EIPBN

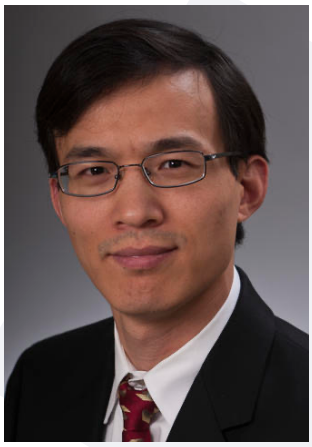
SAN FRANCISCO 2023

Program

The 66th International Conference on Electron, Ion, and Photon Beam Technology and Nanofabrication

Hilton San Francisco Union Square

A Letter from the EIPBN 2023 Program Chair



Qiangfei Xia

May 23, 2023

Dear EIPBN Community,

Welcome to the 66th International Conference on Electron, Ion, Photon Beam Technology and Nanofabrication (EIPBN).

While the COVID-19 pandemic appears to be over, the lasting social, economic, and psychological impact has imposed challenges worldwide including to our community. Yet technological innovation has advanced at a rapid pace. And the irresistible glamor of San Francisco, evidenced by her vibrant culture and innovative spirit, has attracted all of us, including some old-timers who attended the last 3-Beam conference held in SF 49 years ago. This year we have over 400 attendees from 20 countries attending to celebrate these technology breakthroughs at this premier event in our community.

My EIPBN journey started in 2003 when Tim Groves and Mark Schattenburg organized a fantastic conference in Tampa, Florida. At that time, I did not have anything to present, but my Ph.D. advisor Steve Chou at Princeton generously offered junior graduate students like myself the opportunity to attend the best conference in our field. I practice the same tradition with my students. The new technologies and tools I was exposed to in the past 20 years at EIPBN have inspired many of our research projects. The ability to make novel devices and circuits has enabled us to contribute to my current research field, emerging AI hardware. I credit EIPBN for my career development.

EIPBN cannot thrive or even survive without our loyal and generous exhibitors and sponsors who continue to support us. Thank you to our Platinum Sponsors Raith and STS-Elionix; our Silver Sponsors AllResist and Heidelberg Instruments; our Bronze Sponsors GenIsys, JEOL, and Lab14; and all our exhibitors and sponsors: Amuneal, Applied Quantum Materials, Beamfox, Cleanroom Labware, Crestec, Cornell Nanofab, DisChem, EV Group, High RI Optics, ibss Group, Ion Innovations, IonOptika, Jenoptik, KLA, MAEBL, Electron Optica/MEBS, Nanonex, Nanoscribe, NuFlare, PBS&T, Quantum Design, Research, SAES, TEL, Tetramem, TESCAN, Tousimis, UC Components, UpNano, Vibration Engineering Consultants, Vistec, WaferWorld, ZEISS, Zyvex Labs, and ZEON. I also thank government agencies, including AFOSR, DOE, NSF, and ONR, for supporting our student attendees.

Our Program Chair Chih-Hao started his first EIPBN the same year as me. This may partly explain why I thoroughly enjoy working with him. With his creativity and hard work, Chih-Hao has put together a fascinating program with a stellar lineup of speakers that even impressed our government sponsors. Thank you, Chi!

I am grateful to the rest of the caring and capable Steering Committee: Gerald Lopez, Martha Sanchez (Women in Nanofabrication Chair), James Spallas, Rob Illic, Aimee Price (Commercial Session Chair), Wei Wu (Startup Contest Session and Contest Chair), James Owen, and Rick Silver (Short Course Chair). I am also indebted to John Randall, our Financial Trustee, who gave me peace of mind as I scratched my head over the balance sheet; Denise Hayner, our Corporate Accountant; Melissa Widerkehr and Jonni Adams, our Conference Coordinators; Nichole Ballard, our Registrar at YesEvents; and Nicki Davis, our Conference Website Manager and Guidebook App builder. I am appreciative of the incredible contribution of our volunteers, including Xiaogan Liang (Startup Session and Contest), Gina Adam (Women in Nanofabrication), and Guy DeRose (Commercial Session). I am thankful to the Advisory Committee for their continued support and dedication to the conference and the community.

Finally, thank you to all members of the EIPBN Community for joining us this year in San Francisco. Enjoy the conference!

Qiangfei Xia, EIPBN President and Conference Chair
Professor of Electrical and Computer Engineering, UMass Amherst

A Letter from the EIPBN 2023 Program Chair

Chih-Hao Chang

Friday, May 19, 2023

Dear EIPBN Community,

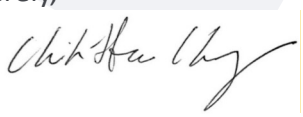
My first EIPBN conference was in 2003 when I was a graduate student. The conference was held in Tampa and chaired by Timothy Grooves and my advisor Mark Schattenburg. What attracted me from the beginning, and the reason why I believe EIPBN still stands out among academic conferences, is the close-knit community where researchers at all stages of their career can have open discussions in intimate settings. It is truly a privilege and an honor to serve as the EIPBN Program Chair 20 years later. I hope the welcoming atmosphere and that attracted me so many years ago can also be found at this conference.

The theme of this year's conference is "Nanofabrication and Integration for the AIoT Era: Challenges and Opportunities." Since the 70s, Moore's Law has guided the semiconductor industry and EIPBN in the push towards ever finer features. As the scaling ran into challenges imposed by physical limitations, the question is where does EIPBN go from here? In an age where the technology buzz words are AI, big data, and metaverse, how can EIPBN contribute? If you look at this year's program, the opportunities are abundant. You will learn about emerging computing architectures such as quantum devices, neuromorphic hardware, nanoelectronics, and nanomagnetics. You will hear about the advances at the forefront of nanolithography using electrons, ions, photons, imprint, and scanning probes. You will see leading researchers presenting work on emerging applications in nanophotonics, plasmonics, metasurfaces, MEMS/NEMS, microfluidics, and biomedical devices. These opportunities are also reflected in our three Plenary Speakers, Dario Gil, Teri Odom, and Ali Javey, who will tell us their perspectives on the future of computing and the role of quantum information, nanophotonics for emerging optoelectronic, energy, and biomedical applications, and wearable nanosensors and big data to monitor human health, respectively.

The program includes a conference-wide Panel Discussion Session titled "The CHIPS Act and the Future of US Semiconductor Manufacturing." The semiconductor industry is going through a rapid transformation and the goal of the panel is to have an open discussion on the challenges and opportunities of semiconductor research, education, and production. The program will continue to include popular networking events including the Welcome Reception, the Commercial Lightning Talks, the Women in Nanotechnology (WIN) Luncheon, Conference Banquet, and the Student Mentor Lunch, where you can mingle and exchange ideas with other attendees.

It has been a pleasure to organize EIPBN 2023 with Qiangfei, the Conference Chair, who showed extreme dedication pondering over every minute of the program, every inch of the event space, and every dollar in the budget. I also want to thank all the members of the Steering and Program Committee, EIPBN 2023 would not be possible without your dedication. I especially want to thank Gerald Lopez and Martha Sanchez for steering the ship and keeping the community engaged during the turbulent Covid pandemic year. I also want to thank James Spallas and Rob Ilic for successfully transitioning the conference back to an in-person event last year. The EIPBN community was able to weather the storm and has gotten stronger because of these four individuals. Thank you for all the invited speakers and panelists, we appreciate you sharing your expertise and perspective.

Sincerely,



Chih-Hao Chang, EIPBN 2023 Program Chair
Associate Professor and Temple Foundation Endowed Teaching Fellowship in Engineering #1
Walker Department of Mechanical Engineering, University of Texas at Austin

About EIPBN 2023

The International Conference on Electron, Ion, and Photon Beam Technology and Nanofabrication (EIPBN), affectionately known as “3-Beams,” is the premier gathering of scientists and engineers who are dedicated to electron, ion and photon lithography, imaging, and analysis; nanofabrication process technologies; atomically precise fabrication; related emerging technologies; and their applications in a broad spectrum of fields. This is the 66th meeting of the EIPBN, where top researchers from academia, government laboratories, and industries from around the world meet to present and discuss recent trends and future innovations in these technologies.

EIPBN is incorporated as a nonprofit organization in the state of New Jersey. The ten-member Steering Committee serves as the corporate Board of Directors. Each year, two distinguished members from the EIPBN community are elected to serve a five-year term. New members participate in the organization of the conference for the first two years. In the third year, they run the meeting as either the Conference or Program Chair. In the final two years, they assist the successor chairs in their duties. Upon completion of their five-year term, Steering Committee members become permanent members of the Advisory Committee.

The 2023 Steering Committee members are Qiangfei Xia, Chih-Hao Chang, James Spallas, Rob Ilic, Gerald Lopez, Martha Sanchez, Aimee Price, Wei Wu, James Owen, and Richard Silver.

EIPBN SAN FRANCISCO 2023

EIPBN is sponsored by two distinguished societies: the American Vacuum Society and the IEEE NANO.

The special events at this year’s conference are highlighted below.

Short Courses
(Tue, May 30, 8:00 am - 2:10 pm)

This event features five lectures given serially by leading authorities in their field of expertise and is a perfect opportunity to further your knowledge of nanofabrication processes and applications.

Startup Session and Contest
(Tue, May 30, 2:30 pm - 3:30 pm)

The EIPBN 2023 Startup Contest is designed to support entrepreneurs, students, research staff, and faculty transition early-stage technologies from the lab into scalable ventures. Entry is open to startups at any stage of development.

Welcome Reception
(Tue, May 30, 7:00 pm - 9:30 pm)

The Welcome Reception will feature small hot bites and drink, and an opportunity to relax, mingle, get reacquainted with colleagues and make new friends. The reception is located in the Golden Gate Ballroom.

About EIPBN 2023

Women in Nanofabrication Luncheon (Thu, June 1, 12:10 pm - 1:40 pm)

Women in Nanofabrication (WIN) is a networking event that brings together women in science and engineering from around the world. This luncheon enhances the fields of lithography and nanotechnology through diversity and inclusion.

CHIPS Panel Discussion (Thu, June 1, 4:30 pm - 6:00 pm)

The CHIPS Panel is a conference-wide event organized to enable an open forum on the US semiconductor research, education, and production. The session will be led by moderator and panelists from industry, government research laboratory, and academia.

EIPBN Banquet (Thu, June 1, 7:00 pm - 10:00 pm)

The 2023 Banquet will be on Thursday, June 1, in the Imperial Ballroom in the Hilton San Francisco Union Square Hotel. The Banquet will feature the Sueños Jazz Band, a Bay Area band that blends classic jazz with modern styles

Student Mentor Lunch (Fri, June 3, 12:00 pm - 1:30 pm)

The Student Mentor Lunch gives students a chance to hear from professionals in academia, government labs and industries. They can learn beneficial information that will help guide them as they grow in their fields. It's a chance to hear from the experts why they chose their field, what it takes to get there, and what it's really like once they arrived. The Student Mentor Lunch also features a speaker who provides an expert "how to" discussion on a new topic each year.

Micrograph Contest

EIPBN holds an annual micrograph contest to highlight the importance of micrographs. Micrographs need not be related to research or to any paper or topic presented at the conference. Submissions may be purely for their beauty and ability to excite curiosity.

The EIPBN Best Student Paper Award

This annual competition highlights outstanding student contributions and fosters the next generation of leaders in the EIPBN community. The competition includes two categories: The Best Student Poster Award and The Best Student Presentation Award.

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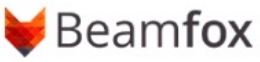
Generous Support for this Conference is Provided by

Exhibitors



EIPBN 2023 Program At-A-Glance

This year's theme is "Nanofabrication and Integration for the AIoT Era: Challenges and Opportunities." The conference opens on Tuesday with the Short Course Session followed by the Startup Session and Contest. The 3-day Commercial Session begins next, featuring 32 exhibitors. Pick-up your game cards at the registration desk and play Exhibitor Bingo to win a $100 cash prize. The EIPBN Welcome Reception is in the Golden Gate Ballroom.

Wednesday begins with the Plenary Session followed by the Poster Session, which will continue through Thursday afternoon. The technical program consist of three parallel oral sessions. This year's program will include a conference-wide Panel Discussion Session on "Challenges and Opportunities: The CHIPS Act and the Future of US Semiconductor Manufacturing" Thursday afternoon. The Conference Banquet is Thursday evening. The conference program also includes several focused workshops and networking events including the Welcome Reception, the Women in Nanotechnology (WIN) Luncheon, and the Student Mentor Lunch.

EIPBN will host the annual Best Student Poster and Best Student Presentation competitions, which are generously sponsored by JEOL. Winners will receive a $500 cash prize and a plaque commemorating their achievements. The Best Student Award winners will be announced at the Conference Banquet.

Local Time	Tuesday, May 30, 2023	Room
7:00am - 6:00pm	**Registration**	East Lounge
8:30am - 3:00pm	**GenISys Breakfast and User Meeting**	Continental 1-3
8:30am - 8:35am	**Short Course Session** *Welcome and Opening Remarks;* Rick Silver, National Institute for Standards and Technology	Continental 4
8:35am - 9:30am	**Short Course 1** *Micro-Resonating Sensors;* Rebecca Cheung, University of Edinburgh	
9:30am - 10:25am	**Short Course 2** *Characterization and Metrology of 3D Semiconductor Structures using X-Ray and Optical Methods;* Alain Diebold, SUNY Polytechnic Institute	
10:25am - 10:40am	**Coffee Break Sponsored by Crestec and AllResist**	Continental 4
10:40am - 11:35am	**Short Course 3** *Atomically Precise Manufacturing of Silicon Quantum Devices;* Joris Keizer, University of New South Wales	Continental 4
11:35am - 12:30pm	**Short Course 4** *Challenges Facing Continued EUV Scaling: Materials Are the Key;* Patrick Naulleau, Lawrence Berkeley Laboratory	
12:30pm - 1:15pm	**Short Course Lunch**	Continental 7-8
1:15pm - 2:10pm	**Short Course 5** *Fabrication of Semiconductor Spin Qubits for Quantum Computing;* Daniel Ward, HRL Laboratories	Continental 4
2:15pm - 2:30pm	**Coffee Break Sponsored by TetraMem**	Continental 4
2:30pm - 3:30pm	**Startup Session and Contest Sponsored by TetraMem** *Welcome and Opening Remarks;* Wei Wu, University of Southern California	Continental 4
2:35pm	**Startup Keynote:** "***From Bio to Nano, From Idea to IPO***" Han Cao, Co-founder, President and CEO, Dimension Genomics	
4:00pm - 8:00pm	**Commercial Exhibit**	Golden Gate
4:00pm - 6:00pm	**Exhibitor Reception Sponsored by KLA and STS Elionix**	Golden Gate
7:00pm - 9:30pm	**Welcome Reception - Bar Sponsored by Raith**	Golden Gate

EIPBN 2023 Program At-A-Glance

Local Time	Wednesday, May 31, 2023	Room
6:45am - 7:30am	**Session Chair Breakfast**	Continental 8
7:00am - 5:00pm	**Registration**	East Lounge
8:00am - 8:30am	**Plenary Session** *Welcome, Opening Remarks, and Announcements;* Qianfei Xia (Conference Chair), University of Massachusetts at Amherst & Chih-Hao Chang (Program Chair), University of Texas at Austin Session Chair: Chih-Hao Chang, University of Texas at Austin	Continental 5-6
8:30am - 9:15am	**Plenary 1** *What's Next in Computing: Scaling with Classical + Quantum Information;* Darío Gil, IBM	
9:15am - 10:00am	**Plenary 2** *Scalable Nanofabrication for Functional Nanophotonics;* Teri Odom, Northwestern University	
10:00am - 10:45am	**Plenary 3** *Wearable Sweat Sensors - Towards Big Data for Human Health;* Ali Javey, University of California Berkley	
10:45am - 11:00am	**Coffee Break Sponsored by SAES and Zeiss**	Golden Gate
10:00am - 5:00pm	**Commercial Exhibit**	Golden Gate
10:45am - 1:10pm	**Poster Session and Best Student Poster Competition**	Golden Gate
12:15pm - 1:10pm	**Lightning Talk Session with Lunch Sponsored by Cleanroom Labware**	Golden Gate
12:00pm - 1:10pm	**Advisory Committee Lunch Meeting**	Continental 7
12:00pm - 1:00pm	**Raith Lunch & Learn: Laser Lithography (register at Raith booth)**	Continental 9
1:20pm - 3:10pm	**Technical Session 1A - Nanoelectronics and Nanomagnetics** Session Chairs: Henry Smith (MIT), Daniel Ward (HRL labs)	Continental 4
1:20pm - 3:10pm	**Technical Session 1B - Optical and Direct-Write Lithography** Session Chairs: Todd Hastings (University of Kentucky), Li Jiang (Tuskegee University)	Continental 5
1:20pm - 3:10pm	**Technical Session 1C - Nanobiology** Session Chairs: Stella Pang (City University of Hong Kong), Regina Luttge (Eindhoven U. of Tech.)	Continental 6
3:10pm - 3:30pm	**Coffee Break sponsored by GenISys**	Golden Gate
3:30pm – 5:20pm	**Technical Session 2A - Electron Beam Lithography 1** Session Chairs: Dieter Kern (University of Tuebingen), Gerald Lopez (University of Pennsylvania)	Continental 4
3:30pm – 5:20pm	**Technical Session 2B - Metasurface/Meta-Optics** Session Chairs: Wei Wu (U. of Southern California), David Czaplewski (Argonne National Lab)	Continental 5
3:30pm – 5:20pm	**Technical Session 2C - Directed Self-Assembly** Session Chairs: Alex Liddle (NIST), James Watkins (University of Massachusetts Amherst)	Continental 6
5:20pm - 7:00pm	**Poster Session Reception Sponsored by STS-Elionix and Nanonex**	Golden Gate
6:00pm - 8:00pm	**STS Elionix User Dinner (invitees by STSElionix)**	Continental 1-2
6:00pm - 9:00pm	**Raith Technical User meeting (register at Raith booth)**	Continental 8-9
7:00pm - 10:00pm	**JEOL User Dinner (invitees by JEOL)**	Continental 3
7:00pm - 10:00pm	**Chairman's Reception (by invitation only)**	Vista Room (45th floor)

