THE 63rd INTERNATIONAL CONFERENCE on ELECTRON, ION, and PHOTON BEAM TECHNOLOGY & NANOFABRICATION

Hyatt Regency Minneapolis
Minneapolis, Minnesota

May 28 – May 31, 2019
www.eipbn.org

Sponsored by:

Tuesday, May 28			
Start Time	End Time	Session	Location
7:00 am	6:00 pm	Registration	Nicollet Foyer
8:30 am	3:00 pm	Nanofabrication Workshop	Nicollet D
3:00 pm	6:00 pm	Commercial Exhibit	Exhibit Hall
7:00 pm	9:30 pm	Welcome Reception	Northstar Ballroom
Wednesday, May 29			
Start Time	End Time	Session	Location
7:30 am	5:00 pm	Registration	Nicollet Foyer
8:00 am	10:45 am	Plenary Session	Nicollet Ballroom
10:00 am	5;00 pm	Commercial Exhibit	Exhibit Hall
10:30 am	1:00 pm	Poster Session	Exhibit Hall
12:00 pm	1:00 pm	Exhibitor Pitch Session	Exhibit Hall
1:20 pm	3:00 pm	Session 1A - 3D-Nanosculpturing	Nicollet A
1:20 pm	3:00 pm	Session 1B - Biomedical Devices	Nicollet B/C
1:20 pm	3:00 pm	Session 1C - Quantum Computing & Technology	Nicollet D
3:00 pm	3:40 pm	Break	Exhibit Hall
3:40 pm	5:30 pm	Session 2A - Electron-& Ion-Beam Lithography	Nicollet A
3:40 pm	5:30 pm	Session 2B - Quantum Computing & Technology	Nicollet B/C
3:40 pm	5:40 pm	Session 2C - Probe-based Lithography	Nicollet D
5:30 PM	7:00 PM	Poster Session	Exhibit Hall
Thursday, May 30			
Start Time	End Time	Session	Location
7:30 am	5:00 pm	Registration	Nicollet Foyer
8:00 am	9:40 am	Session 3A - Advanced Materials Applications I	Nicollet A
8:00 am	9:40 am	Session 3B - Atomically Precise Fabrication	Nicollet B/C
8:00 am	9:45 am	Session 3C - Industrial Highlights	Nicollet D
9:40 am	10:20 am	Break	Exhibit Hall
10:00 am	4:00 pm	Commercial Exhibit and Poster Session	Exhibit Hall
10:20 am	11:40 pm	Session 4A - Advanced Pattern Transfer I	Nicollet A
10:20 am	11:40 pm	Session 4B - Micro-& Nanoscale Mech. Devices	Nicollet B/C
10:20 am	11:50 pm	Session 4C - Nanoimprint	Nicollet D
12:00 pm	1:40 pm	WIN Luncheon	Regency Room
12:00 pm	1:40 pm	Lunch on your own	
1:40 pm	3:50 pm	Session 5A - Advanced Ion-Beam Technologies I	Nicollet A
1:40 pm	3:50 pm	Session 5B - Photonics I	Nicollet B/C
1:40 pm	3:50 pm	Session 5C - Next Generation Electron-Beam Lithography	Nicollet D
3:50 pm	4:10 pm	Break	Exhibit Hall
4:10 pm	5:50 pm	Session 6A - Advanced Ion-Beam Technologies II	Nicollet A
4:10 pm	5:50 pm	Session 6B - Photonics II	Nicollet B/C
4:10 pm	5:50 pm	Session 6C - Simulation & Modeling	Nicollet D
Friday, May 31			
Start Time	End Time	Session	Location
6:45 am	7:30 am	Student breakfast	Lakeshore B
7:30 am	12:00 pm	Registration	Nicollet Foyer
8:00 am	9:50 am	Session 7A - Imaging & Characterization	Nicollet A
8:00 am	9:50 am	Session 7B - Nanoelectronics	Nicollet B/C
8:00 am	9:50 am	Session 7C - Micro-& Nanofluidics	Nicollet D

9:50 am	10:20 am	Break	Nicollet Foyer
10:20 am	11:40 am	Session 8A - Lithographic Materials I	Nicollet A
10:20 am	11:50 am	Session 8B - Neuromorphic Hardware	Nicollet B/C
10:20 am	11:50 am	Session 8C - Advanced Materials Applications II	Nicollet D
12:00 pm	1:30 pm	Mentor Lunch	
11:50 pm	1:30 pm	Lunch on your own	
1:30 pm	2:50 pm	Session 9A - Lithographic Materials II	Nicollet A
1:30 pm	3:10 pm	Session 9B - Nanobiology & Nanomedicine	Nicollet B/C
1:30 pm	3:10 pm	Session 9C - Advanced Pattern Transfer II	Nicollet D
3:10 pm	3:30 pm	Break	Nicollet Foyer
3:30 pm	5:10 pm	Session 10A - Advanced Lithography	Nicollet A
3:30 pm	5:30 pm	Session 10B - Electron & Ion beam Sources & Optics	Nicollet B/C
3:30 pm	5:20 pm	Session 10C -Highlights in Nanofabrication	Nicollet D

Conference Information

CONFERENCE SCOPE: EIPBN, the "3-Beams", Conference, is the premier conference on the science and technology of nano-patterning. Traditionally focused on electron, ion, and photon beams, (the 3 beams), the technology of nanofabrication covered in this conference has grown to include nanoimprint and molecular self-assembly as well. This conference is the place to hear the newest techniques and the latest advances in patterning and device fabrication technology.

CONFERENCE EVENTS
Tuesday Short Courses
The Conference opens on Tuesday morning with a short course.

COMMERCIAL SESSION
On Tuesday, 3:00 pm – 6:00 pm, the commercial session is open. The commercial session features vendors of materials and equipment which are relevant to the conference. Here is your opportunity to meet with vendors who are eager to discuss their latest lithography systems, materials, and characterization instruments and related products. The commercial exhibition schedule is:

Tuesday, May 28, 3:00 pm to 6:00 pm
Wednesday, May 29, 10:00 am – 4:30 pm
Thursday, May 30, 10:00 am – 3:00 pm

Light refreshments are available on Tuesday from 3:00 pm to 6:00 pm.

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Participants in this year's commercial session include:

- Allresist
- Amuneal Mfg Corp.
- Cornell University
- Crestec Corporation
- Eurofins EAG
- Film Sense
- GenISys, Inc.
- Heidelberg Instruments, Inc.
- Himax IGI Precision
- JEOL USA, Inc
- Kurt J. Lesker Company
- LatticeGear
- Nanoscribe GmbH
- Raith America, Inc.
- SAES Group
- STS-Elionix
- Trion Technology
- UC Components Inc.
- Vistec Electron Beam
- Wafer World Inc.
- Zyvex Labs

TUESDAY WELCOME RECEPTION
Tuesday night join us at the Welcome Reception from 7:00 pm – 9:00 pm in the Northstar Ballroom. One ticket to the Welcome reception is included in the registration fee. Additional tickets are for sale at registration.

TECHNICAL SESSIONS
The plenary session begins on Wednesday morning. The rest of the conference has three parallel sessions from Wednesday afternoon through Friday afternoon. The Program theme for this year's EIPBN is "From Nature to Nanoscale Technology in Answering Humanity's Pressing Challenges"

POSTER SESSIONS
Poster Sessions begin after the plenary session on Wednesday, and again in the evening. Refreshments will be provided. The poster schedule is:

- Wed., May 29, 10:50 am – 1:00 pm,
- Wed., May 29, 6:00 pm – 7:00 pm
- Thurs, May 30, 10:00 pm – 3:00 pm

Poster awards and best of Start-up award will be judged and presented at the banquet.

THURSDAY BANQUET
Thursday's banquet will be at the Minnesota Orchestra Hall from 7:00 pm – 10:00 pm. Tickets are $100.

SPONSORS
EIPBN gratefully thanks our conference sponsors. We would like to thank at the time of printing this program:

- **STS-Elionix**, CHARTER PLATINUM SPONSOR, for sponsoring
  - Student Support,
  - the Women in Nanofabrication Luncheon,
  - the Student Mentor Luncheon,
  - the Wednesday Breakfast/Coffee,
  - the Friday Afternoon Ice Cream Break,
  - the Poster Reception drinks,
  - and the Conference USB Drives,
- **GenISys, Inc.**, CHARTER SILVER SPONSOR, for sponsoring
  - the Women in Nanofabrication Luncheon
  - the Wednesday Breakfast/Coffee Sponsorship
  - the Wednesday Afternoon Coffee Break
- Crestec Corporation for sponsoring Student Support
- DisChem, Inc. for sponsoring Student Support
- Heidelberg Instruments, Inc. for sponsoring the Conference Bag
- Intel Corporation for their Charter Sponsorship of the Women in Nanofabrication Luncheon
- JEOL USA, Inc. for their Charter Sponsorship of the Conference Pad Folio and sponsoring the Wednesday Afternoon Coffee Break
- KemLab Inc. for sponsoring Student Support
- KLA for sponsoring:
  - Student Support,
  - the Student Mentor Luncheon
  - the Wednesday Poster Session Lunch
  - the Tuesday Welcome Reception Bar
- NuFlare Technology, Inc. for sponsoring the Conference Lanyard
- Raith America, Inc. for sponsoring the Women in Nanofabrication Luncheon
- Vistec Electron Beam for sponsoring the Thursday Breakfast/Coffee
- Zyvex Labs for the sponsoring Wednesday Poster Session Lunch

WOMEN IN NANOFABRICATION NETWORKING LUNCHEON
The WIN lunch is Thursday, May 30, 12:00 noon in the Regency Room. Current topics related to women in science, relevant to both men and women.

This year's theme is: ***"Speed Networking!"*** Women are encouraged to attend! Men are welcome. Sign-up at the registration desk!

MICROGRAPH CONTEST: On the lighter side, for the 25th year, the conference will sponsor a micrograph contest. Here is your chance to share those strange or beautiful micrographs that you have taken in the course of your work! John Randall, the 1995 conference chairman, presides over this annual event. See the EIPBN website for details.

PUBLICATION: The proceedings of this conference will be published in the November/December 2019 issue of the Journal of Vacuum Science and Technology (JVST). Accepted papers will have publication charges waived and AVS offers membership free to the first and corresponding authors on accepted JVST papers. This eliminates page charges as members publish for free.

CONFERENCE INFORMATION ON THE WEB: You can find up-to-date information on all aspects of EIPBN at www.eipbn.org.

Tuesday, May 28, 2019

Tuesday Short Course
Room: Nicollet D

Session Chairs:
Stefano Cabrini, Lawrence Berkeley National Laboratory
Weilun Chao, Lawrence Berkeley National Laboratory

8:30 am
Welcome and Introduction

8:45 am
Emerging Hardware for Neuromorphic Computing – Qiangfei Xia, Professor of Electrical and Computer Engineering, University of Massachusetts

9:45 am
Nanofabrication of 2D-Material-Based Structures and Devices – Xiaogan Liang, Associate Professor Department of Mechanical Engineering, University of Michigan

10:45 am COFFEE BREAK

11:00 am
Materials for Advanced Lithgraphy – Greg Wallraff, IBM Almaden Research Center

12:00 pm – 1:30 pm Lunch

1:30 pm
Update on EUV Lithography – Patrick Naulleau, Director, Center for X-ray Optics, Lawrence Berkeley National Laboratory

2:30 pm
TBD

Wednesday, May 29, 2019

Plenary Session
Room: Nicollet Ballroom

Session Chairs:
Aaron Stein, Brookhaven National Laboratory
Regina Luttge, Eindhoven University of Technology

8:00 am – Welcome
Aaron Stein and Regina Luttge

8:30 am Plenary 1
Unravelling the Origins of Functionality through Correlative Multimodal Chemical Imaging, Olga Ovchinnikova, Chemical Imaging Team Lead and R&D Scientist, Center for Nanophase Materials Sciences, Oak Ridge National Laboratory

The key to advancing energy materials and biological systems is to understand and control the structure and chemistry at interfaces. While much of the dynamic chemistry can be studied on macro-scale systems, there is a lack of means to localize chemical measurements and correlate them to nanoscale structure of the material. Through a unique merger of advanced scanning probe and ion microscopy with mass spectrometry techniques rooted in innovative data processing and control algorithms, we are now able to understand the interplay between chemical and physical functionality at the fundamental length scales using multimodal chemical imaging. This multimodal imaging transcends existing techniques by providing nanoscale structural imaging with simultaneous chemical analysis. Here, I will discuss how we have developed and used this capability to visualize dynamic material transformations at interfaces, to correlate these changes with chemical composition, and to distil key performance-centric material parameters. One exciting capability is that the AFM can be used to drive materials away from equilibrium at the nanoscale with highly localized electric fields. This allows field confinement effects on localized chemistry in materials to be locally probed, especially at interfaces. This in turn yields direct information on key energy related questions such as electron and ion motion distribution and transport at and between interfaces. Overall, I will focus on ways to unlock the mystery of active interface formation through intertwining data analytics, nanoscale elemental and molecular characterization, with imaging; to better grasp the physical properties of materials and the mechanistic physics-chemistry interplay behind their properties.

9:15 am Plenary 2
Engineering and imaging the tissue microenvironment, Karen Cheng, Department of Electrical and Computer Engineering, The University of British Columbia

The oxygen microenvironment is a key factor affecting tumour cell phenotype, cancer prognosis and treatment efficacy, as well as stem cell proliferation and cell-fate commitment. We use microfluidic methods to generate three-dimensional tumour models that use extracellular matrix components to support cell proliferation. We have developed a microfluidic platform that affords the creation of oxygen profiles that vary in time and space, precise control of the oxygen levels, and stability over time for long-term cell culture, permitting drug screening assays can last several days. Using two-photon microscopy, we track, in real-time, individual cells within 3D tumour spheroids exhibiting cyclic swelling behaviour in response to time-varying oxygen profiles, and observe doxorubicin resistance in hypoxic spheroids. In future, the cell-by-cell analysis enabled by these efforts will permit the characterization of heterogeneity within arrays of micro-tissues, the identification of subpopulations of cells and individual cells, and the assessment of their responses.

10:00 am Plenary 3
Quantum Computing with Super Conducting Circuits, Markus Brink, IBM T. J. Watson Research Center

Quantum computing has made tremendous progress in recent years, including experimental advances and hardware developments. Quantum processors have scaled significantly in size, as measured by the number of quantum bits (qubits) connected on a chip, with devices incorporating 10's of qubits available today. An example of a publicly available quantum system is the IBM Q Experience (www.research.ibm.com/ibm-q). While the goal of fault-tolerant universal quantum computing is still some time away, early applications and demonstrations can be implemented on smaller scale near-term quantum systems. Among the different hardware implementations, Josephson-junction-based superconducting quantum circuits are a promising technology to scale quantum processors. Together with scaling the number of qubits, other metrics need to evolve and improve as well, such as the quality of qubits, hardware integration, and system level performance. In this talk, I will look at the current status and discuss some remaining challenges.

Poster Sessions - Exhibit Hall
10:50 am – 1:00 pm
6:00 pm – 7:00 pm

Commercial Exhibits - Exhibit Hall
10:00 am – 4:30 pm

Exhibitor Pitch Sessions - Exhibit Hall
12:00 pm – 1:00 pm
Session Chair:
Gerald G. Lopez, University of Pennsylvania

12:00 pm - Welcome and Explanation of Session Format

12:04 pm - STS-Elionix, Gerry O'Loughlin

12:11 pm – GenISys, Rick Bojko

12:18 pm – Zyvex Labs, James Owen

12:25 pm – Amuneal Manufacturing Corp., Michael Adolf

12:32 pm – Kurt J. Lesker Company, Sean Armstrong

12:39 pm – SAES GROUP, Andrea Cadoppi

12:46 pm – Wafer World Inc., Sean Quinn

12:53 pm – Cornell Nanofabrication Facility, Amrita Banerjee

1A - 3D-Nanosculpturing
Room: Nicollet A
Session Chairs:
Aurelien Botman, Thermofisher
Hank Smith, Massachusetts Institute of Technology

1:20PM 1A-1 Invited
3D Nano-Printing via Focused Electron Beams: A Perspective, *H. Plank, R. Winkler, J. Sattelkow, A. Weitzer; Christian Graz University of Technology & Graz Centre for Electron Microscopy, J. Fowlkes; Center for Nanophase Materials Sciences, Oak Ridge National Laboratory, C. Schwalb; GETec Microscopy Inc.*

The topic of this talk is 3D nano-printing via focused electron beams. After a basic introduction, we review recent applications using this technology. This ranges from scientific towards industrial applications, which demonstrates not only the flexibility but also the increasing relevance of this additive, direct-write technology.

