Plenary Session
Wednesday, June 1, 2016
Room: Kings Garden 4/5

Session Chairs:
John Hartley, Nuflare, Conference Chair
Pat Watson, Princeton University, Program Chair

8:15 am - 8:35 am **Welcome** John Hartley, Nuflare

8:35 am - 9:20 am **Plenary-1**
Puzzles and Promises in Nanoscale Biology, R. H. Austin, Princeton University

Understanding how biopolymers such as DNA function at the nanoscale is a task for nanotechnology and the tools of a great mix of disciplines. Interesting new phenomena have emerged at the nanoscale that require re-thinking how we look at both biopolymer dynamics and the flow of liquids at the nanoscale. I'll go over both experiments and how we model these phenomena.

9:20 am - 10:05 am **Plenary-2**
Exploring the Universe with Superconducting Detectors, Jonas Zmuidzinas, Caltech

It is not widely appreciated that superconducting detectors are the enabling technology for the world's largest single investment in ground-based astronomy: the ALMA project. This presentation will sketch the history of superconducting detectors, describe their present use and recent developments, and illustrate the future potential for this technology.

10:05 am - 10:50 am **Plenary-3**
Imaging the Dust of Elementary Particles, Sensors and Detectors for the nano-nano-world, Alessandro Marchioro, CERN

Understanding the most basic properties of the tiniest constituents of matter and the laws governing their interactions, i.e. by definition the "elementary particles", requires physicists to conceive, design and operate huge and highly complex scientific instruments. This talk will address and try to explain the apparent contradiction of this statement.

Session 1A - Advanced Etching Techniques 1
Wednesday, June 1, 2016
Room: Kings Garden 3

Session Chairs:
Deirdre Olynick, Lawrence Berkeley National Laboratory
Mark Horn, Pennsylvania State University

1:15 pm - 1:45 pm **1A1 Invited**

Catalyst motion in Metal-assisted Chemical Etching, Owen Hildreth, SEMTE, Arizona State University

Complex 3D geometry can be etched in silicon using Metal-assisted Chemical Etching (MacEtch) by properly controlling catalyst shape, understanding the mechanisms driving catalyst motion, accounting for diffusion timescales, and controlling hole (h+) distribution. This seminar details how to fabricate 2D and 3D geometry using MacEtch.

1:45 pm - 2:05 pm 1A2
Fabrication of High Resolution Zone Plates with High Aspect Ratio using Metal-assisted Chemical Etching, K. Li, M. Wojcik*, C. Jacobsen*, R. Divan*, L. Ocola*, B. Shi*, D. Rosenmann*, Northwestern University, *Argonne National Lab

We describe a metal assisted chemical etching process for fabricating zone plates with high absolute efficiency and fine spatial resolution. The process involves e-beam lithography, metal deposition and lift-off and DRIE to thin the wafer substrate to about 15um. We are now adding ALD process to make zone-doubled zone plates.

2:05 pm - 2:25 pm 1A3
Bio-inspired Silicon Nanospikes Fabricated by Metal-Assisted Chemical Etching for Antibacterial Applications, H. Hu, S. M. Gifford, P. Meyer, G. A. Stolovitzky, IBM T. J. Watson Research Center

We present the results of efficient killing of the bacteria E. coli on silicon nanospike surfaces fabricated using a low-cost metal-assisted chemical etching (MacEtch) approach. We discovered the influence of etching time on the morphology of the silicon nanospikes as well as on bactericidal effects.

2:25 pm - 2:45 pm 1A4
Silicon nanowire and hole arrays by a combination of self-assembly, laser ablation, and wet chemical etching, D. Brodoceanu, T. Kraus, R. Elnathan*, N.H. Voelcker*, INM–Leibniz Institute for New Materials, Saarbrücken, *University of South Australia, Adelaide

We present two unconventional particle-based routes for the fabrication of arrays of vertically-aligned nanowires and arrays of well-defined pores with tunable feature sizes on silicon wafers, by a combination of self-assembly, laser ablation, and metal-assisted chemical etching.

2:45 pm - 3:15 pm 1A5 Invited
Overview of Atomic Layer Etching – From the Ion Beam Perspective, L. Berry, T. Lill, K. J. Kanarik, S. Tan, M. Shen, E. A. Hudson, Lam Research Corporation

In 1959 Feynman pondered about a world where we can “arrange the atoms one by one the way we want them”. Atomic Layer Etch (ALE) combined with ALD enables device manufacturing with near atomic precision. This talk will review current ALE technology, and since this is a Beams conference, address ALE from a beams perspective

Session 1B - Optical and EUV Lithography
Wednesday, June 1, 2016
Room: Kings Garden 4

Session Chairs:
Shane Palmer, Nikon Research Corp. of America
Mark Schattenberg, Massachusetts Institute of Technology

1:15 pm - 1:45 pm 1B1 Invited
Forecasting Optical Lithography - A Fool’s Errand !, D Flagello, Nikon Research Corporation of America

This talk will examine some of the history of technology prediction with an attempt to forecast the future possibilities and scenarios in optical lithography. We will discuss the potential innovations and ideas that may carry us into the future, with a specific concentration on manufacturing possibilities.

1:45 pm - 2:05 pm 1B2
A comparative study of resists and lithographic tools using Lumped Parameter Model, R. Fallica, Y. Ekinci, Paul Scherrer Institute

We present a numerical implementation of the exact Lumped Parameters Model. In addition, a least square fit to experimental CD vs. Dose data (obtained from conventional optical lithography, interference optical lithography, e-beam and ion beam processes carried out on HSQ, PMMA and other resists) is used to validate our model.

2:05 pm - 2:25 pm 1B3
Study on the Dose Performance of EUV Lithography Scanner Using Novel In-wafer Dose Measurement, Jinseok Heo, Insung Kim and Sungsue Kim,Samsung Electronics

In this paper, the dose performance of high-end EUV scanner (ASML NXE 3300) will be analyzed using the novel in-wafer exposure energy measurement and the detailed experimental analysis of dose performance in the EUV scanner will be also discussed.

2:25 pm - 2:45 pm 1B4
Biases in the use of height-to-height correlation to characterize roughness, Chris A. Mack, Lithoguru.com

While previous studies have examined systematic biases in the measurement of power spectral density (PSD) for rough surfaces/features, this paper will explore biases found in the measurement of the height-to-height correlation function (HHCF). Comparison to PSD measurements will be made, and recommendations for best use of HHCF will be given.

2:45 pm - 3:15 pm 1B5 Invited
EUV Lithography for Advanced Nodes, Nicole Saulnier, IBM Research

After more than two decades of fundamental research and development, Extreme Ultraviolet (EUV) lithography is slated to enter the IC manufacturing flow for critical levels in advanced nodes. This talk will focus on advances in the areas of resist materials and computational lithography towards enabling a manufacturable EUV solution.

Session 1C - Nanofabrication and Biology 1
Wednesday, June 1, 2016
Room: Kings Garden 5

Session Chairs:
Shalom Wind, Columbia University.
Saba Ghassemi, University of Pennsylvania

1:15 pm - 1:45 pm 1C1 Invited
Brain on Chip, B. Schurink**, S. Xie**, A.J. Bastiaens*, J.J.F. Sleeboom*, J.P. Frimat*, D.A.M. Mustafa*, J.G.E. Gardeniers**, J.M.J. den Toonder*, R. Luttge*, *Eindhoven University of Technology, **University of Twente

Brain on Chip may provide more relevant physiological tissue models. In this contribution, the combination of microfluidics, tissue engineering and neuroelectrophysiology is presented as a tool to generate a better understanding of both healthy and diseased brain functions. It is the main objective to preserve the cells' three-dimensional morphology.

1:45 pm - 2:05 pm 1C2
Fabrication and characterization of zinc oxide nanowires-based flexible biosensors, Atif Syed, Enrico Mastropaolo, and Vasileios Koutsos, The University of Edinburgh

Novel fabrication process to hydrothermally grow zinc oxide nanowires directly on PDMS substrates for their application in various sensors is presented. The device has been tested as protein biosensor (bovine serum albumin) by monitoring change in electrical resistance. Characterization of the device using AFM and FTIR are also presented.

2:05 pm - 2:25 pm 1C3
A high-throughput nano-electroporation platform for large-scale manipulation and transfection of adult mouse cardiomyocytes, Lingqian Chang, Chiling Chiang, Paul Bertani, Zhaogang Yang, Ly James Lee, Wu Lu, The Ohio State University

We report a high-throughput nanochannel electroporation technique for on-chip manipulation and transfection of large-scale single cells. Our platform, based on a 3D nanochannel array chip, enables massive-parallel delivery of functional cargo into cellular array on the chip. A novel ‘dewetting’ method is applied to trap cells for electroporation at high-throughput.

2:25 pm - 2:45 pm 1C4
Out-of-plane spatial control at single-molecule resolution on biomimetic surfaces, H. Cai, J. Muller*, D. Depoil**, M. Sheetz, M. Dustin**, S. J. Wind, Columbia Unuversity, *NYU School of Medicine, **University of Oxford

A new single-molecule biomimetic platform is presented in which cellular receptors are able to engage ligands at different distances from the cell membrane in order to probe how molecular size affects key cellular processes.

2:45 pm - 3:15 pm 1C5 Invited
Lotus-Leaves-Like tailored surfaces tune the structural configuration of bio-soft matter compounds, A. Accardo, LAAS-CNRS

In this talk I will provide a comprehensive overview of how engineered superhydrophobic devices can be used as a powerful tool to influence the structural configuration of compounds of biomedical relevance (e.g. neurodegenerative peptides and cancer cell exosomes) in a droplet environment, with some recent perspectives on cells/neurons proliferation applications.

Session 2A - Electron Beam Lithography 1
Wednesday, June 1, 2016
Room: Kings Garden 3

Session Chairs:
Tim Groves, SUNY Albany
Rick Bojko, Genisys GMBH

3:35 pm - 4:05 pm 2A1 Invited
Sketch and Peel Lithography, Y. Chen, Q. Xiang, Z. Li, H. Duan, Hunan University

We demonstrate a new patterning concept, termed "sketch and peel" lithography, which can significantly enhance the efficiency of electron-beam direct writing (EBDW) and mitigate the proximity effect of EBDW for fast and reliable fabrication of metallic structures.

4:05 pm - 4:25 pm 2A2
Sub-5 nm electron-beam lithography and metrology of poly (methyl methacrylate) using an aberration-corrected scanning transmission electron microscope, V.R. Manfrinato, A. Stein, L. Zhang, E.A. Stach, C.T. Black, Brookhaven National Laboratory

We performed a unified analysis of poly(methyl methacrylate) as positive and negative tone resist, and electron-beam-induced deposition of carbon using an aberration-corrected scanning transmission electron-microscope (STEM) as the exposure tool. We performed STEM resist metrology and we develop an imaging method for the visualization of the exposure process in situ.

4:25 pm - 4:45 pm 2A3
Patterning of non-planar surfaces via electron beam lithography and its challenges, C.M. Eichfeld, L. Zhang*, R.M. Schmid*,W.S.M.M. Ketelaars**,A.C. Zonnevylle**,The Pennsylvania State University, *Raith America, **Raith

There are challenges that need to be overcome when patterning non-planar substrates compared to conventional flat substrates. Correct pattern placement on non-planar surfaces requires having an accurate height map. In this paper we show how we obtain and use accurate height maps to pattern the surface of non-planar substrates.

4:45 pm - 5:05 pm 2A4
PMMA Stencil Masks for Atom Beam Lithography, D. Shakarisaz, P. Ruchhoeft, University of Houston

Large-area stencil masks consisting entirely of PMMA were fabricated for use with atom beam lithography. The membranes were about one square centimeter in area, were 600 nm thick, and contained patterns with 190 nm openings on a 1 micron pitch.

5:05 pm - 5:25 pm 2A5
Metal Free Adhesion of Au onto Si Native Oxide, G. Lopez, M. Metzler, S. Wood, C. Elliott, G. Kim, A. Thompson*, University of Pennsylvania, *DisChem

Au is typically coupled with a seed layer like Cr when evaporated onto Si. In our work, we present a method to adhere 100nm Au dots onto Si without the use of a seed layer using SURPASS 4000 patterned by EBL and metal lift-off.

Session 2B - Tip-based Lithography
Wednesday, June 1, 2016
Room: Kings Garden 4

Session Chairs:
Josh Ballard, Zyvex Labs
Malcolm Carroll, Sandia National Labs

3:35 pm - 4:05 pm 2B1 Invited
Progress and future of NanoFrazor lithography, Felix Holzner, SwissLitho AG

NanoFrazor lithography was commercialized in 2013 by the startup company SwissLitho. Several NanoFrazor systems have been installed at research facilities all over the world and enabled applications that have not been possible before. This paper summarizes recent advances of the young technology and provides an outlook on future possibilities.

4:05 pm - 4:25 pm 2B2
Atomically Precise Devices: Enabling Fundamentally New Devices at the Ultimate Atomic Limit, Richard Silver, Xiqiao Wang*, Pradeep Namboodiri, Xiao Deng**, and Kai Li
National Institute of Standards and Technology, *University of Maryland, **Tongji University

Atomically precise devices are a key strategic direction as computation architectures move beyond traditional technologies. Controlling the position and electronic or quantum state of individual atoms or

electrons has the potential for broad impact. Deterministic placement of dopant atoms is achieved using hydrogen-based scanning probe lithography.

4:25 pm - 4:45 pm 2B3
Nanolithographic Chemical Patterning on Graphene Using Local Stress and Heat, Shivaranjan Raghuraman, Jonathan R. Felts, Texas A&M University

Combined friction force microscopy and thermochemical nanolithography using heated atomic force microscope tips provides quantitative descriptions of the thermochemical and mechanochemical reduction of graphene oxide, where it is proposed that reduction occurs via surface diffusion induced by the local temperature gradient under the tip.

4:45 pm - 5:05 pm 2B4
Tip-assisted Dopant Incorporation Process for Atomic Precision P-in-Si qubit devices, J. H. G. Owen, J. Ballard, U. Fuchs, C. Delgado, J. N. Randall and J. R. Von Ehr, Zyvex Labs

We have performed STM Lithography of phosphine on Si(001). With tip assistance, we are able to drive P incorporation at a substrate temperature around 250°C, below the temperature used to drive P incorporation by thermal annealing alone. This allows us to perform metrology of the P atom position.

5:05 pm - 5:25 pm 2B5
Integration of scanning probe lithography with directed self-assembly of PS/PMMA based block-copolymers, Matteo Lorenzoni, Laura Evangelio, Armin Knoll[1], Colin Rawlings [1], and Francesc Pérez-Murano, IMB-CNM (CSIC), Campus de la UAB, [1]IBM Research - Zurich

Different scanning probe lithographic techniques might offer unique advantages if integrated in the DSA process. We will present how thermal probe lithography (tSPL) has been used to create guiding patterns for BCP and the outcome will be compared to previous work done employing AFM oxidative nanolithography.

Session 2C - Nanoelectronics 1
Wednesday, June 1, 2016
Room: Kings Garden 5

Session Chairs:
Rebecca Cheung, University of Edinburgh
Xiaogan Liang, University of Michigan

3:35 pm - 4:05 pm 2C1 Invited
Toward high-performance nanoelectronics based on carbon nanotubes, S.J. Han, IBM T. J. Watson Research Center

Low-dimensional carbon materials are promising to replace silicon as the channel material for high-performance electronics near the end of silicon scaling roadmap. In this talk, I will cover recent progress within IBM Research as well as the discussion that highlights most significant challenges from technology points of view.

4:05 pm - 4:25 pm 2C2
Metal Cation Motion Induced Resistance Switching in Highly Reliable Hafnium Oxide based Memristive Devices, H. Jiang, L. L. Han, Q. F. Xia, University of Massachusetts, L. L. Han, H. L. Xin, Brookhaven National Laboratory

We developed a Ta/HfO_2/Pt memristive device that has low programming voltage, fast switching speed, robust endurance and reliable retention. We observed the migration of Ta into the HfO_2 layer that formed a conduction channel. Our results suggest reactive metal cations migration also plays an important role for the resistive switching.