EIPBN 2023 Program At-A-Glance

Local Time	Thursday, June 1, 2023	Room
6:45am - 7:30am	**Steering Committee Breakfast**	Continental 7
7:00am - 5:00pm	**Registration**	East Lounge
8:00am - 9:50am	**Technical Session 3A - Electron and Ion Beam Sources** Session Chairs: Carla Perez Martinez (University College London), Vitaliy Guzenko (PSI)	Continental 4
8:00am - 9:30am	**Technical Session 3B - Metrology and Characterization 1** Session Chairs: Larry Muray (KLA), Chih-Hao Chang (U. of Texas at Austin)	Continental 5
8:00am - 9:30am	**Technical Session 3C - Industrial Highlights** Session Chairs: Aimee Price (The Ohio State U.), Guy DeRose (California Institute of Technology)	Continental 6
9:50am - 10:20am	**Coffee Break sponsored by Vistec**	Golden Gate
10:00am - 1:00pm	**Commercial Exhibit & Poster Sessions**	Golden Gate
10:20am -12:10pm	**Technical Session 4A - Electron Beam Lithography 2: Optics** Session Chairs: Ivan Kravchenko (Oak Ridge National Lab), Adam Steele (ZeroK Nanotech)	Continental 4
10:20am -12:10pm	**Technical Session 4B - Nanophotonics and Plasmonics 1** Session Chairs: Chao Wang (Arizona State University), Wen-Di Li (Hong Kong University)	Continental 5
10:20am -12:10pm	**Technical Session 4C - Bioinspired Nanostructures** Session Chairs: Nichole Cates (Smart Material Solutions), Saba Ghassemi (U. of Pennsylvania)	Continental 6
12:10pm - 1:40pm	**Women in Nanofabrication (WIN) Luncheon Sponsored by Heidelberg, Raith, AllResist, and KLA**	Continental 8-9
12:10pm - 1:40pm	**Lunch on your own**	
1:40pm – 3:30pm	**Technical Session 5A - Neuromorphic Computing** Session Chairs: John Randall (Zyvex Labs), Gina Adam (George Washington University)	Continental 4
1:40pm – 3:30pm	**Technical Session 5B - EUV/X-ray Lithography and Optics** Session Chairs: Alain Diebold (SUNY Polytechnic Institute), Martha Sanchez (Applied Materials)	Continental 5
1:40pm – 3:30pm	**Technical Session 5C - Nanoimprint Lithography** Session Chairs: Stephen Chou (Princeton University), Bruno Azeredo (Arizona State University)	Continental 6
3:30pm - 4:30pm	**Coffee Break sponsored by STS Elionix**	East Lounge
4:30 pm - 6:00pm	**Panel Discussion Session on "Challenges and Opportunities: The CHIPS Act and the Future of US Semiconductor Manufacturing"** Session Chairs: Shida Tan (Intel) Panelists: J. Alex Liddle (NIST), Qing Wu (Air Force Research Lab), Shawn Siddoway (Micron Technology), SV Sreenivasan (U. of Texas at Austin)	Continental 5-6
6:00 pm - 7:00pm	**Break**	
7:00pm - 10:00pm	**Banquet and Award Ceremony - Bar Sponsored by Lab14**	Imperial Ballroom

EIPBN 2023 Program At-A-Glance

Local Time	Friday, June 2, 2023	Room
7:00am - 12:00pm	**Registration**	East lounge
8:00am - 9:50am	**Technical Session 6A - Atomically Precise Fabrication** Session Chairs: Joris Keizer (University of New South Wales), Richard Silver (NIST)	Continental 4
8:00am - 9:50am	**Technical Session 6B - Scalable Nanomanufacturing** Session Chairs: Jack Skinner (Montana Technological University), Ke Du (UC Riverside)	Continental 5
8:00am - 9:50am	**Technical Session 6C - MEMS/NEMS** Session Chairs: Rebecca Cheung (U. of Edinburgh), Leeya Engel (Technion - Israel Inst. of Tech.)	Continental 6
9:50am - 10:20am	**Coffee Break Sponsored by AllResist and Nuflare**	East lounge
10:20am - 12:00pm	**Technical Session 7A - Ion Beam Lithography** Session Chairs: Christopher Holland (SRI International), James Spallas (KLA)	Continental 4
10:20am - 12:00pm	**Technical Session 7B - Nanophotonics and Plasmonics 2** Session Chairs: Rajesh Menon (University of Utah), Frank Vollmer (University of Exeter)	Continental 5
10:20am - 12:00pm	**Technical Session 7C - Micro/Nanofluidics** Session Chairs: Scott Retterer (Oak Ridge National Lab), Selim Hanay (Bilkent University)	Continental 6
12:00pm - 1:30pm	**Student Mentor Lunch sponsored by AllResist, Zyvex, and KLA** **Keynote: *"Do Something Different"* R. Fabian Pease, Stanford University**	Continental 7-8
12:00pm - 1:30pm	**Lunch on your own**	
12:00pm - 1:00pm	**Raith Lunch & Learn: Process Control (register at Raith booth)**	Continental 9
1:30pm - 3:20pm	**Technical Session 8A - Quantum Electronics and Emerging Architecture** Session Chairs: James Owen (Zyvex Labs), Xiaogan Liang (University of Michigan)	Continental 4
1:30pm - 3:20pm	**Technical Session 8B - Scanning Probe Lithography** Session Chairs: Rob Ilic (NIST), Michael Cullinan (University of Texas at Austin)	Continental 5
1:30pm - 3:20pm	**Technical Session 8C - Advanced Pattern Transfer** Session Chairs: Mark Schattenburg (MIT), Dimitrios Kazazis (Paul Scherrer Institute)	Continental 6
3:20pm - 3:40pm	**Ice Cream Break Sponsored by GenISys**	East Lounge
3:40 pm - 5:30pm	**Technical Session 9A - Electron Beam Lithography 3: Processes and Materials** Session Chairs: Leonidas Ocola (IBM), Scott Lewis (California Institute of Technology)	Continental 4
3:40 pm - 5:30pm	**Technical Session 9B - Metrology and Characterization 2** Session Chairs: Keith Brown (Boston University), Xian Du (U. of Massachusetts at Amherst)	Continental 5
3:40 pm - 5:30pm	**Technical Session 9C - Biomedical and Emerging Devices** Session Chairs: Keith Morton (Nat. Res. Council Canada), Mark Schvartzman (Ben-Gurion University of the Negev)	Continental 6
6:00pm - 9:00pm	**Raith User Dinner (register at Raith booth)**	Continental 9
6:30pm - 9:30pm	**JEOL User Dinner (invitees by JEOL)**	Continental 7

Short Courses

Tuesday, May 30, 2023, from 8:00 am to 2:15 pm

The popular EIPBN Short Courses takes place on Tuesday, May 30, 2023, 8:00 am to 2:10 pm. This event features five lectures given serially by leading authorities in their field of expertise and is a perfect opportunity to further your knowledge of nanofabrication processes and applications. This year's Tuesday Short Courses are:

Micro-Resonating Sensors
Rebecca Cheung, University of Edinburgh, Scotland, UK

Prof. Rebecca Cheung is Professor and Chair of Nanoelectronics and Head of the Research Institute for Integrated Micro and Nano Systems in the School of Engineering at University of Edinburgh.

Characterization and Metrology of 3D Semiconductor Structures using X-Ray and Optical Methods; **Alain Diebold,** SUNY Polytechnic Institute

Prof. Alain Diebold is Professor Emeritus and Empire Innovation Professor of Nanoscale Science at SUNY Polytechnic Institute. His research interests are in nanoscale metrology and material science.

Atomically Precise Manufacturing of Silicon Quantum Devices
Joris Keizer, University of New South Wales, Australia

Dr. Joris Keizer is senior research fellow at the School of Physics at the University of New South Wales, Sydney, Australia. His research focuses on atomic scale quantum device fabrication.

Challenges Facing Continued EUV Scaling: Materials Are the Key
Patrick Naulleau, Lawrence Berkeley Laboratory

Dr. Patrick Naulleau is the CEO of EUV Tech Inc., a leading supplier of EUV metrology equipment. He was previously the Director of the Center for X-ray Optic at Lawrence Berkeley National Laboratory.

Fabrication of Semiconductor Spin Qubits for Quantum Computing
Daniel Ward, HRL Laboratories

Dr. Dan Ward is a Scientist at HRL Laboratories in Malibu, CA. His research focuses on nanoscale fabrication and SiGe quantum devices.

Startup Contest

Tuesday, May 30, 2023, from 2:30 pm to 3:30 pm

Dr. Han Cao, *Dimension Genomics*

The EIPBN 2023 Startup Session and Contest is designed to support entrepreneurs, students, and research staff to help facilitate transition of early-stage technologies into scalable ventures. The contest encourages participation from all ventures incorporating new technical findings from any of EIPBN's fields of scientific interest. Entry is open to startups at any stage of development: from early ideation (pre-seed) to technology validation and growth. This contest aims to support the transition of technology and ideas from the lab into a scalable venture.

This year's participating startups will pitch their innovations live to a distinguished panel of judges and the conference audience immediately following Tuesday's Short Courses. The winning startup will be announced at the EIPBN Banquet on Thursday. The Startup Contest winner will receive a sponsored exhibitor package. The Startup Contest is generously sponsored by **TetraMem.**

TetraMem

The Startup Session is kicked off with a Keynote address by Dr. Han Cao titled:

From Bio to Nano, From Idea to IPO

Dr. Han Cao is the Co-founder, President and CEO of Dimension Genomics. Dr Cao previously founded BioNano Genomics, as a spin out of Nanostructure Lab at Electrical Engineering Department of the Princeton University where he was working on a multimillion-dollar project funded by the U.S. Defense Advanced Research Projects Agency (DARPA). Dr. Cao is the key co-inventor of the company's core single-molecule nanoscale whole genome analysis technology, he obtained over $10 M funding from multiple federal government agencies to commercialize the platform technology at BioNano Genomics and has served on many special contracts and grant review panels. BioNano Genomics has grown from a single person company to the stage of commercial products launched and installed on 4 continents with revenue. He oversees the scientific and technical direction of future applications, technology and product development at BioNano Genomics.

Prior to that, Dr Cao was a postdoctoral fellow at the Institute for Human Gene Therapy of University of Pennsylvania Medical Center. Dr. Cao received a B.S. degree from the University of Science and Technology of China and a Ph.D. in molecular biology from the University of Delaware.

Plenary Session

Wednesday, May 31, 2023, from 8:00 am to 10:45 am

The Plenary Session begins on Wednesday, May 31, 2023, at 8:00 am with opening remarks by the Conference and Program Chairs. This is followed by three Plenary Talks by leading visionaries.

Welcome, Opening Remarks, and Announcements

Qiangfei Xia (UMass Amherst), Conference Chair & Chih-Hao Chang (UT Austin), Program Chair

What's Next in Computing: Scaling with Classical + Quantum Information

Darío Gil, IBM

Dr. Darío Gil is IBM's Senior Vice President and Director of Research, leading the technology roadmap and the technical community of IBM, directing innovation strategies in areas including hybrid cloud, AI, semiconductors, quantum computing, and exploratory science. Dr. Gil is responsible for IBM Research, one of the world's largest and most influential corporate research labs, with over 3,000 researchers. He is the 12th Director in its 76-year history. He is also responsible for IBM's intellectual property strategy and business.

Scalable Nanofabrication for Functional Nanophotonics

Teri W. Odom, Northwestern University

Prof. Teri W. Odom is the Joan Husting Madden and William H. Madden, Jr. Professor of Chemistry and Chair of the Chemistry Department at Northwestern University. Her research is on structured nanoscale materials that exhibit extraordinary size-dependent physical properties. She is a Member of AAAS and a Fellow of Optica, APS, MRS, RSC, ACS, AIMBE, the Alfred P. Sloan Research and the David and Lucile Packard foundation. Odom is the Editor-in-Chief of *Nano Letters* and was elected to the National Academy of Sciences in 2023.

Wearable Sweat Sensors - Towards Big Data for Human Health

Ali Javey, University of California, Berkeley

Prof. Ali Javey is the Lam Research Distinguished Chair in Semiconductor Processing and Professor of Electrical Engineering & Computer Sciences at UC Berkeley. His work focuses on the integration of nanoscale electronic materials in low-power electronics, flexible circuits, and energy generation and harvesting. He is the recipient of the MRS Outstanding Young Investigator Award, *Nano Letters* Young Investigator Lectureship, *IEEE Nanotechnology* Early Career Award, and the Alfred P. Sloan Fellowship. Javey is an Associate Editor of *ACS Nano*.

Plenary Session Chair: Chih-Hao Chang, University of Texas at Austin

Women in Nanofabrication

Thursday, June 1, 2023, from 12:10 pm to 1:40 pm

Women in Nanofabrication (WIN) is a networking event that brings together women in science and engineering from around the world. This luncheon enhances the fields of lithography and nanotechnology through diversity and inclusion. There is no charge to participate in this event.

This year WIN is honoring Dr. Stella Pang for her long-term dedication and commitment to EIPBN.

Stella Pang, *City U. of Hong Kong*

For more information about the WIN community, please join the EIPBN Women in Nanofabrication Group.

The WIN Luncheon is generously sponsored by **Heidelberg, Raith, AllResist, and KLA**.

HEIDELBERG INSTRUMENTS The power of direct writing

RAITH NANOFABRICATION

ALLRESIST

KLA

WIN Monthly Meetings

The WIN meetings in Gather Town launched during the EIPBN 2021 conference are continuing. These monthly meetings are held virtually at EIPBN Gather Town. Registered attendees already have access to the Gather Town website. The hour-long meetings typically take place on the first Friday of each month at 7:10 AM PST.

WIN welcomes volunteers to share their career experiences and insights, to present a technical talk about their research. Please contact Martha Sanchez at martha_sanchez@amat.com and add "WIN@EIPBN-Gather/Volunteer" to the subject line.

The WIN Monthly Meetings are generously sponsored by **Heidelberg Instruments**.

CHIPS Panel Discussion Session

Thursday, June 1, 2023, from 4:30 pm to 6:00 pm

EIPBN 2023 will have a special Panel Discussion Session on **"Challenges and Opportunities: The CHIPS Act and the Future of US Semiconductor Manufacturing"** on Tuesday, May 30, 2023, 4:30 pm - 6:00 pm. The goal of the conference-wide event is to have an open discussion on the US semiconductor research, education, and production. The moderator and panelist include representatives from industry, government research laboratory, and academia:

Moderator

Shida Tan, Intel Corporation

Shida Tan is a Principal Engineer at Intel's physical debug technology development group, where she is leading cross-industry R&D projects to develop advanced technologies for on-die circuit analysis for Intel's advanced process nodes.

Panelists

J. Alexander Liddle, National Institute of Standards and Technology

Alex Liddle is the Scientific Director of the Microsystems and Nanotechnology Division at NIST. His division works in a variety of areas, ranging from quantum nanophotonics to biology. His personal research focus is on nanofabrication and self-assembly for nanomanufacturing.

Qing Wu, Air Force Research Laboratory

Qing Wu is the Senior Scientist for Processing and Exploitation at the Information Directorate at Air Force Research Laboratory. His research interests include advanced computing, neuromorphic computing architectures, models and algorithms, and memristor based analog computing.

Shawn Siddoway, Micron Technology

Shawn Siddoway is the Senior Director-Business Operations and Workforce Development at Micron Technology. He is responsible for the global Staff operations, technical workforce development, communications, and site-related activities for Micron's R&D and Engineering division.

SV Sreenivasan, University of Texas at Austin

S.V. Sreenivasan is a Professor in the Walker Department of Mechanical Engineering at UT Austin and holds the David Allen Cockrell Chair and Cockrell Family Regents Endowed Chair #7. His research is in nanofabrication techniques for the emerging electronics, displays and health care sectors.

Student Mentor Lunch

Friday, June 2, 2023, from 12:00 pm to 1:30 pm

The Student Mentor Lunch gives students a chance to hear from professionals in academia, government labs and industries. They can learn beneficial information that will help guide them as they grow in their fields. It's a chance to hear from the experts why they chose their field, what it takes to get there, and what it's really like once they arrived. The Student Mentor Lunch also features a speaker who provides an expert "how to" discussion on a new topic each year.

The Student Mentor Lunch is kicked off with a Keynote address by Prof. R. Fabian Pease presenting:

"Do Something Different"

About Prof. R. Fabian Pease

After 2 years' military service (RAF), Fabian Pease went to Cambridge University and received his BA in Natural Sciences and PhD in Electrical Engineering. For his PhD he designed, built and demonstrated the first scanning electron microscope to achieve 10 nm resolution. He then joined the Faculty at U.C. Berkeley and continued research in scanning electron microscopy. He joined Bell Laboratories in 1967 where he first worked on digital television and then on electron beam lithography.

Prof. R. Fabian Pease

Since 1978 he has been a professor of electrical engineering at Stanford University where he holds the William Ayer Chair. His group's accomplishments include the micro-channel heat sink which could remove 1.5K W from 1x1 cm^2 silicon and winning the Feynman microwriting prize. Pease was a co-founder of Brion Technologies, spent a year on sabbatical at Affymetrix researching DNA synthesis and two years at DARPA managing programs in Advanced Electronics and Molecular Level Printing. He was the recipient of the first IEEE Paul Rappaport Award, the IEEE Cledo Brunetti Award, and the Richard P. Feynman Prize for microfabrication. He is Fellow of the IEEE and a member of the National Academy of Engineering.

Micrograph Contest

The research being done by the EIPBN community is at the leading the drive to develop the technologies required to make smaller and smaller structures.

We have ventured into size regimes where we are dependent on microscopes and the skill of microscopists to see the results of our work. To highlight the importance of micrographs to our community, EIPBN holds an annual micrograph contest.

In this, 28th Annual EIPBN Bizarre and Beautiful Micrograph Contest, we encourage our community to pick their favorite micrographs. Micrographs need not be related to research or to any paper or topic presented at the conference. Submissions may be purely for their beauty and ability to excite curiosity.

There is still time to take your shot at joining the elite company of the winners who have gained Micro-Fame and Nano-Fortune. Entries must be of a single image taken with a microscope and shouldn't be significantly altered.

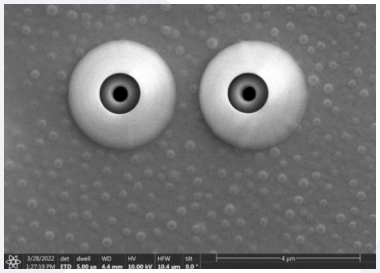
There are micro-cash prizes for the winners of each category. See the EIPBN website to enter. Entries should be submitted by May 27, 2023.

For additional information, contest entry forms, contest rules, and past winners, click here.

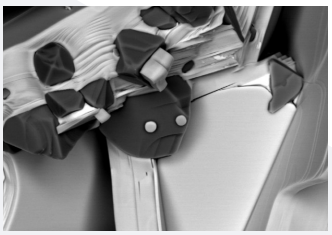
The 2022 Bizarre and Beautiful Micrograph Contest Winners

zyvex™ LABS

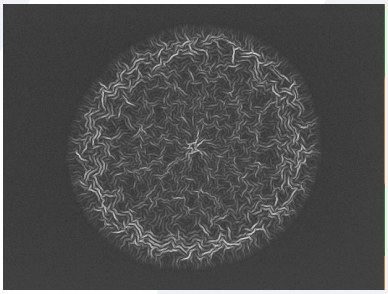
Grand Prize



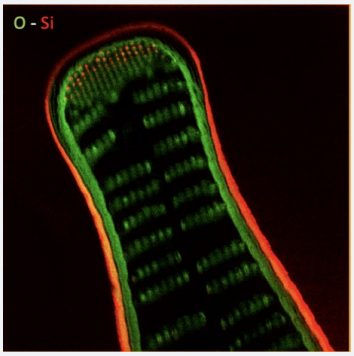
3-Beamers Choice



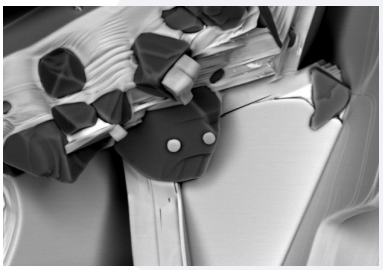
Best Electron



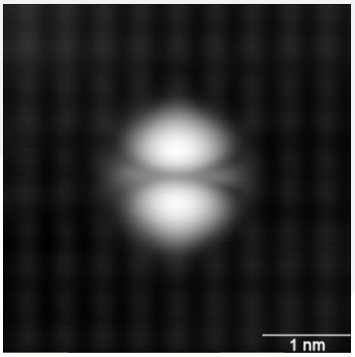
Best Ion



Most Bizarre



Best Scanning Probe



Best Photon

Commercial Session

The Commercial Session features material and equipment vendors which are relevant to the to our community. This year's session features 32 booths and 48 posters, including several first-time exhibitors. The Commercial Session provides opportunity to meet with vendors who are eager to discuss their latest lithography systems, materials, characterization instruments and related products.

Makes sure to check out Industrial Highlights Session 3C on Thursday, June 1 at 8:00 am for in-depth discussions about the research being done by our exhibitors. Don't miss the chance to engage the speakers during the Commercial Session to ask questions or continue the discussion.

