THE 62nd INTERNATIONAL CONFERENCE on ELECTRON, ION, and PHOTON BEAM TECHNOLOGY & NANOFABRICATION

Wyndham Grand
Rio Mar Puerto Rico Golf
& Beach Resort
Rio Grande, Puerto Rico
May 29th – June 1st, 2018
www.eipbn.org

Sponsored by the

Conference at a Glance

Tuesday, May 29			
Start Time	End Time	Session	Location
7:00 am	6:00 pm	Registration	Rio Mar Foyer
8:30 am	3:00 pm	Nanofabrication Short Courses	Caribbean 2
3:00 pm	6:00 pm	Commercial Exhibit	Rio Mar 1-5
4:30 pm	6:00 pm	Puerto Rico Technology Highlights	Caribbean 2
7:00 pm	9:30 pm	Welcome Reception	Marbella Garden
Wednesday, May 30			
Start Time	End Time	Session	Location
7:30 am	5:00 pm	Registration	Rio Mar Foyer
8:00 am	10:45 am	Plenary Session	Rio Mar 6-10
10:00 am	4:30 pm	Commercial Exhibit	Rio Mar 1-5
10:45 am	1:00 pm	Poster Session	Rio Mar 1-5
11:55 am	1:00 pm	Exhibitor Session I	Rio Mar 1-5
1:15 pm	3:15 pm	Session 1A – Scanning Probe Lithography I	Caribbean 1
		Session - 1B E Beam Lithography	Caribbean 2
		Session 1C – Materials for Advanced patterning	Caribbean 3
3:15 pm	3:35 pm	Break	Rio Mar 1-5
3:35 pm	5:45 pm	Session 2A – Atomically Precise Nanofabrication	Caribbean 1
		Session 2B – Imaging and Characterization	Caribbean 2
		Session 2C – NEMS/ MEMS	Caribbean 3
6:00 PM	7:00 PM	Exhibitor Session II	Rio Mar 1-5
6:00 PM	7:00 PM	Poster Session	Rio Mar 1-5
Thursday May 31			
Start Time	End Time	Session	Location
7:30 am	5:00 pm	Registration	Rio Mar Foyer
8:00 am	9:50 am	Session 3A – Nanophotonics I	Caribbean 1
		Session 3B - Advanced Pattern Transfer	Caribbean 2
		Session 3C – Advanced ion beam I	Caribbean 3
9:50 am	10:10 am	Break	Rio Mar 1-5
10:00 am	3:00 pm	Commercial Exhibit and Poster Session	Rio Mar 1-5
10:10 am	12:10 pm	Session 4A – Nanophotonics II	Caribbean 1
		Session 4B – Nanoimprint Lithography I	Caribbean 2
		Session 4C – Advanced ion beam II	Caribbean 3
12:00 pm	1:40 pm	WIN Luncheon	Parrot Room
12:10 pm	1:40 pm	Lunch on your own	
1:40 pm	3:50 pm	Session 5A – Quantum Electronics	Caribbean 1
		Session 5B – Nanoimpring Lithograply	Caribbean 2
		Session 5C – Advanced Ion Beam III	Caribbean 3

Friday, June 1			
Start Time	End Time	Session	Location
7:30 am	12:00 pm	Registration	Rio Mar Foyer
8:00 am	9:50 am	Session 6A – Novel 2D Materials	Caribbean 1
		Session 6B – Scanning Probe Lithography	Caribbean 2
		Session 6C Biomedical Devices I	Caribbean 3
9:50 am	10:10 am	Break	Rio Mar Foyer
10:10 am	12:00 pm	Session 7A - Nanoelectronics	Caribbean 1
		Session 7B – 3D Lithography	Caribbean 2
		Session 7C – Biomedical Devices II	Caribbean 3
12:00 pm	1:30 pm	Exhibitor Thank you lunch	Parrott Room
12:00 pm	1:30 pm	Mentor Lunch	El Moro 1-2
12:20 pm	1:30 pm	Lunch on your own	
1:30 pm	3:20 pm	Session 8A – Neuromorphic Hardware I	Caribbean 1
		Session 8B – Advanced Lithography I	Caribbean 2
		Session 8C – Charged Particle Optics	Caribbean 3
3:20 pm	3:45 pm	Break	Rio Mar Foyer
3:40 pm	5:40 pm	Session 9A – Neuromorphic Hardware II	Caribbean 1
		Session 9B – Advanced Lithography	Caribbean 2
		Session 9C – Nanofluidics	Caribbean 3

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Conference Information

HOTEL LOCATION: The 2018 conference will be held at the 6000 Rio Mar Blvd, Rio Grande, Puerto Rico 00745, Tel: (787) 888-6000, Website: www.wyndhamriomar.com.

REGISTRATION: The conference registration desk at the hotel will be open during the hours listed below. Badges are required to attend the technical sessions.

ONSITE REGISTRATION HOURS
The registration desk is located in the Rio Mar Ballroom foyer.

Tuesday, May 29	7:00 a.m. - 6:00 p.m.
Wednesday, May 30	7:30 a.m. - 5:00 p.m.
Thursday, May 31	7:30 a.m. - 5:00 p.m.
Friday, June 1	7:30 a.m. - 12:00 p.m.

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 29, 3:00 pm to 6:00 pm
Wednesday, May 30, 10:00 am – 4:30 pm
Thursday, May 31, 10:00 am – 3:00 pm

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

Participants in this year's commercial session include: Allresist GmbH, Amuneal Mfg Corp., Carl Zeiss Microscopy, LLC, Cornell University, CRESTEC Corporation, GenISys GmbH, Heidelberg Instruments, Inc., JEOL USA, Inc., Nanonex Corporation, Nanoscribe GmbH, Nanotronics, Netrologix LtdOakridge Oak Ridge National Laboratory - UT-Battelle, Raith America, Inc., SEMTech Solutions, Inc., Zyvex Labs.

TUESDAY WELCOME RECEPTION
Tuesday night join us at the Welcome Reception from 7:00 pm – 9:00 pm at the Marbella Garden. 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.

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 30, 10:50 am – 1:00 pm,
- Wed., May 30, 6:00 pm – 7:00 pm
- Thurs, May 31, 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 Casino Antiguo, in old town San Juan. Banquet tickets cost $100.00 each.

SPONSORS

EIPBN gratefully thanks our conference sponsors. Our current list of sponsors are:

- STS-Elionix for the following sponsorships: Conference Bag, the USB drive, Student Support, Mentor Lunch, Women in Nanofabrication Sponsorship, Poster Reception drinks
- GenISys GmbH for the following sponsorships: Thursday Morning Coffee Break, the Wednesday afternoon cookies and the Thursday afternoon ice cream break
- Raith America, Inc. for the Student Support sponsorship and the Friday ice cream break sponsorship
- JEOL USA, INC for the Pad Folio Sponsorship and the Wednesday morning breakfast sponsorship
- Heidelberg for the Wednesday afternoon coffee break and the EIPBN Outreach Program sponsorships
- KLA-Tencor for the following sponsorships: Tuesday Short Course lunch, the Thursday and Friday morning breakfasts, and the Wednesday Startup/Poster Session lunch
- NuFlare Technology, Inc. for the Lanyard Sponsorship and the Student Support
- TEL for the Student Support and general sponsorship
- Vistec for the Wednesday morning coffee break
- Intel for the Women in Nanofabrication Luncheon Sponsorship
- National Science Foundation for the general conference sponsorship and the Puerto Rico Session support
- DARPA for the general conference sponsorship

WOMEN IN NANOFABRICATION NETWORKING LUNCHEON
The WIN lunch is Thursday, May 31, 12:00 noon in the Parrot Room. Current topics related to women in science, relevant to both men and women, all new format.

This year's theme is: ***"Do you want to get to the next level of leadership? Yes, I do!"*** Women are encouraged to attend! Men are welcome. Sign-up at the registration desk!

MICROGRAPH CONTEST: On the lighter side, for the 24th 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 2018 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 Short Courses
Room: Caribbean 2

Session Chairs:
Stefano Cabrini, Lawrence Berkeley National Laboratory
Aaron Stein, Brookhaven National Laboratory
Erika Penzo, Lawrence Berkeley National Laboratory

8:30 am
Welcome and Introduction

8:40 am
Scanning Probes in Nanostructure Fabrication, Ivo W. Rangelow, Institute of Micro- and Nanoelectronics, Ilmenau University of Technology

9:30 am
The Dawn of Superconducting Quantum Processors, Irfan Siddiqi, University of California at Berkley, Lawrence Berkeley National Laboratory

10:20 am COFFEE BREAK

10:35 am
Electron Beam Lithography, Don Tennant, Cornell NanoScale Science and Technology Facility (CNF)

11:25 am
Technology and Recent Improvements of LMIS for FIB Patterning and FIB Nanofabrication, Jacques Gierak, Centre de Nanosciences et de Nanotechnologies and Sven Bauerdick, Raith GmbH

12:15 pm LUNCH (Sponsored by KLA-Tencor)

1:00 pm
Cold Ion Source Technologies: History and Outlook, Adam Steele, zeroK NanoTech Corporation and Anne Delobbe, Tescan-Orsay Holdings

1:50 pm
GFIS Technology and Applications, John Notte, Carl Zeiss

2:40 pm Ends

Puerto Rico Technology Highlights
Room: Caribbean 2

Tuesday, May 29, 2018
4:30 pm – 6:00 pm

The Puerto Rico Technology Highlights will provide EIPBN attendees an overview of the local nanoscience, photonics, and technology landscape in Puerto Rico, as well as ongoing efforts to rebuild the island following hurricanes Irma and Maria. The format of the session will be 15min-long presentations by local researchers and technology executives, followed by a Q&A session in a panel-style format.

Session Chairs:
Daron A. Westly, National Institute of Standards and Technology
Yajaira Sierra-Sastre, Panel Moderator

4:30 pm – 4:35 pm
Welcome and Introduction

4:35 pm
Emerging Opportunities for Research in Optics and Photonics at the Puerto Rico Photonics Institute, Andrés Díaz, Puerto Rico Photonics Institute, Universidad Metropolitana

4:50 pm
Nanomaterials for Cancer Research: Engineering the Road to Clinical Translation, Madeline Torres-Lugo, Department of Chemical Engineering, University of Puerto Rico (Mayaguez Campus)

5:05 pm
CREST Center for Innovation, Research and Education in Environmental Nanotechnology, Carlos R. Cabrera, Department of Chemistry, University of Puerto Rico (Rio Piedras Campus)

5:20 pm
Puerto Rico Science, Technology and Research Trust, TBD
The mission of the Puerto Rico Science, Technology, and Research Trust is to advance the local economy through innovation driven enterprises, science, and technology. An overview of the entrepreneurial landscape on the island will be provided as well as an update on the rebuilding efforts following hurricanes Irma and Maria.

5:35 pm Panel Session and Q&A

Plenary Session
Room: Rio Mar Ballroom 6-10

Session Chairs:
Lawrence Muray, KLA-Tencor
Shida Tan, Intel Corporation

8:00 am - Welcome
Larry Muray and Shida Tan

8:30 am Plenary 1
What's Next in Information Technology? *Heike Riel, IBM Fellow, Director IoT Technology & Solutions, IBM T.J. Watson Research Center*

Historically, enhancing compute capability has meant integrating ever more and ever smaller devices into both, the memory and the processors. However, such scaling has become much more difficult recently because of physical scaling limits. Yet despite a lot of innovative technologies in materials, devices and architectures, the speed of increasing the density of transistors has slowed down. This raises the fundamental question of what is next?

With the explosion of available data, the internet-of-things and the increasing demand for machine learning, deep learning and artificial intelligence, the computational workloads are significantly changing. Therefore, there is a growing need for specialized hardware which can handle large computational workloads which take too long to run on conventional machines. In that regard, completely new computing paradigms are developed such as quantum computing and non-von Neumann computing.

I will give an overview of our research activities in the field of extending the core technology roadmaps and in the new paradigms of cognitive hardware technologies and quantum computing.

9:15 am Plenary 2
Engineering Microsystems and Biointerfaces for Quantitative Mechanobiology, *Beth L. Pruitt, Deparments of Bioengineering and Mechanical Engineering and, by courtesy, Molecular and Cellular Physiology at Stanford*

Basic life sustaining functions such as breathing, circulation, and digestion are driven autonomously by coordinated contraction of specialized muscle cells, yet how these functions incorporate active feedback via force sensing at the cellular level is an area of active study. Meanwhile, a variety of specialized stretch activated receptors and mechanically mediated biochemical signaling pathways have been identified. Defects in proteins of these mechanically mediated pathways and

receptors have been implicated in disease states spanning cardiovascular disease, cancer growth and metastasis, neuropathy, and deafness. Thus, understanding the mechanical basis of homeostasis (health) and defective cell renewal function (disease) increasingly requires us to consider the role of mechanics. To study how cells and tissues integrate mechanical signals, we and others have developed specialized cell cultures systems and micromachined tools to stimulate and measure forces and displacements at the scale of proteins and cells. Using induced pluripotent stem cell derived cardiomyocytes, we observe cell outputs such as morphological changes, protein expression, electrophysiological signaling, force generation and transcriptional activity in response to mechanical stimuli with an eye to understanding how mechanics influences progression of a genotype with known point mutations into dysfunctional phenotypes

10:00 am Plenary 3
Nanotechnology, MEMS, Microfluidics for Health 4.0 Hypermobility, *Ali Tinazli, Head of Healthcare & Life Sciences Strategy, HP Inc.*

New imperatives of healthcare are focusing on prevention, personalization of diagnostics and treatment, and democratization, including access to everyone, anywhere, anytime at a low cost. The technology convergence in medicine is enabled by the powerful combination of microelectronics, microfluidics, distributed network and data analytics.

Poster Sessions
10:50 am – 1:00 pm,
6:00 pm – 7:00 pm
Rio Mar 1-5

Session Chairs:
Regina Luttge, Eindhoven University of Technology
Rob Ilic, NIST

Commercial Exhibits
10:00 am – 4:30 pm
Rio Mar 1-5

Exhibitor Sessions
11:55 am – 1:00 pm,
5:55 pm – 7:00 pm
Rio Mar 1-5

Session Chairs:
James Spallas, KLA-Tencor
Gerald Lopez, University of Pennsylvania

11:55 am - Welcome and Explanation of Session Format

12:00 pm - STS-Elionix

12:10 pm - Zyvex Labs

12:20 pm - GenISys

12:30 pm - Raith

12:40 pm - Heidelberg

12:50 pm - Carl Zeiss

1A-Scanning Probe Lithography I

Room: Caribbean 1
Session Chairs:
Keith Brown, Boston University
Michael Hirtz, Karlsruhe Institute of Technology

1:15 pm **1A-1** Invited
Thermal and ThermoChemical Scanning Probe Lithographyfor mask-less and marker-less patterning of electronic materials, *Xiaorui Zheng, NYU and CUNY ASRC, Annalisa Calò, NYU and CUNY ASRC, Edoardo Albisetti, NYU and CUNY ASRC, Elisa Riedo, NYU and CUNY ASRC*

Here we demonstrate an innovative strategy based on thermal scanning probe lithography, which goes beyond conventional lithography, to fabricate with high reproducibility metal contacts on 2D materials with exceptional quality, and offer unique advantages, including simultaneous imaging and patterning, self-alignment - no marks required - and closed loop auto-correction.

1:45 pm 1A-2
Tip-Based Fabrication of Single-Layer MoS_2 Nanoribbon Transistors with 30-nm Channel Width, *S. Chen, S. Kim, R. Bashir, A.M. van der Zande, W.P. King, W. Chen, J. Yuan, J. Lou, University of Illinois at Urbana-Champaign, Rice University*

We present here the fabrication of single-layer MoS2 nanoribbon field-effect transistors using tip-based nanofabrication. A heated atomic force microscope cantilever tip defines the channel by depositing PMMA nanoribbons onto the MoS_2 monolayers between he electrodes as etch mask. Gaseous XeF_2 removes the unmasked MoS2.

2:05 pm 1A-3
High-throughput process chain for SET devices based on FE-SPL and SmartNIL (TM) technology, *C. Lenk, Y. Krivoshapkina, M. Hofmann, S. Lenk, T. Ivanov, I. W. Rangelow, A. Ahmad[1], A. Reum[1], M. Holz[1], B.T. Chan[2] Z. el Otell[2], J.-F. de Marneffe[2], M. Eibelhuber[3], D. Treiblmayr[3], B. Schamberger[3], M. Chouiki[3], T. Glinsner[3], TU Ilmenau, [1]Nanoanalytik GmbH, [2]IMEC Belgium, [3]EV Group*

We will present results and review of the high-throughput process chain for the fabrication of single electron transistors operating at room temperature, which is based on reproducing field emission scanning probe lithography prepared templates by nanoimprint lithography and reactive ion etching.

2:25 pm 1A-4
Sharp GaN Nanowires on the Si-Tip of active cantilevers for fast-AFM and Scanning Probe Lithography Applications, *M. Behzadirad, A. K. Rishinaramangalam, D. Feezell, T. Busani, T. Ivanov, A. Ahmad, C. Lenk, M. Hofmann, S. Lenk, I. W. Rangelow, A. Reum[1], C. Reuter[1], M. Holz[1], University of New Mexico, Technische Universität Ilmenau, [1]Nanoanalytik GmbH*

Focused ion beam was used to mount bottom-up grown sharp GaN nanowires (NWs) on an active Si cantilever for nanoscale metrology and field emission lithography applications. Using our fabricated GaN NW probes. image quality, tip stability, and lithographic resolution were remarkably enhanced compared to conventional tips.

2:45 pm 1A-5 Invited
Tip-based Nano-Manufacturing and -Metrology, *T. Gotszalk, Wroclaw University of Science and Technology, T. Fröhlich, R. Fuessl, E. Manske, TU Ilmenau, I.W.Rangelow, TU Ilmenau, Gustav-Kirchhoff-Str.*

Technology of probe based lithography and nanometrology conducted using arrays of piezoresistive probes will be presented. Methods and techniques of integration of active piezoresistive cantilevers with nano- measurement machine will be shown and discussed.

3:15 pm Coffee Break

1B - E Beam Lithography

Room: Caribbean 2

Session Chairs:
Don Tennant, Cornell NanoScale Science and Technology Facility
Aaron Stein, Brookhaven National Laboratory

1:15 pm 1B-1 Invited

Beam Exposure Strategies matter – System Complexity and Application Space Trade-offs, *Ulrich Hofmann, Donald M. Tennant, Timothy R. Groves*

We will present a top-down / bottom-up analysis on fundamental benefits and drawbacks of beam shaping and beam scanning strategies, and discuss the rationale why in the macro world raster-scan based systems are dominating (e.g. monitors, office printers).

1:45 pm 1B-2

Electron-beam patterning organic ice resists, *A. Elsukova, W. Tiddi, A. Han, M. Beleggia DTU Danchip/Cen, Technical University of Denmark, 2800 Kongens Lyngby, Denmark*

Ice lithography is a method for patterning nanostructures using a thin frozen layer of beam sensitive material (organic ice resists (OIR)). I will demonstrate advantages of ice lithography over conventional lithography, discuss various OIR and resolution limits.