1:50PM 1A-2
Self-folding shape memory bilayer structures formed by irradiating anisotropically stressed polycarbonate films, *N. S. Randhawa, J. C. Wolfe, University of Houston*

A method for fabricating 3D shape memory structures made by irradiating anisotropically stressed, 2D polycarbonate substrates with a high dose of He ions or neutral atoms. The SMS fold on their own upon release of the constraints, have short recovery time, are ultra-thin and very resilient.

2:10PM 1A-3
Nano-Calligraphy: Precisely tuning the feature spacing in scanning-probe lithography, *Harish Bhaskaran,Jan A. Mol, Nikolaos Farmakidis Jacob L. Swett, Nathan Youngblood, University of Oxford Department of Materials*

By modifying the tip structure of a standard Atomic Force Microscope (AFM) probe, we develop a new technique which we name Nano-Calligraphy Scanning Probe Lithography (nc-SPL). This technique allows us to produce patterns of variable linewidth based on the writing angle with sub 30nm resolution on a single lithographic path.

2:30PM 1A-4 Invited
Cleanroom in SEM, *C.W. Hagen, G. Jeevanandam, M. Scotuzzi, V. van der Meijden, N. Noordzij, R. van Tol, Y. van Goozen, P. Kruit, Delft University of Technology*

Experiments involving micro-scale or nanoscale devices often require only one, or at most a few, functional devices. To fabricate such devices we propose a low cost and more sustainable solution by bringing together all required process steps in a single tool.

1B - Biomedical Devices
Room: Nicollet B/C
Session Chairs:
Reginald Farrow, New Jersey Institute of Technology
Karen Cheung, The University of British Columbia

1:20PM 1B-1
Motion of dsDNA in a coupled nanochannel/nanopore system under an electric field, *Yuliya Kuznetsova, Alexander Neumann, Olga Amisova and S.R.J. Brueck, Armonica Technologies, Inc.*

Electrophoretic transport of lambda-phage DNA through a coupled nanochannel/nanopore system is observed. The time scale for transport of the 48,500 base pair DNA through the nanoporesis significantly lengthened by the tortuous (extended and convoluted) nanopores as compared with simple thin nanopores.

1:40PM 1B-2
Fabrication and Sharpening of Silicon In-plane Microneedles with Open Capillary Networks, *Y. Li, H. Zhang, R. Yang, C. Zhu, W. Hu, F. Tazrin, M. Kaddoura*, E. J. M. Blondeel*, B. Cui, University of Waterloo, *ExVivo Labs Inc.*

This work presents a deep reactive ion etching (DRIE) of silicon in-plane microneedles integrated with open capillary microfluidic networks. The wedge-shaped needle tip is sharpened by incorporating sacrificial structures (i.e., remaining silicon at the bottom, silicon wafer). The microneedle devices have been demonstrated for skin penetration and capillary filling.

2:00PM 1B-3
A streamlined process for fabricating multi-channel neural probes on optical fiber substrates, *Tamana Afrin Tisa, Maduri Manjunath, Venu Sushir, Mufaddal Gheewala, Apeksha Awale, Pratik Motwani, Navjot S. Randhawa, M. Ashiqur Khan, Hasti Sajedi, E.J. Charlson, Wei-Chuan Shih, J.C. Wolfe, Ariana Andrei*, Valentin Dragoi*, Gopathy Purushothaman**, John A. Dani***, Philip Mauger****, University of Houston, *Univ. of Texas-Houston Medical School, **Parallon Business Performance Group, ***University of Pennsylvania, ****Nanostructures, Inc.*

Simple neural electrode with 4-channel contacts is fabricated on optical fiber for optogenetic application. Metal electrode lines are defined using negative tone resist in lithography. Lateral and rotational alignment is achieved with V-groove jig, cubic bead, and high precision ball bearing. In vivo impedance testing is performed for 3 weeks.

2:20PM 1B-4
Bio-printed hydrogel micro-droplets for culturing and analysis of microbial communities, *Y. Li, A. N. Bible, J. L. Morrell-Falvey, M. J. Doktycz, S. T. Retterer, Biosciences Division, Oak Ridge National Laboratory*

We have developed a high throughput method for printing cell-laden hydrogel droplets and assembling microbial communities for biological studies. Microbes are encapsulated into alginate hydrogel micro-droplets and printed using a extrusion-based bioprinter. We have successfully demonstrated the use of hydrogel micro-droplets to encapsulate and position microbial cells in desired patterns.

2:40PM 1B-5
A microfluidics-integrated photonic nanosensor for rapid and sensitive detection Ebola virus antigens, *F. Zang, Z. Su, G. Kaplan*, and S. Y. Chou, Princeton University, *U.S. Food and Drug Administration*

We present a multi-scale photonic nanoantenna-array-based lateral-flow biosensor platform for rapid detection of Ebola virus (EBOV) antigens. The nanostructured sensor utilizes plasmonic-enhanced fluorescence and successfully detects EBOV soluble glycoprotein (sGP) at the concentration of 1pg/mL. It is a 1000-fold lower detection limit compared to conventional enzyme-linked immunosorbent assay (ELISA).

1C - Quantum Computing & Technology
Rooom: Nicollet D
Session Chairs:
Karl Berggren, Massachusetts Institute of Technology
Markus Brink, IBM

1:20PM 1C-1 Invited
Marrying Top-Down Fabrication and Bottom-Up Assembly of Colloidal Nanocrystals to Construct Devices, Cherie Kagan, University of Pennsylvania

We combining top-down fabrication and bottom-up assembly of colloidal nanocrystals to construct materials and devices with unconventional physical properties.

1:50PM 1C-2
Fabrication Capabilities for Superconducting Quits at MIT Lincoln Laboratory, *B. M. Niedzielski, D. K. Kim, J. L. Yoder, A. Melville, G. Calusine, R. Das, A. L. Day, C. F. Hirjibehedin, J. Mallek, D. Rosenberg, M. Schwartz, S. Weber, D. R. W. Yost, W. D. Oliver, MIT Lincoln Laboratory*

MIT Lincoln Laboratory is working to increase addressability and connectivity of high coherence qubit circuits with 3D-integration techniques. We are developing a three-tier stack process that separately fabricates qubit, interposer, and readout/interconnect chips. I will discuss the fabrication and integration of some key features and their impact on device performance.

2:10PM 1C-3
Moveable Quantum Dot Probe for Detecting Near-Surface Fixed Charges, *Taleana Huff **, Thomas Dienel, Mohammad Rashidi **, Roshan Achal **, Wyatt Vine, Robert A. Wolkow *,** University of Alberta, * Nanotechnology Initiative, **Quantum Silicon*

With nanoelectronics reaching the limit of atom-sized devices, it has become critical to characterize irregularities in the local environment. With atomic force microscopy, we explore variations in the electrostatic topography and demonstrate a new technique using a dangling bond as a charge sensor to probe properties of the surface.

2:30PM 1C-4 Invited
Diamond and 4H-Silicon Carbide Quantum Photonics, *Constantin Dory, Jelena Vučković, E. L. Ginzton Laboratory, Stanford University*

Diamond and silicon carbide host color centers with promise for applications in quantum information processing. However, challenges in nanofabrication need to be resolved to integrate color centers into photonic circuits: I will present on our approaches in device inverse-design and nanofabrication to develop integrated quantum photonic circuits.

2A - Electron-& Ion-Beam Lithography
Rooom: Nicollet A
Session Chairs:
Dan Pickard, Genki Consulting LLC
Aimee Price, Ohio State

3:40PM 2A-1 Invited
How Variable is Variable Shaped Beam?, *Ines Stolberg, Matthias Slodowski, Bernd Schnabel, Ulf Weidenmueller, Vistec Electron Beam GmbH*

These days VSB technology serves various applications. The paper will discuss some application demands and how they can be transformed into hard - and software requirements on the Variable Shaped Beam equipment side. The potentials as well as the high flexibility of VSB lithography systems will be discussed.

4:10PM 2A-2
Fabrication of nanostructures for enhanced resolution in X-ray tomographic imaging, *A. Masurkar, T. Stark, E. Lavely, A. Stein*, Y. Gao*, A. Kiss*, R. Smith*, J. Wang*, Y. Chu*, BAE Systems, *Brookhaven National Laboratory*

This work demonstrates the fabrication and use of "nanotargets," nanostructures that can increase the spatial resolution of X-ray computed tomography. It is shown that 1 um Cu structures can be resolved with a 2 um diameter primary beam that impinges 500 nm diameter Au nanotargets.

4:30PM 2A-3
The potential of negative-tone PMMA e-beam lithography to enhance superconducting nanowire applications, *I. Charaev, M. Colangelo, A. Dane, A. Agarwal, K. K. Berggren, Massachusetts Institute of Technology*

The method of negative-tone PMMA electron-beam lithography is investigated to improve the performance of nanowire-based superconducting detectors.

5:00PM 2A-4 Invited
Multi-beam mask writer MBM-1000, *H. Matsumoto, H. Kimura, R. Ueba, K. Yasui, N. Nakayamada, NuFlare Technology*

MBM-1000 is a multi-beam mask writer based on the writing system with a blanking aperture array. It is designed to write complex OPC patterns with high throughput with fidelity. It has the pixel level dose correction (PLDC) to correct and enhance dose profile by which small patterns were printed better.

2B - Quantum Computing & Technology
Rooom: Nicollet B/C
Session Chairs:
Gregory M. Wallraff, IBM
David Pappas, National Institute of Standards and Technology

3:40PM 2B-1 Invited
Superconducting Nanowires for Single-Photon Detection, Electronics, and Microwave Plasmonics, *Karl K. Berggren, Massachusetts Institute of Technology*

Superconducting nanowires exhibit interesting photonic, electronic, and microwave properties that make them well suited for applications in single-photon detection and quantum information science.

4:10PM 2B-2
Quantum information at the Molecular Foundry - an overview of new toolsets for QIS research, *Adam Schwartzberg, Stefano Cabrini, Frank Ogletree, Shaul Aloni, Alex Weber-Bargioni, The Molecular Foundry, Lawrence Berkeley National Lab*

The Molecular Foundry at LBL is developing a new characterization and fabrication toolset for Quantum information science (QIS). In this talk I will introduce the new user accessible capabilities and show initial directions and progress on advancing state of the art qubit and quantum nanostructure science.

4:30PM 2B-3
A Versatile Common Platform for Quantum Transport Measurements in Fluidic, Cryogenic, and In Situ Electron Microscopy Environments, *J. Swett*, I. Kravchenko**, X. Bian*, O. Dyck**, S. Jesse**, J. Mol*,***, *University of Oxford, **Oak Ridge National Laboratory, ***Queen Mary University of London*

We present wafer-scale fabrication and validation of a common multi-functional low-noise chip platform capable of in situ TEM characterization and fabrication, microfluidic experiments, and cryogenic and scanning probe measurements. Initial results from the platform of TEM fabricated graphene-based quantum devices will be presented.

5:00PM 2B-4 Invited
Investigating Nanofabrication Techniques for Low Dissipation Superconducting Qubits, *Tyler Whyland, Ani Nersisyan, Stefano Poletto, Nasser Alidoust, Riccardo Manenti, Russ Renzas, Cat-Vu Bui, Kim Vu, Yuvraj Mohan, Eyob A. Sete, Sam Stanwyck, Andrew Bestwick, and Matthew Reagor, Rigetti Computing*

We discuss a variety of techniques shown to increase lifetimes for superconducting qubits. We investigated specific combinations of previously reported fabrication techniques on the quality of hundreds of thin film superconducting resonators and qubits. We report that multiple small improvements together can produce qubits having T1 ≥ 110 μs.

2C - Probe-based Lithography
Rooom: Nicollet D
Session Chairs:
Urs Staufer, TU Delft
Mohan Ananth, KLA

3:40PM 2C-1 Invited
Patterning metal contacts on monolayer MoS2 with vanishing Schottky barriers using thermal nanolithography, *Xiaoriu Zheng, Edoardo Albisetti, Annalisa Calo, Xiangyu Liu, Elisa Riedo, New York University*

We report a strategy to fabricate metal contacts on 2D materials with high reproducibility. Our approach is based on a double polymer stack chemical etching/lift off process combined with thermal scanning probe lithography (t-SPL).

4:10PM 2C-2
Investigation of Line Edge Roughness in Field-Emission Scanning Probe Lithography, *S. G. Yazgi, B. E. Alaca, T. Ivanov*, M. Holz**, I. W. Rangelow**, Koc University, *TU Ilmenau, **nano analytik GmbH*

In this study, a novel development method is utilized to shift between negative/positive tone patterning using a field emission scanning probe lithography and to investigate the pattern line edge roughness. Exposed features are patterned and imaged before and after development using the same tip.

4:30PM 2C-3
Design and Nanofabrication of New Heated Atomic Force Microscope (AFM) Cantilever for Nanolithography Applications, *M. Soleymaniha, J. R. Felts, Texas A&M University*

This paper reports the modelling and fabrication process of a novel heated atomic force microscope (AFM) cantilever for thermal dip pen nanolithography (t-DPN) applications.

4:50PM 2C-4
High-performance spin-coatable hardmasks for transferring high-resolution t-SPL patterns, *T. S. Kulmala, S. Bisig, M. Spieser, U. Duerig, F. Holzner, T. M. Gädda*, K. Karaste*, J. T. Rantala*, SwissLitho AG, *PiBond Oy*

Recently, thermal scanning probe lithography (t-SPL) which relies on the thermal decomposition of polymer resists, such as polyphthalaldehyde (PPA) has entered the market enabling single-digit nanometer patterning. Here, we introduce a novel silicon-rich, spin-coatable hard mask that can replace the evaporated SiO2 film in the pattern transfer stack.

5:10PM 2C-5 Invited
Incorporation of Machine Learning in the Automation of Atom-Scale Device Fabrication, *J. Croshaw, M. Rashidi, K. Mastel, M. Tamura, H. Hosseinzadeh*, R. Wolkow, University of Alberta, * Quantum Silicon Inc.*

We present the recent developments made in our lab regarding the use of deep neural networks to automate both the in-situ tip conditioning process of a scanning probe microscope as well as the patterning of atom-scale devices.

3A - Advanced Materials Applications I
Rooom: Nicollet A
Session Chairs:
Yoshihiko Hirai, Osaka Prefecture University
Leonidas E. Ocola, IBM

8:00AM 3A-1
Graphene-based Microsupercapacitors for On-Chip Micro Power Sources, *Hao Yang, Wu Lu, The Ohio State University*

We report electrochemical microsupercapacitors using highly porous vacuum-annealed graphene (VAG) as electrode materials combined with photolithography techniques to pattern the interdigital electrodes. The VAG microsupercapcitor shows a high stack capacitance of 11.30 F/cm3 and an energy density of 1 mWh/cm3 with solid electrolyte.

8:20AM 3A-2
Photochemical Synthesis of Dendritic Silver Nano-particles (AgNPs) for Anti-counterfeiting, *Z. Zhao, N. Chamele, M. Kozicki, Y. Yao, C. Wang, Arizona State University*

We report a novel photochemical method to synthesize dendritic silver nano-particles (AgNPs) in large quantities, and demonstrate the control of their sizes and morphologies. Unique dendrites obtained by this method possess distinctive morphological characteristics that lead to a vast number of unclonable patterns, which possess great potential for anti-counterfeiting labels.

8:40AM 3A-3
Soft Robotics Programmed with Double Crosslinking DNA Hydrogels, *Z. Zhao, C. Wang, Y. Liu, H. Yan, Arizona State University*

We demonstrated a new type of responsive hydrogel (D-gel), whose morphology was dynamically controlled by DNA hybridization induced double crosslinking. By combining with projection lithography, biomimetic “palms” that could mimic the complex gestures of human hands were directly printed. Mechanical operations including catch and release were achieved using the palm.

9:00PM 3A-4
DNA Origami-Templated Assembly of Heterogeneous Nanocavity for Quantum Emitter, *Z. Zhao, X. Chen, A. Basiri, Y. Yao, Y. Liu, H. Yan, C. Wang, Arizona State University*

We devised a novel strategy to construct ultra-small plasmonic nanocavities using DNA origami guided Au nanorod assembly. Precisely confined gaps of only 2-3 nm were achieved. Fluorescent emitters within the nanocavity exhibit splitting peaks in the scattering spectra and enhance fluorescent emission, demonstrating the presence of quantum-scale light-matter interaction.