4:25 pm - 4:45 pm 2C3
3D Hybrid Memristor/CMOS Circuits with 8 Monolithically Integrated Crossbar Layers, Peng Lin, Miguel Angel Lastras-Montaño*, Hao Jiang, Amirali Ghofrani*, Melika Payvand*, Luke Theogarajan*, Kwang-Ting Cheng* and Qiangfei Xia, University of Massachusetts Amherst, *University of California Santa Barbara

We demonstrated the monolithic integration of up to 8 memristor crossbars layers with foundry-made CMOS chip. The Pt/HfO2/TiN memristive devices were engineered to be electrically compatible with the CMOS circuits. Reliable switching performance of the memristive devices was achieved in the integrated chips with reset current down to sub-1μA level.

4:45 pm - 5:05 pm 2C4
Fabrication of Ambipolar Nanoelectronic/Microfluidic-Integrated Biosensors for Cycle-Wise Real-time Biomolecule Quantification, H. Nam, B. Oh, P. Chen, K. Kurabayashi, and X. Liang, University of Michigan

We fabricated WSe_2-based ambipolar FET biosensors, which are integrated with PDMS-based microfluidic channels. The integrated microfluidic channels enable a new approach, termed as Incubation-Flushing-Drying-Measurement (IFDM) cycle-wise quantification, for operating FET biosensors and realizing rapid, low-noise, highly specific real-time biomolecule quantification.

5:05 pm - 5:25 pm 2C5
Electron Spin Resonance Characterization of Damage and Recovery of Si/SiO_2 Interfaces from Electron Beam Lithography, J.-S. Kim, A. Tyryshkin, S.A. Lyon, Princeton University

The fabrication of nanoscale quantum devices in silicon relies on electron beam lithography which creates shallow defects at the Si/SiO_2 interface. The creation and subsequent annealing of these defects is characterized using transport and electron spin resonance techniques in large area MOSFETs.

Session 3A - Nanofabrication for Quantum Computing
Thursday, June 2, 2016
Room: Kings Garden 3

Session Chairs:
John Randall, Zyvex Labs
Ivo Rangelo, Ilmenau University of Technology

8:00 am - 8:30 am 3A1 Invited

Donor quantum-dot coupled qubits, M. Carroll, Sandia National Labs

In this talk I will discuss the first experimental demonstration of coherent singlet-triplet (S-T) rotations in a MOS quantum dot and a single donor system. This represents both a new qubit configuration as well as a central demonstration of coherently coupling a buried donor spin with the oxide-silicon interface.

8:30 am - 8:50 am 3A2
Injection of 2D Electron Gas into a Quantum-Dot Organic Light-Emitting Diode Structure on Silicon Substrate, Daud Hasan Emon, Myungji Kim, Mohammad T. Sharbati, Hong Koo Kim, University of Pittsburgh

We present a new quantum-dot OLED structure on silicon substrate, whose junction area is widely scalable down to nanometer range. We observed two-dimensional electron gas (2DEG) injection at the interface between oxide and semiconductor. Our work demonstrates the possibility of scaling a QD-OLED down to single quantum dot level.

8:50 am - 9:10 am 3A3
High density overlapping gate architecture for Si/SiGe quantum dots, J. R. Petta, D. M. Zajac, T. M. Hazard, and X. Mi, Princeton University

We demonstrate an overlapping gate architecture that enables the isolation of single electrons in a Si/SiGe quantum well.

9:10 am - 9:30 am 3A4
Fabrication of High-Coherence Superconducting Qubits, J. L. Yoder, A. Melville, D. K. Kim, P. B. Welander, R. Das, G. Calusine, D. Hover, L. Racz, D. Rosenberg, A. P. Sears, S. Weber, D. R. W. Yost, W. D. Oliver, S. Gustavsson*, F. Yan*, MIT Lincoln Laboratory, *Massachusetts Institute of Technology

Superconducting qubits are a promising candidate for the fundamental logic element of a quantum information processor. A key metric to characterize the qubit performance is device coherence. This work focuses on materials and fabrication developments to prepare high-coherence superconducting qubits, highlighting developments towards retaining high coherence while increasing device complexity.

9:30 am - 9:50 am 3A5
Direct Write Nanofabrication for Quantum Computing in Silicon and Color Centers in Diamond, E. Bielejec, J. L. Pacheco, J. B. S. Abraham, B. Aguirre, M. Singh, R. Camacho, M. P. Lilly, D. R. Luhman, M. S. Carroll,A. Sipahigil*, R. Evans*, D. Sukachev*, H. Atikian*, M. Loncar*, M. Lukin*, M. E. Trusheim**, T. Schroder**, D. Englund**, Sandia National Laboratory, *Harvard University, **Massachusetts Institute of Technology

Direct write nanofabrication creating deterministic single donor devices for quantum computing research and individual color centers in diamond is presented. This work was performed on the SNL nanoImplanter, a 100 kV sub-10 nm resolution focused ion beam implantation system with ion sources including P, Sb, Si, and Li.

Session 3B - Multi-beam Characterization and Lithography
Thursday, June 2, 2016
Room: Kings Garden 4

Session Chairs:
Alan Brodie, KLA Tencor
Mark McCord, PDF Solutions

8:00 am - 8:30 am 3B1 Invited

Multi-electron-beam technology with applications in microscopy, inspection and lithography, P. Kruit, Delft University of Technology

Multi-electron beam technologies for maskless lithography, full-wafer inspection and (bio) scanning electron microscopy will be reviewed from the point of view of an instrument designer. Recent results with the MAPPER lithography tool and the Delft Multi-Beam scanning electron microscope will be presented.

8:30 am - 8:50 am 3B2
Multi-Beam Magnetic Sector Mass Spectrometry Utilizing Spatially Coded Apertures, Z.E. Russell, E.X. Chen, S.T. DiDona, J.J. Amsden, C.B. Parker, S.D. Wolter*, R.M. Danell**, B.R. Stoner***, G. Kibelka****, M.E. Gehm, D.W. Brady, J.T. Glass, Duke University, *Elon University, **Danell Consulting,***RTI International, ****Xylem OI Analytical

The first demonstration of spatial aperture coding techniques to magnetic sector mass spectrometry presented shows 1D and 2D spatial coding techniques that yield increased mass spectra signal intensity of 10x and 4x (respectively) with no corresponding loss in mass resolution. Application to a Mattauch Herzog mass spectrograph is also shown.,

8:50 am - 9:10 am 3B3
Imaging semiconductor patterns at N10 logic node with a high-throughput multi-beam SEM, J. T. Neumann, T. Garbowski*, S. Halder**, P. Leray**, R. Garreis, D. Zeidler*, Carl Zeiss SMT GmbH, *Carl Zeiss Microscopy GmbH, **IMEC

We use the ZEISS multi-beam SEM to inspect patterns on a semiconductor wafer for process window qualification at N10 logic node. We demonstrate that the multi-beam SEM images the wafer patterns, tracks their variations through the process conditions of the lithography scanner, and finds defects limiting the lithographic process window.

9:10 am - 9:30 am 3B4
Design of a simple add-on to change a single-beam SEM into a multi-beam SEM, M. Scotuzzi, C.W. Hagen, P. Kruit, Delft University of Technology

A simple add-on to change an SEM from single-beam mode to multi-beam mode can be inserted in the electron column via the Variable Aperture port. First order optical calculations shows that a system of 49 beams with a probe size of 1.6 nm, with 50pA current per beam, is feasible.

9:30 am - 9:50 am 3B5
High Throughput Imaging in the Delft Multi Beam SEM, Y.Ren, C. W. Hagen, P. Kruit, Delft University of Technology

Transmission electron imaging system and secondary electron imaging system of our multi-beam Scanning electron microscope with 196 beams will be presented. Design principle and technological challenges will be discussed; recent experimental imaging results will be updated.

Session 3C - Nanophotonics 1
Thursday, June 2, 2016
Room: Kings Garden 5

Session Chairs:
Jack Skinner, University of Montana
Joel Yang, Singapore University of Technology and Design

8:00 am - 8:30 am 3C1 Invited
Optical Antennas Make Fast LEDs, Ming Wu, University of California, Berkeley

Optical antenna can significantly enhance the spontaneous emission rate of nanoscale emitters. In this talk, we will describe the physics behind such enhancement, and present our recent experimental results in optical slot antenna-enhanced III-V (InGaAsP) and monolayer transition metal dichalcogenide nano emitters.

8:30 am - 8:50 am 3C2
Significant Light Extraction Enhancement of Organic Light-Emitting Diodes Using Embedded High-index Deep-Groove Dielectric Nanomesh Fabricated by Large-area Nanoimprint, J. Qi, W. Ding, H. Chen, S. Y. Chou, Princeton University

A new OLED structure using a novel nanopatterned substrate embedding a high-index deep-groove–depth nanomesh, with high light extraction enhancement and large-area nanoimprint fabrication process,

overcomes the key limition of using nanopatterned substrates for increasing light extraction efficiency of OLEDs and offers new approaches for high performance OLEDs lighting and displays.

8:50 am - 9:10 am 3C3
High-Performance Nanoimprinted Perovskite Nanograting Photodetector, Honglei Wang, Balasubramaniam Balachandran, Ross Haroldson, Anvar Zakhidov, Walter Hu, The University of Texas at Dallas

We report high-performance hybrid organic-inorganic perovskite photodetector with highly crystalline nanograting structure implemented by nanoimprint lithography. The nanoimprinted perovskite nanograting photodetector (nano-PSPD) shows significantly enhanced responsivity and superior photocurrent to dark current ratio compared to non-imprinted devices and commercial Si photodetector.

9:10 am - 9:30 am 3C4
Metrology of Sub-65nm Resist Gratings on Flexible Substrate Made by Jet and Flash Nanoimprint Lithography, Ruichao Zhu, S.R.J. Brueck, Noel Dawson, Tito Busani, Praveen Joseph*, Shrawan Singhal*, S.V. Sreenivasan*, University of New Mexico, *University of Texas at Austin

To ensure a good final result following the etching and deposition processes, it is very important to monitor the quality of resist gratings just after the imprint. Scatterometry is a solution to this problem. It is a fast, in-line, non-contact, non-destructive nanoscale metrology tool.

9:30 am - 9:50 am 3C5
Lab-on-a-fiber Sensors with Nanoimprinted Nanostructures on Fiber Sidewall, Z. Zhu, WD. Li, The University of Hong Kong

In this work, we proposed a fabrication method to create nanostructures on the sidewall of a fiber to demonstrate a new form of “lab-on-fiber” for light-matter interaction. We then used this fiber sensor to detect the environment refreactive index. And a theoretical model was developed to explain the experimental phenomenon.

Session 4A – Plasmonics
Thursday, June 2, 2016
Room: Kings Garden 3

Session Chairs:
Chih-Hao Chang, North Carolina State University
Dieter Kern, University of Tuebingen

10:10 am - 10:30 am 4A1
Novel Plasmonic Metamasks for Photopatterning Molecular Orientations in Liquid Crystals, Yubing Guo, Miao Jiang, Chenhui Peng, Oleg D. Lavrentovich, Qi-Huo Wei, Liquid Crystal Institute, Kent State University, Kai Sun, Department of Material Science and Engineering, University of Michigan, Ann Harbor, Oleg Yaroshchuk, National Academy of Sciences of Ukraine

We present a new photopatterning technique for aligning LC molecules in arbitrarily complex orientation patterns by using carefully engineered plasmonic metamasks. Our technique shows high resolution and high throughput, which makes the patterning of LC molecular orientations a repeatable and scalable process for large scale manufacturing.

10:30 am - 10:50 am 4A2
Probing Sub-5 nm Gap Plasmon Using Collapsible Nano-fingers, B. Song, Y. Yao, Y. Wang, H. Liu, Y. Li, W. Wu*, University of Southern California

In this work, we have successfully fabricated gap plasmonic structure with precisely controlled nano-gap by using collapsible nano-fingers. We demonstrated how to define and scale sub-5nm gaps reliably and then we found the optimal gap sizes that give strongest plasmonic enhancement for different gap material.

10:50 am - 11:10 am 4A3
Tilted lithography and pattern transfer for the fabrication of asymmetric 3D plasmonic nanostructures, C. Dreser, D. P. Kern, M. Fleischer, University of Tuebingen

We introduce two fabrication processes for asymmetric 3D plasmonic nanostructures. Tilting the sample during the EBL exposure combined with the evaporation of metals under an angle and the transfer of nano-masks into a gold layer via argon ion milling under a tilting angle enables the fabrication of slanted 3D nanostructures.

11:10 am - 11:30 am 4A4
Self and directed assembly of metallic nanoparticles via PLiD and STEM/ EELS characterization of plasmon-related effects, Yueying Wu, Guoliang Li*, Charles Cherqui**, Nicholas W. Bigelow**, Jon P. Camden*, David J. Masiello**, Jason D. Fowlkes***, Philip D. Rack***, University of Tennessee, *University of Notre Dame, **University of Washington, ***Oak Ridge National Laborato

The physical properties and liquid dynamics underlying metallic thin film dewetting were investigated for the purpose of understanding how initial boundary conditions facilitate precise assembly. Then the crystalline structure and plasmon effect of resultant nanoparticles were examined using a transmission electron microscope (TEM) and Electron energy loss spectroscopy
(EELS).

11:30 am - 11:50 am 4A5:
Patterning large area plasmonic nanostructures on non-conductive substrates using variable pressure electron beam lithography, J. Babocky, J. Fiala*, J. Bok*, Central European Institute of Technology, *TESCAN Brno s.r.o.

Fabrication of plasmonic nano-structers on non-conductive materials in variable pressure which compensates the charging of the sample. The main advantage of our approach is no need of any sample pre-exposure or post-exposure treatment. SEM, transmission spectroscopy and coherence-controlled holographic microscopy techniques were used to charcterize these structures.

Session 4B - Novel Imaging and Characterization Techniques
Thursday, June 2, 2016
Room: Kings Garden 4

Session Chairs:
Larry Muray, Keysight Technologies
Abdel Isakovic, Khalifa University – KUSTAR

10:10 am - 10:30 am 4B1
Design and Testing of a Novel Electron Monochromator for High Resolution Imaging and Spectroscopy, M. Mankos, K. Shadman, V. Kolarik*, Electron Optica, Inc., *Delong Instruments

In this paper, we focus on the design and testing of a novel monochromator that can reduce the energy spread of electron sources from the characteristic range of 0.5 - 1 eV into the sub-100 meV range.

10:30 am - 10:50 am 4B2
Atom Eyes: „The NEeutral helium MIcroscope NEMI, Sabrina Daniela Eder

Here we present our focused neutral helium beam microscope NEMI and the first images. As one of the few existing instruments in the novel field of scanning helium microscopy (SHeM), NEMI offers promising possibilities in its unique way of imaging with a focused neutral helium beam.

10:50 am - 11:10 am 4B3
3D Nano Tomography, TEM Lamella Preparation, and Automated Nanofabrication with ORION NanoFab, S. Eyhusen, B. Goetze, Carl Zeiss Microscopy, LLC

First results on 3D nanotomography, TEM lamella preparation, and automated nanofabrication obtained with ZEISS ORION NanoFab, a helium, neon, gallium multibeam instrument.

11:10 am - 11:30 am 4B4
Fiducial Registration and Field Stitching for Multi-Scale Scanning Tunneling Microscope Lithography, S.W. Schmucker, J.B. Ballard, J.H.G. Owen, U. Fuchs, J.N. Randall, Zyvex Labs

Crossing length scales from nanometers to microns while leveraging the atomic precision of hydrogen depassivation lithography and mitigating scaling limitations of STM hardware requires field stitching technologies. We present our progress on the development of automated fiducial finding and field stitching approaches for the development of STM lithography.

11:30 am - 11:50 am 4B5
High-Resolution Compact FESEM with a Magnetic Immersion Objective Lens, J. Spallas, L. Muray, M. Mankos*, Keysight Technologies, *Electron Optica

We have designed, built and tested a prototype ultra-high resolution field emission scanning electron microscope (FESEM) using a Keysight 8500 FESEM fitted with a new magnetic immersion lens. We will present details of the optical and mechanical design and system performance.