2:05 pm 1B-3

Enhancing the optical activity of chiral metasurface by a transmitted Electron Beam Lithography, *Bing-Rui Lu, Zongyao Yang, Jianan Deng, Sichao Zhang, Yifang Chen, Nanolithography and Application Research Group, State key lab of Asic and System, School of Information Science and Engineering, Fudan University*

In order to improve the optical activity of chiral metasurfaces in the visible frequency while avoiding the interference from the substrate, a one-step self-aligned transmitted-EBL process is developed for a double-layered chiral metasurface sandwiched by a suspended SiNx membrane. FDTD simulation shows that the optical activity is increased by 123%.

2:25 pm 1B-4
On the Trends and Application of Pattern Density Dependent Isofocal Dose of Positive Resists for 100keV Electron Beam Lithography, *G. Lopez, G. de Villafranca, M. Azadi, M. Metzler, K. Lister, N. Belic[1], U. Hofmann[1], University of Pennsylvania, University of Delaware, [1]GenISys*

This work demonstrates the impact of isofocal dose based PEC at 100 keV for positive EBL resists. We extract the pattern dependent isofocal doses for Si (Figures 1 and 2) using a dose matrix of 300 nm line-space tower patterns consisting of various pattern densities.

2:45 pm 1B-5 Invited
Electron Beam Lithography in a new nano world, *Leonidas E. Ocola, IBM*

Given that the field has basically reached the most fundamental of resolution limits, the question arises, is there still room for research in electron beam lithography beyond just incremental improvements to current technology. I will describe areas where electron beam lithography can still provide novel capabilities in nanofabrication today.

3:15 pm Coffee Break

1C - Materials for Advanced Patterning

Room: Caribbean 3
Session Chairs:
Christopher Kemper Ober, Cornell University
Nelson Felix, IBM

1:15 pm 1C-1 Invited
Materials Innovation to Address the Challenges of Advanced Implant Lithography, *J. Cameron, Dow Electronic Materials*

As the complexity of device manufacture continues to increase as a function of node, one of the major contributors to increasing complexity is the large number of implant levels. In this paper, we review recent trends in implant lithography and demonstrate how materials innovation can address these critical challenges.

1:45 pm 1C-2
Atlas 46 – novel negative tone photoresist which combines the good properties of the established SU-8 and CAR 44, *Christian Kaiser,[1] Tobias Mai[1], Matthias Schirmer[1], Maik Gerngroß[1], Georg Schmidt[2,3], Katrin Lehmann[2], Frank Syrowatka[3], [1]ALLRESIST GmbH, Institut für Physik, Martin-Luther Universität Halle-Wittenberg, [2]Interdisziplinäres Zentrum für Materialwissenschaften, [3]Martin-Luther Universität Halle-Wittenberg*

We have designed a solvent-developable negative resist Atlas 46 S ("solid") following the SU-8 which is based on the reproducible raw material of cresol novolac epoxy resin. We furthermore developed a second derivative; resist Atlas 46 R ("removable") which can be patterned similary.

2:05 pm 1C-3
Influence of TMAH development on niobium nitride films, *E. Toomey, M. Colangelo, N. Abedzadeh, K. K. Berggren, Massachusetts Institute of Technology*

Tetramethylammonium hydroxide (TMAH) is used in the electron beam lithography processing of niobium nitride films as a developer and pre-treatment for HSQ. We investigate the effects of exposing NbN to TMAH, and show that TMAH increases the etch resistance of NbN due to a modification of the surface chemistry.

2:25 pm 1C-4
Novel nanoparticle photoresists development for EUV lithography, *K. Sakai* H. Xu, V. Kosma, E. P. Giannelis, C. K. Ober *JSR Corp.*

Extreme ultraviolet (EUV) lithography is a leading candidate for next generation lithography because it enables ongoing scaling of semiconductor devices. We will report recent progress in resolution and sensitivity improvement of our metal oxide nanoparticle photoresists.

2:45 pm 1C-5 Invited
Characterization of EUV resist performance: introducing new metrics, *Geert Vandenberghe, Danilo De Simone, IMEC*

EUV lithography materials are regarded as very critical to enable and extend the EUV lithography technology. We will discuss the various material and patterning challenges as there are: stochastic failures, line-width roughness and practical resolution, as well as the required metrics assess them.

3:15 pm Coffee Break

2A - Atomically Precise Nanofabrication

Room: Caribbean 1
Session Chairs:
John Randall, Zyvex Labs
Armin Knoll, IBM

3:35 pm 2A-1 Invited
Single Atom Scale Manipulation of Matter by Scanning Transmission Electron Microscopy, *S. Jesse, O. Dyck, S. Kim, X. Li, S.V. Kalinin, Center for Nanophase Materials Sciences, Oak Ridge National Laboratory*

Presented are recent results in the use of the atomically focused beam of the scanning transmission electron microscope to control and direct matter on atomic scales. We have demonstrated controlled atomic-scale transformations in solids, and defect formation, and directed introduction and controlled motion of single dopant atoms in 2D materials.

4:05 pm 2A-2
Lithography for Robust, Editable Atomic-scale Silicon Devices, *Taleana R. Huff, Roshan Achal, Mohammad Rashidi, Mark H. Salomons, Martin Cloutier, Lucian Livadaru[1], Thomas Dienel, Jason Pitters, Robert A. Wolkow, University of Alberta, National Research Council of Canada, [1]Quantum Silicon Inc.*

Atomic-scale silicon devices are fabricated by removing hydrogen atoms from silicon surfaces in atomically precise positions. Any errors in fabrication can be corrected for by replacing hydrogen atoms. The resulting silicon surface atom can have its charge controlled and can couple with other silicon atoms leading atomic devices.

4:25 pm 2A-3
Single-Dopant Arrays using Tip-assisted Incorporation Process, *J. H. G. Owen, J. Ballard, E. Fuchs, J. N. Randall, J. R. Von Ehr, Zyvex Labs*

We are developing tip-based incorporation processes for P and Al dopants. Feedback Controlled Lithography is used to create single dimer patterns. Single molecules are adsorbed into these patterns. The tip then removes H locally from the adsorbed fragments giving a higher yield of single dopants than the current process.

4:45 pm 2A-4
Self-tuning PI Control for STM Tip Protection, *F. Tajaddodianfar, S.O.R. Moheimani, J. Owen[1], J. Ballard[1], E. Fuschs[1], J. N. Randall[1], The University of Texas at Dallas, [1]Zyvex Labs llc*

The local barrier height affects stability of STM control system. We propose a method for tuning the controller parameters for improved stability to protect the STM tip and reduce the risk of tip-sample crash. This method improves the STM performance both in imaging and in Hydrogen Depassivation Lithography.

5:05 pm 2A-5
Fluorocarbon-based Atomic Layer Etching of Silicon Dioxide in Conventional Plasma Tools, *Stefano Dallorto*[1,2], Andy Goodyear[2], Mike Cooke[2], Scott Dhuey*, Adam Schwartzberg*, Craig Ward[2], Ivo W. Rangelow[1], Stefano Cabrini*, *Molecular Foundry - LBNL, [1]Ilmenau University of Technology, [2]Oxford Instruments*

Here we investigate the etching rate per cycle (EPC) of CHF3-based ALE on flat and patterned SiO_2 substrates. Patterned features are transferred using various mask materials, which demonstrate different etch rates. Self-limiting CHF3/Ar ALE has proven to pattern features well with great potential for significant improvements in overall etch performance.

5:25 pm 2A-6
The Challenge of Contamination in Atomically Precise Manipulation and Processing of Graphene and 2D Materials, *J. L. Swett, J. A. Mol, D. A. Cullen*, University of Oxford, *Oak Ridge National Laboratory*

This presentation will cover the emerging understanding of contamination on graphene and 2D materials, including the prevalence, which is poorly understood and often unacknowledged, along with characterisation of the contamination and mitigation strategies.

2B - Imaging and Characterization

Room: Caribbean 2
Session Chairs:
John Hunt, Gatan Inc.
Stella Pang, City University of Hong Kong

3:35 pm 2B-1 Invited
Assessing Electron-Optical Uniformity in Multi-electron Beam Arrays, *B. Thiel, M. Mukhtar, SUNY Polytechnic Institute*

A procedure and test structure are described for assessing beam-to-beam variations in electron optical performance of multi-ebeam systems. Contrast transfer functions are calculated by imaging a lithographically patterned random dot array. Noise level, information limit, and noise tolerance can be assessed by examining CTF variations.

4:05 pm 2B-2
In-situ femtosecond pulsed laser ablation for large volume 3D analysis in scanning electron microscope systems, *S. J. Randolph, J. Filevich, A. Botman, R. Gannon, C. Rue, M. Straw, M. P. Echlin*, Thermo Fisher Scientific, *University of California Santa Barba*

We have developed a TripleBeam tool combining a femtosecond pulsed laser beam, plasma focused ion beam, and an electron beam, all coincident at the sample. We will present on results and applications in micro device characterization and its use for in situ large volume 3D analysis.

4:25 pm 2B-3
Imaging with a 196 beam SEM, *W. Zuidema, S. Rahangdale, P. Keijzer, J.P. Hoogenboom, P. Kruit, Delft University of Technology*

Large area and volume imaging with a scanning electron microscope has gained a lot of traction in recent years. In order to increase throughput, we have developed a multibeam SEM. We will describe the tool and the signal detection and show high-resolution imaging results.

4:45 pm 2B-4
Energy-momentum spectroscopy by wavelength- and angularly-resolved Cathodoluminescence, *M. Bertilson, D.J Stowe, T Worsley, T. Franklin, L. Muray, M. Hsueh, J.A Hunt, Gatan Inc*

We demonstrate energy-momentum spectroscopy in a CL setup collected in a highly parallelized manner with high spatial, angular and wavelength resolutions (up to 10 nm, 1° and 0.1 nm respectively).

5:05 pm 2B-5
Towards SEM / broad ion-beam serial-sectioning of large scale biological tissues, *T. Hosman, S. Coyle, C. Spence, M. Hassel-Shearer, C. Booth, J.A Hunt, Gatan Inc.*

Serial-sectioning with broad-ion beams and SEM imaging is demonstrated to produce large (several mm^2) areas and preserve < 5 nm detail on biological block faces, although further work remains before large volume reconstruction is feasible.

5:25 pm 2B-6
Principles and Practice of Electron Beam Induced Current Microscopy of Resistive Nanodevices, *B.D. Hoskins, G.C. Adam[1], E. Strelcov[2], A. Kolmakov, N. Zhitenev, D.B. Strukov[3], J.J. McClelland, NIST, [1]IMT Bucharest, [2]University of Maryland, [3]University of California*

Electron beam induced current (EBIC) microscopy is investigated as a powerful means of characterizing the state dependence of resistive memory devices. By doing combining energy and state dependent characterization with Monte Carlo Modeling, we demonstrate a comprehensive theory for interpreting EBIC measurements in these systems.

2C - NEMS / MEMS

Room: Caribbean 3
Session Chairs:
David Czaplewski, Argonne National Laboratory
Steven Hickman, Magic Leap

3:35 pm 2C-1 Invited
Integrated Photonic and Plasmonic Signal Transduction for Micro- and Nanomechanical Sensing, *Vladimir A. Aksyuk, National Institute of Standards and Technology*

Based on several recent examples, the talk illustrates the significant, yet largely unexplored, technological potential of highly integrated transducers combining Si photonics, MEMS, NEMS, cavity-optomechanical and plasmonics. The combination of high precision, high bandwidth and compactness of such devices offer intriguing new sensing and scientific measurement capabilities.

4:05 pm 2C-2
Fabrication of freestanding initial patterns for polymer actuated 3D micro-origami structures, *A. Hiess, A. Jahn, F. Winkler, R. Kirchner, V.A. Guzenko*, D. Kazazis*, Technische Universität Dresden (Germany), *Paul Scherrer Institute (Switzerland)*

We present the fabrication of freestanding polymeric structures for (origami) folding into 3D assemblies. For actuation, we use capillary forces of reflowing thermoplastic polymers. Freestanding structures are obtained by isotropic dry release etch of silicon.

4:25 pm 2C-3
Acoustic Waves Coupled to Quantum Dots in Nanomechanical Structures, *M. K. Zalalutdinov, D. M. Photiadis, S. G. Carter, A. S. Bracker, C. S. Kim, M. Kim*, D. Gammon, and B. H. Houston, Naval Research Laboratory, *KeyW Corporation*

Lamb waves in 10GHz frequency range are explored as a means of coupling to nanoscale optoelectronic systems. The outcomes of theoretical and experimental study will be shown for propagation of S1 Lamb waves in ultrathin GaAs plates. Preliminary results for acoustic coupling to embedded InAs quantum dots will be presented.

4:45 pm 2C-4
3D Microfabricated scaffolds for the investigation of the mechanical forces exerted by living cells during migration, *E. Desvignes, M. Badi[1], A. Bouissou[2], J. Moran-Mirabal[1], R. Poincloux[2], Maridonneau-Parini[2], C. Thibault, C. Vieu, LAAS-CNRS, Université de Toulouse,France, [1]McMaster University,Canada, [2]Université de Toulouse, France,*

Mechanical forces play a role in the migration cellular processes. We fabricated 3D scaffolds composed of deformable beams that can be bent by living cells migrating inside them. Our results demonstrate the functionality of the scaffolds in understanding the mechanical activity of cells in 3D microenvironments.

5:05 pm 2C-5
DLW-MEMS Integration for Dynamic 3D Microstructures, *Rachael K. Jayne, Jeremy B. Reeves, Thomas J. Stark, David J. Bishop, Alice E. White, Boston University*

Soft 3D microstructures fabricated via direct laser writing (DLW) lithography are coupled with existing micro-electromechanical systems (MEMS) technology to produce dynamic 3D microdevices. These hybrid DLW-MEMS devices have the potential to enable exciting new applications that require microstructure actuation, like tunable optical metamaterials or deformable scaffolds for living cell studies.

5:25 pm 2C-6
Optoelectronic neural probes with passive light switching optical circuits: light control in deep brain tissue, V. Lanzio, A. Koshelev**, P. Micheletti*, G. Presti, E. D'Arpa, M. West, S. Dhuey, S. Cabrini, *Molecular Foundry (Lawrence Berkeley National Laboratory), **Abeam Technologies

To advance neuroscience in vivo experiments, we fabricate neural probes with the capability of recording (electrically) and stimulating (optically) neural networks. Regarding the optical part, we propose an innovative design, based on add-drop ring resonators, which allows passive light switching with a low footprint in deep brain tissue.

Exhibitor Session –5:55 pm – 7:00 pm

Rio Mar 1-5

5:55 pm - Welcome and Explanation of Session Format

6:00 pm - JOEL

6:10 pm – Nanoscribe

6:20 pm - Nanotronics

6:30 pm - CRESTEC

6:40 pm - AllResist

6:50 pm - Cornell University,

3A - Nanophotonics I

Room: Caribbean 1
Session Chairs:
Liya Yu, NIST
Juraj Topolancik, Roche Sequencing Solutions

8:00 am 3A-1 Invited
Optoplasmonic Sensors, *Frank Vollmer, University of Exeter, U.K.*

Optoplasmonic Sensors that combine plasmonic nanostructures with optical microcavities and photonic cyrstals are emerging as a platform for the analysis of biological, chamical and physical entities at the nanoscale. I will review fabrication of Optoplasmonic Sensors which requires advanced lithography and self assembly of micro/nanoscale plasmonic and photonic structures.

8:30 am 3A-2
Investigation of Plasmonic Enhancement of Molecular Fluorescence Using Collapsible Nano-Fingers, *B. Song, Z. Liu, Y. Wang, Y. Yao, F. Liu, Y. Li, H. Yang, D. Meng, B. Chen, P. Hu, T. Ou, S. Cronin, W. Wu, A. Schwartzberg*, S. Cabrini*, University of Southern California, *Lawrence Berkeley National Laboratory*

The ALD-defined gap plasmonic nano-finger structure facilitate direct and precise control on the gap size between the molecule and metallic nanoparticle. This makes collapsible nano-fingers the ideal structure for understanding the role of strong gap plasmon on the optimization of molecular fluorescence enhancement.

8:50 am 3A-3
Ultrathin Metasurfaces Based on Dielectric Nanoresonators for Visible Light, *Haogang Cai, David A. Czaplewski, Alex B. Martinson, Daniel López, Argonne National Laboratory*

Metasurfaces provide wavefront manipulation within a sub-wavelength distance. Existing designs rely on the waveguiding confinement of high-aspect-ratio nanostructures, which are not fully compatible with standard industrial fabrication techniques. We propose metasurfaces based on ultrathin TiO_2 nanoresonators, which achieves diffraction-limited focusing for the visible. We will also demonstrate achromatic metalenses.

9:10 am 3A-4
Large area growth of transition metal dichalcogenides for photonics and optoelectronics, *A. M. Schwartzberg, C. Chen, C. Kastl, S. Aloni, S. Cabrini, A. W. Bargioni, The Molecular Foundry, Lawrence Berkeley National Labs*

In this presentation I will show our recent work on developing new growth processes for creating large area and conformal coatings of bulk and 2D transition metal dichalcogenides. I will also show how these materials have been fabricated into a variety of fundamental and application driven structures.

9:30 am 3A-5
On-chip integrated silicon photonic thermometers with sub-10 uK temperature resolution, *Nikolai N. Klimov, Tobias Herman, Kevin O. Douglass, Michal J. Chojnacky, Zeeshan Ahmed, National Institute of Standards and Technology*

We present results of developing novel on-chip integrated silicon photonic temperature sensors with nanoscale footprint and ultra-high resolution as an alternative solution to legacy-based resistance thermometers. The preliminary results indicate that our nanothermometers are capable of achieving measurement capabilities that are on-par or even better than the state-of-the-art resistance thermometry.

9:50 am Coffee Break

3B - Advanced Pattern Transfer

Room: Caribbean 2
Session Chairs:
Pat Watson, University of Pennsylvania
Martha Sanchez, IBM

8:00 am 3B-1 Invited
A Cleaner Approach to Ion Milling, *Michael Zwolak, B. Robert Ilic, J. Alexander Liddle, Center for Nanoscale Science and Technology, National Institute of Standards*

We have developed an analytical model that reveals the design rules for ion milling nanoscale features using re-entrant hard mask profiles.

8:30 am 3B-2
Towards 5-nm-Focus-Size Fresnel Zone Plates for Hard X-rays, *N. Moldovan, J. Logan, C. Oldham*, R. Divan**, Alcorix Co., *VaporPulse Technologies, Inc., **Center of Nanoscale Materials, Argonne National Laboratory*

Fabrication of Fresnel Zone Plates by depositing sequences of layers with atomic layer deposition around cylindrical pillars etched into Si, followed by batch processing to form membrane containing carrier chips is investigated. The potential for 5 nm finest zones with aspect ratios higher than 100:1 is proven.

8:50 am 3B-3
Moth-eye antireflection nano-structure on glass for CubeSats, *Yaoze Liu, Mohammad Soltani, Bo Cui, Hugh Podmore*, Regina Lee*, University of Waterloo, *York University*

CubeSat is a miniaturized and modular satellite for space research or technology demonstration. To increase the power generation efficiency of solar cell mounted on CubeSats, we report a simple lithography approach to create moth-eye antireflection structure on the quartz cover-glass used to protect the cell from radiation damage.