9:20AM 3A-5
A simplified patterning process for the selective 1D ZnO nanorods growth, *Y. Geng, E. Mastropaolo, K. Jeronimo, M. A. Bin Che Mahzan, P. Lomax, R. Cheung, University of Edinburgh*

A novel patterning method for ZnO piezoelectric nanorods selective growth will be introduced, which can avoid any etching steps and longtime lift-off processes. Details of the selective growth processes of ZnO nanorods and devices fabricated based on this method will be presented.

Thursday, May 30, 2019

3B - Atomically Precise Fabrication
Rooom: Nicollet B/C
Session Chairs:
Ke Du, Rochester Institute of Technology
Josh Ballard, Zyvex

8:00AM 3B-1
Atomic Scale Fabrication and Application of Silicon Dangling Bonds, *Roshan Achal*,**, Mohammad Rashidi*,**, Jeremiah Croshaw*, David Churchill***, Marco Taucer*,**, Taleana Huff*,**, Martin Cloutier****, Jason Pitters**,****, Robert A. Wolkow*,**,****, *University of Alberta, **Quantum Silicon, Inc., ***Memorial University, St. John's, ****Nanotechnology Research Centre*

New technique to repair lithographic errors on a hydrogen-terminated silicon surface using a scanning tunneling microscope. Applications based on the ability to create perfect structures by removing and replacing single hydrogen atoms, including ultra-high density storage and recall of binary information.

8:20AM 3B-2
Assessing the Other Dimension in Atomically Precise Fabrication, *A. M. Katzenmeyer, T. S. Luk, M. T. Marshall, E. Bussmann, P. Q. Liu, J. Olhausen, P. Kotula, P. Lu, E. Anderson, D. M. Campbell, T. M. Lu, D. R. Ward, S. Misra, Sandia National Laboratories*

Hydrogen lithography serves as an atomically precise template for dopant incorporation in silicon; however, additional processing is required for electrical activation which makes assessment of the intended delta layer depth difficult. Here we demonstrate infrared variable angle spectroscopic ellipsometry solves this problem and yields electrical and optical parameters as well.

8:40AM 3B-3
Striving for Atomic Precision for large dopant arrays, *J. H. G. Owen, J. Lake, E. Fuchs, J. N. Randall, J. R. Von Ehr, Zyvex Labs*

We aim to produce arrays of dopants to make 2D Quantum Metamaterials using Hydrogen Depassivation Lithography. We are exploring the effects of different sources of position error, and correcting them systematically. We are also developing cross-correlation image recognition techniques to correct residual position errors and achieve Atomically Precise patterning.

9:00PM 3B-4
Nanofabrication by self-assembly: pathways and defects, *Jacob Majikes, Michael Zwolak, J. Alexander Liddle, Physical Measurement Laboratory, National Institute of Standards and Technology*

Thermodynamics and kinetics together control yield in self-assembly processes. These can be adjusted to improve yield, up to a point. New strategies for error detection and correction are needed to make significant progress. We discuss initial results using a model DNA origami system and speculate on future directions.

9:20AM 3B-5
Towards Single Atom Doping and Control in Silicon, *A. R. Lupini, B. M. Hudak, S. Jesse, J. Song, P. C. Snijders, S. V. Kalinin Oak Ridge National Laboratory*

Single dopant atoms in a semiconductor would provide a promising framework with which to construct quantum systems. Here we show how the electron beam can be used to position dopants inside a material, opening a new pathway for making quantum structures atom-by-atom.

Thursday, May 30, 2019

3C - Industrial Highlights
Room: Nicollet D
Session Chairs:
Gerald G. Lopez, University of Pennsylvania
Aimee Price, The Ohio State University

8:00AM 3C-1
High Speed Electron Beam Lithography Machine for R&D and Low Volume Production, Taichi Suhara, *STS-Elionix*

8:15AM 3C-2
LAB: Pushing Lithography Limits by Simulation, Nit Taksatorn, *GenISys, Inc.*

8:30AM 3C-3
Applications of Atomically Precise Lithography, James Owen, *Zyvex Labs*

8:45PM 3C-4
Photonic Professional GT2: New Solutions for Additive Manufacturing and Maskless Lithography, Benjamin Richter, *NanoScribe*

9:00AM 3C-5
From Micro to Nano: Solutions for High-End Lithography Applications, Niels Wijnaendts van Resandt, *Heidelberg Instruments/Swiss Litho*

9:15AM 3C-6
Demands on Mask Writing and NuFlare E-Beam Mask Writers, Hiroshi Matsumoto, *NuFlare Technology Inc.*

9:30AM 3C-7
Dry, Clean, Particle-Free "Dicing" – NEW Ways for Substrate Downsizing and Singulation, Efrat Moyal, *LatticeGear LLC*

4A - Advanced Pattern Transfer I
Rooom: Nicollet A
Session Chairs:
Jabez McClelland, National Institute of Standards and Technology
Shusuke Yoshitake, Nuflare

10:20AM 4A-1
Fluorocarbon assisted atomic layer etching of SiO_2 using low temperature cyclic Ar/CHF3 plasma, *S. Dallorto, A. Goodyear**, M. Cooke**, S. Dhuey, J. E. Szornel, I. W. Rangelow*, S. Cabrini, Molecular Foundry, Lawrence Berkeley National Lab, *TU Ilmenau, **Oxford Instruments*

With the goal of achieving self-limiting FC-based ALE, we investigated the etch step using low energy Ar ion bombardment. By carefully tailoring the energy of ion bombardment the substrate temperature, it is possible to control the etching depth to approach a self-limiting and aspect-ratio independent behavior.

10:40AM 4A-2
Fabrication of Optoelectronic Cytokine Biosensors through Integration of Low-Noise MoS2 Photodetectors and Biotunable Nanoplasmonic Windows, *Byunghoon Ryu, Younggeun Park, Bo-Ram Oh, Yujing Song, Katsuo Kurabayashi, and Xiaogan Liang**

We present the fabrication of a novel cytokine biosensor, which involves the integration of a biotunable nanoplasmonic window and a few-layer MoS2 photodetector. Such a biosensor combines label-free detection capability of nanoplasmonic structures and low-electronic-noise characteristics of few-layer MoS2, and therefore enables rapid and highly sensitive detection of target cytokines.

11:00AM 4A-3
High volume manufacturing of advanced diffractive optical elements by injection molding, *B. Bilenberg, T. Nielsen, A. Johansson, V. Miljkovic, N. Hansson, I. Czolkos, NIL Technology*

As the applications for complex optical element constantly increase and get more and more advanced there is a need for production of those in high volumes at low cost and on advanced geometries, free forms. We present a solution for making advanced diffractive optical elements by injection molding.

11:20PM 4A-4
Nanofabrication of high aspect ratio and 25 nm wide Au nanostructures using low-temperature development of PMMA and pulse electrochemical deposition, *Xiaoli Zhu*, Bo Cui*, Lintao Liu**, Jiebin Niu**, Changqing Xie**, *University of Waterloo, **Institute of Microelectronics of Chinese Academy of Sciences*

Here, a nanofabrication process of Au patterns with aspect ratio up to 12 and feature size down to 25 nm is demonstrated using low-temperature development of polymethyl methacrylate and pulse electrochemical deposition. This straightforward process would benefit to nanofabrication of HAR metal nanostructures and their wide applications.

4B - Micro-& Nanoscale Mechanical Devices
Rooom: Nicollet B/C
Session Chairs:
Rob Illic, National Institute of Standards and Technology
Rebecca Cheung, The University of Edinburgh

10:20AM 4B-1 Invited
There is plenty of room … in more dimensions, *David A. Czaplewski, Axel Eriksson*, Oriel Shoshani**, Steven W. Shaw***, and Daniel Lopez, Center for Nanoscale Materials, Argonne National Laboratory, *Chalmers University, Sweden, **Ben-Gurion University, Israel, ***Florida Institute of Technology*

We report a MEMS resonator, being driven by a single frequency tone, showing both long term transient responses and complex, robust long-term repetitive responses by allowing multiple modes of the same beam to interact with each other, introducing more dimensions to the governing equation through an internal mode coupling term.

10:50AM 4B-2
Nondegenerate Parametric Resonance in Large Ensembles of Coupled Micromechanical Cantilevers with Varying Natural Frequencies, *C.B. Wallin, R. De Alba, N. Dick*, D. Westly, G. Holland, S. Grutzik**, A.T. Zehnder***, R.H. Rand***, V. Aksyuk, S. Krylov*, B.R. Ilic, National Institute Of Standards And Technology, *Tel Aviv University, **Sandia National Laboratories, ***Cornell University*

We present the collective dynamics of interdigitated arrays of coupled microcantilevers distinguished by their linearly varying length operating in the linear and nonlinear regimes. We specifically highlight the nondegenerate parametric excitation of the microcantilevers which has not been previously demonstrated to the best of our knowledge.

11:10AM 4B-3
Zinc oxide nanowires-based flexible force sensor, *G. S. Wood, M. A. Bin Che Mahzan, K. Jeronimo Martinez, E. Mastropaolo, University of Edinburgh*

We present our work towards a flexible device that combines piezoelectric and resistive transductions to enable static and dynamic force measurements using a single sensor and to maximize force resolution. The device features piezoelectric nanowires embedded into flexible polymer materials.

11:30PM 4B-4
Micro-pump actuated dynamic color-morphing skin for octopus-like camouflage in soft robotics, *Chunxu Wan, Weihao Li, Rifei Chen, Yu Liu, Youwei Jiang, Xing Cheng, Southern University of Science and Technology*

We present a color morphing soft robotic finger with untethered pneumatic actuation by wireless-controlled micropumps . Polystyrene spheres self-assembled on soft and stretchable membranes are used to imitate the “protein crystals” in octopus’ skin, while the internal micro-channels performed as the “muscle” to move the finger.

4C - Nanoimprint
Rooom: Nicollet D
Session Chairs:
Hella-Christin Scheer, University of Wuppertal
Steven R. J. Brueck, University of New Mexico

10:20AM 4C-1
Substrate Conformal Imprint Lithography. High volume NIL production with functional resists, *Marc A. Verschuuren, Philips SCIL Nanoimprint Solutions*

Substrate Conformal Imprint Lithography solves the limitations of soft-stamp based NIL and allows low-pressure wafer scale contact and sub-10 nm resolution using soft silicone rubber stamps. Our AutoSCIL platform was extended with wafer-scale overlay, reaching ~1 micron. Results of optical fully inorganic resists with refractive index from n=1.15 to n=2.1.

10:50AM 4C-2
Direct Nanoimprint of Chalcogenide Glasses for Optical Applications, *D. Yehuda*, N. Ostrovsky*, S. Tzdaka* , E. Kassys**, S. Joseph*, M. Schvartzman*, * Isle Katz Institute of Nanoscale Science and Technology, Ben-Gurion University of the Negev, ** Optical Component Center*

We demonstrate two novel approaches for the direct nanoimprint of inorganic chalcogenide glasses, We showed full pattern transfer into the glass surface, without deforming the substrate. We applied these approaches to produce diffraction gratings onto the glass surface, and characterized it in transmission and reflection modes.

11:10AM 4C-3
Multiple replication of hierarchical structures from polymer masters with anisotropy, *A. Mayer, J. Rond, J. Staabs, M. Leifels, H.-C. Scheer, J. Zajadacz*, M. Erhardt*, P. Lorenz*, K. Zimmer*, University of Wuppertal, *Leibniz Institute for Surface Modification - Leipzig*

Replication is the practical means to work with samples featuring complex structures. In particular when the template is a polymeric one and a multiple replication is required common procedures have to be re-considered. We will focus on the multiple replication of anisotropic structures from a polymeric master for direction-dependent adhesion.

11:30PM 4C-4
Nanoimprint mold fabrication by nanosphere self-assembly for QLED light extraction, *Huiren Peng, Weihao Li, Chunxu Wan, Xing Cheng, Southern University of Science and Technology*

In this work, we present a fabrication strategy combining low-cost nanosphere self-assembly and nanoimprinting technology to obtain large-area nanoimprinting mold for light extraction efficiency enhancement in QLED.

5A - Advanced Ion-Beam Technologies I
Rooom: Nicollet A
Session Chairs:
Adam Steele, Zerok
Paul Alkemade, TU Delft

1:40PM 5A-1 Invited
Cold Atom Ion Sources, *J. J. McClelland, J. R. Gardner, W. R. McGehee, A. Schwarzkopf*, B. Knuffman*, A. V. Steele*, NIST, *zeroK NanoTech*

Ionization of laser-cooled atoms has emerged as a new approach to constructing high brightness ion sources for applications such as focused ion beam (FIB) microscopy and milling. I will review progress in this field and discuss recent developments in Li ion sources and applications.

2:10PM 5A-2
A high-resolution source of single ions using correlated feedback, *A. J. McCulloch, J. S. Laird, R. E. Scholten, The University of Melbourne*

The cold atom ion source, based on photoionization of laser-cooled atoms, has been shown to possess a brightness which surpasses conventional liquid metal and gas field ion sources. Here we investigate the application of cold-atom ion sources to deterministic production of single ions with high spatial and temporal resolution.

2:30PM 5A-3
Nanoscale engineering of 3D plasmonic nanostructures using focused helium ion beam milling, *C. Dreser, A. Bräuer, D. P. Kern, M. Fleischer, University of Tuebingen*

We show the geometric manipulation of pre-patterned nanostructures by focused helium ion beam milling. For this purpose gold nanocones were fabricated and the desired patterns were then carved into these structures with the helium ion beam. We investigate the optical properties of the pre-patterned and nano-engineered nanostructures.

2:50PM 5A-4
The Cesium Low Temperature Ion Source, *A.V. Steele, B. Knuffman, A. Schwarzkopf, J.J. McClelland*, zeroK NanoTech, *National Institute of Standards and Technology*

We present the latest results from the cesium Low Temperature Ion Source (LoTIS). The LoTIS is an ion source for focused ion beam and SIMS applications. It can provide 2 nm spot sizes at 1 pA and up to many nA beam current.

3:10PM 5A-5
Li-containing liquid metal alloy ion sources for focused-ion beam instrumentation, *P. Mazarov, A. Nadzeyka, T. Richter, Y. Yu*, J. E. Sanabia*, L. Bischoff**, G. Hlawacek**, W. Pilz**, N. Klingner**, Raith GmbH, *Raith America, **Helmholtz-Zentrum Dresden-Rossendorf*

3:30PM 5A-6
Cs Ion Coldbeam Suitability for Circuit Edit and Additional Nanomachining Applications, *Y. Greenzweig, R.H. Livengood, R.M. Hallstein, Y. Drezner, M.P. Ly, S. Tan, A. Raveh, A.V. Steele*, B. Knuffman*, A. Schwarzkopf*, Intel Corporation, * zeroK Nanotech*

We report the first-ever successful Cs-based circuit edits performed on 10nm Intel processors, using the Cs LoTIS (coldbeam source) at zeroK NanoTech. We present the results of a battery of tests performed with this Cs beam and comment on the suitability of Cs for circuit edit and other nanomachining applications.

5B - Photonics I
Rooom: Nicollet B/C
Session Chairs:
Cheng Zhang, National Institute of Standards and Technology
Dieter Kern, University of Tuebingen

1:40PM 5B-1 Invited
Terahertz Photonic Devices Employing Functional Nanostructures, *Peter Qiang Liu, University at Buffalo, State University of New York*

In this talk, I will present our efforts in developing several types of THz photonic devices incorporating functional graphene (plasmonic) nanostructures. These graphene nanostructures, being much smaller than the typical THz wavelength, play crucial roles in realizing the functionalities of the THz modulators, photodetectors and molecular sensors to be discussed.

2:10PM 5B-2
Nanoscale photonic dosimetry and calorimetry, *Nikolai N. Klimov, Ronald E. Tosh, Ryan Fitzgerald, Zeeshan Ahmed, Fred Bateman, Lonnie T. Cumberland, Ileana M. Pazos, National Institute of Standards and Technology*

We will give an overview of NIST photonic dosimetry program and its most recent developments. We will explain design, nanofabrication, packaging and interrogation of our radiation sensors. We will show our preliminary results on real-time photonic calorimetry measurements in the electron beam provided by a Van de Graaff accelerator.

2:30PM 5B-3
Inverse design of angle-sensing metasurface by particle swarm optimization, *Yunxiang Wang, Yuanrui Li, Hao Yang, Wei Wu, University of Southern California, Los Angeles*

2:50PM 5B-4
Enhanced Carrier-Envelope Phase Detection with Photoelectron Emission in Plasmonic Nanoantenna Arrays, *Y. Yang, P. D. Keathley, W. P. Putnam*, P. Vasireddy, M. Turchetti, F. X. Kärtner**, K. K. Berggren, Massachusetts Institute Of Technology, *Northrop Grumman Corp., **University of Hamburg and Deutsches Elektronen-Synchrotron (DESY)*

We show on-chip detection of carrier-envelope phase of ultrafast optical pulses by measuring the photoelectron emission current in electrically-connected bow-tie plasmonic nanoantenna arrays. We used parallelized nanoantenna arrays with a nanoscale cathode-anode separation, leading to improved photoelectron collection, higher photoemission current and stronger signal compared to previous work.