Session 4C - Nano-mechanical Systems
Thursday, June 2, 2016
Room: Kings Garden 5

Session Chairs:
Robert Ilic, NIST
David Czaplewski, Argonn

10:10 am - 10:30 am 4C1
Design and Implementation of Soft Polymer-Based Cantilever Probe for Atomic Force Microscopy, F. Yu*, J. Liu*, A.-L. Lin**, N. Z. Khan*, Y. Pan*, Q. Zou*, and J. Jeon*, *Rutgers, The State University of New Jersey, **Clark University

In this work, we report a polymer-based V-shaped AFM probe, which comprises a soft cantilever with spring constant < 0.01 N/m and a sharp probe tip with a radius of curvature ~40 nm.

10:30 am - 10:50 am 4C2
Optomechanical transducer for investigation of frequency fluctuations, Thomas Michels
Vladimir Aksyuk, National Institutes of Standards and Technology

We developed an on-chip cavity optomechanical transducer platform that combines high bandwidth and sensitivity near the standard quantum limit with compactness, robustness, small size, and potential for low cost batch fabrication inherent in MEMS. This transducer allows us to further investigate frequency fluctuations and their origin.

10:50 am - 11:10 am 4C3
Role and characterization of the built-in stress in double clamped beam silicon nanowires, J. Llobet, M. Lorenzoni, F.Perez-Murano. IMB-CNM

Suspended, double clamped silicon nano-beams are fabricated by a combination of focused ion beam exposure and silicon wet etching. Their performance as nanomechanical resonators is characterized. By tuning their geometrical dimensions, the electromechanical response is affected. The presence of built-in stress, characterized by atomic force microscopy, explains this effect

11:10 am - 11:30 am 4C4
Microwave Characterization of Nanocomposite based on Lithographically Defined Nanoparticles, Y.F. Wang, Y.Q. Su, J. Stang, M. Moghaddam, W. Wu, University of Southern California

Top-down lithography is used to fabricate nanoparticles for microwave-absorbing nanocomposites. Our experiments have shown that the nanocomposites based on lithographically defined particles (LDPs) greatly enhance the permittivity/permeability of the composite, leading to much larger microwave absorption efficiency than synthesized-nanoparticle-based nanocomposites.

11:30 am - 11:50 am 4C5
Ultra-Small Hysteresis of Submicrometer Shape Memory Alloys Prepared by Biased Target Ion Beam Deposition for Actuation Applications, H. Hou, R. Hamilton, M. Horn, The Pennsylvania State University

Shape memory alloys can exhibit high work output per unit volume with narrow hysteresis for fast-response, miniaturized actuation applications. This work explores new fabrication of NiTi alloy thin films via biased target ion beam deposition customized with low energy ion beam. Findings confirm ultra-small hysteresis, promising for advancing nanoscale actuation.

Session 5A - Nanoimprint Lithography 1
Thursday, June 2, 2016
Room: Kings Garden 3

Session Chairs:
Stefano Cabrini, Lawrence Berkeley National Laboratory
Qiangfei Xia, University of Massachusetts

1:50 pm - 2:20 pm 5A1 Invited
Full color reflective display based on high contrast gratings, H. Liu, Y. Li, Y. Yao, Y. Wang, W. Wu, University of Southern California

A color reflective display based on stacked tunable “color mirrors” was invented. The “color mirrors” are realized using 2D high-contrast gratings fabricated by combining interference lithography and nanoimprint lithography. The design, fabrication, characterization of the color mirrors, and the color tuning and reconstruction will be presented.

2:20 pm - 2:40 pm 5A2
Overlay improvement in nanoimprint lithography for 1x-nm patterning, K. Fukuhara, M. Suzuki, M. Mitsuyasu, T. Komukai, M. Hatano, T. Kono, T. Nakasugi, Toshiba Corporation, Y. Lim, W. Jung, SK Hynix Inc.,

Nanoimprint lithography (NIL) is becoming a promising technique for fine-patterning with lower cost than other lithography technique. High overlay accuracy is one of the big challenges in NIL.We describe evaluation of NIL overlay performance using the up-to-date NIL tool, and discuss potentials of NIL overlay in the future.

2:40 pm - 3:00 pm 5A3
Replication of Nanostructures on Polyethylene Terephthalate with Laser-Assisted Roller Nanoimprinting, Y.Yajima, K.Nagato ,*, M.Nakao,The University of Tokyo,*Research Fellow of Precursory Research for Embryonic Science and Technology (PRESTO),Japan Science and Technology Agency (JST)

We replicated nanostructures on polyethylene terephthalate (PET) films with laser-assisted roller nanoimprinting. in laser-assisted roller nanoimprinting, because only the surfaces of the mold and polymer are rapidly heated and cooled, nanostructures can be replicated before the crystallization. we demonstarated rapid replication of nanostructures on PET films.

3:00 pm - 3:20 pm 5A4
Near field campanile probe fabricated by nanoimprint lithography, G. Calafiore, A. Koshelev, S. Babin, K. Munechika, aBeam Technologies Inc., T, Darlington, N. J. Borys, J. Schuck, A. Weber-Bargioni, S. Cabrini, The Molecular Foundry, Lawrence Berkeley National Laboratory

A novel approach to fabricate 3D Campanile NSOM probes by direct UV-NIL on the facet of commercial optical fibers is presented. This is a high-yield, inexpensive process to manufacture Campanile probes and paves the way to the commercialization of these cutting-edge plasmonic tips.

3:20 pm - 3:40 pm 5A5:
Flat and highly flexible composite stamps for nanoimprint, their preparation and limits, Marc Papenheim, A. Mayer, S. Wang, C.Steinberg, H.-C. Scheer, University of Wuppertal

A method to prepare a flexible 2-layer stamp (20 µm OrmoStamp as top layer and 300µm PDMS as backplane) being flat at room temperature is given. Imprints with particles on the substrate are performed to identify the limits of the stamp failure (break of top layer).

Session 5B - Atomic Layer Deposition
Thursday, June 2, 2016
Room: Kings Garden 4

Session Chairs:
Golnaz Karbasian, University of California, Berkeley
Ralf Heilmann, Massachusetts Institute of Technology

1:50 pm - 2:20 pm 5B1 Invited
Charged defects mitigation in metal single-electron transistors with tunnel barriers prepared by atomic layer deposition, G. Karbasian, A. O. Orlov, and G. L. Snider, University of Notre Dame

Several native oxide reduction treatments in metal (Ni) single electron transistors featuring ALD tunnel dielectrics (SiO2, Al2O3) are investigated. It is shown that the combination of anneal and remote plasma in hydrogen ambience results in switching noise suppression indicating abatement of charged defects in the junctions.

2:20 pm - 2:40pm 5B2
Single-digit nanofabrication: ultrahigh density sub-10 nm TiO_2 features via the self-aligned double patterning process, Stefano Dallorto, Daniel Staaks, Simone Sassolini, Adam Schwartzberg, XiaoMin Yang**, Kim Y Lee**, Shuaigang Xiao**, Craig Ward***, Ivo W. Rangelow*, Deirdre L. Olynick, Molecular Foundry, * Ilmenau University of Technology, **Seagate Technology, *** Oxford University

With the goal of achieving nanoimprint masks for Bit Patterned Media at 7.5 nm half-pitch and below, with good mechanical stability, we study different materials, SiO_2, $Al2O_3$, and TiO_2. Thermal and plasma

processes are investigated. We demonstrate standing vertical TiO_2 lines with critical dimension below 6 nm can be patterned.

2:40 pm - 3:00 pm 5B3
Atomic Layer Deposition of Ternary Dielectrics for Gate Insulation and Passivation of GaN-based Metal-Insulator-Semiconductor Heterojunction Field Effect Transistors, A. Colon, J. Shi, L. Stan*, R. Divan*, University of Illinois at Chicago, *Argonne National Laboratory

Dielectric materials deposited by Atomic Layer Deposition on InAlN and AlGaN semiconductors are electrically characterized. Metal-Insulator-Semiconductor Capacitors are fabricated to be measured and characterized.

3:00 pm - 3:20 pm 5B4
UV-Accelerated Detection and Recovery of CH4 in ZnO Functionalized Multi-walled Carbon Nanotube Sensors, Md Humayun, R. Divan*, L. Stan*, D. Gotszola*, L. Gundel**, P. A. Solomon***, I. Paprotny, University of Illinois at Chicago, *Argonne National Laboratory, **Lawrence Berkeley National Laboratory, ***Environmental Protection Agency

In this paper we present a UV-based recovery technique for the ZnO functionalized multi walled carbon nanotube (MWCNT)-based chemoresistor methane sensor. We were able to reduce the recovery and consequently detection time of functionalized MWCNT-based methane sensor by utilizing strong UV response of ZnO.

3:20 pm - 3:50 pm 5B5 Invited
Area-selective atomic layer deposition using e-beam and photosensitive masking layers, R.H.J. Vervuurt, A. Sharma, Y. Jiao, W.M.M. Kessels, A.A. Bol, Eindhoven University of Technology

In this contribution we report on the area-selective atomic layer deposition of Pt using temperature stable polymers films. The resists used can be patterned using conventional lithography. It will be discussed that the results can also apply to other materials provided the ALD chemistry is unreactive towards the resist surface.

Session 5C - Nanofabrication through Self-Assembly
Thursday, June 2, 2016
Room: Kings Garden 5

Session Chairs:
Anthony Novembre, Princeton
Alex Liddle, NIST

1:50 pm - 2:20 pm 5C1 Invited
Block Copolymer Nanolithography, S. Y. Kim, C.A de Coulomb, Ulsan National Institute of Science and Technology

Application of patterning with block copolymers in thin films will be firstly reviewed and limitations and challenges of the block copolymer lithography will be discussed.

2:20 pm - 2:40 pm 5C2
Selective Directed Self Assembly of Coexisting Morphologies Using Block Copolymer Blends, A. Stein, G. Wright, K.G. Yager, C.T. Black, Brookhaven National Laboratory

We present Selective Directed Self Assembly where careful design of the pitch and duty cycle of a line grating template causes a single block copolymer blend to simultaneously self-assembles into desired spatial arrangements of coexisting line and dot morphologies.

2:40 pm - 3:00 pm 5C3
Fabrication of Multilayer Complex Nanomesh Patterns, A. Tavakkoli K. G., S. M. Nicaise, K. Gadelrab, A. Alexander-Katz, C. A. Ross, K. K. Berggren, MIT

We used orthogonal self-assembly to produce complex multi-layer nanomesh structures without requiring alignment or high-resolution lithographic templating. BCP grating patterns were used to orthogonally self-assemble another layer of a BCP grating with a different period. We fabricated nanomesh patterns in circles, bends, junctions and with multiple local directions.

3:00 pm - 3:20 pm 5C4
Design Strategy for Layout of Sub-Resolution Directed Self-Assembly Assist Features (SDRAFs), M. C. Tung, J. Doise*,**, J. Ryckaert*, H.-S. P. Wong, Stanford University, *imec, **Katholieke Universiteit Leuven

We propose a method to integrate sub-DSA resolutions assist features (SDRAFs) into DSA template layouts using a grid of SDRAFs. The method demonstrates a narrower range of density variation after the SDRAF assignment, indicating promise to control template overfill.

3:20 pm - 3:40 pm 5C5 :
Multidirectional BCP Alignment by Thermal-Coefficient-of-Expansion Mismatch Shear, S.M. Nicaise, A. Tavakkoli K.G., K. Gadelrab, A. Alfredo-Katz, C.A. Ross, K.K. Berggren, Massachusetts Institute of Technology

Shear-stress alignment of block copolymers has been used to achieve long-range order of nanopatterns. In this work, the mismatch between the thermal-coefficient-of-expansion in a top-coat of silica and silicon substrate produces shear to align PS-b-PDMS polymer cylinders. Alignment is observed over mm distances, with controllable direction and <1-minute annealing.

Session 6 -EIPBN History
Thursday, June 2, 2016
Room: Kings Garden 4/5

Session Chairs:
Don Tennant, Cornell University
Theodore Fedynyshyn, MIT Lincoln Labs

4:00 pm - 4:30 pm 6A1 Invited
History of the Three Beams Meeting, M. Schattenburg, MIT Space Nanotechnology Laboratory

The first meeting of the EIPBN conference took place on March 20, 1959. The small group of electron beam welding enthusiasts who met then would be astonished to see what the meeting has become now. I will discuss the early years of the meeting and how it has progressed to the present day.

4:30 pm - 5:00 pm 6A2 Invited
20 Years of Nanoimprint, S. Y. Chou, Princeton University

The talk will present a personal view of the past, present and future of nanoimprint.

Session 7A - Lithographic Materials
Friday, June 3, 2016
Room: Kings Garden 3

Session Chairs:
Karl Berggren, Massachusetts Institute of Technology
Chris Mack, Lithoguru.com

8:00 am - 8:30 am 7A1 Invited
Directed Self-Assembly patterning options for FinFET formation at 7nm node, C Liu,* E Franke,** F Lie,* S Sieg,* H Tsai,*** K Lai,* H Truong,**** R Farrell,** M Somervell,***** D Sanders,* N Felix,* M Guillorn,* D Hetzer,** A Ko,** J Arnold,* S Burns,* M Colburn*, *IBM Research Albany,**TEL Technology Center, America, LLC, ***IBM Research Yorktown Heights, ****IBM Research Almaden, *****Tokyo Electron America

In this work, three DSA options for Fin patterning, i.e. Grapho, Chemo, and Hybrid processes, are compared with the conventional fin-array-plus-cut method and discussed based on placement error and design complexity. Preliminary learning and structural results, as well as the extendibility for devices with smaller pitches will be further discussed.

8:30 am - 8:50 am 7A2
Rule-based patterning of a multi-state system by block copolymer self-assembly, H. Do, H. K. Choi, J. Chang, C. A. Ross, K. K. Berggren, Massachusetts Institute of Technology

We demonstrate that block copolymer cylinders can form a multi-state system with ladder-shaped structures inside a polygonal confinement when bending angle of the confinement is 90° or above. We describe a design rule based on majority rule to determine the individual state by controlling alignment direction of the ladder-shaped structures.

8:50 am - 9:10 am 7A3
Effect of Elastic Modulus of UV Cured Resist on Demolding Force, M. Shirai, K. Uemura, K. Shimomukai, T. Tochino, H. Kawata, Y. Hirai, Osaka Prefecture University

In this paper we report the effect of elastic modulus of UV cured resist on the demolding force measured by an in-situ process using a rheometer. It was found that the demolding force could be reduced by changing the storage modulus of cured resists.

9:10 am - 9:30 am 7A4
High Resolution Organic Resist Materials for EUV and E-beam Lithography Based on Molecular Glasses: A Comparison of Negative Tone and Positive Tone Approaches to Form Robust Cross-linked Polymer Nanopatterns, Brandon Sharp**, Hannah Narcross**, Clifford L. Henderson*, * School of Chemical and Biomolecular Engineering, Georgia Institute of Technology,** School of Chemistry and Biochemistry, Georgia Institute of Technology

We have shown recently that negative tone resists based on cross-linking of functionalized molecular glass cores can yield excellent high resolution resists. In this paper we will present new negative tone resists based on cross-linking mechanisms and compare these with new resists based on depolymerization of dense polymer networks.

9:30 am - 9:50 am 7A5
High resolution, hybrid 3D topography fabrication using grayscale electron beam lithography, R. Kirchner, H. Schift, Paul Scherrer Institut

We present material independent process rules governing the structures obtained in electron beam grayscale patterning using positive tone resist. We demonstrate the universal applicability of selective thermal reflow for such resists. Application examples range from diffractive optics to bio-inspired patterns.

Session 7B - Emerging Fabrication Techniques 1
Friday, June 3, 2016
Room: Kings Garden 4

Session Chairs:
Aaron Stein, Brookhaven National Laboratory
Bo Cui, University of Waterloo

8:00 am - 8:30 am **7B1 Invited**
Contamination-free suspended graphene structures by a Ti-based transfer method, A. Matruglio, University of Trieste

A comparison between two graphene transfer methods will be described: one using polymer, which is the most used in literature, and a new one involving a thin Titanium layer, to have a cleaner graphene without defects. Some new applications will be shown, as X-ray photoelectron spectroscopy in liquid.