9:10 am 3B-4
High-temperature development of thick hydrogen silsesquioxane resist for fabricating dense and high aspect ratio nanostructures, *Xiaoli Zhu, Lintao Liu, Jiebin Niu, Chanding Xie, Peixiong Shi*, Flemming Jensen*, Jörg Hübner*, Anpan Han*, Institute of Microelectronics of Chinese Academy of Sciences; *Technical University of Denmark*

The high-temperature development of HSQ using salty TMAH developer with wetting agent was investigated, indicating that longer development time can be used to remove footing/bridges between patterns. 20-nm-wide dense lines with HAR up to 20 were developed at 35 ℃ and transferred to Au nanostructures utilizing pulse reversal Au electroplating.

9:30 am 3B-5
Surfaces with Deterministically Fabricated Gradient Nanostructures for Spatially Varying Wettability, *S.Min*,**, S.Li*, Z.Zhu*, C.Liang*, X.Cheng**, W.Li*, *The University of Hong Kong, **Southern University of Science and Technology*

Deterministic and ordered large-area concentric gradient nanostructures are adopted to achieve gradient wettability. To investigate how nanostructures affect the wetting behaviors, the water contact angle was characterized as a function of positions on polymer film and we established a numerical model to link the varied nanostructures with water contact angles.

9:50 am Coffee Break

3C - Advanced ion beam I

Room: Caribbean 3

Session Chairs:
Rick Livengood, Intel Corporation
Sven Bauerdick, Raith GmbH

8:00 am 3C-1 Invited

Source Shot Noise Mitigation in Scanned Beam Microscopy, *M. Peng, J. Murray-Bruce, K. K. Berggren*, V. K. Goyal, Boston University, *Massachusetts Institute of Technology, Boston University*

We demonstrate that novel data processing of many low-dose measurements can yield lowered reconstruction mean-squared error (MSE) without any increase in total dose. In simulations for a sample with mean secondary electron yield ranging from 2 to 8, we obtain an MSE reduction by a factor of 2.4.

8:30 am 3C-2

FIB alternative patterning schemes and non-classical Liquid Metal Ion Sources, *J. Gierak, L. Bruchhaus*, P. Mazarov*, R. Jede*, L. Bischoff**, CNRS - Université Paris-Sud, *Raith GmbH, **Institute of Ion Beam Physics and Materials Research*

In this presentation we will review and discuss some new applications of non-Gallium ion Liquid Metal Ion Sources and beams, their interest and relevance to current nanoscience challenges.

8:50 am 3C-3

Lateral Resolution Images on the BAM-L200 Standard from NanoFab with SIMS, *Fouzia Khanom, Brett Lewis, and John Notte, Carl Zeiss Microscopy*

The Zeiss ORION NanoFab instrument with its He, Ne, and Ga ion beams has recently been enhanced with a custom-designed secondary ion mass spectrometer (SIMS) to enable analytical capabilities at the nanometer scale. New results will be shown including measurements from the BAM-L200 standard.

9:10 am 3C-4

Rapid failure analysis for metal connection using voltage contrast images in helium ion microscopy, *Deying Xia, Shawn McVey, Wilhelm Kuehn, Carl Zeiss Microscopy,*

Helium ion microscope image is an easy and fast way to locate the failure of metal connection in nanoscale for semiconductor processing using voltage contrast. It is also good indication to verify the disconnection of conductive lines for circuit editing and failure analysis techniques using gas-assisted etching process.

9:30 am 3C-5
Nanoscale Chemical Phenomena using HIM-SIMS, *Alex Belianinov, Songkil Kim, Matthew J. Burch, Olga S. Ovchinnikova*

This talk will present new developments in a combined Helium Iom Microscopy and Time of Flight Secondary Ion Spectroscopy tool.

9:50 am Coffee Break

4A - Nanophotonics II

Room: Caribbean 1
Session Chairs:
Nikolai Klimov, University of Maryland
Cheng Zhang, NIST

10:10 am 4A-1 Invited
Revisiting the Photon-Drag Effect in Thin Metal Films, *J..H. Strait, G. Holland, B. R. Ilic, A. Agrawal*, D. Pacifici[1], H.J. Lezec, NIST, *NIST and University of Maryland, [1]NIST and Brown University*

We demonstrate that the sign of the photon-drag effect in smooth metal films is crucially dependent on the surface environment and contrary to the prevailing intuitive model of direct momentum transfer to free electrons.

10:40 am 4A-2
Evaluation of processing characteristics of anisotropic aluminum-assisted chemical vapor etching, *R. Kometani[1,2], M. Okuno[2], S. Warisawa[1,2], [1]Graduate School of Frontier Sciences, The University of Tokyo, [2]Graduate School of Engineering, The University of Tokyo*

Metal-assisited chemical etching technique is a key technology for low-cost and high-speed nanofabrication. In this study, etching characteristics of silicon dioxide by aluminum-assisted chemical vapor etching. And we demonstrated fabrications of various silicon dioxide nanosturcture. This etching technique enables fabrication of various devices such as photonic devices and fluidic device.

11:00 am 4A-3
Directed assembly of perovskite nanocrystals on topographically and chemically patterned surfaces, *Erika Penzo, Matthew Jurow, Alexander Weber-Bargioni, and Stefano Cabrini, The Molecular Foundry — Lawrence Berkeley National Laboratory*

Colloidal nanomaterials display unique chemical and physical properties that make them prime candidates as nanoscale building blocks for the development of future technologies. We study the assembly behavior of perovskite nanocrystals, a novel type of nanocrystals with outstanding optical properties and great potential for applications in optoelectronics and photonics.

11:20 am 4A-4
Femtosecond Pulse Shaping Using Metasurfaces, *W. Zhu, S. Divitt, C. Zhang, H. J. Lezec, Amit Agrawal, National Institute of Standards and Technology*

Metasurfaces provide extremely fine spatial control over the amplitude and phase of incident light. Here, we demonstrate shaping of <15 femtosecond ultrafast laser pulses using a silicon-metasurface acting as both spectral amplitude and phase mask.

11:40 am 4A-5
Asymmetrical Three Dimensional Plasmonic Nanostructures with Multiple Resonance Modes, *S. Zhu, H. Li, M. Yang, S. W. Pang, City University of Hong Kong*

In this study, novel asymmetrical three dimensional plasmonic nanostructures composed of nanopillars inside nanoholes will be developed to provide the hybrid coupling effect of localized surface plasmon resonance, Fano resonance, and Fabry-Perot cavity modes as high sensitivity biosensors.

12:00 PM Lunch Break

4B - Nanoimprint Lithography I

Room: Caribbean 2
Session Chairs:
Matt Colburn, Oculus
Wen-Di Li, University of Hong Kong

10:10 am 4B-1 Invited
Nano Imprint Lithography for Next Generation Devices, *T.Higashiki, Toshiba Memory Corporation*

In order to realize low cost memory productions, NIL has been developing. In this paper, the status of the NIL for high volume manufacturing is discussed, along with key challenges that must be addressed and proprietary technology of NIL such as 3D and wide field patterning is discussed.

10:40 am 4B-2
Electrically-assisted nanoimprint of block-copolymers, *A. Mayer, W. Ai, J. Rond, J. Stabs, C. Steinberg, M. Papenheim, H.-C. Scheer, M. Torman * [1], A. Cian*, J. Zajadacz[2], K. Zimmer[2], University of Wuppertal, *Thundernil, [1]IOM-CNR, [2]Leibniz-Institute of Surface Modification*

The application of an electric field during nanoimprint of a lamella-forming block-copolymer under partial cavity filling conditions is addressed. It is investigated under which processing conditions the electric field is suitable to increase the order achievable without inducing self-assembly defects. Situations with preferential and neutral substrate are explored.

11:00 am 4B-3
Amphiphobic nanoimprinted surfaces showing reversible contact angle modification in electrowetting, *N. Kehagias[1], Z. Lamprakou[2], M. Guttman[3], A. Fernandez[1,4], A. Francone[1], N. T. Chamakos, C. M. Sotomayor Torres[1,5], A. Papathanasiou[2], [1]Catalan Institute of Nanoscience and Nanotechnology, [2]National Technical University of Athens, [3]Karlsruhe Institute of Technology, [4]Iberian National Laboratory, [5]ICREA, Institució Catalana de Recerca i Estudis Avançats*

Nanoimprinted surfaces showing enhanced repellence with small hysteresis angles towards water and oils. Our surfaces were tested in electrowetting experiments, demonstrating an increased range of reversibility in the contact angle modification as well of the dielectric thickness on the reversibility range, suggesting design rules for surfaces with optimum electrowetting reversibility.

11:20 am 4B-4
Detrimental Nanoscale Gas Defects in Manufacturing-Nanoimprint Processes, *D. Li, X. Han, Z. Yu*, X. Liang, University of Michigan, *Seagate Technology PLC*

We present a nanoscale computational fluidic dynamics (CFD) study on the formation and evolution mechanisms of nanoscale gas defects in liquid resists. Such nanofluidic mechanisms can explain the long-term retention of nanoscale gas defects in resists. This work also implies that electric field pulses could eliminate such nanoscale gas defects.

11:40 am 4B-5 Invited
Recent development of nanoimprint and nanoreplication and applications, *L. Jay Guo, The University of Michigan*

We discuss examples of structural colors and optical meta-surfaces facilitated by nanoimprinting, as well as plasmonic lithography masks that can produce deep-subwavelength structures using ordinary UV light. Combining nanoimprinting and ink-jet printing provides a high precision additive process. High aspect-ratio Si nanowires were created by using a new MacImprint mold.

12:00 PM Lunch Break

4C - Advanced ion beam II

Room: Caribbean 3

Session Chairs:
Pieter Kruit, Delft University of Technology

10:10 am **4C-1** Invited
Damage formation in 2D materials due to slow ion irradiation, *F. Aumayr, TU Wien*

The formation of nano-sized pores in 2D materials and the underlying physical mechanism are of specific interest for various application (e.g. as molecular sieves or in nano-optics). In experiments we explore the modifications generated in 2D-materials by slow highly charged ions and use these to tailor the material properties.

10:40 am **4C-2**
FIB based Sketch & Peel with various Ion Species for Fast and Precise Patterning of Large Structures, *A. Nadzeyka, S. Bauerdick, M. Kahl, H. Duan*, Y. Chen*, K. Bi*, Raith GmbH, *Hunan University*

FIB based sketch & peel is able to create isolated metallic structures in a simple and fast way on large areas. Here we further investigate the technique and its applications by continuous patterning strategies across mm's, combining it with sub-10 nm milling and investigating the use of various ion species.

11:00 am **4C-3**
Beam induced deposition of tungsten nanopillars using focused helium and neon ions, *Frances I. Allen, UC Berkeley*

Ion beam induced deposition of tungsten nanopillars using focused helium and neon ion beams from the gas field-ionization source of a Helium Ion Microscope will be discussed, with emphasis on elemental compositions and crystal structures as investigated using Transmission Electron Microscopy. Implications of the results on applications will be addressed.

11:20 am 4C-4
Scanning Transmission Helium Ion Microscopy on 1nm Thick Carbon Nanomembranes, *D. Emmrich, A. Wolff*, A. Beyer, A. Gölzhäuser, Bielefeld University, *Queensland University of Technology*

We show a dark field ion transmission imaging study on 1nm thick carbon membranes. Imaging the same sample site with different acceptance angles, we adjust the image contrast to different sample thicknesses. We compare measured contrasts with simulated scattering angles from Monte Carlo simulation.

11:40 am 4C-5 Invited
Investigating Focused Ion Beam Processing With Simulations: Etching and Deposition with a Precursor Gas, *K. Mahady, S. Tan[1], Y. Greenzweig[1], A. Raveh[1], P. Rack, University of Tennessee, [1]Intel Corp.*

We present a Monte Carlo simulation method for gas assisted focused ion beam induced etching, and ion beam induced deposition. This method is used for a study of the effects of gas flux, and beam scanning parameters on the resolution of etched vias and deposited nanopillars.

12:00 PM Lunch Break

5A - Quantum Electronics

Room: Caribbean 1
Session Chairs:
Karl Berggren, MIT
Igor Vernik, HYPRES, Inc.

1:40 pm 5A-1 Invited
The Challenge of Gregarious Qubits, *Irfan Siddiqi, Lawrence Berkely National Laboratory*

Design principles and practices utilized in our current generation of quantum processors will be discussed.

2:10 pm 5A-2
Hole density and mobility measurements of two-dimensional hole gasses (2DHG) due to aluminum delta layers in silicon, *J.M. Pomeroy*, C.A. Richter*, J.A. Hagmann*, Neil M. Zimmerman*, M.D. Stewart*, Jr., H.-S. Kim[1], A.N. Ramanayaka[1], K. Tang[1] and R. Murray[1], *National Institute of Standards and Technology, [1]University of Maryland*

Aluminum “delta” layers synthesized on Si(100) by depositing a single layer of aluminum and encapsulating it with silicon are patterned into Hall bars and nano-wires and measured by low-temperature transport.

2:30 pm 5A-3
Fabrication of High Inductance Nano Coils with a Neon Focused Ion Beam, *S. Wood, M. Hunt*, O. Painter*, Temple University, *California Institute of Technology*

In this work we describe the advantages and challenges of fabricating planar inductor nano coils with a neon gas field ion source microscope to substantially improve the performance of electro-opto-mechanical quantum superconducting LC (inductor-capacitor) circuits. We describe two methods which show promise for the fabrication of cutting edge quantum electronics.

2:50 pm 5A-4 Invited
Device Scale 2D Magnetothermal Transport from Maskless Direct-write Lithography, *Stephen M. Wu, University of Rochester*

We introduce a fabrication method using direct-write laser photolithography to pattern on-chip magnetothermal devices on 2D materials systems. Using this technique, we are free from relying on large area 2D materials systems, and have the flexibility to explore exfoliated flakes to the monolayer limit.

3:20 pm 5A-5 Invited
Quantum piezoacoustics: From low-dimensional electrons to qubits, *J. Pollanen, Michigan State University, Laboratory for Hybrid Quantum Systems*

I will discuss our work developing hybrid piezoacoustic devices for coupling high frequency microwaves to two-dimensional electron systems (graphene, electrons on helium, etc) and superconducting circuit based quantum bits.

5B - Nanoimprint Lithography II

Room: Caribbean 2

Session Chairs:
Wei Wu, University of Southern California
Yoshihiko Hirai, Osaka Prefecture University

1:40 pm 5B-1 Invited
NanoTechnology within a consumer product held in the palm of your hand, *S. Vo, LEIA Inc.*

At LEIA inc. we are developing an LCD-based interactive holographic display specially designed for mobile devices. We're the manufacturer of the world's first holographic 3D displays for mobile applications.

2:10 pm 5B-2
Flexible optoelectronic devices with metallic nanofiber transparent electrodes, *Cuiping Zhang, Jingxuan Cai, and Wen-Di Li, The University of Hong Kong*

In this abstract, we propose a cost-effective fabrication method for flexible nano-scale metal-mesh transparent electrodes and report its application in flexible optoelectronic devices. The small line width of the meshes results in desirable uniformity of light emitted. And the low-cost fabrication method makes it potential for industrial production.

2:30 pm 5B-3
Plasmonic-enhanced Photo-catalysis using Collapsible Nano-fingers, *Y. Wang, B. Song, H. Shi, S. B. Cornin, W. Wei, University Of Southern California*

We invented a technology to fabricate collapsible nano-fingers to achieve large-area high density optimized hotspots with TiO_2 film located at the hottest part of the hotspots. We demonstrated highest photo-catalysis efficiency that we are aware of.

2:50 pm 5B-4 Invited
Electrochemical nanoimprinting of silicon: A direct patterning approach, *Aliaksandr Sharstnioua, Stanislau Niauzoraua, Bruno Azeredoa, Arizona State University*

This paper demonstrates an electrochemical nanoimprinting process for single-crystal semiconductors for directly etching 3D features into silicon wafers without the need for templates or lithographical steps.

3:20 pm 5B-5 Invited
Single-nanometer accurate 3D nanoimprint lithography with master templates fabricated by NanoFrazor lithography, *T. S. Kulmala, C. D. Rawlings, M. Spieser, T. Glinsner[1], A. Schleunitz[2], F. Bullerjahn[2], F. Holzner, SwissLitho AG,[1] EV Group E. Thallner GmbH[2], Micro Resist Technology GmbH*

Fabrication of high quality 3D master originals remains a challenge. A joint solution for 3D NIL where NanoFrazor thermal scanning probe lithography (t-SPL) used to pattern the master templates with single-nanometer accurate 3D topographies will be presented.

5C - Advanced Ion Beam III

Room: Caribbean 3
Session Chairs:
John Notte, Carl Zeiss
Frances Allen, University of California Berkley

1:40 pm 5C-1 Invited
Applications of a Cold-Atom Lithium Focused Ion Beam, *J. J. McClelland, W. R. McGehee, E. Strelcov*, J. R. Gardner, V. P. Oleshko[1], C. L. Soles[1], Center for Nanoscale Science and Technology, NIST, *Institute for Research in Electronics and Applied Physics, University of Maryland, College Park, [1]Material Measurement Laboratory, NIST*

Progress in cold-atom ion source lithium focused ion beam technology will be discussed with emphasis on applications, in particular 2D optical mode imaging in microresonators and study of behavior of lithium implanted in silicon for battery research.

2:10 pm 5C-2
Focused Ion Beam System Employing a Low Temperature Ion Source, *A.V. Steele, B. Knuffman, A. Schwarzkopf, J.J. McClelland*, zeroK NanoTech, *NIST*

We demonstrate focused ion beam system incorporating a Low Temperature Ion Source. This high-brightness, low-energy spread source of cesium ion is well-suited to addressing next-generation challenges in FIB and SIMS.

2:30 pm 5C-3
Helium Ion Microscope (HIM) assisted atomic re-design makes brittle aluminium oxide plastic, *A. Wolff[1], M.Aramesh[1234], Y. Mayame[4] K. Ostrikov[1], [1]Queensland University of Technology, [2]Commonwealth Scientific and Industrial Research Organization, [3]ETH Zuerich, [4]University of Science and Technology, Republic of Korea*

This study shows how the Helium Ion Microscope (HIM) can help rearrange a nanoporous anodized alumina material on the atomic scale: to shrink its pores well below the sizes it is possible to produce by common methods and to turn the brittle material superplastic. The underlying ion-solid interactions are discussed.

2:50 pm 5C-4 Invited
Fundamental focus beam-solid interactions and applications for rapid prototyping, *M.G. Stanford*, B.B Lewis*, P.R. Pudasaini*, J.D. Fowlkes*[,1], P.D. Rack*[,1], *The University of Tennessee, [1]The Center for Nanophase Material Science, Oak Ridge National Laboratory*

Focused electron, ion, and photon beams have demonstrated unparalleled potential for direct-write nanosynthesis and rapid prototyping. Fundamental focused beam-solid interactions will be discussed as well as specific rapid prototyping applications. This work will discuss an athermal activation process for IGZO as well as patterning and defect engineering in 2D materials.