The popular Exhibitor Lightning Session is held at noon in the Commercial Session on Wednesday, May 31, 2023.

Commercial Session Schedule

- Tuesday, May 30: 4:00 pm to 8:00 pm
- Wednesday, May 31: 10:00 am to 5:00 pm
- Thursday, June 1: 9:00 am to 1:00 pm

$100 Grand Prize!

Collect your raffle card at registration and sign-in at every booth during the Commercial and Poster Sessions to enter a raffle for a $100 cash prize!

EIPBN Best Student Paper Award

This year EIPBN is holding the annual Best Student Paper Award competition that highlights outstanding student contributions and fosters the next generation of leaders in the EIPBN community. The competition includes two categories:

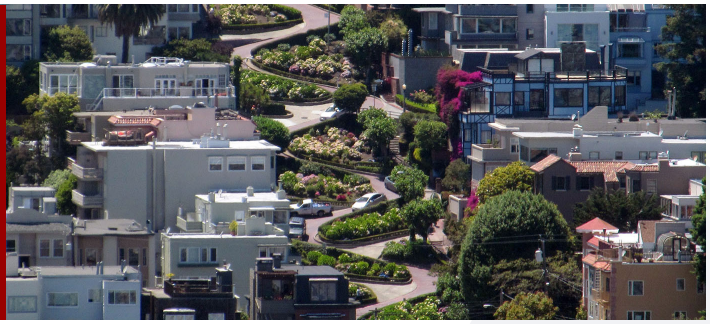
- The **Best Student Poster Award** will be given to the best poster presentation based on technical content, visual organization, and Q&A.
- The **Best Student Presentation Award** will be given to the best oral presentation based on technical tent, clarity, and Q&A.

All student presenters are automatically entered into the competition. A team of three judges, selected by the Steering Committee, will evaluate the presentations and posters of the finalist during the conference. The Best Student Poster Award winner will be announced during the banquet, and the Best Student Presentation Award winner a week after the conference. The winning paper in each category will each receive a $500 prize and an award plaque.

The winners are also invited to give an Invited Poster Presentation at the 2023 Micro and Nano Engineering (MNE) conference, the EIPBN's sister conference in Europe, in Berlin, Germany.

This year the Best Student Paper Award is generously sponsored by **JEOL USA.**

Submit Your JVST B Manuscript



Papers presented at EIPBN 2023 shall be submitted for publication in a Special Collection within the *Journal of Vacuum Science and Technology B (JVST B)*. Deadline for manuscript submission to *JVST B* is Monday, July 31, 2023. All manuscripts are reviewed to the same standards as regular JVST submissions. For more information see https://eipbn.org/manuscripts/.

Submit your manuscripts to *JVST B* using the journal's online manuscript submission system at the *JVST* site: http://jvstb.peerx-press.org. Authors should indicate that the submission is a part of this Special Collection by choosing this year's EIPBN Collection from the drop-down list in the Manuscript Classification tab.

JVST B Best Journal Paper Award

Each year the editors of the *JVST B* select the EIPBN Conference Proceedings Best Journal Paper. The winning authors share a cash award and each author is presented with a certificate acknowledging their exceptional accomplishment. The award will be announced, and presentations made at the following year's conference banquet.

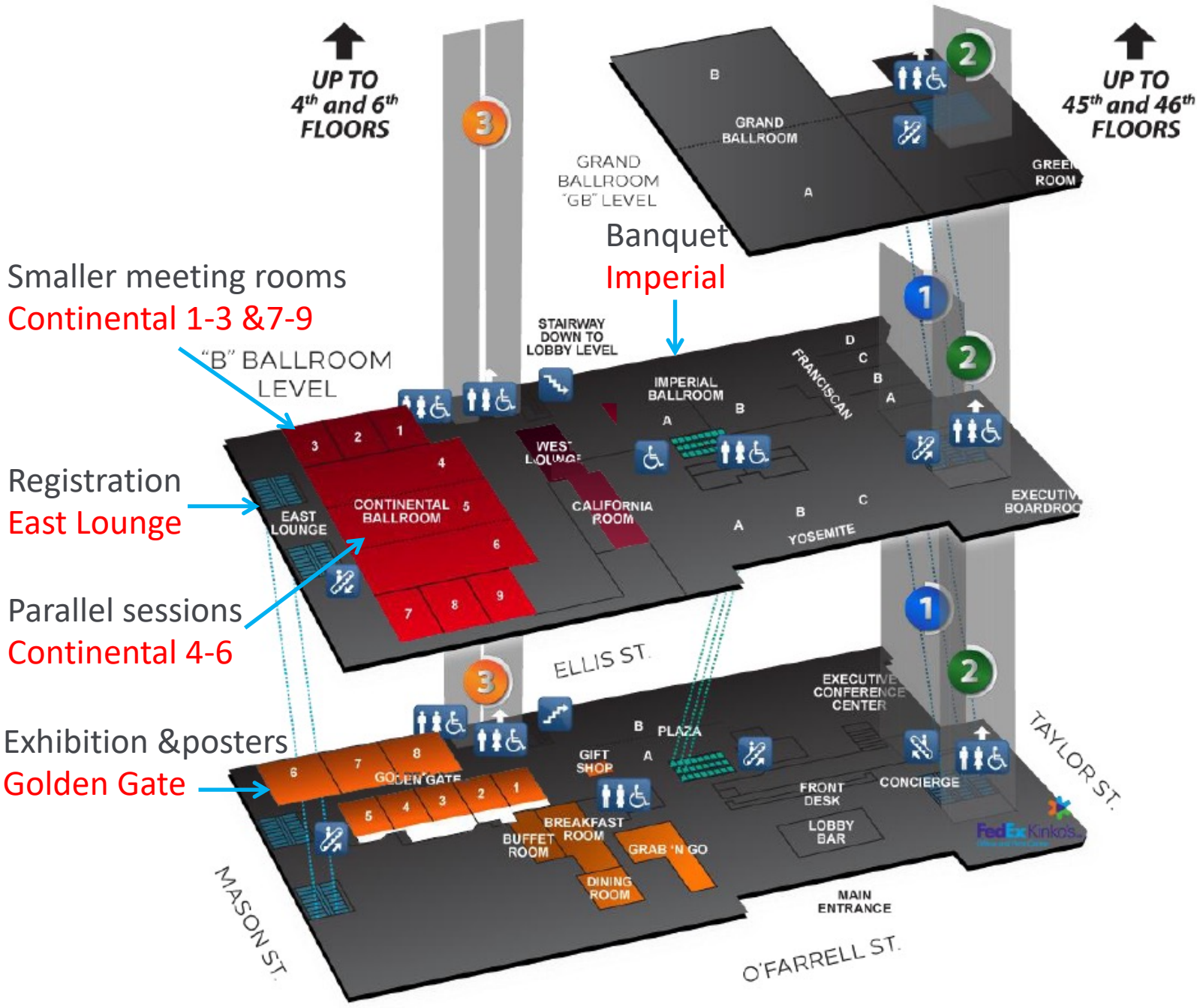
Congratulations to the winners of the 2022 *JVST B* Best Journal Paper Award!

"Pneumatic controlled nanosieve for efficient capture and release of nanoparticles"

by Animesh Nanaware, Taylor Kranbuhl, Jesus Ching, Janice S. Chen, Xinye Chen, Qingsong Tu, and Ke Du

https://doi.org/10.1116/6.0002107

Hilton Floorplans



Hotel and Banquet

Hilton San Francisco Union Square
333 O'Farrell Street, San Francisco, California 94102
Tel: (415) 771-1400. Website: www.hilton.com

The Hilton San Francisco Union Square is steps from the Curran and ACT theaters and just two blocks from Union Square and Westfield shopping center. The Powell Street cable car turnaround, San Francisco Museum of Modern Art, and Moscone Convention Center are within a mile. Enjoy panoramic views from the skybar, the city's highest. The hotel also has an outdoor pool and whirlpool, two restaurants, a lobby bar, and grab-and-go market.

The 2023 Banquet will be on Thursday, June 1, in the Imperial Ballroom in the Hilton San Francisco Union Square Hotel. The Banquet will feature the Sueños Jazz Band. Sueños is a Bay Area band that blends classic jazz with modern styles like hip-hop, neo-soul, and indie rock. They perform with vocals or instrumental, covering everything from 1920s jazz to modern pop music.

36th International Microprocesses and Nanotechnology Conference

MNC 2023

Micro Nano Conference

November 14-17, 2023

Keio Plaza Hotel Sapporo, Hokkaido, Japan

Sponsored by

The Japan Society of Applied Physics

ABSTRACT DEADLINE
June 10- July 1, 2023

Deadline of Early Bird Registration
Oct. 22, 2023

Organizing Chair
Seiya Kasai (Hokkaido Univ.)

Steering Chair
Seiji Nagahara (Tokyo Electron)

Program Chair
Koji Asakawa (Kioxia)

https://imnc.jp/2023/

PLENARY

Dr. Sri Samavedam, *imec, Belgium*

Dr. Heike Riel, *IBM Research Europe, Switzerland*

Dr. Yasumitsu Orii, *Rapidus Corporation, Japan*

SYMPOSIUM

A: Challenge to the physical limit for lithography and devises: Are we ready to boost the scaling roadmap? (tentative)

B: Material Intelligence: Potential of in-materio computing

C: Process and Device Technologies for Quantum Computing (tentative)

D: BioMEMS (tentative)

SECRETARIAT

E-mail: **secretariat@imnc.jp**

SECTION

1: Lithography, Metrology and Related Technologies
- **1-1: Advanced Lithography and Patterning**
- **1-2: Electron and Ion Beam Technologies**
- **1-3: Patterning Materials**

2: Nanotechnology
- **2-1: Nanocarbon & 2D Materials**
- **2-2: Nanodevices**
- **2-3: Nanofabrication**
- **2-4: Inorganic Nanomaterials**
- **2-5: Organic Nanomaterials**
- **2-6: Nano Surfaces, Interfaces, and Advanced Microscopy**

3: Nanoimprint, Hybrid-NIL, Biomimetics, and Functional Surfaces

4: BioMEMS, Lab on a Chip, and Nanobiotechnology

5: Microsystem Technology and MEMS

6: Atomic Layer Processing (ALP)

NNT2023

Nanoimprint and Nanoprint Technologies

October 9-11, 2023
Boston Seaport Hotel, Boston MA

NNT2023
Nanoimprint and Nanoprint Technologies
October 9-11, 2023
BOSTON SEAPORT

Abstract Submission and Registration are open! Submission deadline is June 1.

www.nnt2023.org

NNT2023 is focused on Next Generation Technologies, Products and Manufacturing Processes and is structured with both the research and commercial communities in mind.

Topics include:

- photonics, optics and metamaterials
- augmented and virtual reality
- energy generation and storage
- intelligent nanoscale devices
- functional surfaces
- life sciences
- process technology, tools and metrology
- new materials
- hybrid integration using NIL

Highlights include:

- nanoimprint ecosystem session and roundtable discussion
- extensive poster session
- vendor / company exhibition
- conference dinner cruise on the Boston harbor

Tuesday Dinner Cruise

Sponsored by:

pixelligent

NIL TECHNOLOGY

Conference Chair: Jim Watkins, University of Massachusetts: watkins@umass.edu

MAEBL.org

MEETING FOR ADVANCED E-BEAM LITHOGRAPHY

MAEBL Program

MAEBL at The University of Chicago

Pritzker Nanofabrication Facility

In-Person and Online

Tuesday-Thursday, **September 12-14, 2023**

Register at maebl.eventbrite.com

MAEBLx Meetings

~~**MAEBLx EBL Vendor Applications (EDT): May 3, 2023**~~

MAEBLx Asia-Pacific (AEDT): **July 28, 2023**

MAEBLx North America (EST): **November 15, 2023**

ALLRESIST

DisChem

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Beamfox

CLEANROOM LABWARE

ZEON

Helpful Links & QR Code

Instructions for Downloading the Conference App at: https://eipbn.org/guidebook/

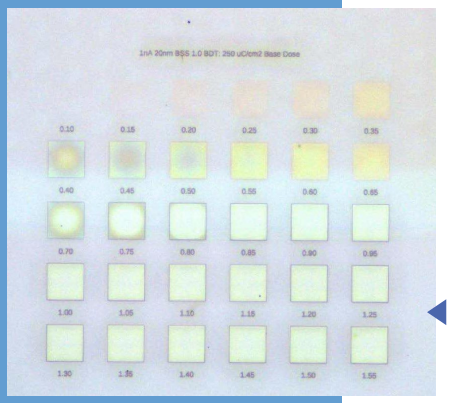
DisChem

CHEMISTRY FOR ADVANCED LITHOGRAPHY

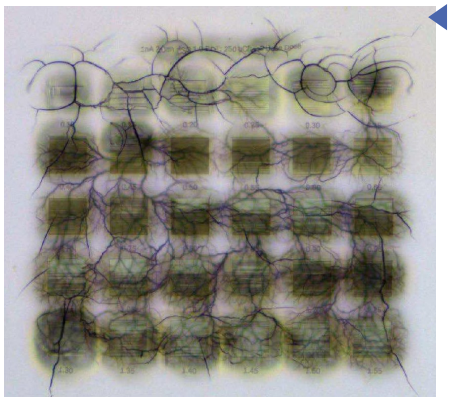
DisCharge+

EBL ANTI-CHARGING AGENT

- Improved shape fidelity and positional accuracy for EBL resist patterning on insulating substrates such as fused silica, quartz, glass, PDMS, etc.
- Water based w/ excellent wetting properties. Spin coat application provides conductive film for anti-charging.
- Suitable for nondestructive SEM imaging of nonconductive materials.
- Easy residue free removal w/ water or IPA.
- Competitively priced. Ideal for both research and industrial applications.
- Two-year shelf life at room temp. Highly stable permanently charged non-polymer formulation.
- Ready to use. No filtration required prior to use.



WITH DisCharge: no charge accumulation, resulting in expected image with no harm to PDMS layer.



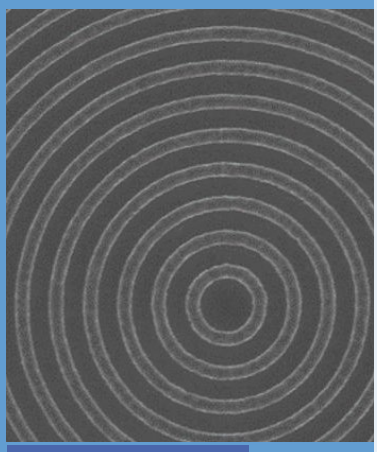
Without DisCharge: charge accumulation and sudden charge dissipation caused by exceeding the dielectric breakdown strength of the PDMS to the Si substrate resulting in significant image distortion in the resist and destruction of the PDMS surface.

anti-charging

H-SiQ *(hydrogen silesquioxane)*

NEGATIVE-TONE ELECTRON BEAM RESIST

DisChem H-SiQ is a negative tone hydrogen silesquioxane (HSQ) resist in MIBK carrier solvent for use in electron beam lithography (EBL). H-SiQ is characterized by excellent pitch resolution, sensitivity and etch resistance for direct write thin and thick film EBL applications. Immediate availability in quantities as low as 20 ml.

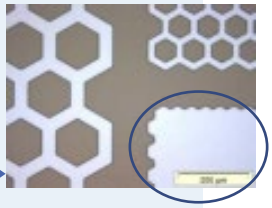


resist

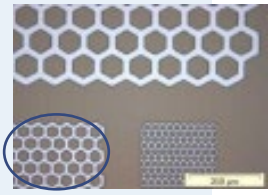
SurPass

RESIST ADHESION PROMOTERS

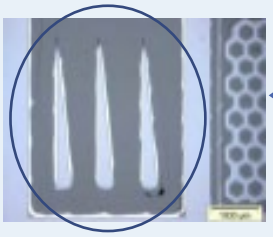
- Improved microlithographic resist adhesion on a broad range of substrate materials.
- Improved adhesion at low doses in electron beam lithography
- Improved removal of critical substrate contaminants
- Reduced z-potential for improved resist coating properties
- Improved patterned resist mold to copper seed layer for subsequent electroforming.
- Increased adhesion of evaporated metals to substrate materials
- Non-Hazardous waterborne formulation



No Adhesion Promoter: some patterns removed during resist development.



With SurPass: Complete Precision Mask



No Adhesion Promoter Resist Mask Undercut During Etching

With SurPass: Complete Precision Mask

adhesion promotion

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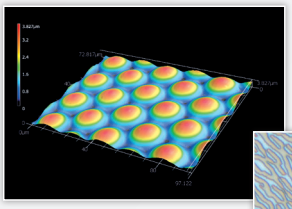
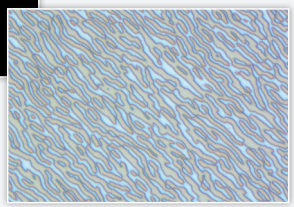
From Micro- to Nanofabrication

LASER

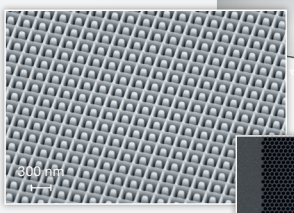


Grayscale Lithography

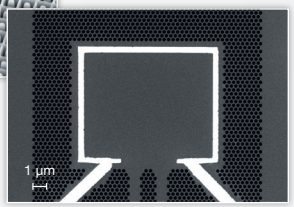


Augmented/ Virtual Reality

FIB

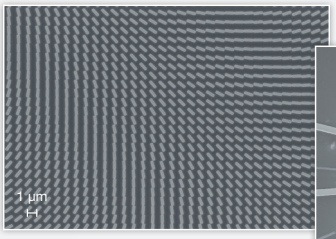


Metasurfaces

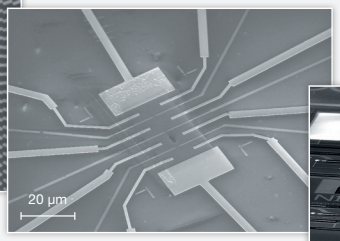


Phononic Engineering

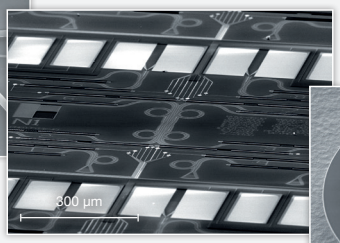
E-BEAM



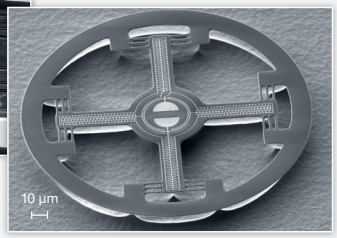
Photonics



Nanoscale Science



Quantum Technologies



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Salamander Epidermis Cilia - Louise Lewis
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Fractal Nanotruss
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We Hope You All Enjoy EIPBN, San Francisco 2023