3:10PM 5B-5
X-ray Shaping Using Gratings and Zone Plates and Wavefront Measurements on the Free-electron Laser, *K. Li, Y. Liu, T. Weiss, M. Seaberg, M. Chollet, A. Sakdinawat, SLAC National Accelerator Laboratory*

X-ray free electron lasers have produced a lot of remarkable and influential results on multiple disciplines. Here we report x-ray beam shaping and wavefront measurements for diamond grating x-ray beam splitters, and spiral zone plates for producing femtosecond x-ray beams with orbital angular momentum.

3:30PM 5B-6
Ultra-Narrow Gap Al/Al2O3 Bowtie Nanoantennas by Focused He Ion Milling Lithography, *Massimo Cuscunà, Daniela Simeone, Giuseppe Calafiore* and Stefano Cabrini*, CNR-NANOTEC, *Molecular Foundry LBNL*

The combination of EBL and He+-ion milling provided a few nanometer milling precision; allowing the fabrication of narrow gap Al bowtie nanoantennas generating EM hot spots at visible frequencies. SEM and optical characterization demonstrate that a 3 nm gap is the intrinsic lower limit because of the Al2O3 oxide formation

5C - Next Generation Electron-Beam Lithography
Rooom: Nicollet D
Session Chairs:
John Randall, Zyvex
Elisa Riedo, New York University

1:40PM 5C-1 Invited
The Next Generation of Extreme-Resolution E-beam Lithography, *J.N. Randall, J.H.G. Owen, E. Fuchs, J. Lake, Zyvex Labs*

For decades Electron-Beam Lithography (EBL) has been the highest-resolution patterning tool of choice for commercial and research uses. Recent research has demonstrated EBL imitations in the single nm regime. Hydrogen Depassivation Lithography is a different type EBL with sub-nm resolution and precision, and should become the leader in ultra-high-resolution lithography.

2:10PM 5C-2
Atom by Atom Fabrication of Single Dopant and Single Electron Transistors for Quantum Technologies, *Richard Silver[1], Xiqiao Wang[2,3], Ranjit Kashid[1], Jon Wyrick[1], Pradeep Namboodiri[1], Scott W. Schmucker[3], Michael D. Stewart Jr.[1], and Neil Zimmerman[1],[1]National Institute of Standards and Technology, [2]Chemical Physics Program, University of Maryland, [3]Joint Quantum Institute, University of Maryland*

We present fabrication and characterization of STM-patterned single electron transistors that demonstrate stable coulomb blockade oscillations. We report electronic properties and tunnel coupling in single electron transistors where the tunnel gap is varied at the dimer row scale. We include spectroscopic measurements of an atomically precise, single atom transistor.

2:30PM 5C-3
STM lithography and surface stability investigation of halogen-terminated Si(100)-(2x1), *K.J. Dwyer, Michael Dreyer, Jennifer E. DeMell*, R.E. Butera*, University of Maryland, *Laboratory for Physical Sciences*

We demonstrate STM depassivation lithography on halogen-terminated (Cl and Br) Si(100)-(2x1) surfaces. Both an atomic precision mode and a field emission mode used for patterning large areas are shown. We also study the stability of halogen-terminated Si surfaces in vacuum and ambient (N2) environments.

5C-4 Moved to Poster P1-06
Field Emission Scanning Probe Lithography with GaN nanowires on active cantilevers, *Mahmoud Behzadirad, Ashwin K. Rishinaramangalam, Daniel Feezell, Tito Busani, Christoph Reuter*, Alexander Reum*, Mathias Holz*, Stephan Mecholdt**, Martin Hofmann**, Ahmad Ahmad**, Tzvetan Ivanov**, and Ivo W. Rangelow**, Center for High Technology Materials, University of New Mexico, Albuquerque, *nano analytik GmbH, **Department of Micro- and Nanoelectronic Systems, Technische Universität Ilmenau*

2:50PM 5C-5
Giving a microscope the intelligence to see and manipulate: automated information extraction for single atom control, *O. Dyck, M. Ziatdinov, X. Li, R. Vasudevan, S. V. Kalinin, S. Jesse, Oak Ridge National Laboratory*

Recent demonstrations have shown promise for using a scanning transmission electron microscope (STEM) as an atomic manipulation platform. To move these demonstrations into main-stream techniques requires development of a suite of tools designed to allow intelligent feedback responses from the microscope. Deep learning-based methods appear to be well suited.

3:10PM 5C-6
A High-Speed Z-Axis MEMS STM Nanopositioner, *A. Alipour, M. B. Coskun, S.O. R. Moheimani, University of Texas at Dallas*

One of the limitations that hinder the throughput of Scanning Tunneling Microscopes (STMs) is the limited bandwidth of the Z axis. We design, build and characterize a high-bandwidth, 1-DOF MEMS nanopositioner with a conductive tip, to replace the Z axis of the currently available STM piezotubes.

6A - Advanced Ion-Beam Technologies II
Rooom: Nicollet A
Session Chairs:
Shida Tan, Intel
Armin Gölzhäuser, Bielefeld University

4:10PM 6A-1 Invited
Imaging and Modification of 2D Materials: How Helium Ion Microscopy helps to fabricate novel filters and capacitors, *Armin Gölzhäuser, Bielefeld University*

The presentation is a progress report on HIM imaging and lithography with two-dimensional (2D) materials, with a particular focus on the integration of 1 nm thick carbon nanomembranes (CNMs) in functional devices. Examples of fabricating novel 2D filters and the implementation of 2D materials in nanocapacitors are discussed.

4:40PM 6A-2
Hybrid refractive-diffractive microlenses in glass and lithium niobate by focused Xe ion beam milling, *S. Gorelick, A. de Marco, Monash University, University of Warwick, ARC Centre of Excellence in Advanced Molecular Imaging*

Using high currents of focused Xe ion beam from a high brightness plasma source allows to rapidly fabricate microlenses in hard substrates (glass, lithium niobate) and pattern diffraction patterns on the curved surfaces of the microlenses.

5:00PM 6A-3
Neon Ion Beam Etching on Photoresist Patterns, *Deying Xia and Doug Runt, Carl Zeiss SMT, Inc. PCS Integration Center,*
Xiaoli Zhu, University of Waterloo

Neon ion beam could effectively etch PMMA and HSQ photoresist patterns defined by EBL. The etch gap could in tens of nanometers with good uniformity for gap array. XeF2 could enhance the etching for HSQ patterns. Neon ion beam etching could modify or repair photoresist patterns, and remove residuals.

5:20PM 6A-4 Invited
Spatially resolved materials modification using Helium Ion Microscopy, *Gregor Hlawacek, Helmholtz Zentrum Dresden Rossendorf*

Helium Ion Microscopy is a high resolution imaging and nanofabrication technique. In this contribution I will present highlights that utilize in-situ characterization and additional instrumentation to create new functionality on the nanometer scale. The examples include fabrication and characterization of ion beam induced nanomagnets and future low power device technologies.

6B - Photonics II
Rooom: Nicollet B/C
Session Chairs:
Wei Wu, University of Southern California
Nikolai Klimov, National Institute of Standarads and Technology

4:10PM 6B-1 Invited
High-Performance Infrared Nano-Rectennas Using New Photonic Nanostructures and 2D Materials, *L. Zhu, P. Y. Chen, University of Illinois at Chicago*

We discuss possibility of rectifying infrared radiation using tunneling nanodiodes based on thermally-oxidized 2D materials, which are engineered into hyperbolic-metamaterials (HMMs) for fully intercept the incident light and covert it into the useful dc electricity.

4:40PM 6B-2
Controlled Reduction of Photobleaching in Plasmon Enhanced Fluorescence Using Collapsible Nano-Fingers, *B. Song, Z. Liu, Y. Wang, Y. Li, H. Yang, D. Meng, B. Chen, P. Hu, T. Ou, S. Cronin, A. Schwartzberg*, S. Cabrini*, and W. Wu, University of Southern California, *Lawrence Berkeley National Laboratory*

We propose a method to reduce photobleaching in plasmon enhanced fluorescence with ultrastrong fluorescence enhancement using collapsible nanofingers. With the controlled reduction of photobleaching in this ultrastrong plasmon enhanced fluorescence, we pave the way for further accurate chemical detection and biological sensing.

5:00PM 6B-3
Nature-Inspired Chiral Metasurfaces for Circular Polarization Detection and Full-Stokes Polarimetric Measurement, *Ali Basiri, Xiahui Chen, Jing Bai, Pouya Amrollahi, Joe Carpenter, Zachary Holman, Chao Wang, Yu Yao, Arizona State University*

We demonstrate bioinspired sub-micron-thick chiral metasurfaces as circularly polarized light filters with extinction ratios of 35 and transmission efficiency of 80% at near infrared, and monolithically integrated the circular and linear polarization filters to perform full Stokes polarimetric measurement of light with arbitrary polarization state with a high accuracy.

5:20PM 6B-4 Invited
Spatiotemporal Manipulation of Optical Fields enabled by Metasurfaces, *A. Agrawal, W. Zhu, C. Zhang, L. Chen, S. Divitt and H. J. Lezec*, *National Institute of Standards and Technology, **University of Maryland*

We discuss the ability of dielectric metasurfaces - flat optical elements composed of an array of deep-subwavelength nanostructures of nanoscale thicknesses - to arbitrarily shape instead the temporal and spatial evolution of optical fields.

6C - Simulation & Modeling
Rooom: Nicollet D
Session Chairs:
Gregg Gelatin, Applied Math Solutions, LLC
Charles Holzwarth, Intel

4:10PM 6C-1
Computational Study on 3-D Mold Profile Correction for Resist Shrinkage in Nanoimprint, *K. Watanabe*, H. Sunagawa*, R. Yamashita**, M. Yasuda*, M. Shirai*, H. Kawata*, Y. Onishi**, Y. Hirai*, *Osaka Pref. Univ.,**Toyko Intitute of Technology*

Correction of the mold profile for nanoimprint is proposed to compensate resist shrinkage for various 3D structures and the effects are evaluated by computational works

Thursday, May 30, 2019

4:30PM 6C-2
Determining the Ultimate Resolution of SEM-based Unbiased Roughness Measurements, *Gian F. Lorusso, Chris A. Mack*, imec, *Fractilia*

Stochastic-induced roughness continues to be a major concern for patterning, but noise in the images of SEM measurements makes roughness measurement difficult. Simulation of synthetic SEM images will be used to explore the resolution limits of standard SEM-based roughness measurement in the presence of varying amount of SEM image noise.

4:50PM 6C-3
Modeling and Fabrication of Randomly Close Packed Nanostructures using Non-Monodispersed Colloidal Particles, *T. Chen, I. Chen, C. Chang, North Carolina State University*

There lacks a scalable fabrication method that allows design of broad bandwidth and wide-angle light extraction. We investigate a novel approach for modeling and manufacturing of light-extraction nanostructures from high-index medium. The results demonstrate the proof-of-concept that randomized close-packing can be patterned using colloidal particles with different sizes.

5:10PM 6C-4
Monte-Carlo Simulation of Charge-Induced Pattern Displacement in E-Beam Lithography, *K.T. Arat, C.W. Hagen, P. Kruit, A.C. Zonnevylle*, W.S.M.M. Ketelaars*, T. Klimpel**, Delft University of Technology, *RAITH B.V., **GenISys GmbH*

Electron beam lithography on insulating substrates is challenging due to beam-induced charging. We use Monte-Carlo simulations to predict charge induced pattern displacement, and investigate how this depends on exposure parameters such as beam energy, dose and scan strategy.

5:30PM 6C-5
Process Correction for E-Beam Exposure of HSQ, *R.J. Bojko, U. Hofmann, N.S. Patrick*, GenISys GmbH, *University of Washington*

An improved calibration procedure for characterizing HSQ exposures yields a significantly better process and PEC operating point, including successful correction for the large mid-range effects observed with HSQ.

Friday, May 31, 2019

7A - Imaging & Characterization
Rooom: Nicollet A
Session Chairs:
Ines Stolberg, Vistec-Semi
Thomas Michels, Genisys

8:00AM 7A-1 Invited
A Multifunctional Microstructure for Microscope Calibration and Nanoparticle Characterization, *K.-T. Liao, C. R. Copeland*, J. H. Myung, D. Kozak, S. M. Stavis*, Food and Drug Administration, * National Institute of Standards and Technology*

We integrate micropillar arrays into microfluidic slits to improve the accuracy of nanoparticle tracking and sizing. The pillar height sets the slit depth and the array pitch enables microscope calibration. These complementary functions yield a microscopic focal volume that is under control and that has traceable dimensions.

8:30AM 7A-2
Optical Scatterometry for In-line Nano-Manufacturing, *J.J. Faria Briceno, Ruichao Zhu, S.R.J. Brueck, University of New Mexico*

This research focuses on an in-line metrological tool that can be used during roll-to-roll (R2R) manufacturing of nano-size structures by using a 2-kHz scanning galvanometer mirror and parabolic optics we accomplished a range ($\Delta\theta$) of ~30º with an initial angle (θi) at ~29º and final angle (θf) at ~59º.

8:50AM 7A-3
SIMS Analysis of a Commercial Lithium Ion Battery Using a Highly Focused Neon Ion Beam, *Fouzia Khanom, U. Golla-Schindler*, Carl Zeiss SMT, Inc., *Aalen University*

The Zeiss Orion NanoFab SIMS was used to perform elemental analysis on a commercial graphite/NMC(Li[Ni1/3Mn1/3Co1/3]O2) pouch cells to observe degradation due to storage and the cycling processes

9:10AM 7A-4
Characterizing Profile Tilt of Nanoscale Deep-Etched Gratings via X-ray Diffraction, *J. Song, R. K. Heilmann, M. L. Schattenburg, A. R. Bruccoleri*, Massachusetts Institute Of Technology Kavli Institute for Astrophysics and Space Research, *Izentis LLC*

The Bosch deep reactive-ion etching (DRIE) process [1] has played an instrumental role in fabricating high-aspect ratio structures. However, it suffers from non-uniform profile tilt problem. We present a fast, high-precision (<0.1 deg of uncertainty), non-destructive x-ray metrology technique developed to characterize profile tilt using nanoscale gratings.

9:30AM 7A-5
In Situ Laser Heating and Excitation in the (Scanning) Transmission Electron Microscope for Real time imaging and excited state spectroscopy, *David A. Garfinkel, Yueying Wu, Gerd Duscher and Philip D. Rack,*, Thomas M. Moore**, Ben Wolf** and Gregory A. Magel** University of Tennessee *Oak Ridge National Laboratory, **Waviks Inc.*

A new in situ optical delivery tool for the (scanning) transmission electron microscope ((S)TEM) has been developed by Waviks Inc. The functionality of the tool is demonstrated through photothermal annealing and dewetting of a supersaturated Ag-Ni thin film, and excited state electron energy gain spectroscopy (EEGS) of plasmonic silver nanoparticles.

7B - Nanoelectronics
Rooom: Nicollet B/C
Session Chairs:
Gina Adam, George Washington University
Alan Brodie, KLA

8.00AM 7B-1 Invited
Organic Electronics for Neuromorphic Computing, *Y. van de Burgt, Eindhoven University of Technology*

Neuromorphic computing could address the inherent limitations of conventional silicon technology in dedicated machine-learning applications. Organic electronic materials can provide neuromorphic systems with low-energy switching and excellent tunability, while being biocompatible and inexpensive. This talk describes state-of-the-art organic neuromorphic devices and provides an overview of the current challenges.

8:30AM 7B-2
Dry Etching of Perovskite Oxides for High Performance Electronic Device Applications, *J. Cheng, C. Wang, H. Yang, S. Rajan, W. Lu*, N. Combs, W. Wu, O. Shoron, S. Stemmer**, *The Ohio State University, **University of California, Santa Barbara*

ICP-RIE etching processes of perovskite oxide BaSnO3 and BaTiO3 at nanometer scales have been characterized with the study of Cl-based or F-based plasma chemistries, and different plasma density or ion energy. Device fabricated under this process demonstrated excellent performances with high saturation current density and high transconductance.