3:20 pm 5C-5 Invited
Electron and Ion Beam Induced Deposition of Nanosuperconductors and Nanomagnets, *R. Córdoba[1,2,3] and J. M. De Teresa[1, 2, 1]Universidad Autónoma de Madrid, [2]Universidad de Zaragoza, [3]Universidad de Zaragoza*

In this work, we show the inclusive scenario of electron and ion beam nanofabrication to grow in a single-step nanosuperconductors and nanomagnets.

6A - Novel 2D materials

Room: Caribbean 1
Session Chairs:
Xiaogan Liang, University of Michigan
Aaron Franklin, Duke University

8:00 am 6A-1 Invited
Two-Dimensional Organic-Inorganic Metal Halide Perovskites: Structures, Properties, and Applications, *Biwu Ma, Yu Tian, Chenkun Zhou, Haoran Lin, Florida State University*

Our recent work on both morphological and molecular two-dimensional (2D) metal halide perovskites, which can exhibit highly tunable narrow and broadband emissions with high photoluminescence quantum efficiencies, will be presented.

8:30 am 6A-2
Rubbing-Induced Site-Selective Growth (RISS) of MoS2 Device Patterns, *B. Ryu, D. Li, Ch. Park, H. Rokni, W. Lu, X. Liang, University of Michigan*

This work advanced the lithography/etching - free nanofabrication techniques for generating emerging layered semiconductor device patterns for making working electronic devices.

8:50 am 6A-3
Intriguing Photoelectricity from 2D Bismuth Grown Directly on Si substrates, *Li Tao, Southeast University, Nanjing, China, Weinan Zhu, Emily Walker,S. Bank, D. Akinwande, UT Austin*

We explore the interesting photoelectronics effect in newly discovered 2D Xene material. The photo-current induced by laser state exhibits 1-2 order higher amplitude than dark current, whereas the polarity/direction of incident light seems have limited impact. Our results suggest a new application direction for 2D Xene devices.

9:10 am 6A-4
Seamless and Scalable Nanofabrication of Silicene Field-Effect Transistors with Prolonged Lifetime, *Li Tao[1,2], Jiayi Chen[1], Hasibul Alam[2], Alessandro Molle[3], Deji Akinwande[2], [1]Southeast University, [2]The University of Texas at Austin, [3]IMM-CNR*
We demonstrated the first integration of multilayer silicene transistors with a seamless and scalable process. It represents a substantial advance over recently exploited single-layer silicene, thus proving a promising avenue for nanoscaled Si-based devices with nontrivial electrical behavior. This effort also provides transferrable knowledge in stabilizing air-sensitive 2D Xene materials/devices.

9:30 am 6A-5
Fabrication of 2D MoS_2 Memristors with Analog and Discrete Memory States, *D. Li, J. Wang, B, Ryu, X. Zhu, W. Lu, X. Liang, University of Michigan*

We present a study on the nanofabrication and characterization of memristive devices based on mechanically printed few-layer MoS2 structures. Such memristors exhibit both analog-tunable and discrete switching characteristics, which could be further exploited for making reconfigurable memristors for both analog and digital computing applications.

9:50 am Coffee Break

6B - Scanning Probe Lithography II

Caribbean 2

Session Chairs:
Rick Silver, NIST
Jason Pitters, National Institute for Nanotechnology, Canada

8:00 am 6B-1 Invited

High Throughput SPM for Nanopatterning and Nanometrology, Hamed Sadeghian*, Rodolf Herfst, Klara Maturova, Abbas Mohtashami, Violeta Navarro, Maarten van Es, Daniele Piras, Department of Optomechatronics, TNO, Delft, The Netherlands, *Eindhoven University of Technology, Eindhoven, The Netherlands

An overview of variety of scanning probe nanopatterning and techniques with the emphasis on the development of a high throughput scanning probe instrument (HT-SPM) which consists of several miniaturized SPM operating in parallel to meet the aforementioned requirements,

8:30 am 6B-2

Analytic and numeric model for field-emission scanning probe lithography, *S. Lenk, C. Lenk, I. W. Rangelow, TU Ilmenau*

We present an analytic and a numeric model for field-emission scanning probe lithography which allow the estimation of the line width for a given tip and parameter set. The analytic model allows the optimisation of tip properties together with the parameter set to reach the highest resolution capabilties.

8:50 am 6B-3

Highly Parallel Scanning Probe Lithography, *John N. Randall, Joshua B. Ballard, Ehud Fuchs, James H.G. Owen, Joseph Lake, Zyvex Labs*

Scanning probe lithography (SPL) has shown great utility in a number of different patterning modes. However, being a serial write technology and requiring mechanical scanning puts significant limits to throughput. A MEMS based scanner with integrated micro-controller would dramatically reduce integration problems and would enable highly parallel lithography operations.

9:10 am 6B-4
Performance of unique 3D devices fabricated using thermal Scanning Probe Lithography, *A. W. Knoll[1], C. Schwemmer[1], C. Rawlings[1], Y. K. Ryu Cho[1], M. Skaug[1], S. Fringes[1], M. Zientek[1], D. Urbonas[1], T. Stoeferle[1], R. Mahrt[1], M. Spieser[2], Y. Lisunova[3], J. Brugger[3], [1]IBM Research – Zurich, [2]SwissLitho AG, [3]EPFL*

The differentiating feature of thermal Scanning Probe Lithography compared to other nanofabrication techniques is the capability to write grayscale features with nanometer accuracy. Here demonstrate two showcases for which nanometer accuracy is required: targeted design of the energy splitting in photonic molecules and nm scale separation of nanoparticle in nanofluidics.

9:30 am 6B-5
Plasmonic Roller Lithography, *Xi Chen, Sungho Lee, Qiaochu Li, Cheng Zhang and L. Jay Guo, The University of Michigan*

We demonstrated a plasmonic roller system combining photo roller lithography (PRL) and plasmonic lithography, which pushes the resolution of PRL to nano-scale by using specially designed masks based on a plasmonic waveguide. By making a flexible photomask, sub-wavelength can be printed continuously over a moving substrate for cost sensitive applications.

9:50 am Coffee Break

6C - Biomedical Devices I

Room: Caribbean 3
Session Chairs:
Regina Luttge, Eindhoven University of Technology
Ali Tinazli, HP

8:00 am 6C-1 Invited
Organs on Chip approach for evaluating drug-induced modulation of the immune response, *L. Businaro[1], A. De Ninno[1], F. R. Bertani, F. Mattei[2], V. Lucarini[2], G. Schiavoni[2], S. Parlato[2], L. Gabriele[2], R. Molfett[3], E. Martinelli [4], A. Mencattini [4], A. Rainer[5], S. Giannitelli[5] and A. Gerardino[1], [1]CNR-Institute for Photonics and Nanotechnologies, [2]Istituto Superiore di Sanità, [3]Department of Molecular Medicine "Sapienza" University of Rome, [4]Dept. Electronic Engineering, University of Rome Tor Vergata, [5]Università Campus Bio-Medico di Roma*

Reconstitution of the immune-cancer system on chip opens a new window to live observation of the host immune response with or without drug treatments, making organ-on-chip approach a cornerstone for dissecting complex biological phenomena and pre-clinical testing of drugs.

8:30 am 6C-2
A 3D microdevice for the in vivo trapping of cancer-associated circulating cells., *A. K. Jiménez Zenteno, A. Estève, E. Bou, C. Blatché, C. Vieu, B. Malavaud*, A. Cerf, LAAS-CNRS, Université de Toulouse, CNRS, INSA, UPS, Toulouse, France, *Department of Urology, Hôpital de Rangueil, Toulouse, France*

This work introduces a unique system for the capture of circulating biomarkers in vivo, relying, for the first time, on a 3D microdevice to be placed directly into the blood circulation, to selectively sort out cancer cells from other blood components based on their physical specificities.

8:50 am 6C-3
Ultrasensitive Ebola virus antigen detection via a nanoantenna-array biosensing platform, *F.Zang, Z.Su, L.Zhou, G.Kaplan[1], S.Y.Chou, Princeton University, [1]Food and Drug Administration*

We have developed a nanoantenna-array-based biosensor for detecting Ebola virus antigens that is 10,000-fold more sensitive than conventional method. The sensor maximizes the excitation laser absorption efficiency, and has demonstrated an analytical sensitivity of 95.8%. These results highlight the significant potential of the nanostructured biosensor in ultrasensitive detection of pathogens.

9:10 am 6C-4
Fabrication of Hollow Silicon Microneedle Arrays for Transdermal Biological Fluid Extraction, *H. Zhang[1], Y. Li[1,2], R. Yang[1], Y. Laffitte[1,2], U. Schmill[1,2], E. J. M. Blondeel[2], M. Kaddoura[2], B. Cui[1], [1]Department of Electrical and Computer Engineering, University of Waterloo, Canada, [2] ExVivo Labs Inc., Canada*

We present an innovative fabrication of hollow silicon microneedle arrays for transdermal biological fluid extraction using the double side deep reactive ion etching. The hollow microneedle array was successfully fabricated with the tip radii < 5 um and hole depth of 300 um and diameter of 30 um.

9:30 am 6C-5
Planar coils for Optimal Micromagnetic Brain Stimulation., *G. Bonmassar*, I. Webb[2], L. Golestanirad, J. Deng[2], Harvard Medical School, [1]Harvard College, [2]Harvard University*

Micromagnetic stimulation (μMS) has shown promise as a means of revolutionizing stimulation of the human nervous system. However, commercial inductors used in μMS are not designed to maximize flux in the tissue. In this work, we fabricate and test silicon-based coil structures for next-generation μMS devices as brain stimulators.

9:50 am Coffee Break

7A - Nanoelectronics

Room: Caribbean 1
Session Chairs:
Mark Reed, Yale University
Tao Li, Southeast University

10:10 am 7A-1 Invited
Scaling, Stacking, and Printing: How Nanomaterials Still Hold Promise for Electronics, *A. D. Franklin, Duke University*

1D and 2D nanomaterials continue to show promise for use in electronic devices. There are three distinct advantages that nanomaterials uniquely offer: scaling, stacking, and printing. These advantages will be reviewed and demonstrated with applications from low-voltage transistors to fully printed biological sensors.

10:40 am 7A-2
Integrated Flexible Solid-state Thin Film Supercapacitors, *S. Ahmed, L. Jiang, B. Oni, N.S. Korivi, Tuskegee University*

A facile approach is reported to make integrated, flexible thin film supercapacitors, based on directly incorporating active electrode material on either side of a solid electrolyte layer. This approach promotes adhesion between electrode material and solid electrolyte and simplifies the packaging of thin film supercapacitors for practical applications.

11:00 am 7A-3
A TiO_2 – based Radio Frequency Resistive Switch, *G.C. Adam, R. Badulescu, S. Iordanescu, N. Wainstein*, S. Kvatinsky*, National Institute for R&D in Microtechnologies (IMT), *Technion - Israel Institute of Technology*

This paper reports the first experimental and simulation results of a radio frequency RRAM switch for the X band using heavily reduced TiOx as active material. The switch shows good insertion loss (-2.1 dB) and isolation (-32 dB) at 10GHz.

11:20 am 7A-4
Cold-Blooded Circuits: Transient Electronics that Require Constant Heat Input to Prevent Dissolution, *X. Zhang, L. M. Bellan, Vanderbilt University*

To produce transient circuitry that requires constant heat input to prevent irreversible dissolution and loss of function, we have combined thermoresponsive polymers that exhibit a lower critical solution temperature (LCST) behavior with conductive nanowire networks patterned with a parylene mask.

11:40 am 7A-5
All-Solid-State Stretchable Supercapacitors Using Polypyrrole-dodecylbenzenesulfonate (PPy(DBS))-CNT Hybrid Partially Embedded in PDMS, *Runzhi Zhang, E. H. Yang, Stevens Institute of Technology*

We develop a supercapacitor with PPy(DBS)-vertically aligned carbon nanotube (VACNT) hybrid partially embedded into PDMS utilizing a facile fabrication technique. Our unique technique ensures a strong hold of the partially embedded PPy(DBS)-VACNTs hybrid into Polydimethylsiloxane (PDMS), which facilitates a stable charge/discharge under varied strains.

12:00 PM Lunch Break

7B - 3D Lithography

Room: Caribbean 2
Session Chairs:
Stefano Cabrini, Lawrence Berkeley National Laboratory
Alex Liddle, NIST

10:10 am 7B-1 Invited
Nano Aperture Ion Source, *Leon van Kouwen, Pieter Kruit, Delft University of Technology Greg Schwind Aurelien Botman , Sean Kellogg, Thermo Fisher Scientific.*

Ion production in the Nano Aperture Ion Source is based on electron impact gas ionization inside a sub-micron sized gas chamber. We present theoretical and experimental parameters of this source, showing this is a good candidate for use in focused ion beam machines.

10:40 am 7B-2
Native and Surface-Modified Nanocellulosic Materials for 2.5D and 3D Fabrication, *S. Saem, A. Esteve, K.[1] Jiménez Zenteno,[1] A. Fatona, A. Accardo,[1] L. Malaquin,[1] A. Cerf,[1] J. Moran-Mirabal, Department of Chemistry and Chemical Biology, McMaster University, Canada, [1]LAAS-CNRS, Université de Toulouse, CNRS, INSA, Toulouse, France*

Cellulose nanocrystals (CNCs) possess unique properties that macro scale cellulose does not. The tuneable surface modification of CNCs enables their use in bio composites suitable for 2.5D and 3D fabrication of structures for cell and tissue engineering. In this talk, the incorporation of CNCs into printing resins is presented.

11:00 am 7B-3
Fabrication of a Macroscopically Degenerate 3D Artificial Spin Ice, *S. Dhuey, A. Farhan, C. Petersen[1], M. Saccone[2], N. Kent[3], Z. Chen[4], M. Alalva[1], P. Fischer[3], A. Scholl*, S. van Dijken[5], Molecular Foundry, Lawrence Berkeley Nat. Lab; ALS, Lawrence Berkeley Nat. Lab; [1]Dept of Applied Physics, Aalto Univ.; [2]Physics Dept, Univ. of California Santa Cruz; [3]MSD, Lawrence Berkeley Nat. Lab; [4]Mat. Sci. and Eng., Univ. of California Berkeley; [5]Dept of Applied Physics, Aalto Univ.*

Artificial spin ices are a 2D array of nano-magnets designed to study geometrical frustration which can lead to degeneracy of ground states and residual entropy. 2D ices show lifting of degeneracy from unequal interactions. We show a 3D square ice which allows recovery of the degeneracy of the ground state.

11:20 am 7B-4
Systematic Study of Roll-to-Roll Colloidal 3D Nanolithography System and Its Applications, *I. Chen, E. Schappell, X. Zhang, C. Chang, North Carolina State University*

We examine the process repeatability of the roll-to-roll colloidal 3D nanolithography system, the defect-free areas are analyzed using image processing and statistical analysis over a long period of time. We also investigate repeatable large-area patterning onto various soft and flexible substrates and explore strain-tunable optical properties.

11:40 am 7B-5
Control of Liquid Film Thickness and Concentration in-situ for Focused Electron Beam Induced Deposition from Aqueous Solutions, *S. Esfandiarpour, J. T. Hastings, Electrical and Computer Engineering, University of Kentucky*

We have proposed a modified surface to increase the control over liquid film thickness and concentration in-situ for the LP-EBIP. Having control over the thickness and concentration enabled us to study the effect of refresh time, dose, number of cycles, and concentration on the copper deposition mechanism.

12:00 PM Lunch Break

7C - Biomedical Devices II

Room: Caribbean 3

Session Chairs:
Reginald Farrow, New Jersey Institute of Technology
Beth Pruitt, Stanford University

10:10 am 7C-1 Invited

Interaction of graphene surfaces with protein: route for effective non-covalent biological functionalization, *T. Alava[1,2], C. Sun[4], A. Hugo[1,2], J. Mann[4], J. Parpia[3], H. Craighead[3], W. Dichtel[4], [1]Univ. Grenoble, [2]CEA, LETI, [3] Cornell University, [4]Northwestern University*

Fundamental considerations on the denaturizing nature of graphene surfaces for protein macromolecules will be presented. Different routes for a robust non covalent protocol for grafting protein at graphene surfaces will be compared to achieve an effective route for biological functionalization of graphene surfaces.

10:40 am 7C-2

A versatile fabrication protocol for graphene gated field effect transistor-based smart biological sensors on arbitrary substrates, *A. Hugo, Zheng Han, Julien Renard, Vincent Bouchiat, Pascal Mailley, Thomas Alava, Univ. Grenoble Alpe, France, CEA, LETI, Minatec Campus, , France, Institut Néel, Université Grenoble Alpes – CNRS:, France. C.A de Coulomb*

We present a novel fabrication protocol for graphene solution gated field effect transistor (SGFET) that can be adapted to arbitrary substrates, we fabricated large surface SGFET sensors on printed circuit boards substrates using the same protocol. Host PCBs contain radar antenna so to perform remote interrogation of the graphene channel.

11:00 am 7C-3

Increasing nanogroove height enhances neuron outgrowth alignment, *A.J. Bastiaens, S. Xie*, R. Luttge, Eindhoven University of Technology, *University of Twente*

Increasing nanogroove height enhances neuron outgrowth alignment. Our AFM characterization of two distinct polydimethylsiloxane substrates reveals that an average height increase of 23 nm correlates with a 10% rise in outgrowth alignment. These insights aid in the design of neuronal network architecture.

11:20 am 7C-4
Towards a Graphene Nanoelectrode Single-Molecule Biosensor Utilizing Quantum Tunneling, *J. L. Swett, J. A. Mol, University of Oxford*

Here we report on the fabrication progress and initial data from a solid-state single-molecule graphene nanogap based biomolecular sensor architecture, which permits simultaneous transverse and transmembrane analyte measurements.

11:40 am 7C-5
A multiplexed intracellular probing (IP) nano-chip for interrogation of myo-fibroblasts and cardiomyocytes gene in cardiac fibrosis, *S. Black, D. Zhu, L. Chang, J. Shi*, University of North Texas, * Ohio State University*

Current tools remain challenging to characterize intracellular biomarkers of the activated myo-fibroblasts and cardiomyocytes in cardiac fibrosis. We report an advanced intracellular probing (IP) nano-chip for precise delivery of molecular beacons into single cell for detection of mRNAs and comprehensive analysis of gene expression in myo-fibroblasts and cardiomyocytes in cardiac-fibrosis.

12:00 PM Lunch Break

8A - Neuromorphic Hardware I

Room: Caribbean 1
Session Chairs:
Alec Talin, Sandia National Lab
Can Li, University of Massachusetts

1:30 pm 8A-1 Invited
Statistical Computing with Photonic Integrated Circuits, *Yichen Shen[1,2], H. Meng[1], Li Jing[1], Dirk Englund[1], Marin Soljacic[1], MIT Lightelligence Inc., MIT*

I will show that some conventional statistical processing algorithms can be equivalently carried out by nanoscaled optical systems, and such can be at least 3 orders of magnitude faster and power efficient in forwarding propagation than an electronic chip.

2:00 pm 8A-2
Ionic Liquid and Amorphous Metal-Oxide Semiconductor Interactions: Towards a New Programmable Neuromorphic Platform, *Walker L Boldman[1], Thomas Z. Ward[2], Cheng Zhang[1], Philip D. Rack[1,3], [1]University of Tennessee, [2]Materials Science and Technology Division, Oak Ridge National Laboratory, [3]Center for Nanophase Materials Science, Oak Ridge National Laboratory*

An electric double layer between ionic liquids and a solid interface results in an electric field, which can be used to electrochemically dope a gated material, resulting in a nonvolatile neuromorphic device. This device combines electrowetting of the ionic liquid and electrochemical doping of amorphous indium gallium zinc oxide.