8:30 am - 8:50 am **7B2**
Ionic Liquid Gating effects on a-IGZO Thin Film Transistors: A Novel Method for Amorphous Metal Oxide Activation, P. R. Pudasaini, J. H. Noh, A. Wong, A. V. Haglund, D. Mandrus, P. D. Rack, O. S. Ovchinnikova*, S. Dai*,T. Z. Ward*, University of Tennessee, Knoxville, *Oak Ridge National Laboratory

We report controllable activation of a-IGZO channel using ionic liquid gating effect. We demonstrate a transparent flexible thin film transistor on a polyamide substrate created using this simple technique. This study demonstrates the potential of field-induced activation as a promising alternative to traditional post-deposition thermal annealing for flexible electronic applications.

8:50 am - 9:10 am **7B3**
Lithiation of Sn Microspheres: Li FIB vs Electrochemistry, J. J. McClelland, W. R. McGehee, S. Takeuchi, J. L. Schaefer,* T. M. Wilson, K. A. Twedt,** E. H. Chang, V. P. Oleshko, and C. L. Soles, National Institute of Standards and Technology, *University of Notre Dame , **University of Maryland

Lithiation of tin-microsphere model battery cathode material is carried out by both low-energy Li+ FIB implantation and conventional electrochemical methods. Comparison of the two methods is made by FESEM imaging and Ga+ FIB cross sectioning. Results suggest Li+ FIB implantation can be useful for studying nanoscale battery processes.

9:10 am - 9:30 am **7B4**
Stretchable Metal-mesh Transparent Electrodes Fabricated through a Solution-processed Approach, C. Zhang, A. Khan, and W. Li, University of Hong Kong

Our work reports a promising low-cost fabrication method for flexible and stretchable transparent electrodes. The whole processes are solution-based, making it possible for mass production. Our fabricated samples show desirable stretchability and uniformity. We also further developed a template-based metal-mesh transparent electrode fabrication following the original fabrication process.

9:30 am - 9:50 am **7B5**
Double-Gate Organic Micro-Electro-Mechanical Relay for Ultralow-Power Flexible Large-Area Electronics, Y. Pan, J. Jeon, Rutgers, The State University of New Jersey

In this work, we propose and demonstrate a polymer-based double-gate micro-electro-mechanical (MEM) relay as a potential alternative to organic thin-film transistors in order to enable ultralow-power flexible large-area electronics.

Session 7C - Focused Beam Induced Processing
Friday, June 3, 2016
Room: Kings Garden 5

Session Chairs:
Todd Hastings, University of Kentucky
Ulrich Hofmann, Genisys GMBH

8:00 am - 8:30 am **7C1 Invited**

Laser Assisted Focused Ion Beam Processing, P. D. Rack, J. D. Fowlkes, University of Tennessee
In this presentation we will introduce a new technique for mitigating sub-surface focused He+ and Ne+ ion beam damage via a pulsed laser assist process. Specifically we will demonstrate experimentally and simulations that silicon amorphization and peripheral damage in graphene can be mitigated via pulsed laser assisted focused ion beam induced processing.

8:30 am - 8:50 am **7C2**
Focused Electron Beam Induced Processing in ultra-high vacuum: new routes for the fabrication of clean metallic nanostructures and the reduction of proximity effects, Fan Tu, Martin Drost, Luisa Berger, Florian Vollnhals, Hubertus Marbach, University of Erlangen

Currently we were able to expand the family of FEBIP techniques with the exploration of Electron Beam Induced Surface Activation (EBISA). In this two step process the surface is first chemically activated via irradation with electrons and after that "developed" with precursor molecule yielding a clean metallic deposit.

8:50 am - 9:10 am **7C3**
Ultra-fast nano-fabrication using Xe-plasma FIB-SEM and its Cu milling applications using the Rocking-stage, S. Sharang, A. Benkouider, T. Hrnčíř, J. V. Oboňa, J. Jiruše, E. Principe*, TESCAN ORSAY HOLDING, *TESCAN USA

In this work we show a novel method using Xe-plasma FIB-SEM and the Rocking-stage for an ultra-fast nano-fabrication of electronic devices and its applications for Cu milling.

9:10 am - 9:30 am **7C4**
Monte-Carlo Simulations of Ion Beam Sputtering in Compounds, K. Mahady*, P. D. Rack* **, S. Tan***, R. Livengood***, A. Raveh***, Y. Greenzweig***, *University of Tennessee, **Center for Nanophase Materials Sciences Oak Ridge National Laboratory, *** Intel Corp.

9:30 am - 9:50 am **7C5**
Focused ion beam nano-trench shape dependence on target material, Y. Greenzweig, Y. Drezner, Z. Malamud, A. Raveh, Intel Israel (74) Ltd.

Shapes of narrow vias etched by gas-assisted focused ion beam (FIB) several tens of nanometers into dielectric and filled by E-beam deposition were studied. Measurements by transmission electron microscopy demonstrated marked differences between the widths of vias etched through targets of PECVD oxide versus FIB induced deposition oxide.

Session 8A - Nanoimprint Lithography 2
Friday, June 3, 2016
Room: Kings Garden 3

Session Chairs
Hao Chen, Intel
Wei Wu, University of Southern California

10:10 am - 10:30 am 8A1
Impact of template stiffness during peeling release in nanoimprint lithography, Florian Chalvin[1 2], Naoto Nakamura[1], Takamitsu Tochino[1], Masaaki Yasuda[1], Hiroaki Kawata[1], and Yoshihiko Hirai[1], [1]Osaka Prefecture Univeristy, [2]Ecole Nat. Sup.de l'Electronique et de ses Applications

Impact of the template stiffness is investigated in both computational and experimental works. For soft template, the release force decreases due to the small area being gradually detached; however the induced stress in the resist increases due to deformations caused by the template bending.

10:30 am - 10:50 am 8A2
Nanoimprinted Perovskite Micro- Nanostructures for Photovoltaics, Bala Balachandran, Ross Haroldson, Yixin Ren, Honglei Wang, Julia Y. Chan, Anvar Zakhidov, Walter Hu, The University of Texas at Dallas

We report the use of nanoimprint to pattern perovskites into ordered micro and nanostructures with improved crystallinity and light absorption for photovoltaics applications. Nanoimprint significantly increases the crystallinity in perovskite nanograting and nanopores as shown in XRD spectrum. Solar cells using perovskite nanogratings have shown large enhancement in photocurrent.

10:50 am - 11:10 am 8A3
Nanoimprint-induced orientation of localized wrinkles with SU-8, C. Steinberg, M. Runkel, M. Papenheim, S. Wang, A. Mayer, H.-C. Scheer, University of Wuppertal

The impact of a pre-patterned SU-8 layer on the orientation of localized wrinkles after a VUV-treatment is investigated. The pre-pattern is realized by nanoimprint. The type of pre-pattern and the initial layer thickness of SU-8 influence the wrinkling alignment and the anisotropy obtained.

11:10 am - 11:30 am 8A4
Printed Active Photonic Crystals in High Refractive Index Functional Materials for Visible Light Applications, C. Pina-Hernandez*, A. Koshelev*, G. Calafiore*, M. Sainato**, S. Dhuey**, K. Munechika*, S. Cabrini**, *aBeam Technologies, **The Molecular Foundry, Lawrence Berkeley National Laboratory,

We present the first printed active photonic crystals with embedded quantum dots, fabricated by the direct printing of high refractive index materials for visible light applications. Arrays of photonic crystals nanocavities with high quality factors were obtained. This work represents a powerful route for the development of novel nanophotonic devices.

11:30 am - 11:50 am 8A5
Surface confined equilibration for super-smooth surfaces, N. Chidambaram, R. Kirchner, M. Altana*, S. Neuhaus**, M. Kristiansen**, H. Schift, Paul Scherrer Institute, *Heptagon Oy, **University of Applied Sciences and Arts Northwestern Switzerland

A novel mastering strategy with 2 photon polymerization for refractive micro optical devices is accomplished. Super smooth surface finish is realized applying a surface sensitive exposure followed by

thermal reflow while retaining the complex 3D profile. For this purpose master structures were imprinted into PMMA through PDMS intermediate reproduction.

Session 8B - Emerging Fabrication and Characterization Techniques 2
Friday, June 3, 2016
Room: Kings Garden 4

Session Chairs:
Sergey Babin, Abeam
Elizabeth Dobisz, Spin Transfer Technologies

10:10 am - 10:30 am 8B1
Fabrication of cylindrical neural probes with integrated conductor wiring, A. Awale, P. Motwani, M. Gheewala, R. Kusko, T.-A. Tisa, W.-C. Shih, J. Wolfe, G. Purushothaman*, J. A. Dani**,V. Dragoi***, University of Houston, *Parallon, **University of Pennsylvania, ***University of Texas-Houston Medical School

Our objective is to fabricate probes on optical fiber substrates for optogenetic studies in the cortex of macaques. Probe design calls for 28 staggered electrodes on each of 4 sides of the probe. Fabrication relies on helium atom beam lithography, a conformal plasma polymerized resist, and an indirect alignment scheme.

10:30 am - 10:50 am 8B2
Systematic study of high throughput fabrication of nano holes and nano pillars in polymer foils by roll-to-roll-extrusion coating., S.Murthy[1,2], H. Pranov[1], H. Pedersen[2], R.Taboryski[2], [1]InMold A/S,Denmark: [2] echnical University of Denmark

This paper investigates a novel roll-to-roll (R2R) process for large area nanostructuring, known as roll-to-roll extrusion coating (R2R-EC), having productivity rates, potentially, exceeding 5m^2/s. Significantly higher than current R2R methods. This will enable large area nanostructuring of functional biomimetic surfaces such as superhydrophobic, anti-reflective, structural colors etc..

10:50 am - 11:10 am 8B3
Ion Beam Injector based on High Current LMIS, P. Laufer, D. Bock, W. Pilz, L. Bischoff*, M. Tajmar, Dresden Technical University, *Helmholtz-Zentrum Dresden-Rossendorf

An ion source injector module based on high current LMIS is presented for the use of different mon - or polyatomic ions in the 100 µA range for large area applications. An asymmetric Einzel lens forms a nearly parallel beam and the desired ions were selected by an ExB filter

11:10 am - 11:30 am 8B4
Multiscale Porous Structure Enabled by Variable Voxel Stereolithography, Yuanrui Li, Huachao Mao, Yuhan Yao, He Liu, Yifei Wang, Boxiang Song, Yong Chen, Wei Wu, University of Southern California

We proposed building multiscale porous structures by using variable voxel stereolithography which is realized by two lasers and an optical filter based on high contrast gratings that were fabricated by nanoimprint lithography. The object-size-to-resolution ratio can reach 10^3 which is one order of magnitude higher than current technology.

11:30 am - 11:50 am 8B5
Characterization of Nanofabricated Electron Transmission Gratings with Electron Diffraction, Y. Yang, R. G. Hobbs, C. S. Kim, O. T. Celiker, A. Agarwal, W. Li, K. K. Berggren, Massachusetts Institute of Technology

Here we report a nanofabricated two-dimensional mesh transmission gratings for electron beams and its characterization with electron diffraction in a TEM with various electron energies. Nanofabricated electron transmission gratings can be used as diffractive electron beam splitters, of which the splitting ratio is tunable by material-imposed electron phase-shift.

Session 8C - Nanophotonics 2
Friday, June 3, 2016
Room: Kings Garden 5

Session Chairs:
Joel Wendt, Sandia National Labs
Martin Feldman, Louisiana State University

10:10 am - 10:30 am 8C1
Sub-10-nm Three-Dimensional Plasmonic Probes fabricated using a Helium Ion Microscope, G. Calafiore, A. Koshelev, K. Munechika, aBeam Technologies Inc., F.I. Allen, P. Lum, Biomolecular Nanotechnology Center, UC Berkeley, J. Schuck, A. Minor, S. Cabrini, The Molecular Foundry, LBNL

We report the fabrication of high-resolution 3D NSOM tips on a AFM probe by Helium Ion Microscope with superior plasmonic performance.

10:30 am - 10:50 am 8C2
Fabrication of Au lamellae nanostructure for high sensitive biosensor applications, Sichao Zhang, Yifang Chen, Bingrui Lu, Jianpeng Liu, Jinhai Shao, Chen Xu, Fudan University

We have developed a novel process based on alternated development/dissolution and electroplating to explore the sensing capability of gold Morpho butterfly wing scales as SPR and SERS. The process developed in this work is of application prospects in multidisciplinary areas.

10:50 am - 11:10 am 8C3
Optical Properties of “Air-Like” Ordered 3D Thin-Shell Nanolattice Materials, X. Zhang, A. Bagal, E. Dandley, J. Zhao, C. Oldham, G. Parsons, C. Chang, North Carolina State University

A new class of low-index nanolattice materials with periodic architecture is demonstrated. The fabrication technique combines three-dimensional nanolithography and atomic layer deposition. Compared with random architectures in conventional low-index materials, the periodic order design enables designable refractive index from 1.3 to 1.025, improved mechanical stability and reduced optical scattering.

11:10 am - 11:30 am 8C4
Subwavelength Focusing of Light with a Slanted-Nanoaperture-Array Metal Lens, M. Kim, Y. S. Jung, Y. Xi, Y. Shi, H. K. Kim, University of Pittsburgh

We have investigated the radiation pattern of nano aperture transmission as a new degree of freedom in shaping transmission wavefronts for negative angle directions. By employing a vertical dipole concept of nano aperture transmission we demonstrate negative-angle refraction and sub wavelength focusing of light with a slanted-nanoaperture-array metal lens.

11:30 am - 11:50 am 8C5
Fabrication of an optomechanical resonator with a two-interface surface plasmonic structure for the wavelength detection, R. Koemtani, M. Goto, E. Maeda: The University of Tokyo

An optomechanical resonator with a two-interface surface plasmonic structure was fabricated in order to detect the wavelength. An optomechanical resonator and a two-interface surface plasmonic structure were made from Au, Ti and SiO_2. As a result, the wavelength resolution for unpolarized light with wavelength of 1550-1562 nm was 0.92 pm.

Session 9A - Focused Ion Beam Lithography
Friday, June 3, 2016
Room: Kings Garden 3

Session Chairs:
Shida Tan, Intel
Jabez McClelland, NIST

1:20 pm - 1:50 pm 9A1 Invited
Focused Helium Ion Beam Josephson Junctions and Nanowires, S. A. Cybart, E. Y. Cho, R. C. Dynes, University of California San Diego

Focused helium ion beams provide a new approach for sub-ten nanometer process control. This is important for Josephson junctions: the basic building block of superconducting electronics whose properties are governed by quantum mechanical tunneling. I will present recent results in the area of helium ion direct-write lithography of Josephson junctions.

1:50 pm - 2:10 pm 9A2
Focused ion beam milling of optical films with complex surfaces at the subnanometer scale, K.-T. Liao*,**, J. Schumacher*, H. J. Lezec*, S. M. Stavis*, *National Institute of Standards and Technology, **University of Maryland

We demonstrate the focused ion beam milling of submicrometer films of silicon dioxide and silicon nitride with subnanometer vertical resolution. Our new patterning capability enables the rapid prototyping of complex surfaces in dielectric materials with novel structure–property relationships for optical applications.

2:10 pm - 2:30 pm 9A3
Ga+ Focused Ion Beam Lithography as a Viable Alternative for Multiple Fin FinFET Prototyping, A. Leonhardt, F. H. Cioldin, M. V. P. dos Santos, J. A. Diniz, L. T. Manera, L. P. B. Lima*, University of Campinas (UNICAMP), *IMEC

This work presents the Ga+ FIB lithography as a viable alternative for obtaining sub-100nm wide fins for FinFET prototypes with good repeatability and reduced processing time. The method relies on shallow cuts on Si upper layer of the fin structure and plasma etching to produce the fins.