8:50AM 7B-3
Photoelectric Effects of Bismuthene for Innovative Sensing and Energy Devices, *Zhaoying Dang[1], Emily Walker[2], Seth Bank[2], Deji Akinwande[2], and Li Tao[1], [1]Southeast University, [2]Microelectronic Research Center, The University of Texas at Austin*

Bismuthene is expected to have tunable bandgap in between graphene and transitional metal dichalcogenides, holding great promise for exotic electronic properties. Despite of success in bismuthene synthesis, there is a lack of device study. Here, while exploring bismuthene field-effect device, we discovered unique photoelectric effect not yet been reported.

9:00AM 7B-4
Plasma Process for Generating Movable Sulfur Vacancies in MoS2 Layers and Fabricating Analogue Ionically-Coupled Multi-Terminal Memristors, *D. Li, J. Yoon, B. Ryu, and X. Liang, Mechanical Engineering Department, University of Michigan, Ann Arbor*

We report that a plasma treatment can form a high density of movable Sulfur vacancies in few-layer MoS2 layers. The memristors made of such plasma-treated MoS2 layers exhibit analogue pulse-programmed switching characteristics with a good linearity. In addition, multiple memristor channels can be ionically coupled for emulating complex synaptic interactions.

9:20AM 7B-5 Invited
Nanofabrication and Characterization of Novel Devices Based on Two Dimensional (2D) Materials, *Saptarshi Das, Pennsylvania State University*

I will present nanofabrication and characterization of a wide range of devices based on 2D materials.

7C - Micro-& Nanofluidics
Rooom: Nicollet D
Session Chairs:
Scott Retterer, Oak Ridge National Laboratory
Wen-Di Li, The University of Hong Kong

8:00AM 7C-1 Invited
Active control of shear and mass transport in microfluidic devices, *W. De Malsche, P. Gelin, µFlow group, Vrije Universiteit Brussel, S. Stroobants, D. Maes, SBB, Vrije Universiteit Brussel*

In the production process of particles, the flow conditions that a particle experiences during its formation play a critical role on the structural properties of particles. In the present contribution we use active actuation to control the flow and to handle particles under formation.

8:30AM 7C-2
Optimal nanofabrication of complex nanofluidics for interfacial characterization of colloidal nanoparticles, *A. Madison, K.-T. Liao, S. M. Stavis, National Institute of Standards and Technology*

We optimize the focused-ion-beam milling of 3D nanofluidic devices in silica films. Test structures demonstrate vertical dimensional control approaching atomic resolution and extending into the submicrometer range. Input of these device dimensions into nanofluidic simulations indicates the potential of measuring the dimensional, optical, and interfacial property distributions of colloidal nanoparticles.

8:50AM 7C-3
Hemiwicking effect on nanoscale; wetting of surfaces derived from in-situ nano-lithography by self-assembly of block-copolymer structures, *Emil Ludvigsen, Nikolaj Mandsberg, Agnieszka Telecka, Sokol Ndoni, Rafael Taboryski, Technical University of Denmark*

We fabricated nano-surfaces supporting hemiwicking flow. The surfaces comprised hexagonal arrays of posts in PMMA with a 10 nm coating of tungsten to tune the surface hydrophilicity. The posts were derived from in-situ nanolithography by self-assembly of PS – PDMS block – copolymer.

9:10AM 7C-4
Nanoscale Details of Liquid Drops on 1D Patterned Surfaces Revealed by Etching, *Xuemei Wang, Juan J. Faria Briceno, Tito Busani, S. R. J Brueck, University of New Mexico*

We use imprint left by KOH etching on the photoresist grating walls to investigate the nanoscale details of the interface between the fluid drop and a 1D nanostructure. The observations show that wetting state is Cassie-Baxter and the edge of fluid drop is pinned at a structure edge.

9:30AM 7C-5
An all-purpose programmable and scalable fluid central processing unit for large-scale parallel droplet manipulations, *Yaru Xing, Xianming Liu, Yu Liu, Rifei Chen, Xing Cheng, Southern University of Science and Technology*

In this work, we present the development of a novel all-purpose programmable and scalable digital microfluidic platform and its peripherals that have unprecedented power and flexibility for microfluidic applications.

8A - Lithographic Materials I
Rooom: Nicollet A
Session Chairs:
Christopher Kemper Ober, Cornell
Alex Liddle, National Institute of Standards and Technology

10:20AM 8A-1
Sub-Micron High Aspect Ratio Direct E-beam Patterning of SU-8 Epoxy Resist, *M. J. Wojcik, V. De Andrade, L. E. Ocola*, Argonne National Lab, IBM*

We directly patterned SU-8 epoxy resist using e-beam lithography to fabricate sub-micron structures down to 200 nm and up to nine aspect ratio. The structures were used at a transmission X-ray microscope for Zernike phase contrast imaging optics alignment and development.

10:40AM 8A-2
A radiation-resistant stencil mask coating for neutral particle nanolithography with reduced stabilization implant, *Rebecca E. Kusko, Hatem Nounu*, Venu Sushir**, Navjot S. Randhawa**, Wei-Chuan Shih**, and JC Wolfe**, Texas Tech University Health Science Center, *Johnson Space Center, **University of Houston*

Radiation resistant coatings for Si stencil masks, based on He+ ion beam vitrification of carbon-containing precursors, are capable of absorbing lifetime He+ exposure up to at least 6 C/cm2. Stable stress in room air has also been established. This paper describes a precursor that reduces the vitrification dose by 94%.

8A-3 Withdrawn

11:00AM TBD

11:20AM 8A-4
Block Copolymer Directed Self-Assembly Defect Modes Induced by Localized Errors in Chemoepitaxial Guiding Underlayers: A Molecular Simulation Study, *J. B. Delony*, P. J. Ludovice**, C. L. Henderson*, *University of South Florida, **Georgia Institute of Technology*

Coarse-grained molecular dynamics simulations have been utilized to explore the possible causes of defectivity in the directed self-assembly of block copolymers. Factors such as defect position, defect shape, and defect density in the chemoepitaxial underlayer will be probed to begin building an understanding of the likely origins of common defects.

8B - Neuromorphic Hardware
Rooom: Nicollet B/C
Session Chairs:
Qiangfei Xia, University of Massachusetts Amherst
Jack Skinner, Montana Technological University

10:20AM 8B-1 Invited
Neuromorphic Computing Hardware with Silicon Photonics, *B. J. Shastri, A. N. Tait*, M. A. Nahmias*, T. Ferreira de Lima*, H.-T. Peng*, P. R. Prucnal*, Queen's University, **Princeton University*

Neuromorphic photonics promises orders of magnitude improvements in both speed and energy efficiency over digital electronics. We will give an overview of neuromorphic photonic systems and their application to optimization and machine learning problems.

10:50AM 8B-2
Large Area Chemical Vapor Deposition of High-Quality Few-Layer MoS2 through Modulation of Precursor Source Temperature Profiles, *J.S. Yoon, B. Ryu, D. Li, X. Liang, University of Michigan*

We present a progressive CVD trial for achieving high-quality large-area few-layer MoS2 through specifically modulating time-dependent temperature profiles set for solid-phase precursors, carrier gas flow rates. Such systematically and progressively acquired CVD results could be used for constructing a quantitative guideline for producing manufacturing-compatible 2D TMDC films.

11:10AM 8B-3
Hardware Acceleration Implementation of Kalman filter with Memristor, *Buyun Chen, Hao Yang, Boxiang Song, Wei Wu University of Southern California*

Kalman filter provides a powerful means to perform signal preprocessing on high-dimensional data and has been widely used in many automatic systems. Here, we analyzed and designed an analog circuit based Kalman filter to accelerate this process, which may have further applications on robotic systems, drones and so on.

11:30AM 8B-4 Invited
Novel Technologies for Artificial Intelligence: prospects and challenges, *Stefano Ambrogio, Pritish Narayanan, Hsinyu Tsai, Charles Mackin, An Chen, Robert M. Shelby, Geoffrey W. Burr, IBM Research-Almaden*

We provide a summary of recent progress in hardware acceleration of AI algorithms, such as training Fully-Connected Networks based on large Phase-Change-Memory arrays. Crossbar arrays of weights encoded as conductances can provide orders of magnitude increases in speed and energy efficiency with respect to state of art CPUs and GPUs.

8C - Advanced Materials Applications II
Rooom: Nicollet D
Session Chairs:
Li Tao, Southeast University
Raja Muthinti, IBM

10:20AM 8C-1 Invited
Plasma-enhanced atomic layer deposition of transition metal dichalcogenides: from 2D monolayers to 3D vertical nanofins, *Ageeth A. Bol, Eindhoven University of Technology*

2D materials have been the focus of intense research in the last decade due to their unique physical and chemical properties. This presentation will highlight our recent progress on the synthesis of two-dimensional transition metal dichalcogenides (2DTMDs) for nanoelectronics and catalysis applications using atomic layer deposition (ALD).

10:50AM 8C-2
Multilayer Stacking of 3D Periodic Nanostructures Assisted by Atomic Layer Deposition, *I-Te Chen,* Dennis T. Lee, Gregory Parsons, Chih-Hao Chang, North Carolina State University*

We investigate a novel approach to stack multiple layers of 3D periodic nanostructures in consecutive steps. This method employs a thin ceramic layer fabricated by ALD as the protection shell of the underlying layer, which allows the further processing of additional photoresist patterning.

11:10AM 8C-3
Parametric Study of 2D Pulsed Laser Deposited (PLD) WSe2 Transistors for enhancing an Infrared (IR) Detector, *S.Mbisike, S.Seo*, J.Phair**, R.Cheung, University of Edinburgh, Gwangju Institute of Science and Technology*, Pyreos Ltd***

A parametric study (length and Width) was conducted on Pulsed Laser Deposited WSe2 Field Effect Transistors (FET). The aim was to determine an optimized FET dimension that would be integrated with an Infrared (IR) detector. The goal is to improve the performance of the IR detector.

11:30AM 8C-4
Cleanroom in an SEM: in-situ area selective ALD, *G. Jeevanandam, R. van Tol, Y. Van Goozen, P. Kruit, C.W. Hagen, Delft University of Technology*

We envision fabricating a device inside a scanning electron microscope (SEM) i.e., “a cleanroom inside an SEM “.In this study, we will concentrate on integrating a thermal ALD tool within the SEM using Platinum electron beam induced deposition (EBID) as the seed layer.

9A - Lithographic Materials II
Rooom: Nicollet A
Session Chairs:
Chris Mack, Lithoguru
James Owen, Zyvex

1:30PM 9A-1
Metal organic cluster photoresists: etch behavior of metal oxide systems, *Kazunori Sakai, Seok Heon Jung*, Wenyang Pan*, Emmanuel Giannelis*, Christopher Ober*, JSR Corp., *Cornell University*

Extreme ultraviolet (EUV) lithography, using 13.5 nm radiation, is the major candidate for next generation manufacturing. Here, we report lithography of zinc oxide-based metal organic cluster photoresists, and EUV patterning below 15 nm. The lithographic performance of this and other metal oxides is described and etch characteristics discussed.

1:50PM 9A-2
New high etch resistant high resolution silsesquioxane based resist for DUV/EUV and e-beam lithography as long shelf-life and more sensitive alternative for HSQ, *Tobias Mai, Christian Kaiser, Matthias Schirmer, Maik Gerngroß, Allresist GmbH, Frank Heyroth, Georg Schmidt, Martin-Luther Universität , Lothar Hahn, Karlsruhe Institute of Technology*

Herein we report our new high etch resistant and high resolution silsesquioxane based resist Medusa 82 suitable for DUV/EUV and e-beam lithography. In comparison to HSQ, Medusa 82 shows a higher process stability and shelf life. The PAG containing resist version shows a significant higher sensitivity and good contrast, too.

2:10PM 9A-3
Micro and nanopatterning of Metal Oxo-Cluster photoresists, *Chun-Cheng Yeh, Shang-Yu Yu, Po-Yi Chang, Dominique Berling, Olivier Soppera, Hsiao-Wen Zan*, CNRS IS2M, *NCTU*

Metal Oxo-Cluster (MOC) based photoresists have emerging as a very interesting alternative material platform for the next generations of photolithography. We describe the synthesis, characterization and DUV photolithography of MOC photoresists, based on Zr, Ti, Hf and Zn, as well as the physical properties of micro-nanopatterns.

2:30PM 9A-4
Sub-10 nm Helium Ion Beam Lithography with Metal–Organic Resists, *M. Hunt, G. DeRose, H. Alty*, A. Wertheim, N. Lee, S. Yeates*, R. Winpenny*, A. Scherer, S. Lewis*, California Institute of Technology, University of Manchester**

It is demonstrated that a class of metal–organic, negative tone resists can yield sub-10 nanometer features when exposed with helium ion beam lithography. Single pass lines as narrow as 7 nm on 18 nm pitch are realizable on silicon both before and after reactive-ion etch.

9B - Nanobiology & Nanomedicine
Rooom: Nicollet B/C
Session Chairs:
Sam Stavis, National Institute of Standards and Technology
Mark Schvartzman, Ben-Gurion University of the Negev

1:30PM 9B-1
Trends in Nanosensor Arrays for Nanobiology & Nanomedicine, *Reginald Farrow, New Jersey Institute of Technology*

In this talk I will outline some of the goals, trends, and obstacles to the development of functional nanoprobe arrays for the purpose of sensing the coordinated activity of intracellular and extracellular signals.

1:50PM 9B-2
Preparation and behavior of ssDNA in porous roof nanochannels, *Anu Suryanarayana*, Olga Amosova, Yuliya Kuznetsove, Xin Jin, S.R.J. Brueck, Armonica Technologies, Inc., Jeremy Edwards, University of New Mexico*

We investigate several approaches to introducing long ssDNA molecules into a coupled nanochannel/nanopore structure. We introduced the ssDNA through wells at the ends of the nanochannels, through nanopores in the roof of the channels, and through in-situ heating/snap cooling and exonuclease digestion.

2:10PM 9B-3
Scalable fabrication of triangular nanopore membranes on sapphire substrate for low-noise DNA detection, *Pengkun Xia, Jiawei Zuo, Pravin Paudel, Chao Wang, Arizona State University*

Solid-state nanopores, have the potential to achieve high-speed and low-cost electrical detection for DNA sequencing applications. Here we present and demonstrate a novel manufacturable approach to create thin membranes with well-controlled dimension and shape on a crystal sapphire wafer, which completely eliminates the large capacitance from the membrane cavity.

2:30PM 9B-4
Combined Electrostatic and Air Driven Electrospinning for Biomedical Applications, *L.G. Huston, E.A. Kooistra-Manning, J.L. Skinner, J.M. Andriolo, Montana Technological University*

An overview of a portable electrospinning device that deposits polymer fibers directly onto surfaces without the use of external electrodes, using a combination of both electrostatic and air driven forces. The device can place fiber mats onto skin infections for targeted antibiotic drug delivery and release.

2:50PM 9B-5
Detection of Filopodia and Cancer Cell Concentration by Hybrid Plasmonic and Impedance Biosensor, *S. Zhu, M. Eldeeb, S. W. Pang, City University of Hong Kong*

A novel biosensor with hybrid plasmonic and impedance detectors are proposed to measure filopodia extensions and cell concentration simultaneously. The effects of micro/nanostructures dimensions and layouts on the extensions of filopodia, and the relationship between filopodia extensions of cancer and normal cells will be studied.

9C - Advanced Pattern Transfer II
Rooom: Nicollet D
Session Chairs:
Weilun Chao, Lawrence Berkeley National Laboratory
Uli Hofmann, Genisys

1:30PM 9C-1
Design Requirements for X-Ray Compatible Liquid Cell, *Alokik Kanwal, B. Robert Ilic, Subhrangsu Mukherjee, Eliot H. Gann, Cheng Wang*, Isvar A. Cordova*, Dean DeLongchamp, and J. Alexander Liddle, National Institute of Standards and Technology, *Lawrence Berkeley National Laboratory*

We present a design for a liquid cell that is compatible with Polarized Resonant Soft X-ray Scattering (PRSoXS). The design utilizes a random pillar pattern to overcome many of the challenges faced with designing vacuum and soft X-ray compatible liquid cells.

1:50PM 9C-2
Ultrathin iCVD films to Control Interfacial Energy for DSA Hole Shrink Applications, *M. Dolejsi, P. Moni*, C. Bezik, C. Zhou, J. J. de Pablo, K. Gleason*, P. F. Nealey, University of Chicago *Massachusetts Institute of Technology*

DSA hole-shrink is useful for shrinking the critical dimension of contact holes for lithographic processes as well as improving the critical dimension uniformity. We utilize iCVD to deposit a single film less than 5 nm thick with ideal chemistry to control and direct DSA both in experiment and in simulation.