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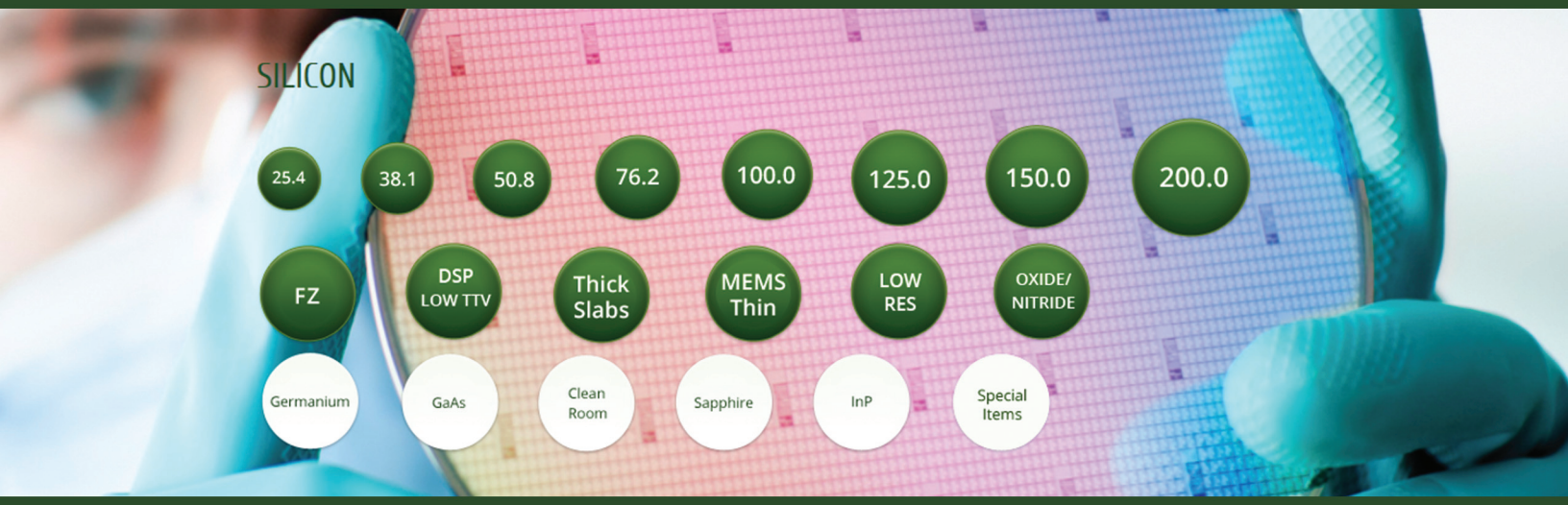

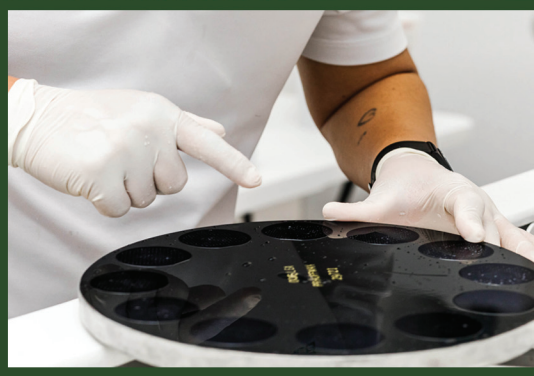

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Plenary Session

Wednesday, May 31, 2023, from 8:00 am to 10:45 am

Wednesday, May 31

Plenary Session
Room: Continental Ballroom 5/6
Session Chair: Chih-Hao Chang, University of Texas at Austin

8:00 am - Welcome
Qiangfei Xia, Conference Chair, University of Massachusetts Amherst and Chih-Hao Chang, Program Chair, University of Texas at Austin

8:30 am – What's Next in Computing: Scaling with Classical + Quantum Information, Darío Gil (IBM)

A new paradigm is emerging, quantum computing, with the potential to solve problems intractable for classical computers. The intersection of quantum and classical computation will bring unprecedented computing power and efficiency. In this plenary, we will discuss this future of computing, its implications, and how we could fulfill it.

9:15 am – Scalable Nanofabrication for Functional Nanophotonics, Teri Odom (Northwestern University)

This talk will describe how metal nanoparticle lattices can function as a powerful platform for smart nanoscale materials. Advances in the design and fabrication of plasmonic lattices based on surface engineering and their expanded applications, from nanoscale lasing to strong coupling to photo-electrocatalysis to auto-regulatory materials, will be discussed.

10:00 am – Wearable Sweat Sensors - Towards Big Data for Human Health, Ali Javey (University of California, Berkeley)

Wearable sensor technologies play a significant role in realizing personalized medicine through continuously monitoring an individual's health state. Human sweat is an excellent candidate for non-invasive monitoring. I will present our recent advancements on fully-integrated perspiration analysis systems that can simultaneously measure sweat rate, metabolites, electrolytes, drugs and heavy metals.

Oral Presentations

Wednesday, May 31

1A - Nanoelectronics/Nanomagnetics

Room: Continental Ballroom 4

Session Chairs: Henry Smith (Massachusetts Institute of Technology), Dan Ward (HRL labs)

1:20 PM 1A1 Invited

Picosecond Spintronics for On-Chip Memory Applications, Jeffrey Bokor (University of California at Berkeley)

We have demonstrated that picosecond charge current pulses are effective at initiating ultrafast magnetization switching. These purely electrical ps magnetic switching mechanisms are suitable for on-chip integration with CMOS, opening up the possibility of ultrafast, embedded, high density nonvolatile magnetic memory, with greatly increased energy efficiency compared to existing SRAM.

1:50 PM 1A2

Multiplexing Rubbing-Induced Site-Selective (RISS) Production of Bi2Se3 Based Memristive Devices, Mingze Chen, Xiaogan Liang (University of Michigan)

We report our recent progress in leveraging the RISS technology to realize site-selective growth of Bi2Se3 features. We further report the memrsitive switching behavior observed from the resistors made from such RISS-produced Bi2Se3 channels, which reveals the potential of RISS-produced Bi2Se3 in the application fields related to neuromorphic devices.

2:10 PM 1A3

Dielectric Engineering Using High-k BaTiO3 and in-situ SiN for Breakdown Enhancement and Current Dispersion Suppression in AlN/GaN HEMTs, Junao Cheng, Can Cao, Mohammad Wahidur, Rahman Siddharth Rajan, Wu Lu (The Ohio State University)

In this work, we report a high-k BaTiO3 (BTO)/Al2O3/in-situ SiN dielectric structure underneath the gate for passivation and field management for breakdown voltage enhancement and suppression of current dispersion.

2:30 PM 1A4

Hybrid Tuning of Sub-filaments to Improve Analog Switching Performance in Memristive Devices, Pan Hu; Sushmit Hossain, Zerui Liu, Deming Meng, Yunxiang Wang, Tse-Hsien Ou, Zhi Cai, Yudi Shi (University of Southern California); Mark Barnell, Qing Wu (Air Force Research Laboratory, Information Directorate); Stephen B. Cronin, Wei Wu (University of Southern California)

We report a method to improve the analog switching performance of memristors through a hybrid tuning of two sub-filaments. One sub-filament takes charge of a coarse adjustment, and the other is responsible for a fine adjustment. The hybrid tuning results in a dynamic range from 600 Ω to 50 kΩ.

2:50 PM 1A5

Robust Ferroelectricity with Suppressed Leakage Current in Ultrathin HfO2/ZrO2 nanolaminates, Guan Feng, Xiaodong Wang (Fudan University); Yize Sun (University of Science and Technology of China); Hao Jiang, Yingfen Wei (Fudan University)

We systematically studied ultrathin ferroelectric HfO2/ZrO2 nanolaminate (NL) films. The capacitors based on 4 nm NL film demonstrated high ferroelectricity (double remnant polarization (2Pr) ~ 20 μC/cm2), low coercive voltage (Vc ~ 0.5 V), >50 X decrease in leakage current when compared with the conventional Hf0.5Zr0.5O2 solid solution (SS) film.

1B – Optical and Direct-Write Lithography

Room: Continental Ballroom 5

Session Chairs: Todd Hastings (University of Kentucky), Li Jiang (Tuskegee University)

1:20 PM 1B1 Invited

Additive Manufacturing of Structures and Electronics: Robotic metamaterials that walk, talk and listen, Xiaoyu (Rayne) Zheng (University of California at Berkeley)

In this talk, I will present a suite of new multi-material additive manufacturing processes and design methodologies to create electronic materials with prescribed structural and functional behaviors. I will present the manufacturing and synthesis of these robotic materials, as well as their mechanics and design methods underpinning their novel behaviors.

1:50 PM 1B2

Direct laser writing of tapered polymer probes for flexible fiber-to-device coupling and wafer-scale optical probing, Edgar Perez, Tahmid Sami Rahman (University of Maryland); Kartik Srinivasan (National Institute of Standards and Technology)

Direct laser writing is used to fabricate 3-dimensional tapered polymer probes with diameters of approximately 1 micron to evanescently couple to on-chip nanophotonic devices for flexible, non-destructive, and wafer-scale optical characterization. Probes utilize suspended waveguides longer than 30 microns, and surface tension is alleviated with auxiliary structures and low-tension solvents.

2:10 PM 1B3

Direct writing immersion laser lithography on graphene monolayers using 2-photon absorption, Jianran Zhang, Johanna Reif, Shouzhuo Yang, Carsten Strobel, Thomas Mikolajick, Robert Kirchner (Technische Universitt Dresden, Center for Advancing Electronics Dresden)

In previous studies, immersion oil is sometimes applied for Two-photon absorption direct laser writing. Our experiments showed that while the immersion time is too long, oil would probably interact with the photoresist and create new and difficult-to-remove compounds with the photoresist. The changed photoresist can neither be exposed nor developed.

2:30 PM 1B4

Localized Electrochemical Deposition of Multi- Metal Structures by Hydrodynamic Flow Confinement, Daniel Widerker, Moran Bercovici (Technion, Israel Institute of Technology); Govind Kaigala (University of British Columbia)

Localized electrochemical deposition is an established approach for direct writing of microscale metal structures. However, to date this method is limited to single materials. We here present a device and method that leverages hydrodynamic flow confinements to enable localized electrochemical deposition of microscale multi-metal structures.

1C - Nanobiology

Room: Continental Ballroom 6

Session Chairs: Stella Pang (City University of Hong Kong), Regina Luttge (Eindhoven University of Technology)

1:20 PM 1C1 Invited

Window to the Rhizosphere: Creating Engineered Habitats to Understand Plant and Microbial Community Development Underground, Scott Retterer (Oak Ridge National Laboratory)

Methods for systematically varying the complexity of engineered habitats with soil-like microfluidic networks have been refined to explore the impact of spatial confinement and network complexity on the growth, migration, and development of plants, bacteria, and fungi in soil-like environments.

1:50 PM 1C2

Molecular Scale Spatio-Chemical Control of the Activating-Inhibitory Signal Integration in NK Cells, Esti Toledo; Guillaume Le Saux; Avishay, Maor Rosenberg, Viraj Bhingardive, Uzi Hadad, Olga Radinsky, (Ben-Gurion University of the Negev); Ana-Sunana Smith, (IZNF, FAU Erlangen-Nrnberg); Angel Porgado,r Mark Schvartzman (Ben-Gurion University of the Negev)

Here we produced a multifunctional platform with molecular scale spatial control of ligands. This platform was fabricated by an "out-of-the-box" fabrication approach, which included nanoimprint lithography with double-angle evaporation. This platform was conceived by bimetallic nanodot patterning with a molecular-scale registry, followed by ternary functionalization with distinct moieties.

2:10 PM 1C3

Micro-patterned surface for Phaeobacter inhibens biofilm growth in a flow-cell system for biosynthetic production of the antibacterial compound TDA, Yuyan Liu, Droumpali Ariadni, Xavier Ferrer Florensa, Claus Sternberg, Paul Kempen, Lone Gram, Rafael Taboryski (Technical University of Denmark)

Growing probiotic bacteria in the aquaculture, to biosynthesize antibacterial compounds, has become a promising way to control the infections. In our research, a polymeric microfluidic chamber, incorporated with three different surfaces of planar, pit, and pillar arrays was studied. The result indicates the enhancement of the antibacterial effect by micropatterns.

2:30 PM 1C4

A workflow for nanoscale imaging of cardiomyocytes differentiated from pluripotent stem cells, Leeya Engel (Technion - Israel Institute of Technology); Richard G. Held (Stanford University); Alison K. Vander Roest (University of Michigan); Magda Zaoralova (Stanford University); Daniel Bernstein (Stanford University); William I. Weis (Stanford University); Alexander R. Dunn (Stanford University)

We present a workflow for imaging pluripotent stem cell induced cardiomyocytes at the nanoscale using cryo-electron tomography together with maskless photo-micropatterning of electron microscopy grids and cryo-focused ion beam milling. This workflow will enable us to resolve structural differences between normal cardiomyocytes and those bearing disease-causing mutations

2:50 PM 1C5

Rapid Bacteria Extraction from Whole Blood Using a Pneumatically-Regulated Nano-Sieve Device, Xinye Chen (Rochester Institute of Technology); Ke Du (University of California Riverside)

This pneumatic-regulated and micro-beads patterned nano-sieve device is able to purify the bacteria from whole blood by combining with a solid phase immunoassay. The pneumatic chamber allows the bacteria capture at high flow rate without leaking issues, meanwhile reaching a very high capture efficiency of target bacteria.

2A - Electron Beam Lithography 1

Room: Continental Ballroom 4

Session Chairs: Dieter Kern (University of Tuebingen), Gerald Lopez (University of Pennsylvania)

3:30 PM 2A1 Invited

Additive Nano Manufacturing of Insulators and Semiconductors Grown by Direct-Write 3D Nanoprinting, Scott Lewis, Guy A. Derose (California Institute of Technology)

We present new materials that can be transformed into insulators and semiconductors when exposed with an electron beam. These materials can be sublimed onto a substrate and exposed to an electron beam which writes the pattern into the material. This process is repeated to produce 3D nanostructures.

4:00 PM 2A2

Fabrication of shallow, ultra-smooth 2.5D profiles in Silicon by HSQ grayscale lithography and through-mask oxidation, Vitaliy Guzenko, Nazanin Samadi, Christian David (Paul Scherrer Institute)

We present a novel patterning technique, utilizing hydrogen silsesquioxane (HSQ) as a resist for grayscale EBL and subsequent transfer of the 2.5D profile into Silicon by dry thermal oxidation. This method allows for fabricating high efficiency reflective X-ray optical elements with complex functionalities.

4:20 PM 2A3

Optimizations on the conductive electron beam coating Electra 92 and the HSQ-alternative Medusa 82, Mandy Sendel, Harry Biller, Maik Gerngro (Allresist GmbH); Matthias Schirmer (CEO); Daniel Langheinrich (Fraunhofer Institute for Electronic Nanosystems); Susanne Hartmann (Chemnitz University of Technology, Center for Microtechnologies,); Georg Heldt, Christian Helke (Fraunhofer Institute for Electronic Nanosystems ENAS)

Allresist and the Fraunhofer Institute for Electronic Nanosystems (ENAS) report on our HSQ alternative, the Medusa 82, and present the first results of our current Electra 92 variant, the AR-PC 5092.02, which is a protective electron beam coating used to minimize charging.

4:40 PM 2A4

Electron-beam patterning of photoluminescent structures in polystyrene using water vapor, Deepak Kumar, Todd Hastings (University of Kentucky)

It is known that electron-irradiation transforms polystyrene (PS) from a non-luminescent polymer into a luminescent material. For example, photoluminescence (PL)

from irradiated PS results from formation of polycyclic-aromatic-hydrocarbons (PAH) or carbon dots. Prior efforts motivated us to study the effect of water-vapor on e-beam induced synthesis of fluorophores in polystyrene.

5:00 PM 2A5

Plasmonic Nano-Disks Arrays made with EBL using the Dots-On-The-Fly Method, Marc Christophersen (Naval Research Laboratory)

Plasmonics and metamaterials have attracted considerable attention over the past decade; these structures are routinely patterned by EBL. For practical application, a large surface area coverage by uniform nanostructures is required. Therefore, accelerating EBL patterning speed for these structures will pave the way towards more practical applications.

2B - Metasurface/Meta-Optics

Room: Continental Ballroom 5
Session Chairs: Wei Wu (University of Southern California), David Czaplewski (Argonne National Lab)

3:30 PM 2B1 Invited

Subwavelength Moiré Index Lens-Array – Flat, Ultra-Thin, Large NA, and Patterned by Large Area Nanoimprint Using a Mold Formed by Multiple-Double-Nanoimprint, Stephen Chou (Princeton University)

The structure, fabrication, and demonstration of a new micro-lens-array, termed "subwavelength Moiré Index lens-array" (SMIL), that has a gradient optical index, in a ultra-thin (~100 nm) flat material layer, created by a subwavelength Moiré pattern resulted from superpositions of two or more periodic structures (e.g., grating or grid)

4:00 PM 2B2

Scalable Nanoimprint Manufacturing of Multi-layer Metasurfaces for Compact Polarimetric Imaging System, Shinhyuk Choi, Jiawei Zuo, Nabasindhu Das, Yu Yao, Chao Wang (Arizona State University)

Metasurface structures are attractive in broad optical applications. Conventional nanofabrication based electron beam lithography (EBL) is very expensive for scalable production and faces challenges for multi-layer integration. Here we propose and demonstrate a multi-functional-direct-NIL (MFD-NIL) process to integrate multiple layers of metasurfaces for high-performance on-chip polarimetric imaging.

4:20 PM 2B3

Enhancement of Transmission and Wavelength Selectivity of Spiral Bull's Eye Structure by Spiral-shaped Bragg Reflector, Tatsunori Oiwa, Shin'ichi Warisawa, Reo Kometani (The University of Tokyo)

We proposed spiral Bragg reflector, which encircles spiral bull's eye structure (SBE). It was demonstrated that spiral reflectors enhance both peak transmission and wavelength selectivity of SBE. This result shows that spiral Bragg reflector reflects outward propagating surface plasmon polariton and alters transmission characteristics of encircled SBE.

4:40 PM 2B4 Invited

Inverse Designed Volumetric Metaoptics for Sorting Light by Color, Polarization, and Spatial Mode, Gregory Roberts, Conner Ballew, Tianzhe Zheng, Ian Foo, Phillippe Pearson, Andrei Faraon (California Institute of Technology)

Volumetric metaoptics are refractive index distributions patterned at subwavelength scales. This represents a vast design space for creating multifunctional optical devices. We present optimized nanophotonic scattering structures capable of sorting light based on its color, polarization, and spatial mode. Further, experimental results of multilayer structures are shown for mid-infrared wavelengths.

2C - Directed Self-Assembly

Room: Continental Ballroom 6

Session Chairs: Alex Liddle (National Institute of Standards and Technology), James Watkins (U. of Massachusetts Amherst)

3:30 PM 2C1 Invited

Directed Self-assembly of Bottlebrush, Rod-Coil, and Multiblock Copolymers, Caroline Ross (MIT)

We will describe block copolymer morphologies, including zigzags, bends, junctions, tiling patterns and hierarchical structures with two independently tunable periods, and their application to nanolithography and nanofabrication. Combinations of novel polymers, templating approaches, and processing techniques yield an extensive array of rectilinear and 3D pattern geometries, expanding current DSA capabilities.

4:00 PM 2C2

Autonomous discovery of emergent morphologies in directed self-assembly of block copolymer blends, Aaron Stein (Brookhaven National Laboratory)

We demonstrate machine-guided discovery of emergent morphologies from cylinder/lamellae BCP blend, conducted without human intervention. This approach maps the morphology-template phase space in a fraction of the time required by manual characterization, highlighting regions deserving detailed investigation. These studies reveal localized, template-directed partitioning of coexisting subdomains manifesting as new morphologies.

4:20 PM 2C3

Fabricating ultrathin isoporous membranes as a platform to understand nanoscale aqueous transport behavior, Wen Chen (University of Chicago); Feng Gao, Seth Darling (Argonne National Laboratory); Paul Nealey (University of Chicago)

The use of block copolymer nanolithography to fabricate free-standing ultrathin isoporous silicon nitride membranes.The membrane fabrication satisfies the requirements for uniformity, qunatative strcustural analysis, mechanical stability, porosity and reproducibility at wafer-level. It allows us to establish an ideal platform to study fundamental transport processes.