2:30 pm - 2:50 pm 9A4
Focused helium-ion induced direct write engineering of 2D materials, Michael G. Stanford, Pushpa Raj Pudasaini, Alex Belianinov, Nick Cross, Michael Koehler, David G. Mandrus, Gerd Duscher, Philip D. Rack, Alex Belianinov*, Adam J. Rondinone*, University of Tennessee, *Oak Ridge National Laboratory

Recent work has realized the potential of ion beams as a tool for processing 2D materials. Here, we utilize a focused He+ beam for direct-write patterning and electrical tuning of 2D materials. Direct-write patterning is enhanced by use of synchronized laser and electrical tuning is achieved by controlling defect density.

2:50 pm - 3:10 pm 9A5
Nanopores in Silicon Nitride Membranes, Graphene and CNM: Milling and Imaging Techniques at the Helium Ion Microscope, D. Emmrich, A. Beyer, A. Gölzhäuser, A. Nadzeyka*, S. Bauerdick*, J. Kotakoski**, Bielefeld University, *Raith GmbH, **University of Vienna

Helium ion microscopy was employed for both milling nanopores in free standing membranes as well as for the inspection of nanopores. Three different membrane types were investigated: 30 nm thick silicon nitride, graphene and 1 nm thick carbon nanomembranes made from aromatic self-assembled monolayers by electron-induced cross-linking.

Session 9B - Nanofabrication and Biology 2
Friday, June 3, 2016
Room: Kings Garden 4

Session Chairs:
Regina Luttge, Technical University of Eindhoven
Reginald Farrow, New Jersey Institute of Technology

1:20 pm - 1:50 pm 9B1 Invited
Micro-fabricated elastomeric pillar arrays for studies of cellular sensing of extracellular matrix rigidity, H. Wolfenson, M. P. Sheetz, S. Liu, J. Hone, Columbia University

Cellular mechanosensing is a fundamental biological phenomenon that is essential for the proper response of cells to features of their environment such as extracellular matrix rigidity. In my talk I will present our work using micro-fabricated elastomeric pillar arrays on cellular rigidity sensing and its potential implications in understanding cancer.

1:50 pm - 2:10 pm 9B2
Probing Breast Cancer Cell Response to Heterogeneous Rigidity at the Nanoscale, J. Liao, A. Guzman, L. Kaufman, S. J. Wind, Columbia University

Surfaces with patterned micro- and nanoscale rigidity are used to develop new insight into the differences in rigidity sensing between different breast cancer cell lines,

2:10 pm - 2:30 pm 9B3
Mulitiplexed Molecular Assays Using Nanoelectronically Barcoded Beads, P. Xie, X. Cao, Z. Lin, M.Javanmard, Rutgers University

We introduce the concept of electronically barcoded micron-sized beads, which to the best of our knowledge, is the first time an impedance based barcoding technique for beads has been used with the potential of achieving high barcode density.

2:30 pm - 2:50 pm 9B4
Fabrication of Hollow-Core Nanoparticles for Drug Delivery and Imaging, D. Shakarisaz, P. Ruchhoeft, University of Houston, Department of Electrical and Computer Engineering, C. Park, T. Randall Lee, University of Houston Deparment of Chemistry

Atom beam lithography is used for high-throughput patterning of gold hollow-core nanoparticles that can potentially carry a payload for drug delivery or imaging. We were able to coat the particles with a thermal sensitive polymer that can encapsulate the payload.

2:50 pm - 3:10 pm 9B5
Micro- and Nano-structured, Biofunctional Block Co-Polymer Interfaces for High-Avidity Bacteria Capture, Ryan R. Hansen, Mohammadali Masigoul, Department of Chemical Engineering, Kansas State

University, Brad S. Lokitz, Scott T. Letterer, Center for Nanophase Materials Sciences, Oak Ridge National Laboratory

A synthetic biointerface that utilizes micro- and nano-structured, bio-functional polymer films for microbe capture is reported. These polymers modify interface chemistry in order to cluster lectin proteins together at high-densities, driving multi-valent binding interactions with bacterial exopolysaccharides. Optimization of this platform will allow for sensitive detection of microbial contamination.

Session 9C - Nanoelectronics 2
Friday, June 3, 2016
Room: Kings Garden 5

Session Chairs:
Diego Scarabelli, Columbia University
Shu-jen Han, IBM

1:20 pm - 1:50 pm **9C1 Invited**
From Nanodevices to Nanosystems: The Carbon Nanotube Case Study, M. M. Shulaker, H. S. P. Wong, S. Mitra, Stanford University

In this talk, I will describe how to transform carbon nanotubes from solely a scientifically-interesting material to working nanosystems. This is enabled through a combination of new carbon nanotube processing and circuit design solutions. I will also discuss how carbon nanotubes are naturally suited for enabling new systems architectures, such as monolithically-integrated three-dimensional (3D) integrated circuits, as well as show recent experimental demonstrations.

1:50 pm - 2:10 pm **9C2**
A New Opportunity to Fabricate Multi-Bit Transistor Memories Using Mechanically Exfoliated Multilayer WSe2 Flakes, M. Chen, H. Rokni, N. Shepherd, W. Lu, and X. Liang, University of Michigan

We previously presented that a multilayer MoS2 flake, after plasma doping, has a rippled top layer, which can serve as a memory channel and enable data storage. Here, we further report that an as-exfoliated multilayer WSe2 flake can enable multi-bit data storage with no need of plasma doping.

2:10 pm - 2:30 pm **9C3**
Suspended two-dimensional MoS2 transistor, R. Zhang, A. Bunting, V. Koutsos*, R. Cheung, Scottish Microelectronics Centre, The University of Edinburgh, *Institute for Materials and Processes, The University of Edinburgh

2:30 pm - 2:50 pm **9C4**
Direct Write Electron Beam Lithography for Top-down Fabrication of sol-gel based ZnO micro-nano FETs, N. Tiwale, Y. Alaverdyan, M. E. Welland, University of Cambridge

Using sol-gel precursors as negative tone resists for e-beam direct nano-patterning of ZnO can provide precise positioning of ZnO nano-devices; while achieving enhanced sensing response due to their nano-crystalline nature. We report ZnO micro-nano FETs fabricated using zinc neodecanoate and zinc naphthenate with improved linear mobility.

2:50 pm - 3:10 pm **9C5:**
Repetitive Nanoprinting Technique for Producing Vertically Stacked Transition Metal Dichalcogenide Heterostructure Arrays and Photo-Response Devices, S. Wi, D. Li, M. Chen, B. Ryu, and X. Liang, University of Michigan

We present an upscalable nanofabrication technique capable of producing uniform multilayer TMDC heterostructure arrays into device sites. Specifically, using this technique, we have demonstrated the fabrication of uniform WSe2/MoS2 heterostructure arrays. Such heterostructures can be used for making photo-response devices.

Session 10A - Advanced Etching Techniques 2
Friday, June 3, 2016
Room: Kings Garden 3

Session Chairs:
Jim Thackeray, Dow ElectronicMaterials
Gerald Lopez, University of Pennsylvania

3:30 pm - 4:00 pm 10A1 Invited
Pattern-generation and pattern-transfer for sub-10nm devices, Ivo W. Rangelow[a], Marcus Kaestner[a], Yana Krivoshapkina[a], Ahmad Ahmad[a], Tihomir Angelov[a], Tzvetan Ivanov[a], Steve Lenk[a], Claudia Lenk[a], Burkhard Volland[a], Elshad Gulyiev [a] Ivaylo Atanasov[a], Alexander Reum[a,b], Valentyn Ishchuk[a], Zahid Durrani[d], Mervyn Jones[d], Deirdre L. Olynick[b], Daniel Staaks[a,b], Stefano Dallorto [a,b], Mathias Holz [a,c], Nikolay Nikolov [c], [a]Ilmenau University of Technology, [b]Lawrence Berkeley National Laboratory, [c]Nano Analytik GmbH, [d]Imperial College London, [e]Mikrosistemi ltd.

Today, high resolution lithographic techniques are typically linked with high capital investment in equipment. We present a relatively low cost, fast sub-10nm Scanning Probe Lithography based on Fowler-Nordheim electron emission from a scanning tip. This is combined with cryogenic etching as an approach to control feature-profiles at the nanometer scale.

4:00 pm - 4:20 pm 10A2
SiO2 plasma etching using SF6 with O2/Ar mixtures down to cryogenic temperatures, S. Rangnekar[1,2], D. Tierno[1,3], D. Staaks[1,3], M. Kocsis[5], I. Rangelow[4], A. Goodyear[6], C. Ward[6], D. Olynick[1], [1]Lawrence Berkeley National Laboratory, [2]UC Berkeley, [3]IMEC, [4]Ilmenau University of Technology, [5]Inpria Corp., [6]Oxford Instruments

We test the utility of SF6 at cryogenic temperatures when etching sub-100 nm features in silicon oxide for applications such as nanoimprint template formation. We use two etching masks, hafnia and chromium, and complementary gases, Ar and O_2. The effect of power, pressure, gas mixtures and temperature will be discussed.

4:20 pm - 4:40 pm 10A3
Fabrication Process for 200 nm-Pitch Polished Freestanding Ultra-High Aspect Ratio Gratings, A. R. Bruccoleri, Izentis LLC, R. K. Heilmann and M. L. Schattenburg, Massachusetts Institute of Technology

A fully integrated fabrication process has been developed to fabricate freestanding, ultra-high aspect ratio gratings with KOH-polished sidewalls. The gratings have a pitch of 200 nm, a depth of 4 µm, and the bars are polished via KOH. The finished gratings span an area of approximately 10 by 30 mm.

4:40 pm - 5:00 pm 10A4
Computational study on novel proximity lithography for deep stepped substrate by Built-in Lens Mask (BILM), Toshiki Tanaka, Hisao Kikuta, Masaaki Yasuda, Hiroaki Kawata, Masaru Sasago, and Yoshihiko Hirai

Novel optical lithography for stepped substrate is newly proposed using built in lens mask (BILM). The pattern is divided into small seed elements and the BILM is obtained by superposition for seed patterns. Fine pattern having around 1 µm linewidth is successfully imaged on 40µm step height.

5:00 pm - 5:20 pm 10A5
Development of a Nanocrystalline Diamond (NCD) Membrane for Vacuum Pressure Separation and Patterned Electron Beam Image Transfer, D. Akemeier, Z. E. Russell, R. Edgington, Y.T. Cheng, L. Galambos, W. F. Aitkenhead, L. Hesselink, Stanford

We have developed a freestanding diamond membrane that acts as a lossless electron transparent window separating clean UHV from lower pressure environments and is compatible with patterned or multibeam applications. The production process and optimization results as well as its intended use in a patterned X-ray system will be described.

Session 10B - Micro and Nano Fluidics
Friday, June 3, 2016
Room: Kings Garden 4

Session Chairs:
Wu Lu, The Ohio State University
Walter Hu, University of Texas, Dallas

3:30 pm - 4:00 pm 10B1 Invited
Microfluidic devices: merging technology and biology, J.M.J. den Toonder, Eindhoven University of Technology

In microfluidics, engineering and life sciences merge. Fluid manipulation principles found in biology can be adopted in microfluidic devices through 'biomimetic design'. The other way around, microfluidic devices can be used to control and understand biological processes. This lecture will show examples of both: artificial cilia, responsive surfaces, and cancer-on-a-chip.

4:00 pm - 4:20 pm 10B2
Nanofluidic Liquid Cell with Integrated Electrokinetic Pump for In Situ TEM, Christopher H. Ray, B. Robert Ilic, Renu Sharma, Glenn Holland, Vladimir Aksyuk, Samuel M. Stavis, J. Alexander Liddle, National Institute of Standards and Technology

We have developed a nanofluidic cell with an integrated electrokinetic pump to enable high-resolution imaging of reactions occurring in liquid in the transmission electron microscope. We describe the fabrication process and operation of the cell.

4:20 pm - 4:40 pm 10B3
Replicating Natural Environments: Soil-inspired Microfluidic Architectures, J. Aufrecht , M. Doktycz, S. Retterer, Oak Ridge National Laboratory and The University of Tennessee

Microfluidic architectures were designed to replicate the physical parameters of sand samples in order to study the emergent phenomena of microbial communities in their natural habitat. The devices were fabricated using a granular media generator, standard photolithography, and poly-dimethylsiloxane molding and characterized with COMSOL Multiphysics simulations and particle velocimetry.

4:40 pm - 5:00 pm 10B4
Ultra-Compact Microfluidic Valves Using Magnetorheological Fluid Patterned on an Elastomeric Membrane, Azam Gholizadeh, Mehdi Javanmard, Rutgers University

We present a novel method for magnetically actuating microfluidic valves while maintaining an ultra-compact system footprint. Our magnetically actuated valves use Magnetorheological (MR) fluids patterned on elastomeric PDMS membranes, and are capable of dynamically opening and closing microchannels with a applied magnetic fields.

5:00 pm - 5:20 pm 10B5
FIB Deposition of Platinum Micropillars in Microchannels for Diffusion Control in Microfluidic devices, Salomão M. S. Junior[1,] Alfredo R. Vaz, Maria H. O. Piazzeta[2], Jacobus W. Swart[1], and Stanislav Moshkalev[1,] [1]UNICAMP, State University of Campinas, [2]Brazilian Nanotechnology National Laboratory

Focused Ion Beam Induced Deposition (FIBID) using organometallic precursors is frequently employed for deposition of metals. In this work was used Pt deposition to create micropillars in microfluidic devices for to increase of lowing liquids to improve the control of mass diffusivity to enhance the mixture of different fluids.

Session 10C - Electron Beam Lithography 2
Friday, June 3, 2016
Room: Kings Garden 5

Session Chairs:
Ming Lu, Brookhaven National Laboratory
Rich Tiberio, Stanford University

3:30 pm - 4:00 pm 10C1 Invited
The Impact of Parallelism on Data Volumes for a Multibeam Mask Writer, N. Chaudhary, Y. Luo, S. A. Savari, Texas A&M University

Future mask writers must transmit terabits of information per second and handle petabytes of data to handle upcoming throughput and resolution challenges. We will examine how parallelism affects the total beam compressed data for one idealized multibeam architecture inspired by the IMS Nanofabrication multibeam mask writer series eMET.

4:00 pm - 4:20 pm 10C2
Dense metasurface with high efficiency dense metasurface for broadband optical vortex by high resolution electron beam lithography, B.-R. Lu, C. Xu, Y. Chen, Fudan University

Metasurface generated optical vortex beams suffer from drawbacks of low efficiency and narrow waveband, hindering the practical use. We use high density subwavelength nano antenna array of the metasurface to achieve broadband efficiency enhancement in visible frequency. This metasurface can find applications in communication encryption, optical microscopy and optical tweezers.

4:20 pm - 4:40 pm 10C3
Fabrication of 3 Dimensional Photonic Crystals with Waveguides for visible Light, S. Dhuey, A. Testini, N. Borys, M. Melli, P.J. Schuck, C. Peroz, S. Cabrini, Molecular Foundry, Lawrence Berkeley National Lab

In this work we demonstrate 3D photonic crystals for the visible light regime fabricated by electron beam lithography. They are made with silicon nitride wires, with a nanoporous resist as the interstitial, forming woodpile structures, some of whic contains defects for waveguiding.

4:40 pm - 5:00 pm 10C4
Electron beam lithography using grafted polystyrene monolayer brush, F.Aydinoglu, R. K. Dey, B. Cui, University of Waterloo

Polystyrene terminated with -COOH was grafted onto a substrate and used as negative e-beam resist. Pattern transfer into silicon was obtained by utilizing an intermediate Al hard mask layer, onto which the mono-layer polystyrene brush was grafted. The process can be employed to carry out nanofabrication on irregular (non-planar) samples.

5:00 pm - 5:20 pm 10C5
Large Area Three Dimensional Structure Fabrication using Multi-layer Electron Beam Lithography, R.K. Bonam, SUNY Polytechnic Institute

Three dimensional nanostructures are of great interest in photonics and sensor communities. In this work, we describe a method that exploits intrinsic resolution and dose control of electron beam lithography systems combined with the penetration depth of high energy electron beams (>100keV) and tailored photoresist contrasts, tones.