2:20 pm 8A-3
Ion Gated Synaptic Transistors Based on Two-dimensional van der Waals Crystals with Tunable Diffusive Dynamics, *Jiadi Zhu[1], Yuchao Yang[1], Ru Huang, Li Song[2], Rundong Jia[1], [1]Peking Univeristy, [2]University of Science and Technology China*

We present an ionic gating modulated synaptic transistor based on a variety of two-dimensional (2D) van der Waals (vdW) layered crystals including WSe_2, $NiPS_3$ and $FePSe_3$ that can bio-realistically emulate both short-term and long-term plasticity with low energy consumption down to 30 fJ/spike.

2:40 pm 8A-4
Electrostriction, capacitive susceptibility, and neuromorphic computing in droplet interface bilayers, *C.P.Collier, C.D.Schuman, A.Belianinov, J.S.Najem*, G.J.Taylor*, R.J.Weiss*, S.Hasan*, G.S.Rose*, S.A.Sarles*, Oak Ridge National Laboratory, *University of Tennessee, Knoxville*

We are integrating droplet interface bilayer and polymer interface technologies with micro- and nanofabrication to develop fundamentally new types of neuromorphic elements that have the composition (biomolecules), structure (biomembranes),and switching mechanism (voltage-sensitive ion channels) of real biological synapses, and operate at lower power than the current state-of-the-art.

3:00 pm 8A-5
Superconducting Nanowire-Based Processor for Training Deep Neural Networks, *M. Onen, B. Butters, K. K. Berggren, Research Laboratory of Electronics, MIT*

We propose a superconducting cryotron-based unit cell that acts as a local information processor. A crossbar architecture can be realized with these unit cells, such that the all the vector matrix multiplications and updates required for training a DNN through backpropagation algorithm can be achieved in O(1) computational complexity.

3:20 pm Coffee Break

8B - Advanced Lithography I

Room: Caribbean 2
Session Chairs:
Jim Cameron, Dow Electronic Materials
Gerald Lopez, University of Pennsylvania

1:30 pm 8B-1 Invited
Exploring the limits of single-expose EUV patterning at IBM, *N. Felix, IBM Research*

Will discuss the current challenges associated with using EUV patterning techniques at advanced nodes.

2:00 pm 8B-2
EUV Achromatic Talbot Lithography: A Method for High-Resolution Patterning of Nanostructures over Large Areas, *D. Kazazis, L.-T. Tseng, Y. Ekinci, Paul Scherrer Institute*

We investigate the resolution limits of ATL for dot/hole arrays based on simulations of the aerial images produced by various masks (nanoholes, nanorings, etc). We also present the nanofabrication of high quality ATL masks on Si3N4 membranes as well as EUV exposure results of high-resolution and dense structures.

2:20 pm 8B-3
Unbiased Roughness Measurements: Subtracting out SEM Effects, part 2, *Gian F. Lorusso, Vito Rutigliani, Frieda Van Roey, Chris A. Mack*, IMEC, *Fractilia LLC*

A given sample set (with given roughness characteristics) will be measured under a variety of CD-SEM conditions: SEM voltage; rectangular versus square pixels; multiple CD-SEM tools Further, efforts to better measure roughness at very low electron doses will be tested. Unbiased roughness measurements will be compared.

2:40 pm 8B-4
Plasmonic Lithography Utilizing Epsilon Near Zero Hyperbolic Metamaterial, *Xi Chen, Cheng Zhang, Fan Yang, Gaofeng Liang, Qiaochu Li and L. Jay Guo, The University of Michigan*

We take advantage of epsilon near zero hyperbolic metamaterial to create deep subwavelength patterns in a photoresist layer using a regular ultraviolet light source. The design can greatly alleviate the difficulty of making the photomask and significantly reduce the exposure time and thus improve the throughput of plasmonic lithography.

3:00 pm 8B-5
Progress in Metal Organic Cluster EUV Photoresists, *H. Xu, V. Kosma, K. Sakai*, E. P. Giannelis, C. K. Ober, Cornell University, *JSR*

Metal oxide photoresists have demonstrated for EUV lithography that they are capable of high sensitivity and high resolution. This paper reports on recent progress in an industry-university study of metal oxide cluster compounds, the factors that control resist performance and recent progress in making working resists from these new materials.

3:20 pm Coffee Break

8C - Charged Particle Optics

Room: Caribbean 3
Session Chairs:
John Hartley, NuFlare Technology
Timothy Grove, University of Albany

1:30 pm 8C-1 Invited
Diffractive Electron Mirrors as Lossless Beam Splitters, *N. Abedzadeh, C-S. Kim, M. Turchetti, R. Hobbs, T. Savas, K.K. Berggren, MIT, M.A.R. Krielaart*, P. Kruit*, *TU Delft*

The results of a proof-of-principle experiment to demonstrate the working of a diffractive electron mirror are presented. Such a device could be used to split and recouple electrons in quantum electron microscopy (QEM).

2:00 pm 8C-2
Frozen Refractory-Metal Taylor Cones as Potential Regenerable Electron and Ion Point-Sources for Nanofabrication and Lithography, *G. Hirsch, Hirsch Scientific*

A recently developed technology using frozen refractory-metal Taylor cones as regenerable field emission sources is described. Current developmental work applying these devices for ultrafast electron microscopy experiments is outlined. The potential for also employing these novel sources with more conventional instrumentation for various nanofabrication and lithography applications is discussed.

2:20 pm 8C-3
High Brightness Metal Coated Silicon Field Emission Electron Sources, *F. A. Hill, R. Garcia, G. V. Lopez, M. Romero, K. Ioakeimidi, Z. Marks, G. Delgado, KLA-Tencor*

We report on the results of simulations and experimental brightness measurements that show that metal coated silicon emitters can have very high reduced brightness levels on the order of 10^10 A/m2/sr/V.

2:40 pm 8C-4
Electron mirror in MEMS technology for phase manipulation of the wave function, *M.A.R. Krielaart*, C.T.H. Heerkens*, P. Kruit*, N. Abedzadeh[1], K.K. Berggren[1], *Delft University of Technology, Dept. of Imaging Physics, [1]Massachusetts Institute of Technology, Research Laboratory of Electronics*

We will show how micro-electrical mechanical system (MEMS) and nanofabrication technology allow for (sub)-millimetre designs of electron optical (mirror/phase-engineering) setups. This approach requires sub-micron alignment accuracy both for individual electrode aperture roundness and intra-electrode axial alignment. This precision is achieved by using an in-house designed hexapod aligner.

3:00 pm 8C-5
Adjoint Optimization for Electrostatic Charged Particle Lens in 3D, *L.T. Neustock, P. Hansen, L. Hesselink, Z.E. Russell*, Stanford University, *Ion Innovations*

We present a method for efficient calculation of the design sensitivities of electrostatic charged particle lensing systems, using adjoint design sensitivity analysis and a commercial finite element solver. As a demonstration we optimize an Einzel lens over 16 shape and voltage parameters to focus oblique rays to a point.

3:20 pm Coffee Break

9A - Neuromorphic Hardware II

Room: Caribbean 1
Session Chairs:
Qiangfei Xia, University of Massachusetts
Gina Adams, National Institute for R&D in Microtechnologies (IMT Bucharest) Romania

3:40 pm 9A-1 Invited
The Non-Volatile Redox Transistor for Neuromorphic Computing, *A. Alec Talin, Sandia National Laboratories*

Memristors are being developed for pattern recognition and machine learning. However, the non-linear, stochastic and energy-costly switching of memristors complicate reduces the energy efficiency and accuracy of neuromorphic algorithms implemented on memristor architectures. I will present recent progress on addressing these challenges, including our non-volatile redox transistor.

4:10 pm 9A-2
Diffusive memristor based artificial synapses and neurons, *Z. Wang, S. Joshi, S. Savel'ev, R. Midya, H. Jiang, W. Song, Y. Li, M. Rao, P. Yan, S. Asapu, Y. Zhuo, P. Lin, C. Li, J. H. Yoon, N. K. Upadhyay, M. Hu[1] J. P. Strachan[1], N. Ge[1], Z. Li[1], J. Zhang[1], Q. Wu[2], M. Barnell[2], H. Xin[3], H. Wu[4], R. S. Williams[1],*

Q. Xia, J. J. Yang, University of Massachusetts Amherst, Loughborough University, [1]Hewlett Packard Labs, [2]Air Force Research Lab, [3]Brookhaven National Laboratory, [4]Tsinghua University

Diffusive memristors with Ag active metal species are of unique temporal evolution of conductance, originating from the underlying electrochemical and diffusive dynamics of Ag, which could be used to simulate the synaptic plasticity and neural integrate-and-fire behaviors for hardware implementation of neuromorphic computing.

4:30 pm 9A-3
Optimized Filamentary RRAM for Neuromorphic Hardware, *W. Wu, B. Gao, H. Wu and H. Qian, Tsinghua University*

RRAM devices with analog switching behavior is particularly important for neuromorphic hardware. In this work, a new device structure is proposed for filamentary RRAM to realize analog behavior. Based on the proposed method, excellent analog behaviors are realized on a RRAM array.

4:50 pm 9A-4
Integration of Memristor on CMOS Chips for Hardware Accelerators, *X. Sheng, C. Graves, X. Li, S. Williams, J. P. Strachan, Hewlett Packard*

Recent development of high density and low power consumption memristor technology has opened a new door for hardware accelerators in advanced computing. In this paper, we present integration of nanoscale memristor arrays on foundry-built 180 nm CMOS circuit chips with focus on BEoL process and nano device scaling down.

5:10 pm 9A-5 Invited
Analog and Neuromorphic Computing with Memristor Arrays, C. Li[1], M. Hu[2] , Y. Li[1], D. Belkin[1,5], H. Jiang[1], N. Ge[3] , E. Montgomery[2], J. Zhang[2], W. Song[1], N. Dávila[2], C. Graves[2], Z. Li[2], J. P. Strachan[2], P. Lin[1], Z. Wang[1], M. Barnell[4], Q. Wu[4], R. S. Williams[2], J. J. Yang[1], Q. Xia[1], [1]Department of ECE, University of Massachusetts, [2]Hewlett Packard Labs, Hewlett Packard Enterprise, [3]HP Labs, HP Inc., [4]Information Directorate, Air Force Research Laboratory, [5]Swarthmore College

Here we report our progress on large-scale memristor based in-memory analog computing from device engineering, integration process, and peripheral circuits development perspectives. We experimentally demonstrated image compression, image convolutional filtering and in-situ training of a multilayer perceptron with 128×64 memristor crossbar arrays, the largest of its kind to date.

9B - Advanced Lithography II

Caribbean 2

Session Chairs:
Eric Panning, Intel Corporation
Tod Hasting, University of Kentucky

3:40 pm 9B-1 Invited

Multi-beam mask writer MBM-1000 for advanced mask making, *H. Matsumoto, H Yamashita, H. Matsumoto, N. Nakayamada, Mask Lithography Engineering Depatment, Nulare Technology, Inc.*

A multi-beam mask writer MBM-1000 based on large area projection optics with blanking aperture array (BAA) for individual beam blanking will be discussed.

4:10 pm 9B-2

Optimization of Inverse Opal Structures for Application as Stable Field Emitters, *L. C. Montemayor, M. Jones, H. Greer, E. Murty, H. Manohara, R. Zhang*, Y. Fan*, P. V. Braun*, Jet Propulsion Laboratory California Institute of Technology, *University of Illinois at Urbana-Champaign*

This work evaluates how variations in inverse opal tip aspect ratio, sharpness, and material impact the field emission performance of inverse opal diodes/triodes. Additionally, optical photolithography techniques are used to create a monolithically integrated gate structure onto the inverse opal cathode with cathode/gate gaps of 5μm or less.

4:30 pm 9B-3

Fabrication of cryogenic resistors for on-chip shunting of superconducting NbN nanowire devices., *M. Colangelo, E. Toomey, K. K. Berggren, Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology*

Fabrication process and preliminary characterization results of lithographically shunted NbN nanowires, featuring on-chip resistors compatible with cryogenic testing temperatures (4.2K) and inductances dictated by nanowire geometry. These devices are characterized by non hysteretic current voltage curves and fast relaxation oscillations.

4:50 pm 9B-4
Patterning of Dense Arrays for MRAM Applications, *Tsai-Wei Wu, Lei Wan, Patrick Braganca, Khiem Tran, Neil Smith, K.C. Patel, Goran Mihajlovic, Young-suk Choi, Jordan Katine, Western Digital Research*

We will present work using ebeam lithography and ion milling to pattern dense arrays of magnetic tunnel junction (MTJ) bits. Arrays were fabricated with bit diameters of 20 nm and full pitch down to 55 nm (on par with DRAM densities) without degradation of the MTJ bit performance.

5:10 pm 9B-5 Invited
3D-Nanoprinting of Functional and Freestanding Structures via Electron Beams: an Application Perspective, *R. Winkler, J. Sattelkow, H. Plank, J.D. Fowlkes*, P.D. Rack*, Institute of Electron Microscopy, Graz University of Technology; Graz Centre for Electron Microscopy; *Center for Nanophase Materials Sciences, Oak Ridge National Laboratory; The University of Tennessee*

We first introduce the basic principles of 3D-nanoprinting via FEBID (3BID), followed by a presentation of 3BID-based proof-of-principle studies (3D-plasmonics, thermal nano-probes). Furthermore, we reflect on application ideas using magnetic, mechanical and optical properties to indicate the high potential, closing by an overview of remaining challenges and further activities.

9C - Nanofluidics

Room: Caribbean 3
Session Chairs:
Leo Ocola, IBM
Yann Astier, Roche Sequencing Solutions

3:40 pm 9C-1 Invited
Nanofluidic Ionic Devices, *M. Reed, S.X. Li, Yale University, W. Guan, Penn State University*

When the geometrical confining size of fluids approaches the ionic Debye screening length, an interesting regime of transport physics can be realized. We have demonstrated a variety of nanofluidic ionic devices which utilize controllable ion selectivity, allowing us to realize ionic diodes, transistors, and artificial ion channels.

4:10 pm 9C-2
Active-matrix driven digital microfluidic system built on printed circuit boards *Yaru Xing, Xianming Liu*, Yu Liu, Rifei Chen, Xiujie Sun, Ruijun Tian, Youwei Jiang, Xing Cheng, Southern University of Science and Technology, *Dalian Institute of Chemical Physics*

We present a central fluid processing platform based on printed circuit board with switching transistors for parallel manipulation of droplets in large scale. The device can be used as an omnipurpose platform for chemical and biological analysis and synthesis.

4:30 pm 9C-3
Measuring Liquid Properties on Nano-scale Photoresist 1D Patterned Structures, *Juan J. Faria Briceno, University of New Mexico, S. R. J Brueck, University of New Mexico, Randy P. Schunk, University of New Mexico, Alexander Neumann, University of New Mexico*

This project focus on measuring liquid properties on nano-scale photoresist 1D patterned structures. Patterned structures from 300 to 1000 nm were used to calculate perpendicular and parrallel contact angles. The goal is to bridge the difference between the micrometer scale fluidic results and nanoscale wetting simulation.

4:50 pm 9C-4
Design and Operation of a Body-in-a-Cube Platform, *Hidetaka Ueno, Takaaki Suzuki*, Mandy B. Esch, National Institute of Standards and Technology, *Gunma University, Japan*

We have developed a cell culture cube with several interconnected cell culture chambers. All cell culture chambers are interconnected so that an exchange of metabolites can take place. The design of the cell culture cube allowed us to reduce the liquid-to-cell ratio within the device to near-physiologic values.

5:10 pm 9C-5 Invited
Analytical separation of colloidal nanoparticles by size exclusion in nanofluidic replicas, *K.-T. Liao* [1], S. M. Stavis*, *National Institute of Standards and Technology (NIST), [1]University of Maryland (UMD)*

We demonstrate the analytical separation of colloidal nanoparticles by size exclusion in complex nanofluidics. As a first step toward the mass production and widespread application of such measurement devices, we replica mold them in a silicone bilayer with high fidelity and stability.

Posters

Poster Session Chair:
Regina Luttge, Eindhoven University of Technology
Rob Ilic, NIST

Start-up Poster Chair:
Stefano Cabrini, Lawrence Berkeley National Laboratory

Rio Mar 1- 5
Wednesday, 10:45 am – 1:00 pm; 6:00 pm – 7:00 pm – Poster Presenters are at their boards
Thursday, 10:00 am – 3:00 pm – Posters are available for viewing

3D Micro and Nanolithography

P1-01 Invited
Renewable nanoparticles as additives for 3D printed hydrogels, *Saem S,† Jiménez Zenteno AK,§ Esteve A,§ Reig§ B, Accardo A,§ Malaquin L,§ Cerf A,§ Moran-Mirabal JM†,* †Department of Chemistry and Chemical Biology, McMaster University, Hamilton, ON, Canada §LAAS-CNRS, Université de Toulouse, CNRS, INSA, Toulouse, France*

This work aims to introduce CNCs as non-cytotoxic bio-based additives for 3D printing resins that enhance the stiffness and confer sites suitable for cellular adhesion. The use of cellulose as an additive also opens the door for the future chemical modification of the scaffolds.

P1-02 Invited
Software based optimization of gray scale laser lithography, *Andreas Ludwig, Dominique Colle, Dr. Peter Heyl*, Daniel Ritter, Nikola Belic**, Dr. Holger Sailer*** *Heidelberg Instruments **GenISys ***Institut für Mikroelektronik Stuttgart*

The authors present a new model-based approach for creating highly accurate topographies with direct write gray scale lithography. The goal is to reduce the number of iterations needed in the optimization process. The quality of the software optimization is quantified by comparing the topography errors of optimized and non-data-optimized exposures.

P1-03
Two-photon polymerization of 3D structures for open-air microfluidics and untethered microrobotic systems, *N. Lavrik, C. McKown*, W. Huang**, Oak Ridge National Laboratory, *University of Tennessee, **ORISE*

Of our particular attention are fabrication sequences that combine 2-photon additive manufacturing with bulk silicon micromachining and thin film processing. Using this strategy, we implemented and explored several types of model systems with an over-arching goal of demonstrating new promising concepts in open-air microfluidics and soft microrobotics.

P1-04
Fabrication of astronomical X-ray reflection gratings using thermally activated selective topography equilibration (TASTE), *J. McCoy, R. McEntaffer, Penn State University*

Exploring cutting-edge techniques in 3D nanolithography is crucial for improving astronomical X-ray spectroscopy. As an alternative to KOH etching, thermally activated selective topography equilibration (TASTE) is being investigated as a means to produce blazed gratings using grayscale electron-beam lithography followed by a thermal treatment to induce a selective polymer reflow.

Advanced Pattern Transfer Concepts

P1-05
Advance Lithography I-Line Resist Profile for Difficult Liftoffs in Compound Semiconductor Technologies, *J. Mason, I. Wathuthanthri, Northrop Grumman Mission Systems*

A new lithography process for hard liftoffs is presented in this work. This process demonstrates a resist profile that uses both a top layer as well as a resist lip.