5:00 PM 2C4

Nanofabrication via Force Engineering for Extreme Nanodevices, Weikun Zhu, Patricia Jastrzebska-Perfect, Farnaz Niroui (Massachusetts Institute of Technology)

We present a fabrication platform where nanoscale forces, including van der Waals and capillary, are engineered to guide scalable and deterministic integration of colloidal nanoparticles into active devices with single-particle resolution and sub-50 nm placement precision. Example applications in developing on-chip nanoscale light-emitting diodes, nanoactuators, and plasmonics will be discussed.

Thursday, June 1

3A - Electron and Ion Beam Sources

Room: Continental Ballroom 4

Session Chairs: Carla Perez Martinez (University College London), Vitaliy Guzenko (Paul Scherrer Institute)

8:00 AM 3A1 Invited

Recent Advances and Applications of Spindt Field Emitters, Christopher Holland, Paul R. Schwoebel, Sterling E. McBride (SRI International)

Spindt field emitter array cathodes have demonstrated unsurpassed emission performance. Each different application places different demands on the array. We discuss three applications under development: mm-wave TWTs, magnet free ion pumps, and mercury ion based atomic clock and the requirements on the cathode array and the status of development.

8:30 AM 3A2

Ion Microscopy, Machining, and Elemental Analysis with the Cesium Low Temperature Ion Source (LoTIS), Adam Steele, Andrew Schwarzkopf, Brenton Knuffman (zeroK NanoTech)

We present FIB and SIMS instruments that include the Cs+ low Temperature Ion Source. The systems are best suited for high-resolution nanofabrication, microscopy, and elemental analysis.

8:50 AM 3A3

Low temperature Caesiums ion source in a standalone FIB system used for imaging and milling processes, Thomas Loeber, Bert Laegel, Georg von Freymann (RPTU)

In this work we show our first results with a new kind of Cs FIB made by ZeroK. All of the results are compared with measurements achieved with a standard FEI Helios Ga FIB. Beside imaging the Cs FIB is also used for structuring of different materials.

9:10 AM 3A4

Focused Ion Beam Milling with Cold Rubidium, Kaih Mitchell, Rory Speirs, Christopher Billington, Andrew McCulloch, Robert Scholten (The University of Melbourne)

To achieve a high-brightness focused ion beam (FIB) for nanofabrication and imaging, we have developed a laser-cooled rubidium FIB. Our apparatus aims to achieve a higher beam brightness and a smaller focus spot size than existing state of the art gallium FIB systems and can be adapted for unique capabilities.

9:30 AM 3A5

Fabrication of high-resolution x-ray source with carbon nanotube emitters based electron beam(C-beam), YiYin Yu, Ketan Bhokkar, Kyu Chang Park (Kyung Hee University at Seoul)

We developed high-resolution x-ray source with CNT based electron sources. With optimized design C-beam design and one focusing electrode, we could obtain focal spot size less than 100 um and higher dose geration at fixed mAs . Dtail of the C-beam electron emitter design, FSS, dose relationship would present.

3B - Metrology and Characterization 1

Room: Continental Ballroom 5

Session Chairs: Larry Muray (KLA), Chih-Hao Chang (University of Texas at Austin)

8:00 AM 3B1 Invited

Continuous inline metrology of roll-to-roll micro-contact print process, Xian Du, Jingyang Yan, Rui Ma (University of Massachussets Amherst)

To solve inline metrology problems in quality monitoring and controlling the R2R micro-contact print process, we proposed a real-time imaging technique based on controlled condensation figures and closed-loop feedback image registration. Our experimental results showed that the method can achieve high-precision pattern metrology for a continuous R2R print process.

8:30 AM 3B2

Complete Compressed Sensing System for Scanning Probe Microscopy, Ed Principe (Synchrotron Research, Inc.); Jeffery J. Hagen, Brian W. Kempshall, Kirk M. Scammon (PanoScientific, LLC)

An approach to overcome barriers to practical Compressed Sensing (CS) implementation in scanning probe instruments is presented which integrates scan generator hardware specifically developed for CS, a novel and generalized CS sparse sampling strategy, and an ultra-fast reconstruction method, to form a complete CS system for electron microscopy.

8:50 AM 3B3

Modeling and Algorithm in Three-dimensional Metrology with Critical Dimension Scanning Electron Microscope, Jielin Zhou, Zhuming Liu (Institute of Semiconductors, Guangdong Academy of Sciences)

In this study, a novel model and algorithm based on 3D version of CASINO software was proposed to investigate height, SWA measurements of trapezoid and inverted trapezoid structures which can be achieved with high accuracy from modeling and simulation results.

9:10 AM 3B4 Virtual

Construction of an Imaging Measurement System for Material Property Change under Controlled Mechanical Stress, Akinobu Yamaguchi, Shunya Saegusa (University of Hyogo)

We have created a tensile tester that is embedded in a synchrotron radiation photoelectron spectroscopy microscope and a micro-Raman spectroscopy imaging system. One is a miniaturized version of an existing tensile tester, and the other is an ultra-compact one using MEMS. Both were successfully tested and evaluated.

3C - Industrial Highlights

Room: Continental Ballroom 6

Session Chairs: Aimee Price (The Ohio State University), Guy DeRose (California Institute of Technology)

8:00 AM 3C1

ZL-1: An STM-based Atomic-Precision Lithography Tool, James Owen, Joshua B. Ballard, Ehud Fuchs, Moutaz Haq, Robin Santini, John Randall (Zyvex Labs)

We have previously developed ZyVector, an STM lithography control system, designed to convert a conventional STM into a lithography tool. Now, we have designed a complete UHV STM system, with ZyVector and the necessary additional capabilities, such as gas dosing and Si epitaxy, to form a complete STM lithography tool.

8:10 AM 3C2

Nanofabrication with 3 different Beams and its Verification by automated SEM Imaging and Metrology, Frank Nouvertne, Torsten Richter, Viacheslav Vlasenko (Raith GmbH)

In this talk, recent highlights spanning the entire Raith product portfolio will be presented. Advanced EBL solutions for specific photonic applications, minimum invasive ion beam microscopy and 3D tomography by new LMAIS empowered GaBiLi source for FIB, and fully automated large area SEM imaging and metrology will be in focus.

8:20 AM 3C3

Patterning with the fourth beam: Advances in thermal lithography with the NanoFrazor, Emine Cagin (Heidelberg Instruments Nano AG)

The NanoFrazor combines thermal scanning probe lithography and direct laser sublimation to create nano and microstructures rapidly and repeatably. Advances in the technology continue to open new application areas and enable novel research in a wide range of material systems. Examples of active stitching, atuomated overlay will be shown.

8:30 AM 3C4

Holographic photolithography tools for industrial-scale nanomanufacturing, Joseph Geddes (Photia Incorporated)

We developed holographic photolithography tools for industrial-scale manufacturing of nanostructured materials with one-, two-, and three- dimensional morphologies. These materials have a variety of applications, including optical coatings and metamaterials, filtration and separations, batteries and electrochemistry, and template patterning.

8:40 AM 3C5

A new tool for single ion implantation and nanoscale materials engineering: System design and source development, Gianfranco Aresta (Ionoptika Ltd)

8:50 AM 3C6

Automation of FIBSEM process and open access control of microscopes, Milo Hrabovsk, Jiri Dluhos (Tescan Orsay Holding); Alena Siudova, Miroslav Jurasek (Tescan Brno)

One of the main challenges of full utilization of FIBSEM in current Nanoprototyping environment is automation of the process, to reduce downtime. Current portfolio of Tescan Essence software modules offer large variety for lamella prep, 3D tomography, automatic imaging, nanopatterning and depositions.

9:00 AM 3C7

Correlative Microscopy: State-of-the-art Imaging Automation Combined with Artificial Intelligence for Efficient Workflows, Sandip Basu (Carl Zeiss Microscopy)

In microscopy, imaging is only the first step. Image segmentation and object classification are still a challenge, while being the foundation for all subsequent image analysis steps. Correlative microscopy solutions from ZEISS enables AI-based means to organize and analyze data and images from multiple modalities in a sample centric workspace.

9:10 AM 3C8

News from the Lab14 Group, Niels Wijnaendts van Resandt (Lab14)

This talk will present a short overview the Lab14 group and new product and application highlights from the LAB14-affiliated members including Heidelberg-instruments, Genisys, Focus group, Specsgroup, 40-30, Notion-Systems, Osiris International and its newest member Nanosurf.

9:20 AM 3C9

The Maskless Aligner – A Success Story, Steffen Diez (Heidelberg Instruments)

The Maskless Aligner is a laser lithography system dedicated to creating microstructures through Maskless laser Lithography, a technology which offers many advantages in micro-fabrication research. This presentation outlines the milestones from concept creation to initial market introduction, and the continuing development of the MLA series for R&D and industry applications.

9:30 AM 3C10

Metrology and Layout-based Automation for SEM Process Monitoring, S. Bauerdick, K. Reuther, K. Gieb, U. Hofmann (GenISys GmbH, Germany); R. McCay (GenISys Inc.)

Nanofabrication and lithography require SEM investigation for improvements and monitoring. While sophisticated lithography instrumentation is standard, conventional SEMs still are used to measure structures. Nowaday's applications ask for acquiring and analyzing many SEM images. We will present a software package for advanced SEM metrology and layout-based automated image acquisition.

4A - Electron Beam Lithography 2: Optics

Room: Continental Ballroom 4

Session Chairs: Ivan Kravchenko (Oak Ridge National Lab), Adam Steele (ZeroK Nanotech)

10:10 AM 4A1

Visualizing the transient response of the local potential on photoconductive antennas using time-resolved SEM, Kohei Kawasaki, Samuel Jeong, Yuga Emoto, Yuki Yamamoto, Yoshiya Kishibe, Yusuke Arashida, Keishi Akada, Shoji Yoshida, Jun-ichi Fujita (University of Tsukuba)

We demonstrated ultra-fast visualizing of the time-resolved potential variation on gold electrodes and GaAs substrates with scanning electron microscopy. Where the femto-second-pulse laser induced the moduration of surface conductance of the GaAs.We estimated the potencial relaxation of the GaAs surface was 47 ps.

10:30 AM 4A2

A Low-Energy Counting Electron Spectrometer Integrated into a Scanning Electron Microscope, John Simonaitis, Maurice Krielaart (Massachusetts Institute of Technology); Benjamin Slayton (Wentworth Institute of Technology); Joseph Alongi (Massachusetts Institute of Technology); Yugu Yang-Keathley (Wentworth Institute of Technology); Karl Berggren, Phillip D. Keathley (Massachusetts Institute of Technology)

In this work, we detail the development of a 10 keV electrostatic electron spectrometer for use in a modified scanning electron microscope. This spectrometer is capable of single electron detection with sub-eV energy and nanosecond temporal resolution, and is designed to study low-energy electron photon interactions.

10:50 AM 4A3

Shift happens: submilliradian goniometry of an electron beam, Andrew Madison, John Villarrubia, Daron Westly, Ronald G. Dixson, Craig Copeland (National Institute of Standards and Technology); John D. Gerling, Katherine A. Cochrane, Alan Brodie, Lawrence Muray (KLA-Tencor); James Liddle, Samuel Stavis (National Institute of Standards and Technology)

Shift happens due to electron beam tilt in scanning electron microscopy. To measure this aberration effect with submilliradian uncertainty, and to calibrate scale factor and correct scanfield distortion, we introduce conical frustrum arrays as multifunctional reference structures. Our concept shows promise for new accuracy in scanning electron microscopy.

11:10 AM 4A4

Modification of electrons trajectory using dielectrics, Esteban Irribarra, Ramn Xulvi, Jhon Chilliquinga (Escuela Politcnica Nacional)

The guiding effect is used to modify the trajectory electrons (0.5 keV – 7 keV) with a 10 cm square borosilicate plate. The results show that changes in the energy of the incident particles do not alter the direction of the deflected beam.

11:30 AM 4A5

Rapid prototyping of etch test structures for hard mask development using electron beam lithography, Barbara Kazanowska, Han Wang Gene Lee, Luisa Bozano (Applied Materials)

Here, electron beam lithography (EBL) is used as a proxy for EUV to generate nanoscale patterns in a maskless, direct write manner that mimic sub 50nm EUV features for expedited material screening and development.

4B - Nanophotonics and Plasmonics 1

Room: Continental Ballroom 5

Session Chairs: Chao Wang (Arizona State University), Wen-Di Li (Hong Kong University)

10:10 AM 4B1 Invited

Nanotechnology for Biosensing, Meta Devices, and THz Devices, Stella Pang (City University of Hong Kong)

Nanotechnology is applied to generate various nanostructures for high-performance biosensors, meta devices, and THz devices. 3D plasmonic biosensors will be shown to monitor cells and biomolecules with high sensitivity. Multiple-layer metasurfaces with twist angles will be developed using nanoimprint to form chiral magic angles for light manipulation.

10:40 AM 4B2

On target – accurate integration of quantum dots and bullseye cavities, Craig Copeland, Adam L. Pintar, Ronald G. Dixson, Ashish Chanana, Kartik Srinivasan, Daron Westly, Rob Ilic, Marcelo Davanco, Samuel Stavis (National Institute of Standards and Technology)

We develop a comprehensive calibration of a cryogenic localization microscope, enabling accurate localization of quantum dots to improve subsequent integration into photonic cavities. The result is a significant improvement in the magnitude and distribution of theoretical Purcell factor across a wide field, enabling dramatic increases of process yield.

11:00 AM 4B3

The plasmonic nano-grating device for photocatalytic water splitting reaction, Samuel Jeong, Gang Yang, Yusuke Arashida, Keisuke Akada, Yoshikazu Ito, Jun-ichi Fujita (University of Tsukuba)

We present an enhancement of photocatalytic reaction using surface plasmon resonance devices. The formation of a photoreaction field using nanograting devices increased the photocatalytic activity with visible light by more than 20-fold. Our approach can provide novel design guidelines of the photocatalytic reaction field.

11:20 AM 4B4 Virtual

Plasmonic cavities and individual quantum emitters in the strong coupling limit, Ora Bitton (Weizmann Institute of Sciences)

We observe strong coupling to both dark and bright plasmonic modes, in the limit of a single quantum emitter positioned within a plasmonic cavity. Spectroscopic observables point to the involvement of a dark excitonic state of the QD and to complex dynamics.

11:40 AM 4B5 Invited

Sensing and Spectroscopy of Single Molecules on Optoplasmonic Microcavities, Frank Vollmer (University of Exeter)

Optical microcavities show greatly enhanced sensitivity when modified with plasmonic nano particles, enabling the sensing of molecules and atomic ions in aqueous solutions. I will present most recent advances in Optoplasmonic single molecule sensing: detection of absorption cross section of molecules attached to plasmonic nano particles from a thermo-optical approach.

4C - Bioinspired Nanostructures

Room: Continental Ballroom 6

Session Chairs: Nichole Cates (Smart Material Solutions), Saba Ghassemi (University of Pennsylvania)

10:10 AM 4C1 Invited

Micro and Nanomanufacturing of Synthetic Brochosomes, Tak Sing Wong (The Pennsylvania State University)

Considered as one of the most sophisticated natural structures, brochosomes are three-dimensional, soccer ball-like microscopic granules with distributed nanoscale cavities produced by leafhoppers. In this talk, I will discuss the micro- and nanofabrication strategies of synthetic brochosomes, as well as their optical characterizations and potential applications.

10:40 AM 4C2

Bioinspired, Sequence-Defined Polymer Brushes as Patternable Surface Modification Monolayers for Semiconductor/Bio Interfaces, Beihang Yu (Lawrence Berkeley National Laboratory); Boyce Chang (Iowa State University); Whitney Loo (University of Wisconsin Madison); Scott Dhuey (Lawrence Berkeley National Laboratory); Padraic O'Reilly (Molecular Vista); Paul Ashby, Michael Connolly (Lawrence Berkeley National Laboratory); Kathleen Ryan, Grigory Tikhomirov (University of California Berkeley); Ronald Zuckermann, Ricardo Ruiz (Lawrence Berkeley National Laboratory)

Control and manipulation of semiconductor/bio interfaces is key to enable biological nanofabrication pathways and new applications at the intersection of semiconductor technology and synthetic biology. Here we demonstrate a new platform using bioinspired, sequence-defined polymers as surface modification monolayers that are functional, patternable, and compatible with semiconductor/bio interfaces.

11:00 AM 4C3

Electrospun Surfaces for Anti-Biofouling Functionalized by Anti-Quorum Sensing Molecules, Amos Taiswa, Jessica Andriolo, Jack Skinner (Montana Technological University)

Electrospun fibrous coatings provide texture and slow release of molecules that interrupt bacterial signaling. Quorum sensing plays an important role in biofilm formation. In this work, polymer blends (polycaprolactone-polyethylene glycol) were used to provide slow release of anti-QS molecules (Urolithin A) to prevent biofilm formation on a nanofiltration membrane.

11:20 AM 4C4

Investigation of Particle Aggregation Behavior in Anti-Dust Nanostructures, Andrew Tunell, Chih-Hao Chang (University of Texas at Austin); Lauren Micklow, Stephen Furst, Nichole Cates (Smart Material Solutions)

Periodic nanostructures fabricated on polycarbonate substrates using a scalable nanocoining and thermal nanoimprint process minimize adhesion forces of particulates and result in dust-mitigation properties. This work will investigate the particle aggregation behaviors and effectiveness of removal mechanisms based on particle density and coating methods.

11:40 AM 4C5

Antireflection Sapphire Nanostructures Fabricated by Low RF Power ICP-RIE, Kun-Chieh Chien, Chih-Hao Chang (University of Texas at Austin)

Biomimic taper or antireflection nanostructures reduce the reflectance and enhance the transmittance by gradually matching refractive indices of two media across the interface. We present a simple technique to fabricate high aspect ratio antireflection nanostructures to enhance transmittance for single-crystal sapphire based on the low RF power ICP-RIE.

5A - Neuromorphic Computing

Room: Continental Ballroom 4

Session Chairs: John Randall (Zyvex Labs), Gina Adam (George Washington University)

1:40 PM 5A1 Invited

Electron Beam Lithography Patterning of Magnetic Nanostructures for Neuromorphic and In-Memory Computing, Jean Anne Incorvia, Thomas Leonard, Samuel Liu, Harrison Jin, Can Cui (University of Texas at Austin); Tianyao P. Xiao, Christopher H. Bennett, Matthew J. Marinella (Sandia National Laboratories); Mahshid Alamdar (University of Texas at Austin)

We will present our results showing how stochastic domain walls integrated into magnetic tunnel junctions can act as logic elements as well as artificial synapses and neurons. We will show that leveraging these dynamical behaviors can benefit many areas of unconventional computing. Challenges in fabricating the devices will be analyzed.

2:10 PM 5A2

Analog content-addressable memories with 2D floating-gate memory transistor, Guoyun Gao, Bo Wen, Can Li (The University of Hong Kong)

We propose and build analog CAM based on two-dimensional (2D) floating gate field-effect transistors (FGFET) to tackle bottlenecks imposed by silicon transistors. We expect large-scale 2D FGFET-based analog CAM to be a promising build block for a near-sensor explainable tree-based machine learning accelerator.

2:30 PM 5A3

Fabrication and Characterization of MoS2 Memristive Devices with Short and Long-Term Memory Behaviors, Seungjun Ki, Mingze Chen, Xiaogan Liang (University of Michigan)

We fabricated MoS2-based memristors and investigated the pulse-programmed response behaviors of such devices. This work indicates that MoS2 memristors exhibit a relatively low threshold field for initiating memristive switching in comparison with oxide-based memristors and exhibit both STP and LTP effects that can be modulated through varying programming pulse parameters.

