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.