P1-06
A Study on the Fine pattern generation Using Elastic Restoration of Blankets, *Seunghang Shin, Yeonho Jeong, Hyun Min Choi, Seonjun Kim, Yoon-Gyo Jung, Young Tae Cho, Changwon National University*

This study suggests a new concept proposal for fine pattern generation by using elastic deformation of Blanket in reverse offset printing process.

P1-07
Chromium hard mask patterning of sub-20 nm films for single-digit nanofabrication, *D. Staaks*'**, Z. Yu***, S. Sassolini*, S. D. Dhuey*, K. Y. Lee***, I. W. Rangelow**, D. L. Olynick*, *LBNL - Molecular Foundry, **Ilmenau University, *** Seagate Technology LLC*

To etch chromium at the deep nanoscale, dimensions must be controlled to the nanometer. This requires a new level of mechanistic understanding. In this work we present results on the plasma etching of chromium thin films in a chlorine and oxygen gas mixture.

P1-08
Etching Process for Producing Variable Sloping Sidewall of III-V Antimonide-based Materials for LED/PD Applications, *X. Li, M. Reza, M. Steer, M. Sorel, I.G. Thayne, D. Lusk*, C. MacGregor*, University of Glasgow, *Gas Sensing Solutions Ltd*

A reliable and controllable etching process through mask engineering and inductively coupled plasma (ICP) etching of the III-V antimonides has been developed obtain a smooth and sloping sidewall etching profile of Al(Ga)InSb based semiconductor materials for making edge emitting LED and photodiode detector (PD) devices.

P1-09
Roll-to-roll Nano-patterning of Packaging Films: Analysis Using AFM, SEM and FIB SEM, *N. Okulova[1,2], P. Johansen[1], L. Christensen[1] and R.J. Taboryski[2], [1]Danapak Flexibles, [2]DTU Nanotech*

Pattern transfer using roll-to-roll extrusion coating allows mass-production of large-scale micro- and nano-surfaces in thermoplastic polymers with up to 2m width and production speed up to 1000m/min for structures between 100nm up to 100µm. An investigation of the yield of the pattern transfer is carried out using FIB-SEM and AFM.

Atomically Precise Fabrication

P1-10
Designer Quantum Materials, Atom-by-Atom, *L. A. Tracy, T. M. Lu, M. T. Marshall, D. M. Campbell, D. R. Ward, A. D. Baczewski and S. Misra, Sandia National Labs*

This paper will focus both on the promise of realizing tunable donor arrays that serve as analog quantum simulations (AQS) of important quantum many body problems, and on our technical progress towards that goal.

P1-11
Scanning Tunneling Microscope Fabrication of Atomically Precise Devices, *Richard Silver*, Xiqiao Wang**, Pradeep Namboodiri*, Ranjit Kashid*, Joe Hagmann*, Jon Wyrick*, Scott W. Schmucker***, M. D. Stewart Jr.*, and Curt Richter*, * National Institute of Standards and Technology, **University of Maryland, ***University of Maryland*

Atomically precise device fabrication with hydrogen depassivation lithography enables a new class of atom-based electronic structures with applications ranging from novel low dimensional quantum metamaterials to devices for quantum information processing. Here we investigate methods to improve dopant confinement and STM patterning fidelity by low temperature quantum transport measurements.

Electron and Ion Beam Lithography

P1-12 Invited
Design of an Anisotropic Noise Filter for Measuring Critical Dimension and Line Edge Roughness from SEM Images, *H. Ji, S.-Y. Lee, Auburn University*

An isotropic noise filter adaptive to the noise level in a SEM image was previously designed for accurate measurement of CD and LER for L/S patterns. A new method of designing an anisotropic noise filter has been developed to improve the accuracy of CD and LER measurements.

P1-13 Invited
Estimation of Critical Dimension and Line Edge Roughness using Artificial Neural Networks, *D. Li, S.-Y. Lee, J. CHoi*, S.-B. Kim*, I.-K. Shin*, C.-U. Jeon*, Auburn University, *Samsung Electronics*

In this study, an approach of employing an artificial neural network for the estimation of critical dimension and line edge roughness in electron-beam lithography, which can avoid the simulation of the electron-beam lithographic process, has been investigated.

P1-14
The Definition of Semiconductors Nanowires using Ga^+ Focused Ion Beam Lithography with Mask of Hydrogenated Amorphous Silicon Film, *A. M. Rosa, L. T. Manera, J. A. Diniz, A. Leonhardt*, School of Electrical and Computer Engineering (FEEC) and Center for Semiconductor Components and Nanotechnologies (CCSNano), University of Campinas (UNICAMP), *IMEC*

This work presents the formation of silicon nanowires (SiNWs), with sub-400 nm wide, and III-V nanowires (III-VNWs), with sub-120 nm wide, using the Ga^+ focused ion beam (FIB) lithography with the protective layer of hydrogenated amorphous silicon (a-Si:H) film.

P1-15
Self Aligned Double Pattern Method for the Definition Silicon Nanowires Using Ga^+ Focused Ion Beam Milling Technique with Mask of Hydrogenated Amorphous Silicon Film, *A. M. Rosa, L. T. Manera, A. Leonhardt*, J. A. Diniz, School of Electrical and Computer Engineering (FEEC) and Center for Semiconductor Components and Nanotechnologies (CCSNano), University of Campinas (UNICAMP), *IMEC*

This work presents the Ga^+ focused ion beam (FIB) milling

technique, with the protective layer of hydrogenated amorphous silicon (a-Si:H) film, and self aligned double pattern (SADP) method for obtaining sub-50 nm wide silicon nanowires (SiNWs).

P1-16
Statistical Comparison of Field Distortion Correction by Z-Stage Movement vs Height-Correction Hardware in a Modern EBL Tool, *Michael P. Young, University of Notre Dame*

The performance of the hardware height compensation mechanism in a modern Gaussian-beam, vector-scan lithography tool is statistically compared with use of the Z stage to correct for height on a field-by-field basis, in order to determine the method most likely to yield the best writing performance on a non-flat substrate.

P1-17
Stochastic simulation of pattern formation in electron beam lithography, *M. Yasuda, M. Koyama, M. Shirai, H. Kawata, Y. Hirai, Osaka Prefecture University*

The pattern formation in electron beam lithography is simulated using the stochastic method. The electron exposure effect for negative type resist is introduced by the crosslinking between the polymer chains. The pattern profiles and the development properties reflect the molecular size of the resist polymers.

P1-18
E-beam lithography using dry powder HSQ resist having long shelf life, *M.Soltani, J.Shen, F.Aydinoglu, B.Cui, University of Waterloo*

HSQ is one of the most popular electron beam resist that offers an ultra-high resolution. But the commercial Dow-Corning HSQ resist solution suffers from a short shelf life of only 6 months. Here we showed that HSQ powder resist, with very long shelf life, can attain very high-resolution structures.

P1-19
Drying Developed Electron-beam Resists Using Supercritical Carbon Dioxide: Compatibility Issues, *M. Lu, Brookhaven National Laboratory*

Critical point drying is a powerful tool for drying high aspect-ratio nano structures, including nanometer-sized resist pattens. This work reports our discovery of material incompatibility issues when drying several popular electron beam resists using liquid CO2 supercritical point drying chemicals.

Maskless and High Throughput Direct Write Lithography

P1-20 Invited
Double-Side Masking and Stress-Released Etching for Fabrication of High Aspect Ratio Graphene Micro-Cantilever, *S.S. Li, M.X. Zeng, Y.F. Huang, R.Z. Zhan, J. Chen, N.S. Xu, J.C. She, S.Z. Deng, State Key Laboratory of Optoelectronic Materials and Technologies, Guangdong Province Key Laboratory of Display Material and Technology, School of Electronics and Information Technology, Sun Yat-sen University*

We report a featured double-side masking and stress-released etching method to fabricate well-shaped graphene micro-cantilever with a high aspect ratio of 3.4. This work provides a promising method for making suspended structures of two-dimensional materials with in-plane flatness for potential MEMS/NEMS applications.

P1-21
Towards Maskless Production of Custom Neuronal Recording Graphene Microelectrode Arrays, *V. P. Gomes, A. M. Pascon, J. W. Swart, R. R. Panepucci*, State University of Campinnos, *Center of Information Technology Renato Archer*

This work aims to demonstrate our advances in the fabrication process for high – performance graphene Microelectrode Arrays (MEAs) that can be custom produced and may be used to explore in vitro neural networks.

Nanoimprint Lithography

P1-22
Visualization of NL polymer distribution in NIL guides for DSA, *K. Asakawa, N. Sasao, T. Sawabe, S. Sugimura, Toshiba Memory*

The distribution of neutralizing layer (NL) for directed self-assembly (DSA) was visualized, which consisted of a single molecular layer in the guiding grooves formed by the nanoimprint lithography (NIL). The relationship between the chemical structures and distribution of the NL polymers was revealed.

P1-23 Invited
Improved etching resistance of UV-cured films with/without hydroxy groups by organic/inorganic hybridization through sequential infiltration synthesis and sequential vapor infiltration, *T. Uehara, Y. Ozaki, S. Ito, N. Hiroshiba, T. Nakamura, M. Nakagawa, IMRAM, Tohoku University*

We investigated whether sequential infiltration synthesis or sequential vapor infiltration, using trimethylaluminum, strengthened etching resistance of UV-cured films toward O2 RIE. We compared etching rates between two UV-cured films made of either a monomer with or without hydroxy groups to discuss infiltration behaviors of trimethylaluminum into the UV-cured films.

P1-24 Invited
Fluidity of an oleophilic monomer in nano-gap between reactive adhesive monolayers for UV nanoimprinting, *S. Ito, M. Kasuya, K. Kurihara*, M. Nakagawa, IMRAM, Tohoku University, *NICHe, Tohoku University*

In this study, in order to understand fundamental effect of the adhesion layer on the monomer viscosity, we investigated nanometer-resolved fluidity of 1,10-decanediol diacrylate between silica surfaces modified with a reactive adhesive monolayer by surface forces and resonance shear measurements.

P1-25 Invited
Quantitative characterization of mechanical properties and residual stress in nanoimprinted polymer films at the microscale, *Ye Tian, Youwei Jiang, Xinglong Huang, Xing Cheng, Southern University of Science and Technology of China*

We present the quantitiative measurement of mechanical properties and residual stress in nanoimprinted polymer structures at the microscale through nanoindentation. The impact of processing conditions on mechanical properties of patterned structures is stuided.

P1-26

Nanofabrication of photonic crystal structures with complex geometries using ALD-enabled imprint lithography, *A. S. Jugessur, Connor Grierson and Andrew Textor, University of Iowa*

In this work, an ALD-enabled nanoimprint technique is applied to fabricate dense PhC structures with sub-50 nm features over areas as large as 10 x 10 mm. In particular, sub-50 nm holes and pillars in the square and triangular lattice configurations have been fabricated using this approach.

P1-27
Rapid thermal nanoimprint through induction heating of nickel mold, *Yang Li, Xinxin Fu, Qian Chen, Aibing Yang, Yushuang Cui, Changsheng Yuan, Haixiong Ge, Nanjing University*

We develop a new novel introduction heating apparatus for thermal nanoimprint. By applying an external current, the ferromagnetic nickel mold is heated up at a high speed. And it cools down fast due to its small thermal capacity. Thus it provides a high heating and cooling efficiency for thermal nanoimprint.

P1-28
Flexible Nanoimprint Template from Amorphous Metals, *Xinglong Huang, Xin Zhuang, Ye Tian, Youwei Jiang, Bingqing Luo, Xing Cheng, Southern University of Science and Technology*

We report the application of amorphous metals for advanced nanoimprint templates. As compared to conventional nickel template, amorphous metal template provides higher resolution, better durability and chemical resistance, and lower surface roughness.

P1-29
Fabrication of high aspect ratio Si nanowires by metal-assisted chemical imprint, *K. Yamada, L. Jay Guo, University of Michigan*

High aspect ratio (~1:50) SiNWs were achieved by MacImprint by employing the Pt-coated anodized aluminum oxide (AAO) membrane mold where the holes through the entire thickness drastically enhances the mass-transport.

P1-30
Decrease nanoimprint lift-off force by poly(ethylene glycol) doping, *Huang Lai, Hang Zhang, Dehu Cui, Southern University of Science and Technology of China*

One of the key issues of successful NIL technology is to avoid adhesion of the polymer to the stamp. In this paper, we mixedmPEG-Azide in the PMMA to decrease nanoimprint lift-off force.

P1-31
Fabricating nanolens arrays by nanoimprint lithography, *Xiaohao Ma, Zeyu He, Dehu Cui, Southern University of Science and Technology of China*

This paper presents an easy and cost-efficient method to fabricate the nanolens arrays by nanoimprint lithography (NIL).

P1-32
Fabricating multilayer channel by double nanoimprint lithography, *Zeyu He, Xiaohao Ma, Dehu Cui, Southern University of Science and Technology of China*

In this paper, the multilayer channel was fabricated by double nanoimprint lithography.

P1-33
Study on resist profile estimation due to shrinkage and mold profile correction in nanoimprint lithography, *T. Iida, K. Watanabe,. Yasuda, H. Kawata, Y. Hirai, Osaka Prefectuer Univ.*

Resist profile estimation function after resist shrinkage is proposed in nanoimprint lithography. Also, automatic mold profile correction to compensate distortions by the resist shrinkage is approached to obtain required pattern profiles.

P1-34
Guiding chart for initial layer choice with nanoimprint, *A. Mayer, M. Papenheim, C. Steinberg, H.-C. Scheer, University of Wuppertal*

When thin residual layers are envisaged with nanoimprint of spin-coated samples the initial layer choice is critical. In order to promote a successful approach without in-depth theoretical and experimental knowledge we will provide a simple guideline for residual layer choice, also documenting the structures obtained with marginally filled cavities.

P1-35
Sub-nanometer gap fabrication using transfer printing by flexible Polydimethylsiloxane (PDMS) substrates, *P. Hu, B. Song, Y. Wang, Y. Li, D. Meng, H. Yang, B. Chen,Wei Wu, University of Southern California*

We develop a fabrication technique to produce nanogaps on arbitrary substrates with gap down to 0.8 nm and atomic-precision gap size control using collapsible nanofingers. Those precisely controllable nanogaps can be used in many applications such as Photocatalyst, Surface-enhanced Raman Scattering, Single Electron Transistor and Quantum Tunneling Junction.

P1-36
Fabrication of Self-standing Thin Polystyrene Films with Through Holes by use of Casting Process, *K. Uchida, H. Kawata, M. Yasuda, Y. Hirai, Osaka Prefecture University*

Self-standing thin Polystyrene film with through holes is fabricated by casting process. PS resin is filled to water soluble PVA pattern with micro pillars, and PVA film is removed in water. Self-standing PS film with 2.5 μm through holes of 2 μm thick is successively fabricated.

P1-37
Selective electroless metallization of micro- and nanopatterns for flexible electronic application through imprint-transfer of palladium nanoparticles, *J. Cai, M. Zhang, C. Zhang, C. Liang, S. P. Feng, W. D. Li, The University of Hong Kong*

An environment-friendly and cost-effective metallization on thermoplastics by imprint lithography and electroless plating for mass production of metallic micro/nanopatterns were experimentally demonstrated.This method uses a hybrid imprint mold which could transfer both patterns and catalytic nanoparticles onto plastic substrates simultaneously for subsequent metallization process.

Probe based Lithography

P1-38 Invited
Field-Emission Scanning Probe Lithography, Low Energy EBID and Correlative Microscopy with AFMinSEM., *Ivo W. Rangelow*, Mathias Holz*,**, Claudia Lenk*, Marcus Kaestner*, Martin Hofmann*, Ahmad Ahmad*,**, Tzvetan Ivanov*, Steve Lenk*, Christoph Reuter**, Alexander Reum*,** Elshad Guliyev*, *Technische Universität Ilmenau, **nano analytik GmbH,*

We present experimental results regarding field-emission scanning probe lithography, low energy electron beam induced deposition and correlative microscopy carried out using our AFMinSEM tool. AFMinSEM combines scanning probe techniques, electron, ion and X-Ray microscopes, resulting in an all-in-one tool for future nanofabrication and nanoanalysis.

P1-39
Experimental study of Field Emission from sharp Silicon, Diamond and Tungsten tips used for Field Emission Scanning Probe Lithography, *C. Lenk*, S. Lenk*, M. Holz**, E. Guliyev*, M. Hofmann*, T. Ivanov*, I. W. Rangelow**, *TU Ilmenau, **Nanoanalytik GmbH*

We present experimental results of the field emission from tungsten, diamond and silicon tips of various radii in dependence of the tip-to-sample distance (<500nm) and bias voltage. These are compared to model predictions. Based on this study optimal parameters for high-resolution, stable field emission scanning probe lithography can be determined.

P1-40
Field-emission scanning probe lithography tool for 150 mm wafer., *Mathias Holz*, Elshad Guliyev**, Ahmad Ahmad*,**, Martin Hofmann**, Claudia Lenk**, Marcus Kaestner**, Tzvetan Ivanov**, Steve Lenk**, Christoph Reuter*, Alexander Reum*,**, and Ivo W. Rangelow**, *nano analytik GmbH, **TU Ilmenau*

We developed field-emission scanning probe lithography (FE-SPL) to generate single-digit nano-features in thin molecular resist layers. Presented is a FE-SPL platform for 150 mm wafers designed as an arch type bridge construction with an integrated bottom positioning stage(150x150 mm² positioning range & 360° rotation for alignment).

P1-41
Field-Emission Scanning Probe Lithography with Diamond tips, *M. Hofmann, M. Kaestner, C. Lenk, A. Ahmad, E. Manske, I. Rangelow*, M. Holz**, *Ilmenau University of Technology, **Nanoanalytik GmbH,*

We present experimental resuts of field-emission scanning probe lithography (FE-SPL) utilizing active cantilevers with diamond tips. Tip wear and emission stability of the diamond tips regarding long-term FE-SPL patterning or AFM measurments will be presented.

P1-42
Scanning Probe Lithography for Bioactive Surface Functionalization, *Michael Hirtz,* Christof M. Niemeyer,** Harald Fuchs*,*** * Institute of Nanotechnology (INT) and Karlsruhe Nano Micro Facility (KNMF), Karlsruhe Institute of Technology (KIT), Germany ** Institute for Biological Interfaces (IBG 1), Karlsruhe Institute of Technology (KIT), Germany ***Physical Institute and Center for Nanotechnology (CeNTech), University of Münster, Germany*

The talk presents the multiplexed deposition of oligo-nucleotides to surfaces for use as versatile yet highly specific binding motifs. The technique allows for a multi-scale presentation of proteins with precise control over number and spatial positioning by DNA origami and response of MCF7 cells is discussed.