Wednesday Poster Session, June 1
Grand Ballroom
10:50 am – 1:00 pm
5:30 pm – 7:00 pm

Session Chairs:
Stefano Cabrini, Lawrence Berkeley National Lab
Shinda Tan, Intel

Advanced Pattern Transfer and Reactive Ion Etching

P1
Down to 7 nm pores in Si by photo-assisted electrochemical etching, F. Aydinoglu, B. Cui, University of Waterloo

We systematically studied photo-assisted electrochemical etching of n-type bare (without pre-patterning) silicon wafer using an electrolyte containing HF. We observed the formation of pores, with diameter down to 7 nm and depth 200 nm when using relatively low applied voltage and very low photo-current.

P2
Nanoscale Patterning using Oblique Angled Deposition Technique in Fabricating Nanostructures with Nanosphere Lithography, Ba Myint, Vivian Ng, National University of Singapore

A new way of fabricating complex nanoscale patterns using oblique angled nanosphere lithography (NSL) is developed. In this NSL technique, an oblique angled beam is used to create more than one set of nanostructure on a single substrate. This beam is formed by varying the opening angle of the shutter.

P3
Ultra high aspect ratio X-ray photon sieves by deep reactive ion etch on silicon and electroplating,
Xin Li, Jianpeng Liu, Chen Shuo, Jinhai Shao, Lu Bingrui,Yifang Chen,Fudan University

It demonstrates a solution for ultra high aspect ratio photon sieves for high diffraction efficiency by DRIE. Vertical Si pillars with nanoscale roughness for Au photon sieves indicates it is promising for new X-ray components. It can also apply to zone plates, light collimators in hard X-ray beyond 10 keV.

P4
Silicon nanostructures with negatively tapered profile by ICP-RIE, Asma Ayari-Kanoun, Ferhat Aydinoglu, and Bo Cui, University of Waterloo, Faycal Saffih, United Arab Emirates University

Silicon structures with a negatively tapered profile (8-10°) have been achieved. These structures can be used for many applications such as water and oil repelling surfaces, Si nanowires for single electron or multi-gate transistors, or for lateral re-entrant AFM tips fabrication.

P5
Study of Reactive Ion Etching for Kinoform Lenses, Abdiel Quetz*, Ming Lu**, Aaron Stein**, Kenneth Evans-Lutterodt** and Andrei Fluerasu**, *Southern Illinois University, **Brookhaven National Laboratory

In this project, we developed the Reactive Ion Etching (RIE) process at the Center for Functional Nanomaterials (CFN) for kinoform lenses, for the CHX beamline, and other NSLS-II beamlines. The RIE was performed on silicon material, achieving an etch dept of 100 microns in the making of the x-ray lenses.

P6
High aspect ratio and high resolution nanofabrication using self-assembly of salt-polymer nanocomposite film, Celal Con, Bo Cui

We developed a low cost self-assembly method to obtain sub-100 nm high aspect ratio (15:1) structures. Metal salt and polymer were dissolved in DMF. Phase separation was induced via annealing the film. After etching polymer, salt islands were formed that can be used as hard mask to etch the substrate.

P7
Large-area Freestanding Si Nanowire Arrays in Organic Matrices, E. Mills, S.Y. Chou, Princeton University

P8 (Invited)
Application of Gettering Layers for Low Temperature Conversion of Magnetic Oxides into Ferromagnetic Metals in Thin Films, Multilayers, and Nanostructured Arrays, W. Qiu, L. Chang, D. Litvinov, University of Houston

This work demonstrates conversion of nonmagnetic cobalt oxide into ferromagnetic cobalt in thin films, multilayers, and nanostructured arrays by low temperature annealing in the presence of tantalum gettering layers. A nanopatterning approach to locally reduce CoO/Pd to Co/Pd is introduced based on the thermodynamically driven reaction between tantalum and CoO.

Optical and Extreme UV (EUV) lithography

P9
Three-Dimensional Colloidal Interference Lithography, Hironori Nagai, Xu A. Zhang, and Chih-Hao Chang, North Carolina State University

We investigate 3D colloidal interference lithography using light scattering to fabricate different geometries of structures with double nano-scaled chambers. Control and design of the geometries by different exposure conditions will be studied with possible applications in drug delivery and nanofluidics.

P10
Evaluating the Optical and Resist Contributions to Line-Edge Roughness in EUV Lithography Using Stochastic Simulation, Anindarupa Chunder, Azat Latypov, Harry J. Levinson,John J. Biafore*, Globalfoundries Inc, *KLA-Tencor Corp.,

P11
Source Imperfection Impacts on Optical Proximity Correction, Lawrence S. Melvin III, Artak Isoyan, Jensheng Huang, Synopsys, Inc

Source Mask Optimization matches the best source shape to a given drawn pattern. While the math and computation can produce highly accurate results, the physical implementation has error associated with it. This paper proposes to study the effect of source imperfections on the final wafer pattern using simulation techniques.

P12
Study of Alternate Hardmasks for EUV Patterning, A. De Silva, I. Seshadri, A. Arceo, M. Belyansky, S. Halle, N. Felix, IBM Corp.

Traditional patterning stacks for DUV/193nm patterning have been based on a tri-layer scheme with an organic planarizing layer, Silicon ARC (anti-reflective coating) or organic BARC (bottom anti reflective coating) and photoresist. At EUV wavelength, there is no longer a need for reflectivity control, so it offers an opportunity to look at different types of underlayers for patterning at sub-36nm pitch length scales. The hardmask layer under the resist can be designed to optimize secondary electron generation at the resist/hardmask interface to improve patterning performance, as well as potentially simplify the patterning scheme. This work explores EUV patterning on deposited hardmasks of various types such as silicon oxides and metal hardmasks.

P13
Fabrication of Magnetically Tunable Periodic Nanostructures, X. Zhang, Z. Luo, A. Poteet, C. Chang, North Carolina State University

The fabrication of magnetically tunable nanostructures was investigated using standard micromachining techniques and Lloyd's mirror interference lithography. A PDMS trimming process using SF6 reactive ion etching was developed to increase aspect ratio to ~11.

Nanofabrication for Biology and Nano-medicine

P14
Development of transparent microwell arrays for optical monitoring and dissection of microbial communities, Michelle Halsted*, Paige Briggs**, Ryan Hansen***, Andrea.C. Timm****, Dayrl P. Briggs****, Scott. T. Retterer****, *University of Tennessee, **Th

The fabrication of transparent microwell arrays with parylene mask for dry lift-off were produced and are being used to stochastically assemble microbial communities. The use of high resolution laser confocal microscopy and laser microscope dissection to characterize communities within these optically accessible microarrays will be discussed.

P15
A CMOS based nano-electrode array for high-throughput electrophysiology, T. Ye, J. Abbott, D. Ham, H, Park, Harvard University

In this work, combining the intracellular capability of nano-electrodes with the scalability of CMOS circuits, we have built the CMOS based nano-electrodes array (CNEA) as a platform for high throughput electrophysiology. Intracellular recording from 364 cardiomyocytes in parallel has been demonstrated.

P16
Lithographically patterned nanostructures for geometric control of coiled-coil protein placement and alignment, M. Bedewy, W. M. Park, H.-W. Do, A. Tavakkoli, A. E. Keating, K. K. Berggren, Massachusetts Institute of Technology

We used e-beam lithography and block copolymer (BCP) lithography to create arrays of designed nanoscale features for selective protein binding. Patterns are transferred to gold by either e-beam evaporation and lift-off, or by a templated dewetting process. In templated dewetting, the formation of self-ordered nanoparticles is guided by BCP pattern.

P17
Electronic Quantification of Surface Proteins on Circulating Tumor Cells Based on Bead-CTC Aggregate Sizing, Z. Lin, S. Lin, M. Liu, P. Xie, J.R. Bertino, M. Javanmard, Rutgers University

Rapid quantification of surface markers on CTCs can allow for prediction of patient response to various cancer drugs. Here, we implemented an electrical-impedance based biochip for quantification of proteins on surfaces of cancer cells. We demonstrated proof-of-concept based on detection of matriptase proteins on the surface of CTCs.

P18
Fabrication of Nanojunction with Sub-10 nm Nanogap for Surface Enhanced Raman Scattering by Tensile Stress Mechanically Breaking, J.J. Li, Y.J. Wang, B.G. Quan, and C.Z. Gu, Chinese Academy of Sciences

This work has developed a technique that advances the mechanically break method in order to produce nanojunctions with the width of the nanogap well controlled below 10 nm. The distinguished Raman signal from ultra-low concentration of protein molecules elucidate that the preponderance of the nanojunction in plasmonic based detection.

P19
Nanoscale interdigital electrode arrays for smart water sensing, Fengquan Song, Yuchen Liang, Winfred Li, John Li, George Du, Amy Wang, Walter Hu, University of Texas at Dallas

For the first time, we apply commercial Surface Acoustic Wave (SAW) device that are used in RF communication to be nanoscale interdigital electrode arrays (nano-IDA) for sensing chlorine concentrations towards smart water monitoring. The nano-IDA with 283 nm in width provides enhanced sensitivity with low cost.

P20
Feature Based Design Software for 3D Printed Microfluidics, P. Shankles* **, L. Millet**, S. Retterer* **, *The University of Tennessee, **Oak Ridge National Lab

Using 3D printers for microfluidics relies on complex CAD programs. The design software described simplifies the design process by having the user assemble common parameterized microfluidic features into a unique device. The fabrication process uses PDMS cured directly on the 3D printer's print bed to further simplify the method.

Electron Beam Lithography

P21
Analytic Estimation of LER for Large-Scale Uniform Patterns in Electron-beam Lithography, R. Guo, S.-Y. Lee, J. Choi*, S.-H. Park*, I-K. Shin*, C.-U. Jeon*, Auburn University, *Samsung Electronics

Previously, an analytic method of estimating and minimizing the LER for a single line was developed, shown to achieve a high accuracy compared with simulation results. In this study, the analytic method for estimating the LER is extended for the large-scale uniform patterns.

P22
The Optimization of T-shape Gate Geometry in GaN HEMTs by Monte Carlo Simulation, Jianan Deng, Jinhai Shao, Yifang Chen*, Fudan University

This work offers a promising solution to the bottle-neck of high frequency operation in GaN-HEMTs by optimizing the gate geometry for power amplifiers in both micro- and terahertz-wave communications.

P23
The effect of the grating profile on the illumination uniformity of the X-ray condenser, Jianpeng Liu, Xin Li, Shuo Chen, Jinhai Shao, Sichao Zhang, Bingrui Lu Chengwen Mao, Yifang Chen

The effect of the grating profile in condensers on the illumination distribution was theoretically investigated by numeral calculation using FDTD software. It was then experimentally verified that

structural defects can deteriorate the uniformity of illumination using the fabricated condenser with integrated gratings. This work is important for achieving high uniformity.

P24
Enhanced etching resistance of e-beam resist Na-PSS by adding metal compound into resist or developer, Celal Con, Bo Cui

Previously we showed poly(sodium 4-styrenesulfonate) can be used as e-beam resist with high etching resistivity. But the resistance was reduced after development because of sodium loss to water developer. Here we reported the enhancement of etching resistance by adding metal compound to the resist or to the developer.

P25
Shape Positional Accuracy Optimization via Writing Order Correction, G. Lopez, M. Metzler, S. Wood, C. Elliott, G. Kim, R. McCay*, S. Stammberger*, University of Pennsylvania, *GenISys GmbH

We present a novel way through data preparation to minimize the impact of drift when exposing a pattern. In our work, we discuss the algorithm and present patterns tolerant to positional inaccuracies via this writing order correction that are both proximity effect corrected and uncorrected.

P26
Mixture of ZEP and PMMA with tunable sensitivity as a liftoff layer with controllable undercut, S. Zheng, R. Kumar Dey, F. Aydinoglu, B. Cui, University of Waterloo

PMMA was added to ZEP resist, and the sensitivity of the resist mixture can be tuned by changing the ratio between the two. By using this mixture as the under-layer below the top PMMA resist, undercut profile with controllable amount of undercut can be achieved for optimal liftoff process.

P27
Measurement error in metal nanostructures on insulating substrates induced by electron beam irradiation, Ranveig Flatabø, Bodil Holst, Martin M. Greve, Antione Coste*, University of Bergen, *École normale supérieure de Lyon

In this work, we study the charging effect in metal nanostructures on insulating materials by scanning electron microscopy. Specifically, we quantify a measurement error in the metal nanostructure dimensions induced by negative charging of the sample.

P28
Noise Filtering for Accurate Measurement of Line Edge Roughness and Critical Dimension from SEM Images, D. Li, R. Guo, S.-Y. Lee, J. Choi*, S.-H. Park*, I.-K. Shin* and C.-U. Jeon*, Auburn University, *Samsung Electronics

In this paper, a frequency-domain method for determining the size and shape of a noise filter to be used for accurate measurement of LER and CD from SEM images is described.

P29
A novel approach for the reduction and inspection of sidewall roughness of patterned resist, Chen Xu, Sichao Zhang, Jinhai Shao, Yifang Chen,Fudan University

We have developed an effective method to reduce sidewall roughness based on thermal radiation induced local reflow without de-shaping the whole profile. Optical reflection spectra is also used to inspect the sidewall roughness and line-edge roughness of patterned resist.

P30
Nanofabrication of arch metal structures as gas/biosensors by grayscale electron beam lithography, Jinhai Shao, Xiaqi Huang, Sichao Zhang, Jianan Deng,Yifang Chen,Fudan University

We have developed a novel nanostructure as arch structure in metals with various radii, periods and thickness like a resonance cavity which can be used as biosensors.

P31
Mask registration and array efficiency for nitride FinFET prototyping, Jae Woo Suh, H. Rusty Harris,E. L. Principe*, Texas A&M University, *TESCAN USA

We examine the electron beam lithography requirements of wide band gap nitride device technology. The etching difficulty, pattern transfer, hard masking and prototyping processes for mask to mask pattern registration is discussed. Geometry dependence of the 2D electron gas density is also described in terms of stress relaxation.

P32
Sub-10 nm Electron Beam Lithography by Using Rapid and Cold Development of ZEP-520A, C. Nien, C.H. Chung, V.C. Su, and C. H. Kuan, National Taiwan University

In this work, we study the effects of development time and the temperature on the exposure pattern and show that sub-10 nm pattern could be achieved by using a rapid and cold development process.

P33
Aberration-Corrected Electron-Beam Lithography, V. Manfrinato, A. Stein, L. Zhang, E. Stach, C. Black, BNL

Here we report the development of an aberration-corrected electron-beam lithography system by installing a pattern generator to an aberration-corrected scanning transmission electron microscope operating at 200 keV. We will show the sub-10 nm patterning capability of this system.

Nano-photonics

P34 (Invited)
Design and Fabrication of an In-Plane Nano structured Solar Concentrator, J. Tippens, A. Bagal, C. Chang, Department of Mechanical and Aerospace Engineering, North Carolina State University

A new type of solar concentrator utilizing nano structures as a diffraction grating is demonstrated. Fabrication involves interference lithography and replication ends in nano pillars of a clear polymer on a glass substrate. The design shows that light trapping results in an electrical efficiency that maintains glass's optical properties.

P35
Low-Workfunction Metal Doping for Making WSe2 Photovoltaic Devices, D. Li, S. Wi, and X. Liang, University of Michigan

P36
Nanofabrication of metasurface with gold polycyclic radial apertures for optical vortex by EBL, Xiaqi Huang, Jinhai Shao, Sichao Zhang, Jianan Deng, Bingrui Lu, Yifang Chen,Fudan University

A novel PMMA/NEB bilayer process by EBL has been developed for replicating 100 nm width radial apertures on 80 nm thick gold film,which has been successfully applied to the fabrication of metasurface as a converter of optical vortex.

P37
In-Plane Optical Power Flow Control with Nano-Fabricated Plasmonic Structures for Micro Total Analysis Systems, M. Okuno, R. Kometani, E. Maeda, The University of Tokyo

Eclipse-like plasmonic structure for in-plane optical power flow control for Micro-TAS was proposed. Illumination for the plasmonic structure make the analyte move in one direction. To confirm our idea, the surface enhanced Raman intensity of fabricated structure was analyzed.

