPa was maintained about 10 minutes.

12:40

O-NANO-23

Wafer scale integration of carbon nanotubes interconnections and carbon NEMS using a combination of dielectrophoresis and capillary assembly

Florent Seichepine [1], Christophe Vieu [1], Emmanuel Flahaut [1], Liviu Nicu [1], Sven Salomon [1], Maeva Collet [1]

[1] CNRS LAAS/CIRIMAT, Toulouse/France

We propose a versatile way to integrate dense layers of oriented carbon nanotubes (CNT) at the wafer scale using buried electrode dielectrophoresis (DEP) coupled to capillary assembly (CA). The CNT are concentrated on the deposition sites by controlling the CA and DEP is used to align them. This technique create dense CNT deposition independent from the DEP electrodes. CNT layers are then connected using a metalization step. With this process we realized an array of suspended, oriented CNT NEMS.

O-LITH-43

Challenges on Electron-Beam Lithography for Future Application Requirements

Ines Stolberg [1]

[1] Vistec Electron Beam Lithography Group, Jena/Germany

The paper will discuss application demands and how they can be transformed into modifications on the electron-beam equipment side. Optical application requirements and semiconductor industry demands will be exemplarily discussed in more detail. Today massively parallel e-beam lithography concepts are under investigation worldwide. Vistec's Multi Shaped Beam (MSB) approach as one of the promising potential candidates will be described and some lithography performance results presented.

O-LIFE-31

Nanoscale thermal time of flight sensors

Klaus Kallis [1], **Vadim Valentinovic Vendt** [1], Christian Küchenmeister [1], Horst Fiedler [1]

[1] TU Dortmund, Dortmund/Germany

A new developed sensor that consists of a symmetric phalanx of four nanoscale pn-junctions and one heating filament for a thermal time of flight detection is presented. Shrinking the pn-junctions to nanoscale dimensions minimises the dissipated heat. This allows the detection of flow rates in critical fluids like explosives or in medical environments. The sensor concept is introduced, SEM-micrographs are presented, the electrical and thermal characteristics of the sensor are discussed.

13:00 – 13:10 The End