2:10PM 9C-3
Efficient Bacteria Trapping and Retrieving via Low Aspect Ratio Nano-Sieve Device, *Xinye Chen[1]; Luke Falzon[2] Ruo-Qian Wang[3], Ke Du[1], [1]Rochester Institute of Technology, [2]The University of Dundee; [3]Rutgers, The State University of New Jersey*

We report a new fabrication process that is capable of pattering extremely low aspect ratio PDMS based nano-sieve device without roof collapsing. Leveraging the small sieve size and adaptive microfluidic channel, this nano-sieve device enables rapid and efficient bacteria isolation, concentration, and retrieval.

2:30PM 9C-4
Metallic Nanostructures on Arbitrary Surfaces Fabricated by Solution-processed Nanopatterning and Nanotransfer Printing, *J. Cai, Z. Gan, C. Zhang, W. D. Li, University of Hong Kong*

A novel method for fabricating metallic nanostructures on arbitrary surfaces through a vaccum-free, solution-processed strategy is reported. Large-area gold nanodisks with patterning resolution <50 nm were fabricated by nano-masked electrodeposition and transferred onto versatile substrates with high fidelity including silicon, glass, polyimide, PDMS and uneven glass reagent bottle.

2:50PM 9C-5
Fabrication of Ultrahigh Aspect Ratio Trenches by Two-Step KOH Anisotropic Wet Etching, *Huseyin Ekinci*, Ripon Kumar Dey, Bo Cui; University of Waterloo, *Erzincan University*

We introduce a novel technique to achieve very high aspect ratio trenches by a two-step KOH anisotropic wet etching. After the first KOH, the sidewalls of the trenches were protected and then the second KOH was applied. This approach has a great potential to produce sub-micron ultrahigh aspect ratio gratings.

10A - Advanced Lithography
Rooom: Nicollet A
Session Chairs:
Takeo Watanabe, University of Hyogo
Martha Sanches, IBM

3:30PM 10A-1
Black Silicon for high-contrast alignment marks fabricated using maskless photolithography and optimized Bosch Reactive-Ion Etching, *M. Yusuf, G. K. Herring*, L. T. Neustock*, U. Raghuram**, S. Kommera**, V. Narasimhan***,M. A. Zaman*, L. Hesselink*, Department of Chemical Engineering, Stanford, Department of Electrical Engineering, Stanford*, Stanford Nanofabrication Facility**, Intermolecular Inc***.*

A simple, rapid workflow for selectively patterning macro-scale areas of black silicon on a silicon substrate to fabricate high-contrast holographic marks for high-precision alignment. Using maskless photolithography and multiplexed reactive-ion etching, investigation of the process-structure-property relationship between the etching process conditions, black silicon morphologies, and light absorption is carried out.

3:50PM 10A-2
Super-resolution Interference Lithography using Spirothiopyran molecular switches, *H. Vijayamohanan, E. Palermo, C. Ullal, Rensselaer Polytechnic Institute*

Here, we introduce a super-resolution interference lithography technique by combining photochromic switching in spirothiopyran with the Thiol-Michael addition click chemistry. The low saturation threshold of our writing system allows for parallel writing over an area spanning two millimeters with feature sizes of λ/7 obtained using a 1.5 W laser.

4:10PM 10A-3
Empirical Modeling of Lithographic Error in Direct Write Laser (DWL) Lithography, *N. Xie, D. Jones, G. Lopez, University of Pennsylvania*

Patterns printed by DWL lithography may yield errors including a critical dimension bias versus the design, positional inaccuracy, and shape infidelity. To understand how to minimize these errors and determine the minimum CDs achievable by DWL lithography, we investigated these errors and built models to explain their source.

4:30PM 10A-4
The Integration of High-efficiency Vortex Light Emitters by 3D Photolithography, *Wenbo Mao, Stanley Feeney, Daniel Getega, Guixiong Zhong, Jiangdong Deng, Marko Lončar, Fang Bo*, Harvard University, *Nankai University*

4:50PM 10A-5
Step-and-repeat Nanopatterning Using Compact Two-beam Fibre-optic Interference Lithography, *Zhuofei Gan, Chuwei Liang, Jingxuan Cai, Dehu Cui*, and Wen-Di Li, The University of Hong Kong, *Southern University of Science and Technology*

In this research we have developed a two-beam fibre-optic interference lithography (2-FOIL) setup to overcome some specific limitations. In our 2-FOIL setup, complex optical components are replaced by single-mode polarization-maintaining fibre-optic components, which can be achieved to guide, split, expand and control the laser beams.

10B - Electron & Ion beam Sources & Optics
Rooom: Nicollet B/C
Session Chairs:
Marty Feldman, Louisiana State University
Kale Beckwitt, Intel

3:30PM 10B-1
Design for a 10keV Multi-Pass Transmission Electron Microscope, *S. A. Koppell, A. J. Bowman, Y. Israel, B. B. Klopfer, M. A. Kasevich, T. Juffmann*, M. Mankos**, K.Shadman**, Stanford University, *University of Vienna, **Electron Optica*

We have designed a 10keV proof-of-concept multi-pass transmission electron microscope which is currently being built by Delong Instruments. The design features fast-switching gated mirrors which cause electrons to image a sample multiple times before hitting the detector. This will significantly decrease damage at constant signal to noise.

3:50PM 10B-2
Micro-deflectors with two axes for a double micro-mirror aberration corrector, *T. Kishimoto* **, H. Dohi*, M.A.R. Krielaart**, C.T.H. Heerkens**, R.F.C. van Tol**, J.H.M van der Linden**, P. Keijzer**, P. Kruit**, *Delft University of Technology, **Hitachi High-Technologies Corp.*

SEMs play an important role in semiconductor fabrication. We report first steps to introduce a micro mirror aberration corrector which has two mirrors in order to go beyond the present resolution limit. We have designed, fabricated and tested a deflector system without mirrorsfor the aberration corrector.

4:10PM 10B-3
A high brightness source of energetic helium atoms for neutral particle lithography, *Venu Sushir, Navjot Randhawa, Hong-Jie Guo, Barry Craver, Apeksha Awale, Pratik Motwani, John C. Wolfe*

In Neutral particle lithography, secondary electron diffusion begins to degrade resolution in thin resist for mask openings below ~5 nm and printing becomes impossible below ~4 nm. Thus, the domain for direct substrate modification begins with 5 nm feature sizes; This requires a very small source with high flux density.

4:30PM 10B-4
A programmable phase patterning device for electron beams, *S. A. Koppell, A. J. Bowman, Y. Israel, M. A. Kasevich, Stanford University*

We have designed a phase patterning device for electron beams that is nearly transparent and straightforwardly scalable to hundreds of thousands of phase elements which can be programmed in parallel. The technology to control electron wavefronts will enable exciting new techniques including simplified aberration correction and exotic beam shaping.

4:50PM 10B-5
Nanosecond Pulse Electronics for Gated Electron Mirrors, *J.W. Simonaitis*, M. Turchetti*, N. Abedzadeh*, B.B. Klopfer**, S.A. Koppell**, M.A. Kasevich**, K.K. Berggren**

This work is on the development of vacuum-compatible, 100 volt nanosecond rise time electronics with better than 1% accuracy for the switching of gated electron mirrors and other time-dependent charged particle optics.

5:10PM 10B-6
Extending Multibeam SEM Technology to 331 Beams, *C. Riedesel, I. Müller, N. Kaufmann, A. Adolf, N. Kämmer, H. Fritz, D. Zeidler, Carl Zeiss Microscopy GmbH*

We have demonstrated the successful operation of a multi-beam scanning electron microscope with 331 beams for the first time. The architecture of the existing multi-beam technology fully supports the scale-up of the number of electron beams to 331, and scaling beyond this number is straightforward.

10C - Highlights in Nanofabrication
Rooom: Nicollet D
Session Chairs:
Supriya Jaiswal, Astrileux Corporation
Richard Bojko, Genisys

3:30PM 10C-1 Invited
Wanted: More Photons for EUV Lithography, *S.L. Jaiswal, Astrileux Corporation*

To manufacture affordable next-generation technology in high volumes, chipmakers will need single-exposure extreme ultraviolet (EUV) lithography using light at 13.5 nm. EUV tools use high power light sources. However, there is a critical need to deploy energy-efficient lithography tools that produce more photons to create affordable, sustainable electronics.

4:00PM 10C-2
Photopatterning of Molecular Orientations for Fabrication of Liquid Crystal Flat Optical Devices, *H Yu, M Jiang, Y Guo, T Turiv, OD Lavrentovich, V Ray*, W Lu**, QH Wei. Kent State University, *University of Michigan, **Ohio State University*

We present new plasmonic metamasks for photopatterning arbitrary designer molecular orientations. The new metamasks yield very high broad-band transmission in the UV-visible wavelengths and significantly reduce exposure doses. We will present its application in fabricating liquid crystal flat optical devices for laser beam shaping with ultra-high efficiency.

4:20PM 10C-3
UltraHigh Aspect Ratio Silicon Structures for Energy Storage Applications, *Donald S. Gardner, Kenan Li, Douglas Van Campen, Anne Sakadinawat, Stanford Synchrotron Radiation Lightsource, SLAC National Accelerator Labs*

Integrated high-aspect-ratio structures are important for IoT energy storage, sensors, and x-ray optics. New silicon structures with aspect ratios >500:1 were prepared, approximately an order of magnitude higher than before. Devices prepared with these structures can provide integrated on-chip energy storage in a compact form factor with minimal packaging.

4:40PM 10C-4
Vapor-phase infiltration synthesis of hybrid nanocomposite resist for next generation lithography, *N. Tiwale*, A. Subramanian**, K. Kisslinger*, M. Lu*, A. Stein*, C.-Y. Nam* **, *Brookhaven National Laboratory, **Stony Brook University*

We have developed organic-inorganic hybrid resists by utilizing infiltration synthesis of AlOx into spin-coated, commonly used resist, poly(methyl methacrylate) (PMMA) thin film. The patterning characteristics of the synthesized hybrid resist are investigated with the use of electron beam lithography (EBL) and reactive ion etching.

5:00PM 10C-5
Novel approach for precise and flexible micro-nano patterning of surfaces towards enabling controlled textures on arbitrary objects, *G. Rius, O. Muntada, F. Pérez-Murano, A. García-Granada*, T. Baldi*, C. Colominas*, IMB-CNM-CSIC, *IQS*

We present original, versatile method for transferring micro/nanopatterned structures to arbitrary surfaces. Micro/nanostructures are defined by microelectronics processes onto polymer films. Compound layer is delaminated and transferred to the target substrate. Method has been demonstrated on curved, steel mold surfaces, at wafer scale, and used in plastic injection replication .

Posters

LITHOGRAHY

P1-01
(Invited) Low-contrast electron beam lithography process for fabrication of sloped sidewall HSQ spacers, *M. Colangelo, D. Zhu, K. K. Berggren, Massachusetts Institute of Technology*

We propose the fabrication of sloped sidewall HSQ spacers to provide device separations while preserving metal traces continuity exploiting the normally-unwanted side exposure from backscattered electrons. Applications where metal continuity is essential for signal propagation and integrity (ground continuity in microwave devices) may benefit from this fabrication process.

P1-02
Fabrication of sub-10 nanometer half-pitch dense line and space structure by using electron beam lithography, *M. Shibata, H. Ohkubo, H. Ohyi, CRESTEC CORPORATION*

In this study, sub-10 nanometer half-pitch dense line and space structure of 50 x 50 micrometer square was fabricated on HSQ using an electron beam lithography system with 130 keV beam energy.

P1-03
Self-aligned structures by a single-step through-membrane 100-keV electron beam lithography, *S. Gorelick, A. de Marco, Monash University, University of Warwick, ARC Centre of Excellence in Advanced Molecular Imaging*

Thanks to the high energy (100 keV) of the electrons beam, the electrons are able to propagate through a thick membrane stack and expose the resist on both sides of the membrane, while the single step exposure ensures that subsequently etched structures in the membrane are perfectly aligned.

P1-04
A multi-row writing method for massively-parallel electron-beam systems, *S.-Y. Lee, B.-S.Ahn*, J. Choi*, S.-B. Kim and C.-U. Jeon*, Auburn University, *Samsung Electronics*

A writing method for massively-parallel electron-beam systems, which mitigates the negative effects of faulty or abnormal beams by minimizing the spatial localization of affected pixels, is designed and a realization of the method is described with the requirements.

P1-05
Effects of Abnormal Beams on Writing Qualities in Massively-parallel E-beam Systems, *M. N. Hasan, S.-Y. Lee, B.-S. Ahn*, J. Choi*, S.-B. Kim* and C.-U. Jeon*, Auburn University, *Samsung Electronics*

In a massively-parallel electron-beam system, it is likely that some beams are abnormal. The effects of abnormal beams on the writing qualities are analyzed through an extensive simulation. The multi-row writing method is compared with single-row writing methods in terms of quality metrics such as exposure fluctuation, LER, etc.

Posters

P1-06
Field Emission Scanning Probe Lithography with GaN nanowires on active cantilevers, *Mahmoud Behzadirad, Ashwin K. Rishinaramangalam, Daniel Feezell, Tito Busani, Christoph Reuter*, Alexander Reum*, Mathias Holz*, Stephan Mecholdt**, Martin Hofmann**, Ahmad Ahmad**, Tzvetan Ivanov**, and Ivo W. Rangelow**, Center for High Technology Materials, University of New Mexico, Albuquerque, *nano analytik GmbH, **Department of Micro- and Nanoelectronic Systems, Technische Universität Ilmenau*

P1-07
On the Trends and Application of Isofocality for Negative Resists in Electron Beam Lithography, *G. Lopez, M. Zhang, G. Shao, G. de Villafranca, K. Lister*, N. Belic**, U. Hofmann**, University of Pennsylvania, University of Delaware*, GenISys GmbH*

Continuing our research on isofocality in electron beam lithography (EBL) to enable process robustness and repeatability, this work examines the isofocality of commercially available negative resists, namely, Medusa 82 by AllResist GmbH and maN-2403 by Micro Resist Technology GmbH. Techniques and applications of our findings will be shown.

P1-08
Why So Negative? Ways to make PMMA useful as a negative-tone resist in EBL., *Y. Lilach, D. Ratnayake, A. Popratiloff, The George Washington University, Washington DC*

Cross-linked PMMA (usually called negative-tone PMMA) can be a useful fabrication step, as long as a few pitfalls are avoided. Some of these useful properties, and the solutions to the pitfalls will be presented.

P1-09
Soft x-ray varied-line-spacing gratings by near field holography with an electron beam lithography-written mask, *Ying Liu, University of Science and Technology of China*

We demonstrate that dynamic near field holography (NFH) with an electron beam lithography-written phase mask can be expected in the fabrication of soft X-ray varied-line-spacing gratings. With the introduction of dynamic NFH, soft X-ray VLSG with reduced the stray light is achieved compared to its EBL-written mask.

P1-10
Optical property constant calculation for Advanced absorbers application, *Shuwei Liu, Weimin Li, Khor Wui Cheng, Vibhu Jindal, Applied Materials*

EUV lithography has been widely considered as the next generation lithography technology. Advanced absorber other than TaN is expected to reduce mask 3D effect and phase jump issue. In this article, optical properties of advanced absorber has been measured by EUV beamline and optical constants have been calculated by simulation.

P1-11
Evaluation of EUV transmittance and mechanical strength of Si-based EUV pellicle film by nitrogen ion implantation, *Gi-Sung Lee, Hae-Chul Hwang, Ki-Nam, Kim, National Nanofab Center*

This study investigated the transmittance and mechanical strength of silicon-based EUV films by controlling the nitrogen ion dose.
As a result, we confirmed the correlation between the transmittance and the mechanical strength according to the nitrogen ion implantation amount

P1-12
Investigation of ma-N 2400 Series Photoresist as an Electron Beam Resist for Superconducting Nanoscale Devices, *E. Toomey, M. Colangelo, K. K. Berggren, Massachusetts Institute of Technology*

We study the use of ma-N 2400 series DUV photoresist as an electron beam resist for patterning superconducting nanoscale devices. We report the patterning of repeated lines of widths down to 30 nm, and single features with a minimum dimension of 20 nm.

P1-13
Three-Beam Lloyd's Mirror Interference Lithography with Liquid Immersion, *Shubhro Saha, Zhiren Luo, and Chih-Hao Chang, North Carolina State University*

Here we report a liquid-immersion, three-beam Lloyd's mirror lithography system that can have more pattern versatility and higher pattern resolution. This is achieved by allowing the angle between the two mirrors to be changed, leading to more interference conditions. The resolution can also be improved by using liquid immersion.