P38
Refractive Index and Temperature Sensing Using a Plasmonic Optical Fiber Probe Fabricated by Double-Transfer Nanoimprint Lithography, S.Li, W.Li,The University of Hong Kong

We use double transfer UV-NIL to pattern metal nanostructures on fiber facet. The electric field between metal hole and disk array layers was enhanced and it caused resonant dip in reflection spectrum. This plasmonic fiber probe was applied to realize refractive index and temperature sensing.

P39
Design and Fabrication of Plasmonic Notch Color Filters, Ray J. H. Ng*, Nicholas Z. W. Oh, Ye Yu, Sihao Wang, K. W. Yang*, Singapore University of Technology and Design, Institute of Materials Research and Engineering

We propose to use surface lattice resonances to create notch filters. Plasmonic color filters have been of great recent interest as they can be actively controlled and tunable. Using a Lloyd mirror setup, we are able to produce ~60nm tall aluminum discs with a minimum period of <300nm.

P40
Patterned Fabrication of ZnO Nanowire Arrays for Nanoplasmonic Waveguide Applications, Huizhong Xu, Thomas Lamson, Sahar Khan, St. John's University

We demonstrate the patterned fabrication of ZnO nanowire arrays of varying spacings and diameters down to 50 nm. These ZnO nanowires show superior optical transmission properties and may be constructed as devices for single-particle imaging of highly concentrated molecules in biomedical applications.

P41
Investigating the color change in annealed gold nano particle arrays, V. R. A. Holm, M. M. Greve, B. Holst, University of Bergen

The optical properties of large 2D arrays of ordered gold MNP's are investigated using SEM, AFM and a spectrometer setup, and how they are affected by annealing up to 600 deg. C.

P42
Nanofluidic Flow-Assisted Assembly (NFAA) of Well-Dispersed Plasmonic Nanostructures into Nanoslit Sensors, H. Izuoka*, H. Nam, J.S. Yoon, Wenjie Wan**, and X. Liang, University of Michigan, *Nagoya University, **Shanghai Jiao Tong University

P43
Plasmonic Nanostructures using Cell-less Liquid-Phase Electron Beam Induced Deposition, S. Esfandiarpour, J. T. Hastings, University of Kentucky

Nano-electronics

P44
Study of Ion-Induced Defect Migration in Boron-Nitride Encapsulated Graphene, G. Nanda, P. Alkemade, Kavli institute of Nanoscience, Delft University of Technology

Using the local probe techniques, we investigate the extent of He+ induced damage in graphene that is encapsulated between hexagonal boron-nitride (hBN) flakes. We show that encapsulation slows down the lateral migration of defects in graphene. Furthermore, we fabricate graphene nanoribbon devices with one-dimensional electrical contacts.

P45
Atomic Emission Spectroscopy of Electrically-Triggered Exploding Nanoparticle Analytes on Graphene/SiO_2/Si Substrate, S. Liu, M. Kim, H.K. Kim, University of Pittsburgh

Nanoparticle analytes (CdSe quantum dots) placed on graphene/SiO2/Si substrate are atomized by pulsed voltage for atomic luminescence, which enables chip-scale atomic-emission spectroscopy for elemental analysis. Kinetic electrons impinge upon nanoparticles through graphene, charging the analytes until Coulomb repulsion exceeds binding force. The nanoparticles explode producing characteristic luminescence.

P46
Initial Design and Nanofabrication of Energetically Efficient Biologically Motivated Contact , S. S. Azhar, I. A. H. Farhat, A. Stein*, A. F. Isakovic, Khalifa University, *Brookhaven National Laboratory

The motivation for the introduction of biologically motivated contacts is presented. This is followed by the examples of early development of mesowires and contacts that follow modified and simplified biological patterns that can serve as initial test patterns for the future implementation of the biologically motivated contacts in nanoelectronics.

P47
Thermal stresses and cracks in a solution-processed ITO nanoparticle-thin film heater, K. Yang, K. Cho, S. Kim*, K. Im**, *Korea University, **TNB Nanoelec Co. Ltd.

We investigate the relationship between thermal stresses and cracks for solution-processed ITO NP thin film heaters. It is demonstrated that the thermal stresses at high temperatures bring about severe deformation of the ITO NP thin film heater and consequently the deteriorating performance of the heater.

P48 (Invited)
Artificial Two-dimensional Lattice Structures Assembled by Atom Manipulation Technique,
Masashi Nantoh, K. Takashima*, T. Yamamoto*, K. Ishibashi, RIKEN, *Tokyo University of Science

We have fabricated artificial two-dimensional lattice structures of Fe atoms and CO molecules on a Cu(111) surface using atom manipulation technique with a LT-STM. The spectroscopic measurements indicate that the symmetry of the sublattice degree of freedom of the CO triangular lattice is originally broken.

Novel Imaging and Characterization Techniques

P49 (Invited)
Ultra-Low-Voltage Imaging Using a Miniature Electron Beam Column, J. P. Spallas and L. P. Muray, Keysight Technologies

We investigate imaging and contrast modes in the ultra-low energy regime using a commercial field emission electron microscope with a miniature electron beam column equipped with a retarding field lens that allows imaging with < 0.5 keV electrons.

P50
Assessing the local nanomechanical properties of self-assembled block co-polymers thin films by Peak Force tapping, Matteo Lorenzoni*, Laura Evangelio*, Célia Nicolet**, Christophe Navarro** and Francesc Pérez-Murano*, *IMB-CNM (CSIC), **Arkema France

AFM is widely used to image surface topography at the nanometric scale or to map the qualitative differences of local surface properties such as friction or elastic modulus. Using PeakForce quantitative nanomechanical mapping is possible to reliably measure Young's modulus of BCP film with high spatial resolution and surface sensitivity

P51 (Invited)
Design and Numerical Analysis of a Coherent Electron Resonator for the Quantum Electron Microscope, W.P. Li*, C-S. Kim, R. G. Hobbs, O. T. Celiker, K. K.Berggren, P. Kruit**, Massachusetts Institute of Technology, *Beihang University, **Delft University o

The quantum electron microscope (QEM) is a proposed EM modality to reduce the radiation damage of sensitive samples. An improved design was integrated with an existing scanning electron microscope for the proof-of-concept of a coherent electron resonator. The automatic differentiation technique was used to obtain electron optical properties of QEM.

Nano- and Micro- Electromechanical Systems

P52 (Invited)
High Speed AFM Imaging and Nanolithography with Parallel Scanning Probes, Nikolay Nikolov, Ahmad Ahmad*, Tihomir Angelov*, Tzvetan Ivanov*, Alexander Reum*, Ivaylo Atanasov*, Elshad Gulyiev*, Valentin Ishchuk*, Marcus Kästner*, Yana Krivoshapkina*, Steve

This paper presents the fabrication and characterization of a parallel cantilever device integrating four self-sensing and self-actuating probes in an array controlled by a multi-channel FPGA controller. The cantilevers are actuated thermo-mechanically and their bending is measured piezoresistively. The piezoresistive read-out routinely ensures atomic resolution and a high imaging speed.

P53
Six - axes AFM in SEM with self-sensing and self-transduced cantilever for high speed analysis and nano-lithography, T. Angelov, M. Holz*, E. Gulyiev, A. Ahmad, A. Reum, I. Atanasov, T. Ivanov , V. Ishchuk, M. Kästner, Y. Krivoshapkina, S. Lenk, C. Lenk,

These work goals at providing a new eloquent representation of detailed results from combined examinations, by applying fast AFM-methods and SEM-image fusion, AFM-SEM combined metrology verification and 3D-visualization.Combined AFM and SEM capabilities provide a view of sample topography due to a large number of hybrid imaging and sub-10nm measurement techniques.

P54
An Optimized Dual-Axis Electrolytic Tilt Sensor, Shaoda Zhang, Yang Deng, Xing Cheng, Southern University of Science and Technology

A low-cost version of electrolytic tile sensor is fabricated and characterized for the measurement of a wide range of tilt angles with accuracy and good repeatability.

P55
RF Sputtering of ZnO (002) Thin Films on top of 3C-SiC-on-Si (100) Substrates for Low Cost Piezoelectric Devices, V. Sasi, A. Iqbal, G. Walker, A. Iacopi and F. Mohd-Yasin, Queensland Micro- and Nanotechnology Centre, Griffith University, Australia.

RF sputtering is employed in the deposition of ZnO thin film because of high deposition rate, good control of the film texture and stoichiometry, thickness uniformity and surface smoothness. In this work, we deposited c-axis ZnO thin films on top of epitaxial 3C-SiC/Si (100) substrates by RF magnetron sputtering.

P56

Micropiercing of titanium foil by combination of a roll press method and dry etching, R. Fukuyama, J. Taniguchi, Tokyo University of Science

We proposed micropiercing of Ti foil by combination of the roll-to-substrate (RTS) process and dry etching process. By using this method, an aperture ratio was 92% and there are a few curls to the Ti foil. Moreover, the burr height was reduced to 1/9 compared with only RTS.

P57
Microfabrication of Planar Spectrum Splitting and Beam Concentration Diffractive Optical Element for Lateral Multijunction Photovotaic System, B.G. Quan, D.F. Lin, J.J. Li, C.Z. Gu, Q.B. Meng, and G.Z. Yang, Chinese Academy of Sciences

In this work we have designed and fabricated a 32-level broad-band DOE to simultaneously split and concentrate the sunlight for lateral multijunction photovoltaic system. The concentrating and splitting performance the surface-relief DOE was characterized by measuring the spectrum as a function of position.

P58
Electrical characteristics of a-Si:H TFTs under bending stresses, H. Oh, K. Cho, S. Kim, Korea University

In this study, we investigate the effect of the channel dimension on the electrical characteristics as TFTs are bent. For a channel width of 50 μm, the TFT operates safely under bending with a compressive radius of 3 mm and a tensile radius of 4 mm

P59
The effect of acid treatments on the conductivity of spin-capable carbon nanotube, D. Jung[1,2], H. Kim[2], [1]The University of Texas at Dallas, [2]Korea Institute of Industrial Technology

In this paper, we present new efforts to reduce sheet resistance of the CNT film using simple acid treatments. We found that adding fuming acid treatment after immersion treatment is an efficient way to obtain high conductivity CNT films.

P60
Carbon nanotube yarn based thermal sensor for measuring acceleration and tilting, Daewoong Jung, Maeum Han*, Gil S. Lee**, Korea Institute of Industrial Technology, *Gyeongbuk Technopark, **University of Texas at Dallas

A thermal convection-based sensor using CNT yarn is presented along with a simple and easy fabrication method. This sensor can be applied to both acceleration and tilting measurements without the modification of structure. The experiment results show a linear and stable sensitivity with low power consumption.

Nano-imprint Lithography

P61 (Invited)
Viscosity range of UV-curable resins usable in screen printing with polyimide through-hole membrane masks for sub-100 nm-wide imprint patterns, T. Uehara, A. Onuma, A. Tanabe, K. Nagase*, H. Ikedo*, N. Hiroshiba, T. Nakamura, and M. Nakagawa, IMRAM, Tohoku University, *MINO GROUP

Our group proposed a screen printing as a discharging method for high-viscosity UV-curable resin. We revealed the viscosity range of resins usable in screen printing and measured discharged droplets volume for position selective placement. We also demonstrated uniform residual layer thickness in sub-100 nm size imprinting with screen printing.

P62
High fidelity 3D thermal nanoimprint with UV curable PDMS stamps, N. Chidambaram, R. Kirchner, M. Altana*, H. Schift, Paul Scherrer Institute, *Heptagon Oy

3D master structures prepared with two photon polymerization are replicated into PMMA, using hot embossing with PDMS stamps. Higher stiffness UV curable PDMS is used for this purpose without any heating-curing step. The influence of embossing parameters on the replication is studied. Micron-sized and 100nm sharp features are well reproduced.

P63
Nanoimprint technology for patterning functional ZrO2 ceramic materials, Bo Yu, Dandan Li, Yulong Chen, Dazhi Sun, Xing Cheng, Southern University of Science and Technology

We report the patterning of functional ZrO2 ceramic materials by nanoimprinting ceramic-bearing resist followed by controlled high-temperature sintering.

P64
Self-cleaning Properties of Nanostructured Polypropylene Foils Fabricated by Roll-to-Roll Extrusion Coating, A. Telecka, L. Sun, R. Taboryski, Danish Technical University

The paper presents systematic wetting properties study of nanostructured polypropylene foils fabricated by R2R extrusion coating process.Metal templates were prepared through maskless black silicon etching process and consequent electroplating.Wetting properties of fabricated PP foils were characterized by contact angle measurements of water sessile drop in static and dynamic method.

P65
Thermal Nanoimprint of Soda-Lime Glass Using Induction Heating and Sapphire Molds, Jingxuan Cai, Xu Guo*, Haixiong Ge*, Wen-Di Li, The University of Hong Kong, *Nanjing University

In this research, a soda-lime glass nanoimprinting method using sapphire molds is demonstrated and a 650 nm period hexagonal hole array is fabricated on the soda-lime glass substrate. Moreover, application of the imprinted glass substrate as a SERS substrate is demonstrated.

P66
Hierarchical micro/nano structures for enhanced self-cleaning applications, Ariadna Fernández, Achille Francone, Clivia M. Sotomayor Torres*, Nikolaos Kehagias, Catalan Institute of Nanoscience and Nanotechnology, *ICREA, Institució Catalana de Recerca i

In this paper we present a flexible and adaptable fabrication method to create complex hierarchical structures over inherently hydrophobic resist materials. We have tested these surfaces for their superhydrophobic behavior and successfully verified their self-cleaning properties.We achieved a water contact angle of 166 º and a hysteresis about 5-7º

P67
A New UV-curable Resist with Liquid Volume-Expanding Monomers, Haodi Min, Zengju Fan, Nan Zheng, Xing Cheng,Southern University of Science and Technology

In this work we report a new UV-curable resist formulation with minimal volume shrinkage by mixing volume-expanding liquid monomers with conventional epoxy monomers.

P68
Molecular orientation evaluation of negative-tone and positive-tone photo-cross-linkable liquid crystalline polymer pattern fabricated by nanoimprint-graphoepitaxy, Makoto Okada, Yusuke Taniguchi*, Yuichi Haruyama, Hiroshi Ono**, Nobuhiro Kawatsuki*, and Shinji Matsui, LASTI, Univ. of Hyogo, *Department of Applied Chemistry, Graduate School of Engineering, Univ. of Hyogo, **Department of Electrical Engineering, Nagaoka Univ. of Technology

We fabricated negative-tone and positive-tone photo-cross-likable liquid crystalline polymer patterns by nanoimprint-graphoepitaxy and observed the patterns by polarized optical micrography (POM) under crossed-nicols. The observational results indicate that the molecular reorientation behavior is different between negative-tone and positive-tone patterns.

P69
Fabrication of Patterned Multilayer Structure by using Novel Reversal Imprinting, K. Fujii, Y. Sawada, H. Kawata, M. Yasuda, Y. Hirai, Osaka Prefecture University

We propose novel reversal imprinting by using patterned poly-vinyl alcohol (PVA) film as a tentative stamp in order to fabricate patterned multilayer structure. The 180 nm polymethylmethacrylate (PMMA) pattern can be obtained. The three layer structure of patterned PMMA film can be also successfully fabricated.

P70
DNA Nanostructures Mediated Molecular Imprinting Lithography, C. Tian, H. Kim, W. Sun*, P. Yin*, H. Liu, University of Pittsburgh, *Harvard University

We developed and demonstrated an advanced stamp fabrication method to construct polymer stamps with diverse features and spatial resolution of down to 2 nanometers. DNA nanostructures with various dimensions served as masters to transfer negative tone patterns to poly(methyl methacrylate) (PMMA) with high fidelity.