2:50 PM 5A4

Error-feedback-based auto-tuning algorithm for faster memristor programming, Sushmit Hossain, Buyun Chen, Zerui Liu, Yunxiang Wang, Ryan Bena, Hsiang-chun Cheng, Quan Nguyen, Mike Shuo-Wei Chen, Wei Wu (University of Southern California)

Computing applications and the backpropagation algorithm used in NNs require memristors to be tuned to specific conductance levels in short times. The algorithm mostly used in programming the memristor is the "write-verify algorithm". Here we present a modified version of this algorithm which shows significant improvement over the traditional one.

3:10 PM 5A5

A Memristor-Based Edge Computing System for Accelerating Support Vector Machine, Zerui Liu, Sushmit Hossain, Yudi Shi, Hsiang-Chun Cheng, Pan Hu, Deming Meng, Buyun Chen, Hao Yang, Yunxiang Wang, Boxiang Song, Bofan Zhao, Tse-Hsien Ou, Cai Zhi (University of Southern California); Mark Barnell, Qing Wu (Air Force Research Laboratory); Stephen Cronin, Wei Wu, Mike Shuo-Wei Chen (University of Southern California)

In this study, a high-performance support vector machine (SVM)-based edge computing system is implemented using memristors to demonstrate the feasibility to revolutionize the field of computation, optimization, and decision-making.

5B - EUV/X-ray Lithography and Optics

Room: Continental Ballroom 5

Session Chairs: Alain Diebold (SUNY Polytechnic Institute), Martha Sanchez (Applied Materials)

1:40 PM 5B1 Invited

Extreme ultraviolet interference lithography towards high- and hyper-NA lithography, Yasin Ekinci, Iacopo Mochi, Dimitrios Kazazis (PSI)

We discuss the progress in EUV lithography and discuss the challenges towards 6 nm half-pitch. We demonstrate using EUV interference lithography that this is feasible and show novel approaches to overcome the limitations of the photoresists.

2:10 PM 5B2

Development of Monolithic X-ray Achromats, Joan Vila-Comamala, Peng Qi, Umut T. Sanli, Ana Diaz, Christian David (Paul Scherrer Institut); Georg Schulz, Griffin Rodgers, Bert Mueller (University of Basel)

We report the development of a monolithic X-ray achromat by combining several nanofabrication techniques. It is composed of a diffractive and refractive part. The diffractive elements is made by high resolution electron beam lithography and electroplating. The refractive lens was produced by two-photon polymerization 3D printing.

2:30 PM 5B3

Progress in fabrication of free-standing gold gratings for phase contrast X-ray microscopy, Olga V. Makarova (Creatv MicroTech, Inc.); Ralu Divan (ANL); Nicolaie Moldovan (Alcorix Co.); David A. Czaplewski (Argonne National Laboratory); Michela Esposito (University College London); Cha-Mei Tang (Creatv MicroTech, Inc.); Joseph D. Ferrara (Rigaku Americas Corp.); Alesandro Olivo (University College London)

We present the progress towards a refined process allowing to obtain gratings with submicron aperture slits (700 nm) and to substantially improve gold grating flatness (bellow 200 nm over the entire 4 mm x 4 mm area) for higher X-ray phase contrast imaging resolution and accuracy.

2:50 PM 5B4

EUV lighting technology with carbon nanotube based cold cathode electron beam(C-beam) irradiation technique, Bishwa Chandra Adhikari, Kyu Chang Park (Kyung Hee University at Seoul)

We present novel EUV ligting source fabrication technique with electron beam irradation technique. CNTs based cold cathode electron beam(C-beam) is used for excitation of anode target. With moderate irradiation of C-beam on Sn anode, we could obtain EUV lighting. The lighting depend on the irradiation, such as bias and current.

3:10 PM 5B5 Virtual

Creation of X-ray multi-scale microfabrication system, Akinobu Yamaguchi (University of Hyogo)

We have created a beamline for multiscale X-ray microfabrication. This system enables a process that can simultaneously fabricate micrometer-scale high-aspect-ratio fabrication and sub-micrometer-scale microstructures.

5C - Nanoimprint Lithography

Room: Continental Ballroom 6

Session Chairs: Stephen Chou (Princeton University), Bruno Azeredo (Arizona State University)

1:40 PM 5C1 Invited

Scalable Fabrication of High Performance, All-Inorganic Metalenses, Waveguides and Diffractive Optics via Nanoimprint Lithography, Dae Eon Jung, Vincent J. Einck, Lucas Verrastro, Amir Arbabi, James Watkins (University of Massachusetts)

All-inorganic visible wavelength metalenses with absolute efficiencies of 75% (>90% design efficiency) were fabricated using nanoimprint lithography (NIL) with cycle times of 2 minutes. Atomic layer deposition (ALD) as a post-imprint treatment enabled tuning of the refractive index from 1.9 to 2.2 using a small number of cycles.

2:10 PM 5C2

Scalable Nanofabrication of High Index Optical Components Using Nanoimprint Lithography, Parth Pandya, Shrawan Singhal, S.V. Sreenivasan (The University of Texas at Austin)

In this paper, we have introduced a scalable process of fabricating of high index inorganic nanostructures with complex geometries using nanoimprint lithography. This can be used to fabricate optical components for applications such as AR/MR waveguides and metalenses while meeting the requirements of high manufacturing throughput and optical performance simultaneously.

2:30 PM 5C3

Antireflective structures directly imprinted on chalcogenide glasses, Sivan Tzadka (Ben Gurion U.), Natali Ostrovsky (Ben Gurion U.), Esti Toledo (Ben Gurion U.), Guilluame Le Saux (Ben Gurion U.), Hadar Frankenstein Shefa (Optical Component Center), Evyatar Kassis, Shay. Joseph (Optical Component Center), Mark Schvartzman (Ben Gurion U.)

Thermal nanoimprint is the most attractive method for surface patterning of chalcogenide glasses due to the low their low Tg. Still, one major challenge remains, direct imprint of ChG without deforming its shape. Here, we present three novel approaches for a direct imprint of ChG without deforming the substrate's shape

2:50 PM 5C4

Study on induced strain during releasing process for slanted grating structure in nanoimprint process, Yuusei Kunitou, Yoshihiko Hirai, Masaaki Yasuda (Osaka Metropolitan University)

we discuss the induced strain caused by the release process of the slanted structure using numerical simulation for various peeling release in nanoimprint.

3:10 PM 5C5 Invited

Large-Area Nanopatterning with Focused Ion Beam Milling, Nanocoining, and Roll-to-Roll Thermal Embossing, Nichole Cates, Lauren Micklow, Stephen Furst (Smart Material Solutions, Inc.)

Scalable nanopatterning processes are needed for industrial-scale manufacturing of nanotechnologies that have been proven in the lab. Here, we present high-throughput nanopatterning by rapidly replicating and stitching together small-area patterns to seamlessly nanopattern hundreds of square feet using focused ion beam (FIB) milling, nanocoining, and roll-to-roll (R2R) processes.

Friday, June 2

6A - Atomically Precise Fabrication

Room: Continental Ballroom 4

Session Chairs: Joris Keizer (University of New South Wales), Richard Silver (National Institute of Standards and Technology)

8:00 AM 6A1 Invited

APAM 2D bipolar device fabrication, James Owen, Robin Santini, Ehud Fuchs, John Randall (Zyvex Labs)

We continue to develop sample designs and patterning technology to improve the precision and throughput of atomic-scale STM lithography. A new sample design allows for rapid location of the device area, while software improvements allow for more precise alignment of new patterns to existing atomic-scale structures.

8:30 AM 6A2

Low-Temperature Contacts for Atomically Precise Delta-Doped Silicon Microelectronics, Ramyapriya Krishnasamy, Alexandra Joshi-Imre (Univerisity of Texas at Dallas); John Randall, Robin Santini (Zyvex labs); Wiley P. Kirk, Jeffrey B. Murphy (3D Epitaxial Technologies, LLC); Walter Voit (University of Texas at Dallas); James Owen (Zyvex Labs)

This research will discuss the challenges and importance of good electrical contacts to atomically precise devices. In addition, it will explore the ways to overcome those challenges in achieving electrical contacts to delta-doped atomically precise devices.

8:50 AM 6A3

Fabrication of Donor-based Quantum Devices in Silicon using Scanning Tunneling Microscopy, Pradeep Namboodiri, Jonathan Wyrick, Fan Fei, FNU Utsav (National Institute of Standards and Technology); Xiqiao Wang (Rigetti Computing); Joseph Fox, Rick Silver (National Institute of Standards and Technology)

We will present the fabrication of atomic scale quantum devices using hydrogen-based scanning probe lithography. We will discuss the design, fabrication, and use of surface top gates to address individual components individually or globally in few-donor/quantum dot devices as well as arrayed 2x2 devices.

9:10 AM 6A4

Direct integration of atomic precision devices with CMOS, Shashank Misra (Sandia National Laboratories)

We have integrated atomic precision advanced fabrication with CMOS manufacturing in the middle-end-of-line, which leaves the parent CMOS intact, and permits the integration of novel devices. Potential applications include TFETs for energy-efficient digital, single electron transistors that work at room temperature for sensing, and CMOS contacts with improved contact resistance.

9:30 AM 6A5

Atomically Precise Fabrication Templated by Hydrogen and Halogen Monolayer Resists, Robert Butera, Esther Frederick, Scott Schmucker, Quinn Campbell, David R. Wheeler, Shashank Misra (Sandia National Laboratories)

We utilize halogen adatoms to passivate and protect lithographically defined patterns while maintaining the integrity and difference in chemical reactivity of the patterned region. We discuss the identification of selective chemistries that target attachment to the halogenated regions and function as effective growth inhibitors for area-selective, atomic layer deposition processes.

6B - Scalable Nanomanufacturing

Room: Continental Ballroom 5

Session Chairs: Jack Skinner (Montana Technological University), Ke Du (University of California at Riverside)

8:00 AM 6B1 Invited

Wafer-scale structural coloration using interference lithography and grayscale-patterned secondary exposure, Zhuofei Gan, Hongtao Feng, Chuwei Liang, Wen-Di Li (The University of Hong Kong)

A high-throughput and wafer-scale nanopatterning method of interference lithography and grayscale-patterned secondary exposure is proposed that could spatially modulate nanostructure feature sizes on large scale while maintaining sufficiently high resolution. The method is demonstrated in the fabrication of wafer-scale structural color paintings.

8:30 AM 6B2

Design and roll-to-roll nanofabrication of plasmonic solar light absorbers, Maria Serra Gonzlez, Matthias Keil (DTU); Nastasia Okulova (Inmold A/S); Rafael J. Taboryski (DTU)

A large scale fabrication of a plasmonic metasurface for solar light absorption is presented. A novel combination of resolution enhancement techniques on a DUV Stepper allowed the fabrication of a hexagonal array of nanopillars, later replicated to the large scale using a roll-to-roll method.

8:50 AM 6B3

Patterned Wettability Induced Growth of Perovskite Nanowire Arrays, Guannan Zhang, Zhao Sun, Chuiwei Liang, Liyang Chen, Wen-Di Li (The University of Hong Kong)

A template-free fabrication method to realize the controllable growth of perovskite nanowire arrays via the inducement of patterned wettability is demonstrated. The strategy shows a facile method to fabricate perovskite nanowire arrays, paving the way to low-cost, large-area, and rapid fabrication of high-performance perovskite optoelectronic devices.

9:10 AM 6B4

Metalized ceramic corrugated films as lightweight space-based microwave reflectors, Victoria Fethke, Mohsen Azadi, Matthew F. Campbell, Igor Bargatin (University of Pennsylvania)

We report metalized mechanical metamaterial reflectors that are made of few-100 nm thick aluminum oxide covered by ~ 10 nm thick metal films, such as aluminum. These films' corrugated design prevents them from wrinkling or tearing relative to traditional planar membranes. Areal density of reflectors is less than 2 g/m2.

6C - MEMS/NEMS

Room: Continental Ballroom 6

Session Chairs: Rebecca Cheung (University of Edinburgh), Leeya Engel (Technion - Israel Institute of Technology)

8:00 AM 6C1 Invited

Nanopore-Integrated Microwave Sensors for Capacitive Detection of Single Nanoparticles inside Liquid, Arda Secme (Bilkent University, and Caltech); Berk Kucukoglu (Bilkent University, and EPFL); Hadi Sedaghat Pisheh, Hatice Dilara Uslu, Selim Hanay (Bilkent University)

We will first discuss microwave capacitive sensors enhanced with micro/nanofabricated sensing region and compare them their mechanical MEMS/NEMS counterparts. Then we will present an entirely-electronic system for the capacitive detection of nanoparticles in liquid. Beyond sizing nanoparticles, the proposed paradigm can open the way for dielectric-based classification of nanoparticles.

8:30 AM 6C2

Integration of mode localized coupled resonators with ZnO nanowires for ammonia gas detection, Dexiang Zhang, Graham S. Wood, Andreas Tsiamis, Camelia Dunare, Peter Lomax, Rebecca Cheung (University of Edinburgh); Yuk Sim Tang, Neil Mullinger, Eiko Nemitz (UK Centre for Ecology & Hydrology)

We report the fabrication and integration processes of mode localized coupled resonators (MLCRs) with zinc oxide nanowires (ZnO NWs) for ammonia gas detection.

8:50 AM 6C3

Effects of Cobalt-60 Irradiation on the Performance of AlN-Transduced Microelectromechanical Resonators, David D. Lynes, Hengky Chandrahalim (The U.S. Air Force Institute of Technology)

This work presents the effects of gamma ray radiation on piezoelectrically transduced resonators. Two AlN-transduced resonators are designed and fabricated, with and without a silicon dioxide thin film.The AlN-transduced microelectromechanical resonators are exposed to 1 Mrad(Si) using Cobalt-60 (Co-60) Underwater Irradiator and systematically characterized in-situ.

9:10 AM 6C4

Development of a dual-compartment microelectrode array for investigation of neuronal network media exchange, Victoria Ravel, Imtiaz Hossen, Olivia Ladriscina, Omar Sbaih, Rhonda Dzakpasu, Gina Adam (The George Washington University)

Dual-compartment microelectrode arrays are needed to assess the impact of cell culture media exchange between two initially isolated neuronal networks. This work presents the development of microelectrode electrode arrays integrated with autoclavable biocompatible resin rings with removable silicon plugs. The developed structures can be used for various studies in neurophysiology.

9:30 AM 6C5

Nanoscale Strain Gauges on Flexible Polymer Substrates, Devin Brown, Isha Lodhi, Biya D. Haile, Oliver Brand (Georgia Institute of Technology); David R. Myers, Wilbur A. Lam (Emory University, Georgia Institute of Technology)

Nanometer scale strain gauges are presented for high throughput measurement of cell forces on flexible and soft polymer substrates. The strain gauges were characterized and demonstrated successful transduction of mechanical strain to electrical resistance change.

7A - Ion Beam Lithography

Room: Continental Ballroom 4

Session Chairs: Christopher Holland (SRI International), James Spallas (KLA)

10:20 AM 7A1

Multiple ions from a single source for nanofabrication with top-down FIB on a lithography platform, Torsten Richter, Achim Nadzeyka, Paul Mazarov, Lars Bruchhaus, Fabian Meyer (Raith GmbH)

Liquid Metal Alloy Ion Source (LMAIS) is a versatile FIB source technology delivering various ion species from a single source. Combined with a lithography platform unlimited process pathways become possible. We present latest advances in LMAIS source technology with related applications such as Lithium ion beam lithography and ion microscopy.

10:50 AM 7A2

Understanding and Controlling the Beam Energy Spread of Ionic Liquid Ion Sources for Focused Ion Beam Applications, Nazli Turan, Szymon Dworski, Euan Donovan-Hill, Charles N. Ryan (University of Southampton)

A beam source capable of working with different ionic liquid (IL) compositions in each polarity provides flexibility in surface processing. We aim to demonstrate the potential of ILISs for FIB applications while addressing the inherent challenges of the implementation and investigating the effects of electric field via simulations and experiments.

11:10 AM 7A3

Large area Si-FIB patterning of SiO2 hard mask on 3D crystallographic nanostructures, Erwin Berenschot, Yves Janssens, Yasser Pordeli, Niels Tas (University of Twente, MESA+ Institute, Faculty of Science and Technology); Achim Nadzeyka, Torsten Richter, Otto Carel (Raith Group)

We report about the use of a Si-ion beam from a vertical FIB to selectively open an 8 nm silicon dioxide hard mask on top of silicon nano "wedges". This resistless approach enables relative high resolution patterning on top of 3D nanostructures. Subsequent selective etching of silicon nanostructures is demonstrated.

11:30 AM 7A4

Enhancement of thermal and photo-thermal carbonization of polymers by focused ion beam implantation of gold, Nickolay Lavrik, Ivan Kravchenko, Dale K. Hensley (ORNL)

Ion implantation of metals is a promising approach to catalytic synthesis of carbon nanomaterials. Here we explore ion implantation of gold into polymer to enable carbonization of polymer precursors without exceeding the temperature range compatible with CMOS processing and to make it potentially compatible with flexible electronics MEMS technology.

7B - Nanophotonics and Plasmonics 2

Room: Continental Ballroom 5

Session Chairs: Rajesh Menon (University of Utah), Frank Vollmer (University of Exeter)

10:20 AM 7B1 Invited

Higher-Efficiency Microlenses for Zone-Plate-Array Lithography, Henry Smith, Mark K. Mondol (MIT); Feng Zhang, Timothy Savas, Michael E. Walsh (LumArray, Inc.)

Improvement to Zone-Plate-Array maskless photolithography performance via diffractive-optical simulation and nanofabrication

10:50 AM 7B2

Multi-Level Diffractive Lens (MDL) for extended-depth-of-focus over 50 mm fabricated by Grayscale Lithography, Tina Hayward, Apratim Majumder (The University of Utah); Ryan R. Ahern (VideoJet Technologies, Inc.); Rajesh Menon (University of Utah)

This project used an optimization-based inverse multi-level diffractive lens design – with an extended-depth-of-focus of 50 mm, fabricated the design using grayscale lithography, and experimentally characterized the lens. Experiments found an extended-depth-of-focus of 58.8 mm and an efficiency of about 78.86%.

11:10 AM 7B3

Three-Dimensional Periodic Nanolattices with Precisely Controlled Refractive Index, Vijay Anirudh Premnath, Chih-Hao Chang (University of Texas at Austin)

The research focuses on the fabrication of precise engineered structures using Directed Self Assembly, UV Lithography and Atomic Layer Deposition with a focus of achieving control in effective refractive indices to the scale of 0.0004. The project finds applications in emerging display technologies as in developing 3D light field displays.

11:30 AM 7B4 Invited

Three Dimensional Optical Metasurfaces using Two-Photon Lithography, F. Balli, M. Sultan, S. Lami, D. Kumar, A. Thuringer, and J. Todd Hastings (University of Kentucky)

We review recent developments in 2.5 and 3D optical metasurfaces fabricated using two-photon lithography. Optical system of interest include achromatic metalenses, varifocal metalens, and focusing filters. We also present novel results in wide-color gamut imaging using arrays of focusing metafilters.

7C - Micro/Nanofluidics

Room: Continental Ballroom 6
Session Chairs: Scott Retterer (Oak Ridge National Lab), Selim Hanay (Bilkent University)

10:20 AM 7C1 Invited

Micro-/nano-scale platforms for the controlled ex-vivo mechano-stimulation of cells, Mark Schvartzman (Ben-Gurion University of the Negev)

We engineered micro/-nano- engineered platforms for cell stimulation of lymphocyte activation. The platforms were based on nanoimprinted molecular patterns of signaling ligands and mechanoresponsive nanowires. We also engineered micropatterns with varied stiffness and used them to reveal a new mechanism of cell mechano-sensing.