P1-43
Quantifying Liquid Transport and Patterning using Atomic Force Microscopy, *N. Farmakidis, V. Saygin, K. A. Brown, Boston University*

Atomic force microscopy (AFM) provides unique insight into the nanoscale properties of materials through its ability to image and pattern materials at these scales. Here, we propose an AFM-based technique for quantitatively analyzing the transport of soft materials from an AFM probe to a surface

P1-44
Photo-actuated Pens for Molecular Printing, *Zhongjie Huang[1], Le Li[2], Xu A. Zhang[1], Nourin Alsharif[2], Xiaojian Wu[1], Zhiwei Peng[1], Xiyuan Cheng[1], Peng Wang[1], Keith A. Brown[2], and YuHuang Wang[1], [1]University of Maryland, [2]Boston University*

Performing scalable scanning probe lithography is very difficult due to the serial nature of the writing process. Here, we explore the photo-actuation of pen arrays composed of polydimethylsiloxane-carbon nanotube composites, and report the first demonstration of photo-actuated pens for molecular printing.

P1-45
Massively Multiplexed Tip-Based Photochemical Lithography under Continuous Capillary Flow, *A. B. Braunschweig, Advanced Science Research Center, City University of New York*

A printing tool that combines microfluidics, organic photochemistry, and massively-parallel tip based lithography was developed. This instrument creates multiplexed patterns with micrometer resolution or can rapidly determine the kinetics of organic reactions at interfaces. This flexible printing strategy could lead to the rapid advancement of “Omics” research.

Optical/EUV

P1-46
Effect of Molecular Structure on Lithographic Performance of Aqueous Base Soluble Epoxide Molecular Resists, *Brandon L. Sharp*, Hannah L. Narcross*, Laren M. Tolbert**, and Clifford L. Henderson*,***, *School of Chemical and Biomolecular Engineering, Georgia Institute of Technology, **School of Chemistry and Biochemistry, Georgia Institute of Technology, ***Department of Chemical and Biomedical Engineering, University of South Florida*

P1-47
Phenol Functionalized Polymerization Control Additives for Negative Tone Cationic Molecular Resists, *H. Narcross*, B. Sharp*, C.L. Henderson** , *Georgia Institute of Technology, **University of South Florida*

Directed Self Assembly

P1-48
Microphase Separation of High-χ Poly(4-tertbutyl styrene) - block - Poly(2-hydroethyl methacrylate), *C.L. Breaux*, B. L. Sharp*, H. Li**, B. Li**, M. Neisser**, C.L. Henderson***, *Georgia Institute of Technology, **Kempur Microelectronics, Inc., ***University of South Florida*

P1-49
Limits of Asymmetric Homopolymer Addition in Block Copolymer-Homopolymer Blends in Modulating the Directed Self-Assembly Behavior of Block Copolymers, *C.L. Breaux*, P. J. Ludovice*, C.L. Henderson**, *Georgia Institute of Technology, **University of South Florida*

Biomedical Devices
P2-01
Wearable flexible nano-transfection device for on-skin gene editing with CRISPR-Cas9, *C. Chitrikar, D. Zhu, L. Chang, Y. Hao*, H. Chang*, Department of Biomedical Engineering, University of North Texas, *Northwestern Polytechnical University*

Current gene delivery techniques show challenges in on-skin transfection of CRISPR-Cas9. We report a novel flexible intracellular delivery nano-device patched on the skin for precise gene delivery into epidermis, achieving precise dose control and high transfection efficiency. This simple implement to nano-device show promises for deterministic in vivo gene editing.

P2-02
Tumor Cell Traversing Behavior in Three-Dimensional Platform with Porous Topography, *Z. Y. Liu, W. G. Zhang, S. W. Pang, City University of Hong Kong*

In this work, a three-layer platform consisted of the gratings, porous membrane, and trenches below was developed to mimic the in-vivo microenvironment for nasopharyngeal carcinoma cells. The topography of porous membrane and trench depth were systematically varied and the cell traversing behavior through the porous membrane was investigated.

P2-03
Effects of Dimensions, Topography, and Layers for Nasopharyngeal Carcinoma Cell Migration on Three-Dimensional Scaffold Platform, *W. Zhang, Z. Y. Liu, S. W. Pang, City University of Hong Kong*

A multiple layer scaffold platform with embedded grating topography was developed to mimic the combined guidance effect of collagen fibers and micro/nanoscale features in extracellular matrix in vivo. The guidance effect due to multiple layers of trenches with different width and embedded topography will be investigated.

P2-04
Cell Migration on Microposts with Surface Coating and Confinements, *J. N. Hui, S. W. Pang, City University of Hong Kong*
To study cell migration under different degrees of confinements, micropost platforms with controlled protein coating and top covers were developed. Cell morphology and spreading were affected by physical constraints and surface coating, which resulted in different cell migration speed and path.

P2-05
A Nanofabricated Enzyme Biosensor, *S. Yadav, A. Vasudevan, A. J. Ojeda, A. Aslam, A. Kanwal, G. A. Thomas, R. C. Farrow, New Jersey Institute of Technology*

P2-06
Design and Optimization of High-throughput Cell Pairing Chip for Cell Fusions, *Chaoran Tao, Chunhui Wu, Rifei Chen, Yu Liu, Zhenming Yu, Youwei Jiang, Xing Cheng, Southern University of Science and Technology*

We present the design, fabrication and characterization of a cell trapping and pairing chip with on-chip cell fusion capabilities. This device can serve as an easy-to-use and highly efficient platform for studying cell-cell interactions on the single cell level.

P2-07
Regulation of the immune synapse and cytotoxic activity of natural killer (NK) cells by nanolithographic ligand patterning, *Yossi Keydar, Guillaume Le Saux, Avishai Edri, Uzi Hadad, Angel Porgador, Mark Schvartzman, Gurion University of the Negev*

We engineered a nanochip for the controlled activation of human Natural Killer (NK) cells, made of nanopatterned matrices of MICA ligands that recognize activating receptors in NK cells . Using this chip, we elucidated the role of spatial ligand distribution in NK cell cytotoxicity.

Carbon Based Nano Devices (CNTs & Graphene)

P2-08 Invited
Opto-Thermionic Cathodes for SEM, *C. Kuzyk, C. Aiello*, F. Pease*, M. Chang, K. Jessen, A. Nojeh, University of British Columbia, *Stanford University*

Optically stimulated carbon nanotube forests and LaB6 are investigated for their use as cathodes in an economical and compact SEM design. Characterizing and minimizing the emission spot size whilst maintaining an emission of at least 10 nA from these cathodes is of particular concern.

P2-09
A Stretching/Bending-Insensitive Flexible Pressure Sensor with Carbon Nanotube-PDMS, *Runzhi Zhang, E. H. Yang, Stevnes Institute of Technology*

We develop a flexible pressure sensor utilizing an interlocking system based on vertically aligned carbon nanotube (VACNT) carpets on Polydimethylsiloxane (PDMS) substrate. Our fabrication technique ensures high flexibility of VACNT-PDMS
structure, which enables a relatively consistent electrical conductivity and resistance under varied strains at a constant pressure.

P2-10
Anode effect of carbon nanotube cold cathode electron beam (C-beam) for high resolution x-ray tube, *Yi Yn Yu, Ji Hwan Hong and Kyu Chang Park, Kyung Hee University, Tae Sul* * World Beam Solution Co. Ltd*

We developed x-ray tube with CNT cold cathode. The performance of x-ray images strongly depend on the anode shape and CNT beam formation. Improved x-ray image quality with optimization will be discussed.

P2-11
Selectivity through Optimization of Metal Oxide Morphology: Towards Selective Chemiresistive MWCNT/TiO_2 VOC Sensors, *Igor Paprotny, Michela Sainato, Ralu Divan*, Liliana Stan*, and Yuzi Liu*, University of Illinois, Argonne National Laboratory*

In this work, we explore morphology of functionalization of multi-walled carbon nanotubes (MWCNTs) with TiO_2, by atomic layer deposition (ALD), resulting in a MWCNT/TiO_2 system that shows selectivity to certain hydrocarbon gasses.

Micro- and Nanoscale Mechanical Devices

P2-12 Invited
Absolute deflection measurements in a MEMS/NEMS Fabry-Perot interferometry system, *R. De Alba*,**, C. B. Wallin*,**, S. Krylov***, B. R. Ilic*, *National Institute of Standards and Technology, **University of Maryland, ***Tel Aviv University*

Laser interferometry is a common, robust, non-invasive technique used to measure motion in MEMS/NEMS devices. Here we characterize this technique in the limit of large deflections, where readout nonlinearity can be used to measure device vibration amplitude, substrate distance, and device angle with high accuracy.

P2-13
High-aspect-ratio gold electroplating for microelectronic, optoelectronic, and microsystem applications, *O.V. Makarova, Creatv MicroTech Inc, R. Divan, ANL, CNM N. Moldovan, Alcorix Co. C.-M. Tang, Creatv MicroTech Inc*

High-aspect-ratio electrodeposition of gold is a key technology in fabrication of microelectronic, optoelectronic and microsystem devices, and various imaging applications from x-ray optics to biosensors. Gold deposit should be ductile, low stress, fine grain and void-free. We report gold electrodeposition into high-aspect-ratio nanometer-wide trenches and nanoporous anodic aluminum oxide membranes.

P2-14
The Collective Behavior of Large Ensembles of Coupled MEMS Cantilevers with Varying Natural Frequencies, *C. Wallin[1,2], N. Dick[3], R. DeAlba[1.2], D. Westly[1], S. Grutzik[4] A. Zehnder[5], R. Rand[5], V. Aksyuk[1], S. Krylov[3], B.R. Ilic[1], [1]National Institute of Standards and Technology, [2]University of Maryland, [3]Tel Aviv University, [4]Sandia National Laboratories, [5]Cornell University*

We present the collective dynamics of coplanar interdigitated arrays of coupled microcantilevers distinguished by their linearly varying length operating in the linear and nonlinear regimes. More specifically, we find the devices exhibit localized mode characteristics, increased mode separation at higher harmonics, abrupt pattern switching, hysteresis, and synchronization.

P2-15
Fabrication of nanomechanical resonators elastically coupled in series for sensitive thermal stress detection, *K. Tanaka, E. Maeda, S. Warisawa, R. Kometani, University of Tokyo*

Nanomechanical resonators elastically coupled in series were proposed in order to achieve Q factor independent thermal stress detection for the higher resonation wavelength measurement. These resonators were fabricated by focused-ion-beam ion implantation and wet-etching process. The maximum thermal stress detection resolution was 643 Pa.

P2-16
Fabrication of Nano-micro hybrid pattern using Anodic Aluminum Oxide template and resins, *Seonjun Kim, Yeonho Jeong, Seunghang Shin, Hyun Min Choi, Yoon-Gyo Jung, Young Tae Cho, Changwon National University*

This study is about nano-micro hybrid structures by anodic aluminum oxide and resins using nano imprint lithography

P2-17
Array of electromagnetically cantilevers for force-distance spectroscopy metrological investigations, *W. Majstrzyk, K. Orłowska and T. Gotszalk, Wroclaw University of Science and Technology, P. Janus, A. Sierakowski, P. Grabiec Institute of Electron Technology*

Fabrication and metrology of arrays of electromagnetically actuated cantilevers for precise force-distance spectroscopy will be presented. Results of characterization and molecular interaction measurements will be showed.

Nanoelectronics

P2-18
Fabrication of high performance far ultraviolet (UV) light sources with carbon nanotube cold cathode pumping, *Sung Tae Yoo and Kyu Chang Park, Kyung Hee University, Choon Tae Sul, World Beam Solution Co. Ltd.*

We developed ultraviolet light sources with CNT cold cathode electron beam pumping. We obtained high efficiency UV light with areal electron beam. The perforance of UV light sources with electron emission characteristics wll be discussed.

P2-19
Reduced contact resistance by surface treatment in Ga_2O_3 film-based devices, *X. Wang, J. Shi, R. Divan*, D. Rosenmann*, University of Illinois at Chicago, *Argonne National Laboratory*

Our studies mainly focus on the reduction of the contact resistance via plasma enhanced surface treatment in the Ga2O3 film-based devices. The chlorine-based/fluorine-based gases were used to treat the contact region. The effects of the etching process along with the rapid thermal annealing were systematically studied.

P2-20
Effects of Crystallinity of Switching Layer Material on Memristive Device, *Hao Yang*, Boxiang Song*, Buyun Chen*, Yifei Wang*, Pan Hu*, Yunxiang Wang*, Yuanrui Li*, Deming Meng*, Xiaodong Yan*, Yue Pan**, Han Wang* and Wei Wu*, *University of Southern California, Los Angeles, **Huawei Technologies CO., LTD.*

The development of memristors attracts great interest among the semiconductor industry. However, significant effort is needed to tailor the memristor technologies for emerging applications. Besides selecting appropriate oxide and contact
layer material, we demonstrated a new method to optimize the memristor by controlling the crystallinity of switching layer.

P2-21
Ion Migration Studies in 2D Molybdenum Trioxide Thin Flake through Ionic Liquid Gating, *C. Zhang, P. Pudasaini, A. Levlev*, Z. Ward*, D. Mandrus, O. Ovchinnikova*, P. Rack, University of Tennessee, *Oak Ridge National Laboratory*

Study of ion migration in few-layer MoO3 devices through ionic liquid gating. 2 types of ionic liquid, BMIM-TFST and LiClO-PEO, were involved. Secondary ion mass spectroscopy was carried out to investigate the ion exchange. Results of short-pulse tests show the potential of these MoO3 devices as neuromorphic computing elements.

P2-22 Invited
High Sensitivity Magnetometers and Gradiometers Based on Nano-Josephson Junction SQUIDs, *Y. Zhou*, E. Cho*, S. Cybart*, M. Chernyashevskyy**, and I. V. Vernik**, *University of California Riverside, **HYPRES Inc.*

We are developing high sensitivity magnetometers and gradiometers from HTS nano-Josephson junction SQUIDs fabricated with direct-write helium FIB. We simulate, design, fabricate and evaluate magnetometer and gradiometer integrating a helium FIB HTS SQUID and a flux concentrator. This will lead to instrumentation with superior performance and small (SWAP).

Nanofabrication for Energy Sources

P2-23
Irradiation Synthesis of Nanostructured FeSn2-carbon Nanofiber Composites as Highly Stable Anodes for Super-capacitor, *Manman Zhang, Mingwu Fan, Tiaoqin Yu, Jiang Huang, Jun Yang, Long Zhao, Kangjun Xie, Wei Qi*, *Huazhong University of Science and Technology*

P2-24
Flexible photodetector using ambient-processed blade-coated perovskite film on nanostructured polymers, *L. Chen, J. Cai, W. Li, the University of Hong Kong*

We propose a facile approach to directly pattern perovskite nanostructures from its precursor solution in ambient condition. By blade-coating a perovskite layer on a nanostructured plastic substrate, we can not only make a large-area uniform perovskite film but also pattern the perovskite layer simultaneously during the crystallization process.

P2-25
Electrospun Charge Transport Structures for Hybrid Perovskite Solar Cells, *J.P. Murphy, M.C. Brockway, Jessica M. Andriolo, and J.L. Skinner, Montana Tech Nanotechnology Laboratory*

Increasing efficiency in solar cells can be accomplished through increasing the interfacial area between absorber material and charge transport materials in solar cell devices. Electrospun nano-fibers possess remarkably high surface area; nanofibers utilized at absorber/transport material interfaces are expected to increase efficiency in perovskite solar cells.

P2-26
Nanogap Electrochemical Cell for Methanol-Contained Ethanol Solution Detection, *Tse-Hsien Ou, Yifei Wang*, Dan Fang**, S. R. Narayan**, Wei Wu*, Mork Family Department of Chemical Engineering and Material Science, *Ming Hsieh Department of Electrical Engineering, **Department of Chemistry, University of Southern California*

We applied nanogap electrochemical cells (NECs) for methanol and ethanol detection in water solutions. As the different chemical structures between two alcohols, the different activation energies are required for redox. The NECs have enough sensitivity to differentiate methanol and ethanol that can be further applied to fake alcoholic drink detection.

P2-27
Synthesis and supercapacitor performance of polyanilinenitrogen-doped ordered mesoporous carbon composites, *J. Huang, J. Yang, Huazhong University of Science and Technology*

Nanophotonics and Plasmonics

P2-28 Invited
High Sensitivity Optical Biosensor based on silicon dimer arrays, *Z. Liu, T. Pu, J. Niu, L. Shi, C. Xie, Institute of Microelectronics of Chinese Academy of Sciences*

We proposed silicon dimer arrays with low-loss and strong magnetic response as a new biological nanosensor. It's the first time to use silicon nanodimer as the building block for optical sensing metasurface. The spectral sensitivity can be up to 528 nm/refractive index unit (RIU) much higher than the reported 289 nm/RIU.2

P2-29 Invited
Fabrication of stoichiometric silicon nitride devices for nonlinear photonics, *D.A. Westly, Q. Li*, X. Lu*, G. Moille*, B. Ilic, K, Srinivasan, National Institute of Standards and Technology, *University of Maryland*

The top-down fabrication of thick stoichiometric silicon nitride devices for nonlinear photonic applications is presented. We show methods to prevent film cracking and produce low loss input coupling with an oxide lift-off process. Coupling losses, resonator quality factors, and octave-spanning frequency comb generation data are presented.

P2-30
MEMS-stencil lithography for mechanically-tunable infrared metasurfaces on 3D-DLW printed scaffolds, *J. B. Reeves, R. K. Jayne, L. K. Barrett, T. J. Stark, A. E. White, D. J. Bishop, Boston University*

A MEMS based method for patterning 3D-printed polymer scaffolds is described. We demonstrate the precision and utility of the method by fabricating a resonant metallic patterns on a mechanical metamaterial scaffold. In this way, an infrared metasurface with strain-tunable reflectivity is created.

P2-31 Invited
On the Fabrication and Performance of a Diamond Metalens for Imaging Quantum Emitters, *R. Grote, G. Lopez, University of Pennsylvania*

In this work, we explain the process modeling, the fabrication and ultimately the device performance of a diamond metalens that can image an individual quantum emitter, an isolated nitrogen-vacancy (NV) center in diamond, using a dielectric metalens composed of subwavelength pillars etched into the diamond's surface.

P2-32
Solution-processed flexible plasmonic nanodisk arrays for biomolecular detection, *J. Cai, C. Liang, C. Zhang, S. Min, W.D. Li The University of Hong Kong*

A solution-processed cost-effective fabrication process of flexible LSPR sensors was experimentally demonstrated. The fabrication method utilizes residual-layer-free thermal nanoimprint lithography, electrodeposition, and imprint transfer. After immobilization of bovine serum albumin (BSA) proteins, the fabricated LSPR sensor was capable of the detection of anti-BSA proteins with concentrations down to 1 ppm.

P2-33
Continuous Achromatic Flat Subwavelength Grating Lens over whole Visible Bandwidths, *M. Ye, V. Ray, Y. S. Yi, University of Michigan*

Results from simulation, fabrication, and characterization of a novel achromatic micro lens with low-index contrast based nano structures are presented.

P2-34
Focused Ion Beam Fabrication of a Chiral Infrared Polarizer, *S. Norris, N.D. Bassim, T. Folland*, J.D. Caldwell*, McMaster University, *Vanderbilt University*

Valuable new optical devices have been made from patterned structure-based metamaterials. Devices generally require fabrication on a nanometer scale in three dimensions with stringent substrate requirements, making conventional fabrication difficult. Here we present a novel chiral metamaterial fabricated via FIB that transforms an unpolarized mid-infrared source into circular polarized light.