P71
Characteristics of residual layer thickness on liquid transfer imprint lithography and roll press method, T. Hayashi, J. Taniguchi, Tokyo University of Science

We examined the characteristics between the replica mold materials and residual layer thickness on roll press motion in LTIL.Holes patterns are transferred residual layer less onto Si substrate by roll press and LTIL. As a result, hard replica mold is suitable for LTIL mold material.

P72
Fabrication of large area super hydro-phobic film by R2R nano imprint system, Ji Hoon Kim, Young Tae Cho, Yoon Gyo Jung, Sin Kwon*, Changwon National University, *Korea Institute Machinery and Materials

We made hydro-phobic film by applying R2R continuous nano-imprint system in order to produce large area over 1 m2 with low price. the hydro-phobic film which shows contact angle of more than 150 degrees in 1 m2 area could be fabricated.

P73
Optical Waveguiding in UV-Curable Nanoimprint, Weihao Li, Xing Cheng, Southern University of Science and Technology

Refractive index mismatch between resist and template protrusions can result in inhomogeneous light distribution in micro- and nanoscale structures due to waveguiding effect. This work extensively investigate the UV light distribution in UV NIL as a function of template pattern size and height, and resist indexes.

P74
Thin PDMS antisticking layer formed by using PDMS-disilanol for nanoimprinting, Makoto Okada, Shinji Matsui, LASTI, Univ. of Hyogo

We formed a thin PDMS antisticking layer by using PDMS-disilanol and evaluated the release property for nanoimprinting.

P75
Etching Characteristics of Fe_3O_4 Thin Film for Absorptive WGP with 45 nm Line and Space Pattern Fabricated by Nano Imprint Lithography, Y.T. Cho, J.H. Kim, Y.J. Kim, Y. H. Jeong, Y.G. Jung, Changwon National University

Fe_3O_4 can be optimal material for absorptive wire grid polarizer by the previous simulation research. It could be deposited by E-beam evaporator and 45nm line pattern was fabricated on that thin film by nano imprint lithography. We suggest several etching method for Fe_3O_4 thin film.

P76
Effects of Contact States on Polymer Pattern Deformation during Demolding Process in Nanoimprint Lithography, Qing Wang, Lijun Ma

The process of demolding plays an important role to determine the success of imprinting fine patterns. In the demolding process, separating the mold from the patterned layer is easy to induce defects. Therefore, it is necessary to investigate the demolding behaviors in contact detaching process.

P77
Soft-Substrate-Rigid-Feature (SSRF) Nanoimprint Lithography, Liran Menachem, Mark Schvartzman, Ilse Katz Institute for Nanoscale Science and Technology

We introduce a novel concept of hybrid Soft-Substrate-Rigid-Feature (SSRF) nanoimprint mold based on PDMS substrate with HSQ relief features. Our approach provides the high pattern fidelity and small feature size offered by hard molds together with the low sensitivity to defects and flexibilty as offered by soft molds.

P78
Nanometer dimension control on silicon imprint mold using atomic layer deposition for large-area nanofabrication, A. S. Jugessur, Yiman Lyu, Anthony Zhang and Nathan Kofron, University of Iowa Microfabrication Facility, Optical Science and Technology Cent

In this work, nano-scale features on a nanoimprint mold are reduced in size by 30-50 % to generate nanostructures in the sub-100 nm range using atomic layer deposition, thereby eliminating the need to fabricate a new mold. This simple approach is used to generate large-area nanostructures in a cost-effective fashion.

P79
A significant vaporized degradable film assisting demoulding technics in nanoimprinting lithography, Jia Yang, Dehu Cui, South University of Science and Technology of China

In this artical,we seek for a new way to avoid adhesion of the polymer to the stamp by using some degradable natural products to form a very good anti-adhesion property on the substrate.

P80
Large-area Fabrication of Chirped Gratings, C. Zhang, M. Ji*, W. Shen, H. Ge* and W. Li, University of Hong Kong, *Nanjing University

In this work, we develop methods that can arbitrarily modulate the spatial distribution of periodicity in ordered patterns by deforming elastomeric substrates with specially designed shapes, and we further transfer the modified grating patterns on the deformed elastomeric substrates onto a rigid substrate for future use as a nanoimprint template.

Directed Assembly

P81

Hexagonal Dot Pattern Fabrication by Self-assembled Colloidal Silica Grafted with a Concentrated Polymer Brush, T. Sawabe, A. Watanabe, N. Kihara, R. Yamamoto,K. Ohno*, Toshiba Corporation, *Kyoto University

In the present work, we investigated the fabrication of non-close-packed hexagonal dot pattern by self-assembly of polymer grafted silica particles. We also discuss results of solvent annealing for better ordering and the pattern transfer onto the substrate.

P82
Local Positional Alignment of InSb Nanostructures by Self-Assembled Epitaxial Growth on Ge Substrate, Thanavorn Poempool, Zon, Suwit Kiravittaya*, Suwat Sopitpan**, Supachok Thainoi, Songphol Kanjanachuchai, Somchai Ratanathammaphan and Somsak Panyakeow, University, Bangkok Thailand, *Naresuan University, **Thailand Microelectronic Center (MTEC), National Science and Technology Development Agency (NSTDA)

Realization of InSb nanostructures by using self-assembled growth in Stranski-Krastanov mode has been investigated. Here, we report on the molecular beam epitaxial growth of InSb nanostructures by self-assembled growth on (001) Ge substrate. Local alignment of InSb nanostructures on anti-phase domain (APD) boundary of GaAs buffer layer is observed.

P83
Free Energy and Frequency of Defects in Chemoepitaxial Block Copolymer Directed Self-Assembly: Effect of Pattern Density Multiplication Factor, Defect Size, and Defect Position, Benjamin D. Nation, Caleb L. Breaux, Peter J. Ludovice, Clifford L. Henderson, Georgia Institute of Technology

Increased DSA pattern density multiplication factors allow for smaller feature sizes but do so at the expense of larger numbers of defects. Here a coarse-grained molecular dynamics simulation is used to calculate the free energy and frequency defects as a function of pattern density multiplication, defect size, and defect position.

P84
Neutral surface modification by e-beam exposure for PS-b-PMMA self assembly, Abdul Aziz Al Mutairi, Babak Shokouhi, Gary Yu*, Bo Cui, University of waterloo, *Advanced Polymer Materials Inc.

We previously demonstrated self-assembled monolayer (SAM) of 3-MPTS acted as neutral layer to obtain vertical lamella self assembly of symmetric PMMA-b-PS. Here we show e-beam exposure can “damage” the SAM layer, leading to the change of lamella orientation for symmetric BCP self assembly, or cylinder orientation for asymmetric BCP.

Novel Direct Write and Maskless Lithography

P85
Polymer Molecular Weight Governs Feature Size During Tip-Based Fabrication of Polymer Nanostructures, S. Chen, W. King, Univerisity of Illinois at Urbana-Champaign

We investigate polymer deposition from a heated atomic force microscope cantilever tip, and in particular how polymer molecular weight affects the feature size of the polymer nanostructures. The ultimate goal is to understand the relationship between polymer properties and the nanostructures that can be fabricated.

P86
On the Magnetic Properties of Clean Iron Nanostructures Fabricated by Focused Electron Beam Induced Processing, Fan Tu, Martin Drost, Florian Vollnhals, Esther Carrasco, Andreas Späth, Rainer Fink and Hubertus Marbach, Friedrich-Alexander Universität Erla

High purity Fe nanostructures with controlled size were fabricated via electron beam induced deposition in our UHV system. The chemical composition and magnetic properties of the corresponding Fe nanostructures were investigated with Scanning Transmission X-ray Microscopy.

P87
Lithography via Aligned Electrospun Fibers, J.D. Beisel, J.P. Murphy, E.A. Kooistra-Manning, J.L. Skinner, S. Nicolaysen*, O. Boese*, J. Fleming*, W. Nakagawa*, Montana Tech of the University of Montana, *Montana State University

Aligned electrospun fibers are deposited and used as a mask for lithography. Fiber alignment is controlled through electric field manipulation by changing the relative voltage applied to each electrode. This research focuses on developing the methods, hardware, and expertise required for electrospinning to become a viable method of lithography.

P88
Single photon direct laser writing using high power laser diode to fabricate diffractive optical elements, G.H. Kim, H.J. Lim, K.B. Choi, J.J. Lee, S.G. Kwon, Korea Institute of Machinery and Materials

This paper is related to the direct laser writing to fabricate diffractive optical elements which have micron scale or below. We developed a compact laser system using laser diode based on single photon polymerization. We will show a simple line pattern for infrared optical filters and process in detail.

P89
The next generation of Maskless Lithography, S. Diez, T. Besson, Heidelberg Instruments GmbH

The new Maskless Aligner makes it possible to align and expose patterns directly and easily. Its new optical engine based on the DLP(TM) device alongside a high power fiber-coupled diode laser has considerably increased the writing speed. Beside speed, direct writing offers many additional advantages and possibilities over standard lithography.

P90
Electron-Beam Induced Deposition of Highly Conductive Copper Nanowires from Bulk Liquids, A. M. Syam, J. T. Hastings, University of Kentucky

Focused Ion Beam Lithography

P91
Reconstructing Focused Ion Beam Profile by Iterative Simulation Methodology, E. Chang, V. Ray, University of Maryland

We propose a simplified, simulation-based methodology for reconstructing the focused ion beam profile from sputtering and implantation information available from single TEM micrographs of lines etched by FIB. A bi-Gaussian beam profile model was assumed. Simulated implantation and etching profiles were compared with experimental data to construct the beam profile.

P92
Ultrafast nanofabrication with Xe plasma FIB-SEM and its planar milling applications with novel Rocking stage Technology, S. Sharang,A. Benkouider, Tomas Hrncir,Jozef V. Obona, Jaroslav Jiruse, Tescan Brno s.r.o., Edward Principe, Tescan USA

Performing and analyzing nano-fabricated samples of larger volumes at ultrafast speeds with the use of Xe plasma ion source. Performing planar milling applications using the rocking stage to investigate fast milling capabilities of Xe plasma FIB-SEM system.

P93

III-V NanoWires for Junctionless Transistors Fabricated by Focused Ion Beam (FIB) System, C. R. Almeida, H. T. Obata, A. R. Vaz, M. A. Cotta and J. A. Diniz, State University of Campinas.

Gallium Focused Ion Beam have been used to define III-V (InGaP or GaAs) nanowires (III-V NWs) and three terminals of transistors: gate, source and drain. The results are able to indicate the applicability of InGaP or GaAs nanowires in III-V Junctionless Transistors fabrication.

Materials

P94
Lightweight Ultrastrong Thin-Shell Nanolattice Material for Enhanced Energy Dissipation, Abhijeet Bagal, Xu A. Zhang, Rahnuma Shahrin, Erinn C. Dandley, Junjie Zhao, Christopher J. Oldham, Gregory N. Parsons, Christopher Bobko, and Chih-Hao Chang, North C

A lightweight, ultra-strong nanolattice material with periodic thin-shell architecture is demonstrated. The fabrication technique combines three-dimensional nanolithography and atomic layer deposition. Unique architectural arrangement of constituent elements within nanomaterial results in near-linear scaling between material stiffness and hardness with respect to density. This nanomaterial exhibits enhanced energy absorption per volume.

P95
Growth of high quality graphene on sub-300 nm thick copper thin films, J. H. Cho, M. Cullinan, J. Gorman*, The University of Texas at Austin, *NIST

Graphene is grown directly using CVD method below 250nm.

P96
MWCNT-PET Films Prepared by Solution Casting for Electronics Applications, N. Nujhat, S. Ahmed, L. Jiang, N. Korivi, Tuskegee University

We report a method to prepare conductive and transparent films of multi-walled CNTs (MWCNTs) with excellent adhesion to flexible polyethylene terephthalate (PET) surfaces. Our method employs solution casting combined with a post-processing treatment to form MWCNT-PET layers able to withstand Scotch-tape test, with high stability in fluids and other environments.

P97
Materials characterization for Multi-Layer Electron Beam Lithography, Ravi K. Bonam*, College of Nanoscale Science and Engineering, SUNY Polytechnic Institute; *IBM Reserach

Successful implementation of Multi-layer lithography for fabricating three-dimensional structures involves depositing multiple photoresists. Here we present the use of Hansen Solubility Parameters to identify compatible solvents and developers. The three dimensional representation of polymers and their solubility in different solvents makes it possible to select compatible solvents and developers.

P98
Fabrication of Metallic Microstructured Nano-Accordions for Transparent Electrodes, J.-H. Min, A. Bagal, J. Z., Mundy, C. Oldham, G. Parsons, C.-H., Chang, North Carolina State University

There have been numerous interests on developing flexible conductors using various fabrication technologies. Here we demonstrate a novel approach to fabricate transparent metallic electrodes using microstructured nano-accordion structures. Electrical and mechanical characterizations of the transparent metallic nano-accordions will be performed to confirm the superiority of our structures as flexible conductors.

P99

3D Nanostructures fabricated by ion beam technology, Changzhi Gu, Junjie Li, Wuxia Li, Institute of Physics, Chinese Academy of Sciences, China

We developed a technique for the geometrical manipulation of freestanding nanowires using ion beam irradiation with nanometer-scale resolution to fabricate 3D nanostructures, and also designed and fabricated a 3D hierarchical structure of flower-like few-layer graphene nanosheets grown on diamond nanocone arrays.

P100
Melt Electrospinning: Method for Producing Photo-converting Nanocomposite Materials, J.P. Murphy, J.M. Andriolo, J.L. Skinner, Montana Tech

A study of a fabrication technique for producing novel photo-converting nanocomposite materials using melt electrospinning.

P101
Microfluidic-Integrated Capillary Electrophoresis for Metabolite Detection in a Miniaturized Bioreactor, R. Luttge, Eindhoven University of Technology

A previous developed bioreactor cell culture concept is combined with microchip capillary electrophoresis (CE) for the successful measurement of lactate ions by contactless conductivity detection.

Charged Particle Optics and Sources

P102 (Invited)
Low Temperature Ion Source for Focused Ion Beam Nanomachining Applications, A.V. Steele, B. Knuffman, A. Schwarzkopf, J. J. McClelland*, zeroK NanoTech, *National Institutes of Standards and Technology

We present progress toward the integration of our low-temperature ion source with a Vectra 986 FIB column. We will directly measure the source brightness via the current distribution in the focal spot. We explain the details of this measurement method, as well as data obtained to date.

P103 (Invited)
End-form changes in high brightness HfC electron sources, J. Lovell, W. Mackie, G. Magera, Applied Physics Technologies

Work continues on a new electron source for high brightness applications. Modeling and experimental performance on test stands and in a Philips XL40 FEG SEM are reported for HfC(210) and (110) cathodes. Work in varying pressures and end-form changes are discussed.

P104 (Invited)
Development of Patterned Electron Beam Image Transfer though a Nanocrystalline Diamond Thin Film Membrane/Window, Z.E. Russell, D. Akemeier, R. Edington, EY.T. Cheng, L. Galambos, W.F. Aitkenhead, L. Hesselink, Stanford University

In an effort to create an electron transparent vacuum window, we have developed a free standing nanocrystalline diamond thin film which can separate regions of ultra-high and low vacuum, and can emit secondary electron beam patterns from the low vacuum side corresponding to the pattern incident on the UHV side.

P105 (Invited)
Aberration Calculation of Chicane Type Magnetic Sector using Differential Algebraic Method, Y. Shirasaki, M. Enyama, Hitachi Ltd.

The differential algebraic method was used to accurately calculate aberrations of a stigmatic chicane-type magnetic sector and we confirmed that the aberrations are minimized when the trajectory is anti-symmetric across the midline of the magnetic sector.

P106 (Invited)
Laser-Micromachined Carbon Xerogel Ionic Liquid Ion Sources for Focused Ion Beams, C. Perez-Martinez, J. Gierak*, P.C. Lozano, Massachusetts Institute of Technology, *CNRS Laboratory for Nanostructures and Photonics

Ionic Liquid Ion Sources (ILIS) could supply kiloDalton molecular ions or reactive ion species for Focused Ion Beam applications. We report the fabrication of carbon xerogel microtip emitters via laser micromachining, and will present the emission characteristics of this new ILIS configuration in both high and low energy regimes.