P1-14
aquaSAVE™ Antistatic Agent for Electron Beam Lithography, *Takahiro Mori, Akira Yamazaki, Mitsubishi Chemical Corporation*

aquaSAVE™ which consists of self-doped conductive polyaniline derivatives is water-based antistatic agent. aquaSAVE™ can make uniform Charge Dissipation Layer on any resists and provide improved place accuracy. It is expected that electrons accumulate on the resist surface will increase for further miniaturization.

P1-15
(Invited) Computational study on micro 3-dimensional imaging using novel photolithography, *D. Sugihara, A. Misaka, K. Sato, H. Kikuta, H. Kawata, M. Yasuda, M. Shirai, M. Sasago, Y.Hirai, Osaka Prefecture University*

we study possibility on the 3-dimensional imaging using the built-in lens lithography by computational works. Micro cylinder and crossing lines in space are demonstrated. Optimizing the layout design, 3-dimensional imaging are demonstrated by elimination of interference.

P1-16
Greyscale E-Beam Lithography Revisited: Dynamic Range and Roughness of Patterns on Silicon, *I. I. Kravchenko, N. V. Lavrik, A. Gujrati* and T. D. B. Jacobs*, Oak Ridge National Laboratory, *University of Pittsburgh*

This study focuses on critical remaining challenges in greyscale EBL: out-of-plane accuracy; dynamic range; and surface roughness. Our goal is to identify protocols that result in 3D topologies with the highest fidelity. Analysis of artifacts and additional surface roughness introduced by the processing steps involved in greyscale EBL is presented.

P1-17
3D contact stencil masks for lift-off process on extremely uneven surface, *Ming Lu, Zhixiu Liang, Huolin Xin* Brookhaven National Laboratory, *University of California, Irvine*

Traditional lift-off process limits its application to the substrates with surface unevenness smaller than the wavelength of exposing light or the depth of field of the optics. We report a new approach utilizing 3D contact stencil masks fabricated by 3D lithography, which works with substrates with hundreds microns of unevenness.

P1-18
Nanoscale Lift-Off Process Using Field-Emission Scanning Probe Lithography, *M. Hofmann, S. Mecholdt, A. Ahmad, T. Ivanov, E. Manske, I. W. Rangelow, M. Holz*, TU Ilmenau, *Nanoanalytik GmbH*

In this work we will present the utilization of diamond tips for field emission scanning probe lithography (FE-SPL) purposes in order to generate chromium metal features by lift-off for the generation of future quantum devices.

P1-19
Tip-based electron beam induced deposition (TB-EBID) with active cantilevers, *M. Holz[1,2], C. Reuter[1,2], S. Mechold[2], A. Ahmad[1,2], M. Hofmann[1], A. Reum[2], T. Ivanov[1], E. Guliyev[1] and I.W. Rangelow[1,2], [1]Technische Universität Ilmenau, MNES,*
[2]nano analytik GmbH

Tip-based electron beam induced deposition (TB-EBID) is an alternative technique, using low energy electrons (<50eV) field-emitted from the tip of an active cantilever. Combining conventional AFM technology with EBID is enabling high resolution structure writing and imaging.

P1-20
Development of Free-standing Membrane-based Electrostatic Lenses for Nanopantography, *Prithvi Basu*, Ryan Sawadichai**, Ya Ming**, Vincent M. Donnelly**, Demetre J. Economou**, Jiming Bao* and Paul Ruchhoeft*, * Department of Electrical and Computer Engineering, ** Department of Chemical and Biomolecular Engineering, University of Houston*

We have fabricated free-standing lens arrays from SU-8 membranes for use in nanopantography. When the membrane is placed against a conducting surface and a potential is applied, ions entering each lens focus to a small spot on the substrate and large arrays of nanoscale patterns can be printed.

Posters

P1-21
Opening the road to custom astronomical UV gratings, *Fabien Grise, Randall L. McEntaffer; Nicholas E. Kruczek*, Kevin C. France*, Brian T. Fleming, Eduard R. Muslimov**, Jean-Claude Bouret**, Amandine Caillat**, The Pennsylvania State Univ. (United States), *Univ. of Colorado Boulder (United States), **Aix*

A combination of electron beam lithography, dry and wet etching allows us to fabricate custom ultraviolet (UV) blazed gratings with unprecedented efficiency, close to the theoretical limit. These results are opening the way to new applications in the field of astronomical UV spectroscopy.

P1-22
One-step assembly of multi-layered structures with orthogonally oriented stripe-like patterns on the surface of a capillary tube, *2 authors same affiliation: Y. Lin, Y. Sun, State Key Laboratory of Polymer Physics and Chemistry, Changchun Institute of Applied Chemistry, Chinese Academy of Sciences*

We presented a facile, rapid and controllable method for the construction of orthogonal stripe patterns in one-step on the inner and outer surfaces of a capillary tube using the confined evaporative self-assembly (CESA) method.

P1-23
Optimization of Swelling Process in Solvent Vapor Annealed Block Copolymer Thin Films, *H. Huang*, T Chang, Changchun Institute of Applied Chemistry, Chinese Academy of Sciences*

We realized fast-assembly of block copolymer thin films by accelerating the swelling rate in high surface-to-volume vessel. Rapid swelling of BCP thin films was achieved after 10 s annealing and long range ordered morphology formed after 1-3 min.

P1-24
Assembly of Aligned Silver Nanowires using Roll-to-Roll System, *S. Mohanty, I-Te Chen, C. H. Chang, North Carolina State University*

In this work, Silver nano-wires are coated on a silicon substrate using a roll-to-roll system. A method is discussed to align the nano-wires in a uni direction in order to improve the electrical properties of nanowire. The work has applications in transparent and stretchable conductors.

P1-25
Nanoscale metallic resistors in soft polymers, *D. K. Brown*, M. Kim*, O. Brand*, D. R. Myers*,**, W. A. Lam*,**, *Georgia Institute of Technology, **Emory University*

This paper presents a fabrication method for nanoscale metallic resistors using electron-beam lithography and a transfer process to soft polymers. The technique uses a standard lift-off process with PMMA resist on a layer of Parylene C and a sacrificial layer of polyacrylamide (PAA) enabling the transfer from silicon to polymer.

Posters

P1-26
Effect of oxygen plasma cleaning on non-switching pseudo-Bosch etching of high aspect ratio silicon pillars, *A. Pan, F. Aydinoglu, B. Cui, University of Waterloo*

Pseudo-Bosch process utilizes non-switching SF6/C4F8 gas to etch silicon with smooth sidewall. Here we show that, by dividing the etching into many short cycles, with each cycle containing etching using SF6/C4F8 and cleaning using O2, one can obtain higher etching rate and higher aspect ratio silicon structures at no cost.

P1-27
Tunable nanoparticle self-assembly on magnetic template with dynamic optical properties, *Z. Luo, B. Evans*, C. Chang, North Carolina State University, *Elon University*

Based on previous work, here we report the method to fabricate self-assembled nanoparticles with 1D periodicity on magnetic template. This structure demonstrates dynamic birefringent effects, which can potentially be used as tunable polarization element.

P1-28
Controlled Synthesis of Nanowires/Nanorods via Electrodeposition in Anodisc Alumina Templates, *M. Nehra*, D. Kedia*, N. Dilbaghi*, K.H. Kim**, S. Kumar*,**, *Guru Jambheshwar University of Science and Technology, **Hanyang University,*

The electrochemical deposition technique offers accurate process control for growth of different nanostructures for diverse applications. The different parameters and operating conditions can be optimized for electrodeposition of highly-ordered nanowires/nanorods inside the pores of anodisc template such as electrodeposition potential, time durations, and pH and concentration of the solution.

P1-29
Effects of mask material conductivity on lateral undercut etching in silicon nano-pillar etching, *R. Dey, B. Cui, Waterloo Institute for Nanotechnology (WIN), University of Waterloo.*

Minimal lateral etches under the etch mask is essential to achieve very high aspect ratio silicon nanostructures. Here we report that insulating metal oxide etch mask like chromium oxide and aluminum oxide provides less lateral etch than conducting metal etch mask like chromium and aluminum using non-switch “pseudo-Bosch” dry etching.

P1-30
Characteristics of thermal imprint with perovskite layers, *A. Mayer, N. Pourdavoud, J. Staabs, J. Rond, R. Heiderhoff, P. Görrn, R. Riedl, H-C. Scheer, University of Wuppertal*

Perovskites have prospects for optoelectronic devices prepared from solution. This study deals with the quality improvement of MAPbBr3 layers obtained by planar hot pressing (PHP). The focus is on the impact of the pristine layer preparation, the PHP parameters and the crystallization process of the perovskite during PHP itself.

Posters

P1-31
Double replication for characterizing cracks in surface-hardened PDMS, *M. Leifels, A. Mayer, P. Görrn, H.-C. Scheer, University of Wuppertal*

Cracks occur after stretching VUV-hardened PDMS. To freeze cracks at different strain and to analyze cracks in cross-section by SEM, a double replication on Si are reasonable for quantifying the crack characteristics (shape, width, depth). The effect of the preparation conditions and strain will be discussed and compared with theory.

P1-32
Blazed gratings for X-ray astronomy fabricated by grayscale e-beam and nanoimprint, *Jake McCoy*, Randall McEntaffer*, Chad Eichfeld* and Marc Verschuuren**, *Pennsylvania State University. **Philips SCIL Nanoimprint Solutions*

Improving instrumentation for X-ray astronomy requires investigating advanced techniques in nanofabrication to produce state-of-the-art X-ray reflection gratings. Thermally activated selective topography equilibration is used to fabricate a blazed grating topography in PMMA. Then, substrate conformal imprint lithography (SCIL) is used to produce grating replicas in a silica sol-gel resist.

P1-33
(Invited) Sidewall Channel Fabrication Using Membrane Projection Lithography and Metal Assisted Chemical Etching, *R. Chaudhary, H. Yamamoto, G. P. Watson*, University of Pennsylvania*

Horizontal, enclosed nanochannels have interesting potential applications in nanofluidics, nanobiotechnology, DNA sensing, photonic crystals, and optical waveguides. Membrane projection lithography and metal assisted chemical etching are combined to fabricate 100 to 400 nm nanochannels in the sidewalls of patterned Si substrates.

P1-34
Plasma Etching of Sapphire Antireflection Nanostructures, *Y.-A. Chen, C.-H. Chang, North Carolina State University*

Sapphire have many applications in photonics and optoelectronics. However, the high index mismatch to air causes large Fresnel reflection losses. We report the fabrication of subwavelength structures on sapphire wafer to reduce optical reflection losses and increase transmittance. We also evaluated Cl2, BCl3, and HBr etch rates and selectivity.

P1-35
Nanostructure manufacturing via holographic photolithography, *J. B. Geddes III, Photia Incorporated*

We report on development of optical holographic methods for high-throughput manufacturing of nanostructured materials with one-, two-, and three-dimensional morphology.

P1-36
Brilliant Fluorescent Resists for E-beam and Photolithographic Applications, *Christian Kaiser, Matthias Schirmer, Tobias Mai, ALLRESIST GmbH, Thomas Steglich, Präzisionsoptik Gera Philipp Basitan, Marita Steffen, Michael U. Kumke, Universität Potsdam*

Incorporation UPNCs into standard PMMA and the new Atlas 46 resist system. The resulting resists good upconverting activity. Additionally several organic soluble fluorescent dye could incorporate into the same resists. Those showed good fluorescence as well. Yet the combination different organic dyes showed no upconverting activity.

P1-37
Process Window Enhancement through Shape Proximity Effect Correction of an Electron Beam Lithography Process, *K. M. Awana*, G. Lopez**, L. Chrowstoski*, and J. F. Young*, *University of British Columbia, **Singh Center for Nanotechnology, University of Pennsylvania*

The resolution limit in an electron beam lithography process depends on the resist, substrate, the proximity effect, and the e-beam writer itself. In this work we look at using shape proximity effect correction to improve the process window of a ZEP520A process on silicon on insulator samples

P1-38
An Improved Method to Estimate SEM Beam Spot Size and Measurement Resolution, *Chih-Yu Jen*, Yoyo Lin*, Eric Ma, Xuedong Liu, Weiming Ren, Kevin Liu, ASML*

A new more precise method, which incorporates information about the sample geometry, is proposed to more accurately estimate SEM beam spot size and measurement resolution. Our hope is this new method can be adopted as the new industry standard.

P1-39
Patterning Si at the 1 nm Length Scale with Aberration-Corrected Electron-Beam Lithography: Engineering of Si Plasmonic Properties, *Fernando Camino, Vitor Manfrinato, Aaron Stein, Lihua Zhang, Ming Lu, Eric Stach and Charles Black, Center for Functional Nanomaterials, Brookhaven National Laboratory*

1-nm resolution Si patterning is demonstrated using aberration-corrected electron-beam lithography (AC-EBL) and reactive ion etching. In addition, AC-EBL is used to fabricate nanowires with line edge roughness (LER) of 1 nm, and to modulate the Si volume plasmon energy, thus demonstrating control of electro-optical properties of nanostructures “by design”.

MATERIALS

P2-01
(Invited) AweSEM: Removing Barriers to Innovation with a Tabletop, Low-Cost SEM, *C. Kuzyk, E. Blankenburg*, G. Robinson-Leith, H. Li*, M. Chang, M. Cen*, B. Ye**, G. Hu*, K. Jessen, A. Nojeh, R. F. Pease*, University of British Columbia,*
**Stanford University, **Palo Alto High School*

We present a novel, low cost scanning electron microscope that is aimed to reduce the barriers to innovation everyone. We have produced images with a prototype that includes a permanently sealed vacuum chamber, an optically stimulated carbon nanotube forest based cathode, and permanent magnetic lens.

P2-02
Micro-textured electrolyte-electrode interfaces in solid-state supercapacitors, *O. Omoregie, E. Aigbogun, L. Jiang, B. Oni, N.S. Korivi, Tuskegee University*

A novel approach is presented to improve solid-state supercapacitor capacitance and energy by micro-scale texturing of the electrolyte-electrode interface. The texturing increases the surface area available for nano-scale electrode material, thereby increasing device capacitance. Devices with textured interfaces show 2-4 times higher capacitance than those with non-textured interfaces.

Posters

P2-03
Closed cavity resonator formed by suspended large monolayer graphene-based membrane, *J.Xu, G. S. Wood1, A.K. Al-mashaal, E. Mastropaolo and R. Cheung, M. J. Newton, Acoustics and Audio Group, University of Edin*

P2-04
Development of graphene-based immunosensor for highly sensitive biosensing of waterborne pathogens, *Arushi Gupta, Amit L. Sharma, Akash Deep, Ki-Hyun Kim*, CSIR-Central Scientific Instruments Organisation (CSIR-CSIO), *Hanyang University*

P2-05
Ultrafast response time as a clue to study heat transfer in nanostructured materials, *S. Patankar, H. Fan, E. Ostrumov, M. Chowdhury, A. Mills, D. Jones, A. Nojeh*

Vertically aligned arrays of carbon nanotubes exhibit anomalous heat localization. This phenomenon, the "Heat Trap" effect, can been used in cathode materials in thermionic energy conversion devices. In this work, we study the ultrafast time dependence of this effect to help identify the relevant microscopic physical processes.

P2-06
Effect of electron beam annealing duration on the optical-electrical properties of ZnO thin films, *Y. Li, X. Kong, L. Han, Institute of Electrical Engineering Chinese Academy of Sciences*

The effect of electron beam(EB) annealing duration on the optical-electrical properties of pure ZnO thin films was studied. Pure ZnO precursor films prepared by sol-gel spin coating method were directly annealed by EB for different time from 20 s to 480 s. The structural, optical-electrical properties were investigated.

P2-07
Hollow Mn_2O_3 Nanoparticles for Supercapacitor Electrodes via Solvothermal and High-Temperature Processing, *M.C. Brockway, J.L. Skinner, Montana Tech Nanotechnology Laboratory*

Manganese oxide nanoparticles with hollow morphologies are fabricated for supercapacitor electrodes. Manganese sulfide nanoparticles are synthesized using solvothermal processes. The particles are subsequently calcined to convert to hollow Mn2O3 particles via the nanoscale Kirkendall effect. The morphologies and storage capacities of the nanoparticles are examined.

P2-08
(invited) Nanoimprint-induced strain engineering of two-dimensional materials, *Chuying Sun, Jingxuan Cai, Kaiyue Zhao, Wendi Li, The Univerisity of Hong Kong*

Nanoimprint is proposed to introduce controllable and periodic strain profile on graphene. The strain distribution is verified by the work function of graphene measured by Atomic Force Microscopy and a two-dimensional model by Abaqus. The relationship between pressure, imprint depth and strain were also investigated to achieve controllable strain.