10:50 AM 7C2

Silicon-based microfluidic grating for neutron phase imaging, Sarah Robinson, Ryan P. Murphy, Youngju Kim, M. LaManna, Caitlyn M. Wolf, Katie M. Weigandt, Daniel S. Hussey, Klimov (PML, National Institute of Standards and Technology)

The development of a dynamic source grating is a first step to realizing a neutron analog of a spatial light modular. We will present progress towards fabrication and sealing of over 2,000 microfluidic channels and infilling with a neutron absorbing fluid for far-field neutron interferometry.

11:10 AM 7C3

Micro fluidic device with SERS active nanostructure fabricated on boehmite, Shunya Saegusa, Taku Tanaka (University of Hyogo); Masayuki Naya (Keio University); Takao Fukuoka, Sho Amano, Yuichi Utsumi, Akinobu Yamaguchi (University of Hyogo)

We have studied on a method to fabricate SERS-active structures of gold nanofève using the boehmite structure due to its advantage of easy fabrication on a wide range of substrates. In this study, microfluidic devices incorporating the above SERS structures were fabricated and evaluated for detection processes.

11:30 AM 7C4 Invited

Development of novel microfluidic devices for scalable manufacturing for point-of-care diagnostics., Keith Morton (National Research Council Canada)

Microfluidic-based devices will enable precise and personalized health monitoring and care at the point-of-need. I will present microfluidic device design and manufacturing approaches for scalable fabrication of novel, all-plastic, bio-diagnostic devices that automate extraction and analysis of cells, RNA, DNA and protein biomarkers from complex biological samples.

8A - Quantum Electronics and Emerging Architecture

Room: Continental Ballroom 4

Session Chairs: James Owen (Zyvex Labs), Xiaogan Liang (University of Michigan)

1:30 PM 8A1 Invited

End-to-end Platform to Support the Democratization of System-scale Prototyping based on Emerging Devices, Gina Adam (George Washington University), Imtiaz Hossen, Osama Yousuf, Brian Hoskins, Advait Madhavan, Martin Lueker-Boden, Patrick Braganca, Vasileia Georgiou and Tiffany Santos

2:00 PM 8A2

Solid State, Atom-based Devices for Analog Quantum Simulation and Quantum Manipulation, Rick Silver, Fan Fei, Pradeep Namboodiri, Jon Wyrick (National Institute of Standards and Technology); Xiqiao Wang (Rigetti); FNU Utsav (National Institute of Standards and Technology); Joseph Fox (University of Maryland)

NIST is using atomically precise fabrication to make few-donor/quantum dot devices and arrayed few-donor devices for analog quantum simulation (AQS). The AQS experiments are used to explore the Hubbard phase space using atomically engineered materials whose properties, such as magnetic ordering or Mott insulating phase, depend on the atomic configurations.

2:20 PM 8A3

New method of fabrication of suspended metallic Single Electron Transistor (SET), Mohammad Istiaque Rahaman, Gergo P. Szakmany, Alexei O. Orlov, Gregory L. Snider (University of Notre Dame)

We have done fabrication of suspended metallic Single Electron Transistor (SET) by a new method. The performance of our SET is better than the reported works on suspended SETs. This device would be a gateway for better understanding of the source of the noise in the SETs.

2:40 PM 8A4

Improving AlOx based Single Electron Transistors for Quantum Charge Sensing, Runze Li (University of Maryland); Pradeep Namboodiri (National Institute of Standards and Technology); Zachary Barcikowski (University of Maryland); Yanxue Hong, Joshua Pomeroy (National Institute of Standards and Technology)

The resistance of aluminum oxide (AlOx) thin films is explored by varying the plasma oxidation duration, which can reduce the RC (resistance*capacitance) time constant and improve the bandwidth of charge sensors.

3:00 PM 8A5

Reducing Losses in Superconducting Qubits, Bethany Niedzielski Huffman (MIT Lincoln Laboratory)

Superconducting qubits for quantum computing are electronic circuits that can be fabricated using similar tools and processes as classical computer chips. However, careful choices are needed during the fabrication process to minimize performance losses, including the superconducting materials and substrates that are used, and reducing surface oxides or process residuals.

8B - Scanning Probe Lithography

Room: Continental Ballroom 5

Session Chairs: Rob Ilic (National Institute of Standards and Technology), Michael Cullinan (University of Texas at Austin)

1:30 PM 8B1 Invited

Towards Femtogram-Scale Materials Discovery using Scanning Probe Lithography, Keith Brown (Boston University)

This work explores recent progress in transforming scanning probe systems into platforms for combinatorial materials discovery studying samples approaching the femtogram scale. We focus on innovations in the area of closed-loop nanopatterning and controlled mixing of fluid samples using scanning probes.

2:00 PM 8B2

Improving Current On/Off Ratio of Oxygen-Doped WSe2 transistors by Selective Scanning Probe Lithography, Sihan Chen, Yue Zhang, William P. King, Arend M. van der Zande, Rashid Bashir (University of Illinois Urbana-Champaign)

WOx degenerately p-dopes WSe2, leading to in high on-current but low on/off ratio in transistors. In this work, we use a scanning probe to selectively remove monolayer WOx on a bilayer WSe2 channel, which significantly improves the current on/off ratio of oxygen-doped WSe2 transistors while preserving their high on-current.

2:20 PM 8B3

Image reversal through NanoFrazor patterning and pattern transfer processes: from nanoholes to nanopillars, Jana Chaaban, Myriam Kppeli (Heidelberg Instruments Nano AG); Ute Drechsler (IBM Research Europe); Emine Cagin (Heidelberg Instruments Nano AG)

NanoFrazor uses thermal scanning probe lithography for the simultaneous patterning and inspection of nanoscale structures. Here, we discuss a complete NanoFrazor patterning and pattern-transfer solution that allows for the image reversal of any written design. In particular, we showcase how this process creates sub-100 nm diameter nanopillars from nanoholes.

2:40 PM 8B4 Virtual

3D nanolithography by means of Scanning Probe Lithography, Eider Berganza (Karlsruhe Institute of Technology)

Following a bioinspired approach that relies on the ink spreading inhibition, we present a process to build 3D metallic structures, by coating the substrate with Serum Albumin protein and patterning with Phospholipid ink.

8C - Advanced Pattern Transfer

Room: Continental Ballroom 6

Session Chairs: Mark Schattenburg (Massachusetts Institute of Technology), Dimitrios Kazazis (Paul Scherrer Institute)

1:30 PM 8C1 Invited

Conformal Electrochemical Nanoimprinting of Silicon: Towards Bio-Inspired Infrared Meta-Optics, Aliaksandr Sharstniou (Arizona State University); Shouhong Fan (University of Colorado at Boulder); Emmanuel Dasinor (Arizona State University); Yifu Ding (University of Colorado Boulder); Bruno Azeredo (Arizona State University)

Due to the incompatibility of semiconductor micromachining with non-planar substrates, multifunctional optical meta-surfaces have only been demonstrated in polymeric lenses. In this presentation, a new method of conformal electrochemical nanoimprinting is presented to directly micromachine a nature-inspired sharklet pattern onto a silicon lens as both an anti-reflective and anti-fouling surface.

1:50 PM 8C2

Metal assisted chemical etching: towards CMOS compatible catalyst for high aspect ratio nanostructures, Lucia Romano, Craig Lawley (ETH Zurich & Paul Scherrer Institute); Marius Mahlum Halvosen (Univ. of Oslo & CERN EP-LBD); Konstantins Jefimovs, Vitaliy Guzenko (Paul Scherrer Institute); Marco Stampanoni (ETH Zurich & Paul Scherrer Institute)

MacEtch is a plasma free, anisotropic chemical etching that uniquely defies the isotropic nature of conventional wet etching, through local catalyzed electrochemistry. Here a new milestone for a CMOS compatible MacEtch process for high aspect ratio Si nanostructures using Ru as a very reactive catalyst for oxygen based gas-phase etching.

2:10 PM 8C3

High Aspect Ratio Structures for Meta-surface Optics, Bruce Burckel, Katherine M. Musick, Travis R. Young, Loren Gastian, John Mudrick (Sandia National Laboratories)

High aspect ratio etching in silicon and gallium arsenide for metasurface optics is demonstrated. Interferometric lithography is used as a rapid prototyping solution to provide patterns with relevant dimensions for studying etch dynamics. The final patterns are created using e-beam lithography.

2:30 PM 8C4

Large area fabrication of high aspect ratio sub-micrometer Si structures by displacement Talbot lithography and deep reactive ion etching, Konstantins Jefimovs, Lucia Romano, Mehdi Heydari (Paul Scherrer Institute)

We report on wafer scale nanofabrication utilizing displacement Talbot lithography and Si deep reactive ion etching. Si grating structures with lines and spaces of 325 nm and the depth of ~21 µm are demonstrated. Such structures have application in X-ray and neutron optics, MEMS, photonics and structured biointerfaces.

2:50 PM 8C5

Understanding mechanical behavior of porous polymeric stamps during large-area metal-assisted chemical imprinting of silicon, Emmanuel Dasinor, Aliaksandr Sharstniou, Bruno Azeredo (Arizona State University); Yifu Ding (University of Colorado)

This work aims to understand the changes in the polymeric stamp's morphology during Mac-Imprinting both experimentally and numerically.

9A - Electron Beam Lithography 3: Processes and Materials

Room: Continental Ballroom 4

Session Chairs: Leonidas Ocola (IBM), Scott Lewis (California Institute of Technology)

3:40 PM 9A1

Measurement of Placement Accuracy and Overlay in E-beam Lithography with 2-D Vernier Arrays, Robyn Seils, Sean Branagan (Raith America, Inc); Akhil Dodda (Western Digital Research Center); Amanda Wscieklica (Raith B.V.); Alexei L. Bogdanov (Western Digital Research Center)

A new method that employs 2-D overlaid Vernier arrays to measure field stitching, placement, and overlay errors using simple SEM image processing is presented. As compared to the preceding methods, overlaid 2-D Vernier arrays can provide the measurements with sub-1 nm accuracy directly on resist after e-beam lithography step.

4:00 PM 9A2

Direct Writing of Tris(xanthato)Bi(III) Precursors for use in Future Optoelectronic Devices, James Mann (The University of Manchester); Scott Lewis (California Institute of Technology); Richard Winpenny (The University of Manchester)

Tris(xanthato)Bi(III) resists have been shown to produce 30 nm half pitch structures after exposure to an electron beam. Monte Carlo simulations and experimental dose requirements show a close relation, indicating changing the ligand affects sensitivity of the resist. Future applications are for thermoelectric, memory, and photodetector devices.

4:20 PM 9A3

Direct Writing of Metal-Organic Resists for Alignment Marker Fabrication in Electron Beam Lithography, Guy DeRose, Scott M. Lewis (California Institute of Technology); Hayden Alty, Ahmad Chaker (School of Chemistry and Photon Science Institute, The University of Manchester)

We have found that chromium pivalate and zinc acetate can be decomposed under an electron beam for use as lithographic resists. A fabrication method is presented, along with Monte Carlo simulations and XPS data, that show these resists can be used to make direct-write alignment markers for Electron Beam Lithography.

4:40 PM 9A4

Assessment of Gaussian Beam Shape in E-beam Lithography with 2-D Vernier Arrays, Amanda Wscieklica, Sean Branagan (Raith America, Inc); Akhil Dodda (Western Digital Research Center); Robyn Seils (Raith America, Inc); Alexei Bogdanov (Western Digital)

E-beam writing with the highest throughput requires tight control of the beam spot size and roundness across the scanning field of the tool. Here we present a method to determine the shape and size of the e-beam spot after exposure, based on two-dimensional Vernier arrays and agnostic of SEM artifacts.

9B - Metrology and Characterization 2

Room: Continental Ballroom 5

Session Chairs: Keith Brown (Boston University), Xian Du (University of Massachusetts at Amherst)

3:40 PM 9B1

Towards Quasi-real-time, Tip-based Process Control in Roll-to-Roll Nanomanufacturing, Michael Cullinan (The University of Texas at Austin); Liam Connolly (National Institute of Standards and Technology); Barbara Groh (The University of Texas at Austin)

This work presents a proof-of-concept prototype tool to perform tip-based measurements on flexible, nanopatterend substrates in a R2R manner. The goal of this tool is to facilitate quasicontinuous scanning of R2R substrates using atomic force microscope sampling without the need to halt the web.

4:00 PM 9B2

Metrology of Periodic 3D Nanostructures using Spectroscopic Scatterometry, Kwon Sang Lee, Kun-Chieh Chien, Michael Cullinan, Chih-Hao Chang, Barbara Groh (The University of Texas at Austin)

In this work we demonstrate a non-destructive, high-throughput method for 3D metrology of periodic nanostructures using spectroscopic scatterometry. This approach is based on measuring the reflectance spectra of nanostructures and comparing them with optical simulations. Initial results show distinct spectral responses depending on exposure conditions and porosity.

4:20 PM 9B3

A "Dual-Field" Illumination Schema for Enhanced Contrast in Automated Optical Defect and Debris Detection, Zach Russell, Mathieu Therezien, Tomas J. McIntee (Ion Innovations); Vivian Hsu, Missy Thompson, Oyku Demirel, Sonny Vo (LeiaInc)

Ion Innovations, in collaboration with Leia Inc., has developed a hardware-assisted computer vision system for automated defect detection that readily and simply acquires "dual-field" images using simultaneous dark-field and bright-field illumination without losing the information collected by either type of illumination alone and without requiring advanced post-processing.

9C – Biomedical and Emerging Devices

Room: Continental Ballroom 6

Session Chairs: Keith Morton (National Research Council of Canada), Mark Schvartzman (Ben-Gurion University of the Negev)

3:40 PM 9C1

Conductive Electrospun Fibers for Photovoltaic Applications, Luke Suttey, Ellie L. Ostermiller, Jessica Andriolo, Jack Skinner (Montana Technological University); Dennis J. Moritz, John J. Borkowski (Montana State University)

Conductive electrospun polycarbonate/multiwall carbon nanotube/hydroxyl functionalized multiwall carbon nanotube composite fibers are being fabricated for use in a electrospun fiber based solar cell. Conductive fiber composites fabricated will be used as the central electrode in a three layer triaxially spun photovoltaic fiber.

4:00 PM 9C2

Rapid Quantification of SARS-COV-2 Neutralizing Antibodies Using Electronic Nanoparticle Sensors, Md Ashif Ikbal, Seyedsina Mirjalili, Maziyar Kalateh Mohammadi, Yeji Choi, Mohammad Altarfa, Jose Solano (Arizona State University); Laura A. VanBlargan (the National Institutes of Health); Ching-Wen Hou (Arizona State University); Michael S. Diamond (Washington University School of Medicine); Vel Murugan, Chao Wang (Arizona State University)

Natural infection or vaccination triggers an immune response comprising the expression of neutralizing antibodies in the bloodstream against the Severe Accurate Respiratory Syndrome Coronavirus 2 (SARS-COV-2) virus.The proposed methodology shows great promise in low-cost, rapid (<20 min) screening for the assessment of therapeutic antibodies and individual immunity against uprising variants.

4:20 PM 9C3

Aerosol Jet Printing Enabled Dual-Function Electrochemical and Colorimetric Biosensor for SARS-CoV-2 Detection, Li Liu (University of California Riverside); Zhiheng Xu, Adrian Moises Molina Vargas (University of Rochester); Stephen J. Dollery (Biological Mimetics, Inc.); Michael G. Schrlau, Denis Cormier (Rochester Institute of Technology); Mitchell R. O'Connell (University of Rochester); Gregory J. Tobin (Biological Mimetics, Inc.); Ke Du (University of California Riverside)

A dual-function electrochemical and colorimetric sensing platform using graphene electrodes for detecting acute SARS-CoV-2 is developed with a high sensitivity, selectivity, acceptable rapidity, and excellent extensibility. In addition, the aerosol jet printing electrodes make the biosensor inexpensive and adaptable for detecting viral infections in point-of-care settings.

4:40 PM 9C4

Photocatalysis and Light Scattering by Sensitized Nanofibers for Denitrification, Jessica M. Andriolo (Montana Technological University); Emma K. Orcutt (Montana State University); Erik M. Grumstrup (Montana State University); Alec Talin (Sandia National Labs); Jack Skinner (Montana Technological University)

Nitrogen-based fertilizers are critical to the production of successful crops for farmers, yet use of these supplements has led to nitrate contamination of surface and ground waters. In this work, a catalytic electrospun filter was designed to use photons from natural sunlight to promote reduction of aqueous nitrate.

5:00 PM 9C5

Molybdenum disulfide/ sodium dodecyl sulfate thin films deposited on APTES functionalized silicon using electrophoretic deposition, Alex Young, Chris O'Loughlin, Theda Daniels-Race : Louisiana State University

This report presents the fabrication of MoS2/ sodium dodecyl sulfide (SDS) thin films onto 3-aminopropyl-triethoxysilane (APTES) functionalized semiconductor (silicon) substrates by electrophoretic deposition (EPD). We present how the MoS2/ SDS solutions used in this work facilitated significant improvement in the resultant EPD driven thin films compared to depositions without SDS.

Poster Presentations

Wednesday, May 31
Talk with Authors: 10:45 am – 1:10 pm, 5:20 pm – 7:00 pm

Thursday, June 1
Talk with Authors: 10:00 am – 1:00 pm

Advanced Pattern Transfer

P1-1 Invited

High aspect ratio etching of sub-300nm resolution oxide transmission gratings using design of experiment (DoE), Marc Bernet, Chantal M. Silvestre, Bettina Wissmann, Kristian J. Buchwald, Rafael Taboryski (DTU Nanolab)

In the presented project we optimize reactive-ion etching (RIE) parameters for the fabrication of oxide transmission gratings. A statistical method using design of experiment (DOE) is used to find the optimum values for the reaction in order to maximize the etch rate, the uniformity and the selectivity for industrial scalability.

P1-2

Influence of water background on the etching rates of silicon and photoresist of a broad reactive ion beam, Peter Birtel, Felix Linß, Frank Frost (Leibniz Institute of Surface Engineering (IOM))

For different water background pressures, the spatially resolved removals of silicon and photoresist as well as the resulting selectivity were investigated on a large area. It was shown that the reproducibility of the broad reactive ion beam etching process can be improved by adjusting the water background pressure.

P1-3

High aspect ratio arrays of silicon nanostructures with controllable tapered sidewall by non-ICP plasma DRIE, Ripon K. Dey (metamaterial)

High aspect ratio (HAR) nanostructures with smoother and angled sidewall profiles have gained significant interest due to their versatile applications in nano-optics. We here demonstrated the HAR arrays of silicon nanostructures with smoother and controllable tapered sidewall by non-ICP plasma DRIE.

P1-4

Characterization of a broad reactive ion beam for the processing of optical relevant materials, Erik Rohkamm, Frank Scholze, Daniel Spemann, Frank Frost (Leibniz Institute of Surface Engineering (IOM))

For a variation of the applied RF-power, a reactive broad ion beam was investigated regarding its current density, ion energy and mass distributions. It was shown that the interaction of the extracted ions with background particles leads to a fragmentation relevant for the ultra-precise processing of surfaces.

Electron and Ion Beam Lithography

P2-1 Invited

Apparatus for studying low energy electron-photon interactions inside a Scanning Electron Microscope, John Simonaitis, Maurice Krielaart, J. Alongi, Karl Berggren, P. D. Keathley (Massachusetts Institute of Technology)

We present an apparatus for studying nanostructure-mediated electron-photon interactions at low electron energies. Central to our approach is the patterning of nano-sized structures directly onto the tip of a fiber optical core that acts as an electron-photon interaction region.