P2-35
Gallium Nitride on Gallium Oxide Substrate for IntegraTED Nonlinear Optics, *Kashif M Awan, Mufasila M Muhammad*, Iman, S. Roqan*, Ksenia Dolgaleva,* University of Ottawa, *King Abdullah University of Science and Technology

In this work, we report on the fabrication of GaN waveguides on Ga2O3 substrate and their optical characterization to assess their feasibility for efficient four-wave mixing (FWM).

P2-36
Plasmonic Enhanced Burst Release from Electrospun Fibers Exposed to Light, *J. M. Andriolo, M. L. Joseph, J. P. Murphy, M. C. Brockway, J. L. Skinner, Montana Tech Nanotechnology Laboratory*

Gold NPs were embedded in polyethylene glycol electrospun polymer fibers and interrogated with light to initiate a plasmonic response of the particles. Such response generates heat that can melt the fibers and release medical treatment contained within the fibers. Efficiency was improved ~40% as compared to non-embedded fibers.

P2-37
Polarization Independent Perfect Reflection metasurface via Mie resonances in Dielectric Nanoclusters, *T. Pu, Z. Liu, J. Niu, L. Shi, C. Xie, Institute of Microelectronics of Chinese Academy of Sciences*

A new type perfect reflection metasurface is demonstrated numerically and experimentally using silicon hexamer as the building block. The perfect reflection property enable dielectric metasurface based on silicon hexamer to become a superior magnetic-based resonance device in nanophotonics applications, such as optical sensor.

P2-38
A Self Contained Portable Surface Enhanced Raman Scattering Needle Probe, *B. Adewumi, S. Basu, D. Biswas, T. Daniels-Race, and M. Feldman, Louisiana State University*

A battery operated hand-held Raman spectrometer is described for clinical applications. It employs surface enhancement at the end of an optical fiber needle probe. An audio signal is available to transmit data by telephone from remote locations for analysis at a central laboratory.

P2-39
Direct Laser Writing of Photonic Devices on a SU-8 Platform, *J. C. Ramirez, Vanessa P. Gomes, C. A. Finardi, R. R. Panepucci, Center of Information Technology Renato Archer*

In this work we describe the direct laser writing of su-8 photonic devices at 405 nm using H-nu 470 photoinitiator for rapid prototyping of photonic devices.

P2-40
Non-linear Optical Metamaterials over Multiple Wavelength Ranges for Ultrafast and Secure Communication, *Y. Li, V. Jankovic*, P. Hu, M. Knight*, P. Hon*, W. Wu, University of Southern California, *Northrup Grumman Corporation*

We propose to demonstrate metamaterials with high non-linearity at optical and microwave frequency simultaneously for the first time. The property is crucial for realizing nonlinear mixer in the optical superheterodyne receiver. We predict that it will take a significant leap of Si photonics.

Advanced Ion Beam Technologies

P3-01

Effect of 120 MeV Ti^{+9} ion irradiation induced modifications in structural, optical, morphological and electrical properties of titanium dioxide and tin oxide nanocomposite thin films, *Vikas Kumar, N. Koratkar* and Rajesh Kumar,* Guru Gobind Singh Indraprastha University, *Rensselaer Polytechnic Institute

In the present communication, we have study the effect of swift heavy ion induced modification in nanocomposite thin films of tin oxide (SnO_2) & Titanium Dioxide (TiO_2). Key Words: SHI, UV-Visible, XRD, I-V, AFM, RBS.

P3-02

Using FIB/SEMs to Investigate Biological Samples, *A. Wolff[1], Y.Zhou[2,4)], J.Lin[3,4], Y.Peng[5], J.Ramshaw[5,6], Y.Xiao[2,4], [1]Queensland University of Technology (QUT), [2]Institute of Health and Biomedical Innovation, Queensland University of Technology (QUT), [3]Department of Implantology, Xiamen Stomatological Research Institute, Xiamen Stomatological Hospital, [4]The Australia-China Centre for Tissue Engineering and Regenerative Medicine (ACCTERM), Queensland University of Technology, [5]CSIRO Manufacturing, [6]University of Melbourne*

FIB/SEMs have become the "go to" tool in material science and semiconductor industry. This study looks at the physics behind the ion-solid interactions and derives a technique which allows the tool to be used on soft materials like polymers and biological samples without causing heat damage.

P3-03

Dynamics of Graphene Milling Using the Helium Ion Beam, Songkil Kim[1,2], Anton V. Ievlev[1,2], Ivan V. Vlassiouk[3], Matthew J. Burch[1,2], Ondrej E. Dyck[1,2], Xiahan Sang[1,2], Raymond R. Unocic[1,2], Alex Belianinov[1,2], Sergei V. Kalinin[1,2], Stephen Jesse[1,2] and Olga S. Ovchinnikova[1,2], [1]Oak Ridge National Laboratory, [2]Institute for Functional Imaging of Materials, Oak Ridge National Laboratory, [3]Energy & Transportation Science Division, Oak Ridge National Laboratory, Oak Ridge

This talk describes the dynamics of graphene milling using a Helium Ion beam.

Beam Induced Processes

P3-04 Invited
Process condition dependence of liquid-phase focused electron beam induced etching of copper, *S. K. Lami, G. Smith, E. Cao, J. T. Hastings, University of Kentucky*

This work focuses on 1-Investigating the effect of liquid thickness on the process of liquid phase electron beam induced etching of copper as a function of process variables.2-Developing a predictive model through utilizing JMOSEL Monte Carlo analysis for electron interaction with liquid coupled with COMSOL for mass transport modeling.

P3-05
Latest development for failure analysis – When ions meet chemistry, *G. Goupil, A. Delobbe, Orsay Physics T. Hrncir, Sharang, Tescan Brno P. Gounet, STMicroelectronics*

To reach and observe impending failure in a semiconductor, FIB processing is one of the most reliable sample nano-preparation method existing. Coupled with a special gas injected at the surface, the area of interest is perfectly smoothed and prepared for probing.

P3-06
Focused He^+ Ion Beam Induced Implantation and Damage in Si - A Preliminary Study, *Rongrong Li, Rui Zhu*, Jun Xu, Electron microscopy lab, Peking University*

Physical mechanism of focused He ion beam induced damages and implantations under different doses in crystal silicon was studied by aberration-corrected TEM and Monte Carlo simulations. Nano-sized bubbles and local defects were observed in different implanted areas. A schematic physical process was proposed to illustrate the phenomena.

P3-07
Fine-Tuning Nanowire Shape Using 3D Focused Electron Beam Induced Deposition, *E. Mutunga, P.D. Rack*, J.D. Fowlkes*, The University of Tennessee, *Oak Ridge National lab, H. Plank*, R. Winkler*, Graz University of Technology, *Graz Center for Electron Microscopy*

A 3D FEBiD multi–path exposure procedure used to modify nanowire cross–section from non-circular shapes to circular during nanowire growth.

P3-08
Characterization of Helium-Ion Machined Fluidic Structures, *J.R. Wilson, K.L. Klein, L. Barner,* A.E. Vladár, **University of the District of Columbia, *Messiah College, **National Institute of Standards and Technology*

We have developed new methods for producing fluidic structures via a direct-write process in silicon using the focused helium ion beam. This paper presents the characterization and testing of these nanofluidic structures, which could lead to rapid-prototyping of complex fluidic devices.

P3-09
Radiation synthesis of 2-aminomethyl pyridine functionalized adsorbent and its application for perrhenate removal, *W.Qi, L.Zhao, Huazhong University of Science and Technology*

Electron and Ion Beam Sources and Optics

P3-10
Achieving highly accurate adjoint sensitivities for charged particle optics: design, optimization and tolerancing, *P. Hansen, L.T. Neustock, L. Hesselink, Z.E. Russell*, Stanford University, *Ion Innovations*

We calculate accurate design sensitivities for charged particle optics using a purpose-built discrete adjoint finite element code and adjoint charged particle dynamics code. Sensitivity to electrode shapes is calculated at hundreds of surface points. Discrete adjoint tools outperform continuous adjoint calculations built with existing software.

P3-11
Laser-cooled lithium as a bright source for focused ion beam microscopy, *J. R. Gardner, W. M. McGehee, J. J. McClelland, Center for Nanoscale Science and Technology, National Institute of Standards and Technology*

Progress is reported on a second-generation magneto-optical trap ion source (MOTIS) for nanoscale lithium ion microscopy. In addition to secondary electron and ion backscatter microscopy, a lithium focused ion beam (FIB) can be used for
precise ion implantation, allowing uniquely detailed studies of ion dynamics.

P3-12
Control of photoemission properties from NEA-GaAs surfaces by repetitive thermal pretreatments, *Y. Inagaki, K. Tanaka, H. Iijima, T. Meguro, Tokyo University of Science*

We have investigated photoemission properties of GaAs surfaces prepared by repetitive thermal pretreatment and negative electron affinity (NEA) activation cycles. It is shown that the photoemission efficiency (QE) drastically varied with the pretreatment sequence.

P3-13
Preparation of Ga-terminated NEA-GaAs (100) surface by HCl-isopropanol treatment for nano-analysis by STM, *R.Fukuzoe, M.Hirao, D.Yamanaka, Y.Iwabuchi, H.Iijima, and T.Meguro,Tokyo University of Science*

Negative electron affinity(NEA) photocathodes are expected to be next generation electron emission source. NEA-surface are made by adding Cs and oxygen alternatingly onto the clean GaAs-surface. STM is used to investigate surface morphology of GaAs(100)surfaces prepared by HCl-isopropanol(HCl-iPA) treatment and annealing in UHV. The method indicates improvement in surface quality.

P3-14
Analysis of Cs Layer on InGaN by Temperature-Programmed Desorption Method, *Multiple authors different affiliations: M.Kashima, D.Sato*, A.Koizumi*, T.Nishitani**, Y.Honda***, H.Amano***, H.Iijima, T.Meguro,Tokyo University of Science, *Photo electron Soul Corp., **Institute for Advanced Research, Nagoya University, ***Institute of Materials and Systems for Sustainability, Nagoya University*

The adsorption states of Cs on the p-InGaN(0001) forming the negative electron affinity (NEA) surface were investigated by the temperature-programmed desorption (TPD) method using a quadrupole mass spectrometer. The photocurrent emitted by illuminating a 406-nm laser diode was monitored through the NEA activation and the following TPD measurement.

P3-15
Selective hydrogen ion beams from nano-structured emitters, *R. Urban, K. Nova, M. Salomons*, R. Wolkow, J. Pitters*, University of Alberta, *National Research Council of Canada*

Hydrogen ion beams are useful for scanning ion microscopy and rely on nanotip GFIS emitters. However, a mixture of H^+, H_2^+ and H_3^+ is generated depending on the tip structure and operating parameters. We will discuss reaction conditions and operating constraints for various tips and the production single ion species.

P3-16
Variation of field of view according to Si deflector shape in a microcolumn, *H.W. Kim, Y.B. Lee, D.W. Kim, S.J Ahn, T.S Oh, H.S Kim, Sun Moon University*

We have fabricated a modified Si deflector by changing the size of deflector electrodes.The influence of electrode size on the field of view will be discussed.

P3-17 Invited
Determination of aberration coefficients in an SEM using electron ptychographic imaging, *A. Agarwal, Hector Iglesias*, Chung-Soo Kim, Karl K. Berggren, Department of Electrical Engineering and Computer Science, Massachusetts institute of Technology, *Department of Physics, Massachusetts institute of Technology*

We have used electron ptychographic imaging to extract the coefficient of spherical aberration (Cs) from a 200 kV electron beam. Our extracted Cs is 1 mm, which is about a factor of two larger than the tool's specified Cs.

Imaging and Characterization

P3-18 Invited
Applying Helium Ion Microscopy to Study Alport Syndrome in Mice, *Kenji Tsuji*, Jeffrey H. Miner**, James M. Daley***, John Notte****, Teodor G. Păunescu*, Hua A. Jenny Lu*, *Massachusetts General Hospital, and Harvard Medical School; **Washington University School of Medicine, *** Research Laboratory of Electronics at Massachusetts Institute of Technology, **** Carl Zeiss Microscopy*

The kidney is imaged at high magnification, with no metal coating, to reveal 20 nanometer features that are essential for the kidney's proper function as a filter. The helium ion microscope reveals these details to help understand the differences between healthy kidneys and kidneys affected by Alport syndrome.

P3-19
Electrical Biasing Transmission Electron Microscope Sample Holder Compatible with Focused Ion Beam Sample Cleaning, *F. Camino, M. Lu, M-G Han, Brookhaven National Laboratory*

We present an electrical biasing TEM holder on which FIB lift-out samples are mounted in a flag-style fashion, with both sides of the lamella available for FIB cleaning after electrical contact definition. The holder does not require a sample support layer and minimizes stray capacitance and leakage current contributions.

P3-20

Polymer-Metal Coating for high contrast SEM cross sections towards single-digit nanoscale imaging, *D. Staaks*'**, D.L. Olynick*, I. W. Rangelow**, M.V.P. Altoe*, *LBNL - Molecular Foundry, **Ilmenau University*

In scanning electron microscopy (SEM), imaging nanoscale features by means of the cross-sectioning method becomes increasingly challenging with shrinking feature sizes. In this work we present a new composite sample preparation method for high performance cross-sectional SEM imaging.

Multibeam and High Throughput Imaging Instruments

P3-21 Invited
SIMS performed on the Helium Ion Microscope: new prospects for highest spatial resolution imaging and correlative microscopy, *J.-N. Audinot, J. Notte*, T.Wirtz, LIST, *Zeiss*

We have developed a Secondary Ion Mass Spectrometry system specifically designed for the Helium Ion Microscope. Here, we will present a number of examples taken from various fields of materials science and life science to show the powerful analytical capabilities and correlative microscopy possibilities enabled by the integrated HIM-SIMS instrument.

P3-22
Impact of image contrast on pattern inspection using electron microscopes, *S. Iida, T. Uchiyama, Evolving nano process Infrastructure Development Center, Inc.,(EIDEC)*

Impact of electron image contrast on defect detection capability was investigated. The image contrast is affected by pattern size and charging effect. Our developed inspection algorithm allows detection of sub-10-nm-sized defects on hp 45 nm and hp16 nm LS patterns.

P3-23
Effects of Lithographic Parameters in Massively-Parallel Electron-beam Systems, *S. Moon, S.-Y. Lee, J. Choi*, S.-B. Kim*, I.-K. Shin* C.-U. Jeon, Auburn University, *Samsung Electronics*

The effects of lithographic parameters such as the beam size and blur, the exposing interval, the probability for a beam to be faulty, etc. on the writing quality and efficiency, e.g., dose latitude, line edge roughness (LER), and total dose required have been investigated through simulation.

Emerging Technologies

P4-01

Fabrication of magnetic nanostructures for real-time manipulation of ferrofluid, *Z. Luo, B. Evans*, C. Chang, NC State Univ., *Elon Univ.*

A fabrication method for magnetic periodic pillar array is reported here. The structure can be used to manipulate nanoparticle assembly in real-time, resulting in a tunable photonic structure. We will present detailed fabrication and particle assembly results.

P4-02

Microfabricated Registration Marks for Automated Location Calibration, *D. Klyachko, J. Spallas, L. Muray*, Keysight Technologies, *KLA-Tencor*

Location Finder sample embedding a 2D bit pattern is designed and used for calibrating the displacement of SEM images in the presence of electric field. The design of the sample allows to scale it to sizes compatible with optical and particle beam applications.

P4-03

Thin-Film Characterization on a Novel Wrinkled Elastomeric Substrate with Applications in Force Sensing, *Zakareya Hussein, Atif Syed*, Vasileios Koutsos, University of Edinburgh, *Netrologix Ltd*

This submission demonstrates the use of novel wrinkle patterned stretchable substrate for emerging pressure sensing applications and characterises the behaviour and fatigue of Au thin-films of different thicknesses sputtered on top subjected to cyclic tensile strain tests. Furthermore, Stencils are used as shadow masks to fabricate compact stretchable strain gauges.

P4-04

Wetting Properties of Hybrid Zinc Oxide Nanostructures, *Atif Syed, Netrologix Ltd, Dimitrios Mamalis, Khellil Sefiane, Vasileios Koutsos, School of Engineering, The University of Edinburgh, Enrico Mastropaolo, School of Engineering, Institute for Integrated Micro and Nano System, The University of Edinburgh*

In this work, we present the synthesis and characterization of unique ZnO nanowires (NWs) on nanoplate (NP) nanostructures (ZNWNP). These nanostructures were synthesized using a one-step process. The nanostructures
exhibited a high degree of hydrophobicity without the need of any functionalisation. In-depth wetting properties are presented.

Process Simulation and Modeling

P4-05
The Importance of High-Level Simulation in the Co-Design of Neuromorphic Systems, *C. Schuman, A. Belianinov, P. Collier, Oak Ridge National Laboratory*

Nanodevices are frequently proposed for neuromorphic systems, but their impact on application performance is not well-understood. We connect low-level device modeling with high-level simulations that allow for understanding the impact of device behavior on real application performance and to drive innovation at both the device level and the application level.

P4-06
Simulation assisted separation of stochastic effects in EUV lithography and their contribution to line edge roughness and defectivity, *Ulrich Welling, Georg Viehoever, Thomas Muelders, Hans-Jurgen Stock*

In this work we use simulations to show the influence of the stochastic effects (shot noise and PEB) on the pattern formation in EUV in the resist and separate their influence on LER and defectivity.

P4-07
Polymer filling and mold durability for different shape cavities in nanoimprint lithography, *Qing Wang, Lijun Ma, Shandong University of Science and Technology*

The effects of different shape cavities on polymer filling and mold durability are investigated. Research results show that mold with semicircular cavity can achieve complete filling under a little pressure, but the maximum Von Mises stress is greater than that of the other twoshape cavity molds.

P4-08
Limits of model-based CD-SEM metrology, *J. Belissard, J. Hazart, S. Labbé*, F. Triki*, CEA-Leti, *Université Grenoble-Alpes*

The CD-SEM is the most general purpose tool used for non-destructive metrology in the semiconductor industry. However, we are now dealing with patterns dimensions in the same order of magnitude as the electron interaction volume and the usual edge-based metrology methods fail. This paper analyses limits of model-based metrology methods.

P4-09
Effect of Homopolymer Additive Molecular Weight on the Patterning Behavior of Directed Self-Assembly of Block Copolymer-Homopolymer Blends, *J. B. Delony**, C.L. Breaux*, P. J. Ludovice*, C.L. Henderson**, *Georgia Institute of Technology, **University of South Florida*

Startup Contest

P5-01
A start-up concept: Commercializing MESOTAS-SIEVE Brain-on-chip technology in neuropharmaceutical drug development, *A. Bastiaens, R. Luttge, Eindhoven University of Technology*

P5-02
Nanskin - Novel electronic skin for robotics application, *Atif Syed, Zakareya Hussein, Netrologix Ltd*

P5-03
Opto-Thermionic Cathodes for AweSEM, *C. Kuzyk, C. Aiello*, F. Pease*, M. Chang, K. Jessen, A. Nojeh, University of British Columbia, *Stanford University*

P5-04
Surface Roughness Improvement in EUV Mask Materials, *S.L. Jaiswal, D. Humphrey, A. Sumitro, L. Zhang, P. Shah, E. Kirillova, Astrileux Corporation*