P2-09
Large size and high productive growth of SnS2 nanoflakes for good performance photodetecting application, *Xiansheng Jia, Chengchun Tang, Changzhi Gu, Junjie Li, Institute of Physics, Chinese Academy of Sciences*

High-quality SnS2 nanoflakes with large-size and high-production are vertically grown on Si substrate by a modified CVD method, showing the thickness-dependent photodetection capability and the highest responsivity. this work provides an efficient path to prepare SnS2 crystal samples with the optimal thickness as promising candidates for high-performance optoelectronic applications.

Advanced Ion Beam Technologies, Beam-Induced Processes & Imaging And Characterization

P3-01
Giant Conductivity Modulation of Aluminum Oxide using Focused Ion Beam, *Simone Bianconi, Hooman Mohseni, Northwestern University*

Conductivity modulation in aluminum oxide of up to 14 orders of magnitude is here demonstrated, using focused ion beam nanopatterning. The method can be applied to both bulk crystalline sapphire and thin film, allowing the creation of conductive zones embedded in a mechanically hard, chemically inert, and bio-compatible dielectric matrix.

P3-02
Energy dependence of self-organized nanostructures on photoresist surfaces by ion bombardment at normal incidence, *Ying Liu, Gaoyuan Yang, University of Science and Technology of China*

The ion bombardment of inorganic materials is extended to an organic surface of photoresist. The energy dependence of self-organized nanostructures on photoresist surfaces was investigated. Nanoholes with diameters approximately 10-20 nm were observe on photoresist by Ar+ ion bombardment with enegies from 350 eV to 550 eV at normal incidence.

P3-03
Removing halos around IBID deposits with a broad ion beam, *Boyd Verdoorn, Koos Roodenburg, Jan Stroes, Paul Alkemade, Delft University of Technology*

We investigate the capability of Beam Induced Polishing and Sputtering (BIPS) to remove halos around IBID objects. For this purpose, we used EDX analysis, electrical measurements, and ion and electron microscopy. We found that halo removal by BIPS is effective, but the actual IBID object gets easily damaged as well.

P3-04 Withdrawn

membrane, and deposition of conductive material on the underside of the membrane.

P3-05
(Invited) Design of small low energy electron gun, *Wang Yan, Institute of Electrical Engineering, Chinese Academy of Sciences*

A low energy supplementary electron gun was designed. In order to improve the efficiency of the main electron beam in defect detection, the supplementary electron beam can be used for charge neutralization and pre-scanning.

P3-06
SEM imaging using photo-electron beam by semiconductor photocathode, *T. Nishitani, D. Sato, H. Shikano, T. Kawamata, A. Koizumi, H. Iijima, Photo electron Soul Inc.*

The spatial resolution and SN of the SEM image using the semiconductor photocathode were compared with those of the SEM image using the thermionic cathode. The semiconductor photocathode can be expected to take the SEM image with 15 times higher throughput than the same emission current of existing thermionic cathode.

P3-07
The annealing effect for the air-exposed surface on the GaN photocathode, *D. Sato, T. Nishitani*, Y. Honda, H. Amano, Nagoya University,*

Semiconductor photocathode is an attractive candidate for e-beam lithography because of its multiple e-beams emission. On the other hand, ultra-high vacuum environment is essential for a GaAs photocathode. This study shows that robust GaN photocathode survive atmosphere gas exposure and the functional surface recovers with an anneal in vacuum chamber.

P3-08
Influence of high energy ion beam irradiation on nanocrystalline hafnium dioxide high-gate dielectric thin films grown by atomic layer deposition, *Rajesh Kumara, Vishnu Chauhan, University School of Basic and Applied Sciences, Guru Gobind Singh Indraprastha University, Prateek Hundekar[1], N. Koratkar[1], [1]Rensselaer Polytechnic Institute*

HfO_2 is a promising candidate for gate dielectrics material. HfO_2 high-gate k thin films were grown by atomic layer deposition. These thin films were irradiated by 120 MeV Au ion beam. The pristine and irradiated HfO2 thin films were characterized by XRD, AFM, UV-Vis., Raman, FTIR, PL, XPS and RBS.

P3-09
Wavefront Metrology for X-Ray Free Electron Laser Instruments, *Yanwei Liu, Matthew Seaberg, Diling Zhu, Kenan Li, Peter Walter, Yiping Feng, David Fritz, Anne Sakdinawat, SLAC National Accelerator Lab*

Here we report a robust, sensitive and accurate single-shot wavefront sensor for X-ray FEL beams using single grating Talbot interferometry. When illuminated by coherent x-rays, gratings made with E-beam lithography form high contrast self-images at fractional Talbot planes, from which wavefront errors can be extracted.

P3-10
Measuring thickness in thin NbN films for superconducting devices, *O. Medeiros, M. Colangelo, I. Charaev, K Berggren, Massachusetts Institute of Technology*

We present the use of a commercially available ellipsometer for quickly measuring the thickness of NbN thin films for the fabrication and performance improvement of superconducting nanowire single photon detectors. The process conveniently determines the optical constants and thickness of absorbing thin films.

P3-11
The quality analysis for brazing joint of copper/ diamond window using micro-computed tomography, *Ma Yu-tian, Liu Jun-biao, Zhao Wei-xia, Niu Geng, Han Li,Institute of Electrical Engineering, Chinese Academy of Sciences*

The diamond window severs as the transmission x-ray substrate and also the vacuum isolation component for micro-focus source. The micro-computed tomography is the prominent equipment to detect the hidden solder joints of copper/ diamond.

P3-12
Startup Award: zeroK NanoTech, *A.V. Steele, B. Knuffman, zeroK NanoTech Corporation*

zeroK NanoTech will empower users of focused ion beam (FIB) instruments by commercializing its new ion source technology. In fields from semiconductor development to sub-cellular biology, end-users have a pressing need for instruments that provide higher-resolution, faster, material modification and elemental analysis.

P3-13
An Improved Method to Estimate SEM Beam Spot Size and Measurement Resolution, *Chih-Yu Jen*, Yoyo Lin*, Eric Ma, Xuedong Liu, Weiming Ren, Kevin Liu, ASML*

A new more precise method, which incorporates information about the sample geometry, is proposed to more accurately estimate SEM beam spot size and measurement resolution. Our hope is this new method can be adopted as the new industry standard.

Application Fields

P4-01
Fabrication and Characterization of Multilayer Heater-Cryotrons, *R. Baghdad*, B. A. Butters*, S. Iqbal**, E. A. Toomey*, A. N. McCaughan***, Q. Y. Zhao****, A. E. Dane*, and K. K. Berggren*, *Massachusetts Institute of Technology,**University of Rochester, ***National Institute of Standards and Technology,**** Researc*

We investigated multilayer-hTrons (M-hTron) where the heater is placed on top of the superconducting channel and is galvanically isolated from the channel by placing a thin layer of an oxide film between the heater and the channel.

P4-02
Fabrication of Extremely Shallow "Nano-Sieve" Device with Positive Photoresist Sacrificial Layer, *X. Chen* and K. Du*, *Rochester Institute of Technology*
*R. Wang**, **Rutgers*

We demonstrate a novel and simple approach for building a stable PDMS "nano-sieve" device with an aspect ratio of 4,000:1 (width/height) without roof collapsing.

P4-03
Improvement of Electrical Characteristics of Neural Electrode by Electroplating Process, *Dong Hyun Baek, Dae Wook Kim, Seung Joon Ahn, Ho Seob Kim, Sun Moon University*

Electrocorticography (ECoG) is still challengeable because of stability and difficulty in long term recording. For the stable measurement of ECoG, the development of electrode array with low contact impedance. In order to pursuit this purpose, we have developed neural interface with parylene-C and evaluated its electrical performance in-vitro.

P4-04
Fabrication and integration of graphene interdigitated resistors on printed circuit boards for RF interrogation of biological sensors., *Madhav Kumar, Adrien Hugo, Riad Othmen[1], Zheng Han, Victor Engelhardt, Christophe Delaveaud, Camille Jouvaud , Julien Renard[1], Vincent Bouchiat[1], Pascal Mailley, Thomas Alava, University of Grenoble and CEA/LETI, [1]University of Grenoble*

We present a new fabrication process that is adapted to rough subtrate such as a printed circuit board. We detail the fabrication of gold electrodes by gold sputtering though stencil as well and graphene transfer. Finally we present the RF interrogation protocol.

P4-05
Neuronal cell network activity enhanced by nanogrooved substrates, *A.J. Bastiaens, T. van Nunen, J.P. Frimat, R. Luttge, Eindhoven University of Technology*

Nanogrooved substrates aid in engineering organized neuronal cell cultures for enhanced in vitro brain models. Complementing previous studies on neuronal network organization, we now investigate neuronal network function on nanogrooves using calcium imaging analysis. As outlook, we want to extend preliminary findings using differentiated stem cells on nanogrooved substrates.

P4-06
Development of siRNA Functionalized Graphene Oxide Based Therapeutic Nanoformulation to Ameliorate Type-2 Diabetes Mellitus (T2DM), *V. Singh, R. Sandhir*, N.K. Singhal, National Agri-Food Biotechnology Institute, *Panjab University*

Diabetes mellitus type 2 is a long term metabolic disorder and around 400 million people affected from this disease worldwide. In the current study functionalized graphene oxide nanosheets has been successfully exploited to deliver therapeutic siRNA in controlling the hyperglycaemic state in case of type 2 diabetic mellitus.

P4-07
A True-Color SEM-CT, *W. Zhao, J. Liu, G. Niu*, Y. Ma, Y. Wang, L. Han, Institute of Electrical Engineering of Chinese Academy of Sciences, *University of Chinese Academy of Sciences*

Based on SEM, a true-color Nano-CT with three targets of different materials is proposed, and principal component analysis algorithm is used to form a true-color image. This equipment can perform high-resolution imaging of substances with similar attenuation coefficients but different compositions such as biological material.

P4-08
Nanoscale Mechanosensing of Natural Killer Cells is Revealed by Antigen-Functionalized Nanowires, *G. Le Saux, N. Bar Hanin, A. Edri, U. Hadad, A. Porgador, M.Schvartzman, Ben-Gurion University of the Negev*

We report a novel nanowire-based platform for the detection and monitoring of cell forces, which integrates both mechanical and chemical cues. We used this platform to explore mechano-sensitivity of Natural Killer (NK) cells, whose mechano-regulation has been mostly unexplored up to date.

P4-09
Rapid fabrication of thermoplastic nanoforest substrates for high efficient capture of cancer cells, *H. Feng, W. Jin, Y. Huang, Y. Chen, Chinese Academy of Sciences*

We report a one-step simple and low-cost fabrication process to form nanoforest structures on thermoplastic substrates. The nanoforest structures are dense and high-aspect-ratio nanopillars, which exhibit excellent capture specificity and sensitivity for rare cells due to the 3D hierarchical nanostructures. The platform has great potential for rare cell detection.

P4-10
Hydrodynamic Induced Deformation of Nano-Sieve Fluidic Device for Efficient Microparticle Trapping and Deposition, *X. Chen, K. Du, Rochester Institute of Technology, L. Falzon, University of Dundee, R. Wang, Rutgers, The State University of New Jersey, J. Zhang, Carollo Engineers, X. Zhang, CRRC Corporation Limited*

Taking the advantage of the flexibility of the microfluidic structure, we demonstrate a portable and highly precise device that can efficiently trap, separate, concentrate, and release the colloids with a high flow speed.

P4-11
(Invited) Absolute deflection measurements in a MEMS/NEMS interferometry system, *R. De Alba*,**, C. B. Wallin*,**, G. Holland*, S. Krylov***, B. R. Ilic*, *National Institute of Standards and Technology, **University of Maryland, ***Tel Aviv University*

We demonstrate a novel calibration procedure for laser interferometry systems used to measure micro-mechanical motion. Our procedure is independent of the geometry or material composition of the micro-mechanical device under test, and enables simultaneous readout of static and dynamic device deflection. We validate our results using a commercial optical profilometer.

P4-12
Interferometric investigation of suspended monolayer TMDCs enabled by e-beam lithography, *S. Dong, S. Nathamgari, X. Zhang, H. Espinosa, Northwestern University*

E-beam lithography and other micro and nanofabrication methods have been utilized to make devices with suspended monolayer transition metal dichalcogenides (TMDCs), a family of layered 2D materials that grew popular in recent years. Devices of monolayer TMDCs suspended between electrodes allow investigation of fundamental properties such as piezoelectricity and resonances.

P4-13
Optical Probing of Acoustic Vibration through Coupled Plasmon Resonance, P. Hu, Y. Li, B. Song, Y. Wang, W. Wu, University of Southern California

Vibration in nanostructures is of considerable interest in recent years. In order to study how vertical vibration modulates optical response, we demonstrate a practical method to optically probe three-dimensional vibration modes (both in-plane and vertical modes) using Ultrafast Transient Absorption Spectroscopy.

P4-14
Reflective Metamaterial Polarizer Enabled by Solid Immersion Lloyd's Mirror Interference Lithography, *F. Hong, R.J. Blaikie, University of Otago*

In this study, a reflective metamaterial polarizer (RMP) with dual-layer silver gratings (58nm half-pitch) fabricated by a solid-immersion Lloyd's mirror interference lithography (SILMIL) technique is demonstrated. Highly birefringent omni-directional broadband reflection was experimentally measured. A new scheme for creating reflective thin-film waveplates is also proposed.

P4-15
Resonant Lattice Kerker Effect in Metasurfaces of Titanium Dioxide Nanodisks, *L. Li, L. Shi, C. Xie, Chinese Academy of Sciences*

With the rapid development of the concept of light-induced artificial electromagnetics in the field of metamaterials, the Kerker effect has been promoted as never before and quickly penetrated into nanophotonics. Here we investigate the arrays of titanium dioxide (TiO2) nanodisks, which realize the resonant lattice Kerker effect.

P4-16
Super Resonance from Gain-Assisted Silicon Nanowires, *S. Chen, L. Shi, J. Niu, C. Xie, Institute of Microelectronics of Chinese Academy of Sciences*

We report super resonance from gain-assisted silicon nanowires, where one-dimensional periodic silicon lines are placed on top of a silica layer. The excellent performance of super resonance based on high-order magnetic resonance is demonstrated. The enhanced near-field of active nanostructures, compared to passive nanostructures, is also been found.

P4-17
Enhanced Plasmonic Activity of Polymer Fibers Through Nanoparticle Doping, *J.M. Andriolo, M.L. Joseph, M.H. Griep,* and J.L. Skinner, Montana Technological University, *Army Research Laboratory*

Gold nanoparticles (NPs) exhibit a plasmonic response that can be used for photothermal energy conversion. Gold NP-polymer matrices were used to provide localized heating of electrospun fibers. Spectroscopic ellipsometry was used to characterize the complex optical constants, and infrared heat mapping of gold NP-polymer thin films was performed.

P4-18 Withdrawn

P4-19
(Invited) All-Dielectric Hybrid Metasurface for Visible or Near-IR Applications, *H. Yang, H. Liu*, Y. Yao**, B. Song, Y. Li, B. Chen, D. Meng, Z. Liu, P. Hu, Y. Wang, T. Ou, W. Wu, University of Southern California, *Google LLC, **Apple Inc.*

Due to the limitations from material selection as well as fabrication techniques, the application of all-dielectric metasurface for the visible and near-IR range is limited. We demonstrated using hybrid all-dielectric metasurfaces to solve this problem. Moreover, hybrid metasurfaces can also be used to select the desired optical modes.

P4-20
(Invited) Progress, challenges and outlook of three-dimensional hybrid CMOS/ReRAM systems, *G.C. Adam, George Washington University*

This work presents an overview of the efforts to design, fabricate and characterize three-dimensional analog ReRAM crossbars, both standalone and monolithically integrated with CMOS, and using them for prototyping promising applications in neuromorphic computing. Challenges and a potential roadmap for future progress of this technology are also discussed.

P4-21
Nanochannel-based microfluidic device for quantitative measurement of bacterial chemotaxis, *Y. Li, S. E. Parker, A. N. Bible, J. L. Morrell-Falvey, M. J. Doktycz, S. T. Retterer, Biosciences Division, Oak Ridge National Laboratory*

We designed and fabricated a nanochannel-based microfluidic device for quantitative measurement of bacterial chemotaxis. The device consists of a central imaging chamber with nanochannels on one side and microchannels on the other. Our preliminary results show that the number of cells trapped in the central chambers increases with glutamate concentration.