P2-2

Challenges and Possibilities of Aberration-Corrected Electron-Beam Lithography on non-Electron-Transparent Substrates, Fernando Camino, Nikhil Tiwale, Sooyeon Hwang, Judith C. Yang (Brookhaven National Laboratory); Xu Du (Stony Brook University)

We present the point spread function (PSF) of aberration-corrected electron-beam lithography (ACEBL) in PMMA spin-coated on thick SiO2/Si substrates. We also printed hole arrays in PMMA (pitches around 26 nm) coated over SiNx/Si substrates with incrementally increasing Si layer thickness to study the effect of the substrate on the patterns.

P2-3

An Analytic Study of Exposure Contrast over Feature Edge in Electron Beam Lithography, Soo-Young Lee (Auburn University)

The dependency of exposure contrast on electron-beam lithographic and PEC (proximity effect correction) parameters is investigated using an analytic model. The analytic results (mathematical expressions) from this study allow us to see the behaviors of exposure contrast explicitly and clearly without a time-consuming simulation for each individual case.

P2-4

Geometric Control of Cell Behavior by Biomolecule Nanodistribution, Milo Hrabovsk (Tescan Orsay Holding); Miroslav Jurasek (Tescan Brno); Jakub Pospisil (Masaryk University); Josef Jaros (St. Anne's University Hospital)

Many dynamic interactions within the cell microenvironment modulate cell behavior and cell fate. However, the pathways and mechanisms behind cell−cell or cell−extracellular matrix

interactions remain understudied, as they occur at a nanoscale level. Recent progress in nanotechnology allows for mimicking of the microenvironment at nanoscale in vitro using EBL technique.

P2-5

Abrupt pattern transitions in argon ion bombarded swinging Si., Rakhi, Subhendu Sarkar (IIT Ropar)

Performed experiments on Ar+ irradiated swinging Si surfaces with different azimuthal angles at 67◦ ion projection and swing speeds from 1 to 16 RPM. Current surface evolution models do not adequately predict the findings that show that a multitude of ion-induced effects can drive the system into instability.

P2-6

Effects of Highly Charged Ions bombardments on film-Coated Glassy Carbon, Audu Innocent (Federal University of Health Sciences)

Gassy carbons coated with thin films of tungsten were bombarded with highly charged Xe40+ ions. Samples were characterized by Raman spectroscopy and atomic force microscopy and SEM. Virgin glassy carbon has a crystalline size of 2.91 nm, which reduced in size with ion energies. AFM results indicate hillocks formation.

P2-7

Interferometrically Evaluating Patterning Accuracy of EBL/KOH Ultraviolet Gratings for Astronomy, Jared Termini, Keri Hoadley, Casey DeRoo, Cecilia Fasano (University of Iowa); Erika Hamden, Jessica Li (University of Arizona)

We have used EBL patterning and KOH wet etching to create a prototype UV grating and measured it interferometrically to empirically determine the patterning accuracy. These measurements will provide vital feedback about the quality of our grating fabrication processes and inform us of potential areas of improvement.

P2-8

Designing Hydrogen Silsesquioxane: Control Over Particle Size, Shelf-Life, and Sensitivity. Part II, R. T. Endean, D. E. Scott, D. M. Antoniuk, J. G. C. Veinot, Applied Quantum Materials Inc.

Applied Quantum Materials Inc. (AQM) is a supplier of hydrogen silsesquioxane (HSQ). The shelf-life of HSQ variants in methyl isobutyl ketone has been studied. Light scattering methods were employed to determine the variant's particle diameters. The shelf-life of AQM's standard HSQ in various organic solvents will be presented.

P2-9

Experimental Studying of CNT Field Emission Array with Double Insulator, A. Burtsev, I. Navrotsky, K. Shumikhin, Kotelnikov Institute of Radio Engineering and Electronics RAS.

We present the results of experimental investigations of cathode-gate structure containing carbon nanotubes in double insulator. Experimental specimens of the electron gun, containing 2 μm diameter of cells with vertical CNTs, produce the cylindric electron beam of 0.8 mm and current up to 14 mA.

Flexible Devices

P3-1

Flexible Piezoelectric Pressure Sensors with In-Memory Computing Capabilities For Intelligent Electronic Skin, Sayani Majumdar, Tapio Makela, Tapio Pernu (VTT Technical Research Centre of Finland); Wuyu Zhao, Qiangfei Xia (University of Massachusetts Amherst)

We report arrays of polymeric ferroelectric sensors, capable of sensing static and dynamic touch and their integration with memristor crossbar array-based in-memory computing hardware for classification of touch, similar to human skin. These near-sensor computing platforms, capable of computing at the edge, will substantially reduce data communication, increasing computing efficiency.

P3-2

A novel method to manufacture ultra-thin 2D flexible devices, Elham Easy, Xian Zhang (Stevens Institute of Technology)

This study successfully transferred angstrom scale 2D materials onto flexible substrates using liquid polydimethylsiloxane as a medium. It represents a significant step forward in addressing the challenges associated with the fabrication of 2D flexible devices. This successful manufacturing method shed light on the next-generation wearable electronics.

P3-3

A novel wet transfer technology for manufacturing flexible 2D material devices, Yingtao Wang (Stevens Institute of Technology); Xian Zhang (Stevens Institute of Technology)

In this work, we invented a Poly(methyl methacrylate) (PMMA)-sacrifice wet transfer method to precisely and easily transfer two-dimensional (2D) materials onto a flexible substrate, Polydimethylsiloxane (PDMS). 2D materials can also suspend stably on flexible substrates with trenches of ~10 µm. This shed light on flexible electronics.

MEMS/NEMS and Microfluidics

P4-1 Invited

Self-focusing Nanomechanical Sensors for High-throughput Detection of Single Viruses and Nanoparticles, Mohammed Alkhaled, Batuhan Kaynak, R. Tufan Erdogan, Hashim Alhmoud, Hadi Sadaghat Pisheh, Mehmet Kelleci, Ilbey Karakurt (Bilkent University); Cenk Yanik (Sabanc University); Z. Betul Sen (Bilkent University); Burak Sari (Sabanc University); Ahmet Murat Yagci (METU MEMS Center); Aykut zkul (Ankara University); M. Selim Hanay (Bilkent University)

We increased the throughput of nanoelectromechanical systems-based mass spectrometry (NEMS-MS) by integrating a polymeric ion lens to focus particles electrostatically to the NEMS resonator. This integration allowed for the first operation of NEMS-MS entirely under atmospheric conditions, leading to the successful detection and weighing of nanoparticles and single SARS-CoV-2 viruses.

P4-2

Design and Simulation of a Planar Resonance Pull-in Microshutter Array, Jason V. Clark (Oregon State University); Yingsong Han (Auburn University); Li Jiang, Naga S. Korivi (Tuskegee University); Huafeng Liu (Huazhong University of Science and Technology)

We propose a new type of microshutter array that can open and close in-plane instead of out-of-plane as all others. Our in-plane shutter opens at a much smaller voltage than out-of-plane by one to two orders of magnitude. A tradeoff with our in-plane design is a reduction in light throughput.

P4-3

Numerical study on the impact of the geometric shape of micropillar array electrodes on the performance of a microfluidic biosensor, Maliheh Azimi Roueini, Amal Kabalan (Bucknell University)

We studied and compared the effects of different shapes of micropillar array electrodes on the operation of microfluidic biosensors numerically with COMSOL Multiphysics in order to design a microfluidic biosensor with an ideal sensitivity.

P4-4

Amorphous WNx Metal the Best candidate for Accelerometers and Gyroscope, Abdulilah Mayet (King Khalid University)

Nanoelectromecahnical (NEM) switches and devices are getting more attention for their higher resonant frequency ƒo, low power consumption and lower threshold voltage, thanks to their nano scale size. These unique characteristics give NEM switches the preference and vantage against classical and larger in size switches microelectromechanical switches (MEMS).

P4-5

Quantum dots Enhanced IMPACT Chip for Viral Nucleic Acid Detection, Mengdi Bao, Yu Chang (University of California, Riverside; Rochester Institute of Technology,); FNU Yuqing (Rochester Institute of Technology); Ke Du (University of California, Riverside; Rochester Institute of Technology)

To eliminate end-point signal measurement and achieve visualized readout, we coupled quantum dots (Qdots), single-stranded DNA, and gold nanoparticles (AuNPs) to form a Förster resonance energy transfer (FRET) assay for viral detection. In this work, we switched from organic quenchers to AuNPs in an effort to obtain straightforward visual readouts.

P4-6

Design of MEMS vibration sensor for harsh environment, Narendra Lakal, Xian Du (University of Massachusetts); Ali H. Alshehri, Keith W. Brashler, Mohammad Ba'adani, Doru C. Turcan (Saudi Arabian Oil Company); Kamal Youcef-Toumi (Massachusetts Institute of Technology)

This article presents the design, analysis, and proposed fabrication process of a piezoelectric (AlN) MEMS (Si substrate) vibration sensor with parylene encapsulation for long-duration applications in an oil environment.

The proposed sensor is designed to work at a temperature of up to 150C with a frequency range of 10 kHz.

Nanofabrication for Energy Applications

P5-1

Effects of doping on the power factor and efficiency of nano-materials for thermoelectric generator, Wiqar SHAH (International Islamic University)

This work related the waste heat conversion in electrical energy through nano-materials

P5-2

Photocatalytic performances of electrospun Cu-doped TiO2 nanofibers depending on Cu content and electron beam irradiation, So-Hyeon Lee, Jae-Yoon Kim, Han-Sol Yoon, Kyeong-Han Na, Won-Youl Choi (Gangneung-Wonju National University)

Cu-doped TiO2 nanofibers were fabricated using the electrospinning method. Electron beams of 5-20 kGy were irradiated on the nanofibers to enhance photoactivity. It was observed that the photodegradation performance of electron beam treated Cu-doped TiO2 nanofibers to methylene blue and methylene orange was improved compared to pure TiO2 nanofibers.

P5-3

Adhesion and Excitation Lifetime of Perovskites on Modified Substrates, Xavier Vorhies, Jack Skinner (Montana Technological University); David F. Bahr (Purdue University); Jessica Andriolo (Montana Technological University); Erik M. Grumstrup (Montana State University)

Using a modified nanoindentation method we quantify the adhesion of perovskites on TiO2 substrates. The excited state lifetimes and optoelectronic properties are determined using ultrafast pump-probe microscopy and time-resolved photoluminescence spectroscopy. We hypothesize that improved adhesion at the perovskite-substrate interface will correlate to more efficient electron transfer into the ETL.

P5-4

Pulsed Laser Assisted Fabrication of 2D Chalcogenides for Energy Conversion Devices, Arulraj Arunachalam (Universidad Tecnolgica Metropolitana)

2D Molybdenum disulphide (MoS2) thin films were fabricated by pulsed laser ablation technique using a KrF excimer laser, with controlled temperature and thickness under in-situ conditions. With increase in temperature, an improvement in crystallinity is observed leading to the enhancement of active sites in MoS2.

Nanophotonics and Plasmonics

P6-1

Fabrication of Nanoscale T-Structures for the Realization of Metasurfaces with Double-Peak Absorbance, Jacob Waitkus, Ke Du (University of California at Riverside); Shuai Feng, Theodore Ndukaife, Sui Yang (Arizona State University)

The combination of nanostructures here forms a unique metasurface capable of biological and chemical sensing. From the 20 nm gap between the T-structures, a unique double-peak transmission spectrum is obtained that is sensitive to minor changes in the surrounding refractive index due to the presence of chemicals or biological components.

P6-2

Plasmonic-Enhanced Carbon Dioxide Photo-Reduction using Collapsible Nano-fingers, Tse Hsien Ou, Pan Hu, Zerui Liu, Yunxiang Wang, Sushmit Hossain, Sonia Zhang, Deming Meng, Boxin Zhang, Stephen Cronin, Wei Wu (University of Southern California)

Collapsible nano-fingers to do CO2 photo-reduction. A high-intensity hot spot generate a great number of electron-hole pairs inside the TiO2 spacer that can facilitate the chemical reduction and oxidation reaction. Higher hydrocarbons were generated in the CO2-saturated deionized water when nano-fingers existing.

P6-3

Coupling nano-electronics and photonics through precise alignment with silicon color centers, Nikki Ebadollahi (NIST/University of Maryland); Vijin K. Veetil, Matthew A. Pelton, Marcelo I. Davanco, Kartik A. Srinivasan, Pradeep N. Namboodiri, Joshua M. Pomeroy (NIST)

Realizing an efficient link between silicon spin qubits and telecommunication photons using silicon color centers (CCs) requires precise overlay between photoluminescence maps of the CCs and lithographic design patterns of quantum dot structures.

P6-4

Measured and Simulated Optical Transmission Through Nanoholes in a Bilayer of Gold and Vanadium Dioxide, Zachary Givens, Eugenii Donev (Austin Peay State University)

We investigate optical transmission through nanohole arrays with plasmonic and phase-switching functionalities. We fabricated previously simulated Au+VO2 arrays and measured their transmission spectra to determine if large computed peak ratios survive real-world conditions. Incomplete milling of the VO2 layer may explain why measured ratios are lower than predictions for thru-holes.

P6-5

Implementation and Characterization of Tunable Reconfiguration and Actuation in Microbowls using atomic force microscopy, Yue Liu, Yan Nie (Helmholtz-Zentrum Hereon)

In our work we enhance the programmability of temperature-memory micro-objects using atomic force microscopy to achieve a sequential shape reconfiguration or actuation at different geometrical levels on demand.

Optical Lithography

P7-1 Invited

In-Situ Metrology of Direct Write Laser Ablation using Optical Emission Spectroscopy, Briana Cuero, Kun-Chieh Chien, Chih-Hao Chang (University of Texas at Austin)

In this work we aim to study the emitted spectral information during direct-write laser ablation and use data-driven approaches to identify and monitor the key wavelength in real time. The initial results show a strong correlation between a key wavelength of 790 nm and the morphological change in glass.

P7-2

Direct-Write Lithography and Etch of Images by Dithering Process, Thomas Mittelbrun, Francisco Saldana Fernandez, Gyuseok Kim (University of Pennsylvania)

We demonstrate a pattern transfer process of images by conduction dithering. This work details the data preparation and fabrication of images into a SiO2 thin film using Heidelberg direct-write lithography and reactive ion etching (RIE). The optimal image process method, pixel size, and exposure dose are proposed.

P7-3

Sequential Infiltration on Two-Photon Polymerized IP-L 780 3D Microstructures for Photonic Applications, Anuj Singhal (The University of Illinois at Chicago); Ralu Nana Divan (Center for Nanoscale Materials, Argonne National Laboratory); Jack Lachowicz (The University of Illinois at Chicago); Liliana Stan (Center for Nanoscale Materials, Argonne National Laboratory); Igor Paprotny (The University of Illinois at Chicago)

Sequential infiltration synthesis(SIS) can be used to infuse metals and metal oxides deep into polymers. In this work, mechanical, temperature degradation, and SEM analysis are performed on ZnO-infused IP-L-780 resin based 2-photon polymerized structures. SIS to achieve enhanced refractive index in photonic crystals for spectroscopic sensing applications is also shown.

P7-4

Sub-50 nm EUV Lithography using Colloidal Nanoparticles, Saurav Mohanty, Ethan Flores and Chih-Hao Chang (University of Texas at Austin)

We propose using colloidal nanosphere lithography coupled with a 30 nm EUV light source to pattern periodic geometric patterns with sub 50 nm feature sizes.

Scalable Micro/Nanomanufacturing

P8-1 Invited

Fabrication of Hierarchical Nanostructures using Binary Colloidal Nanosphere Assembly, Ethan Flores (University of Texas at Austin); Saurav Mohanty (The University of Texas at Austin); Andrew Tunell (University of Texas at Austin); Chih-Hao Chang (University of Texas at Austin)

In this work we present the fabrication of hierarchical nanostrucures using binary colloidal assembly. Using a two-step coating process, we seek to create sub-50 nm features by depositing smaller nanoparticles into the voids of an array of larger polystyrene (PS) nanoparticles with hexagonal closed packed assembly.

P8-2

Electrospun Ethylcellulose Nanofibers for Dental Resin Modified Glass Ionomer Cement, Kyeong-Han Na, (Gangneung-Wonju National University); Moo-Hyun Seo (Spident Co.); So-Hyeon Lee, Jae-Yoon Kim, Han-Sol Yoon, Won-Youl Choi (Gangneung-Wonju National University)

Ethylcellulose nanofibers were fabricated using electrospinning. It was pulverized using cryogenic milling and mixed with dental resin-modified glass ionomer cement. The mechanical properties and working time were improved by the nanofiber network dispersed in the resin.

P8-3

Portable Electrospinner with Ionized Airflow to Improve Performance in Humid Environments, Harold Pearson, Isaac Gilfeather, Jack Skinner, Jessica Andriolo (Montana Technological University)

Here we aim to achieve higher precision during fiber deposition in humid environments to improve reliability of electronic or photovoltaic devices or medical bandages fabricated on-demand in the field. We have modified the portable electrospinner to include ionized airflow to remove charge buildup in the device caused by changing humidity.

P8-4

Measuring the Patterning Precision of Large Area Advanced Lithography with Interferometry, Cecilia Fasano, Casey DeRoo (University of Iowa); Fabian Grise (Pennsylvania State University); Keri Hoadley, Jared Termini (University of Iowa); Chad Eichfeld, Jake McCoy, Randall McEntaffer (Pennsylvania State University)

We adapt a classic technique from diffractive optics which, when applied to lithographic patterning, allows researchers to assess the characteristic errors of patterns produced via lithography over large-areas non-destructively.This presentation is an outgrowth of our efforts to integrate electron-beam lithography and nanoimprint lithography into a process for fabricating astronomical gratings.

Metrology and Simulation

P9-1

Thermal Analysis with High Accuracy of Multi-beam Mask Fabrication, Yanjun Zhang, (Zhuming Liu (Guangdong Academy of Sciences)

In this study, the thermal effect of the electron beam on photoresist and substrate during lithography was simulated with a finite element numerical method. The numerical research shows that the thermal analysis method in the study provides a guide to optimize process parameters of mask fabrication.

P9-2

Particle-based simulation and experimental validation of the beam properties in electron beam physical vapor deposition, Paul Nizenkov, Stephen Copplestone, Asim Mirza (boltzplatz - numerical plasma dynamics GmbH); Andreas Jendrzey, Neil Morrison (Applied Materials Web Coating GmbH)

As a first step in an effort to optimize the hardware for electron beam physical vapor deposition, we compare numerical simulations of the electron beam propagation using the open-source plasma simulation software PICLas with experimental measurements. Good agreement between the simulations and experiment was achieved.

P9-3

A magnetostatic Boundary Element Method (BEM) solver for the General Particle Tracer (GPT) code, Sebastiaan van der Geer, Marieke de Loos (Pulsar Physics)

Here we present a new extension to the well-established GPT simulation code that allows for the calculation of magnetostatic fields in complex 3D geometries using a hierarchical Boundary Element Method (BEM) solver. The extension incorporates parametric coil modelling, relativistic particle tracking and aberration analysis up to 7th order.

P9-4

A Universal Atomic Probe: integrating digital and analog lithography and Near Field Spectroscopy, Tito Busani, Isaac Stricklin (University of New Mexico)

We propose a multi-functional lithography and metrology systems. A Multipurpose Atomic Force Microscopy (MAFM) probe that integrates UV lithography, field emission lithography and digital lithography in a single system that allows patterning generation with atomic accuracy, real time inspection with atomic resolution and nano meter Raman Spectroscopy.

P9-5

Characterization of Nano-grating Profiles using Standard Ellipsometry and Deep Neural Networks, Zijie Jiang, Wen-Di Li (The University of Hong Kong)

In this research, we propose a new method based on deep neural networks and gradient descent method to fully reconstruct the profile of nano-gratings using standard ellipsometry data (i.e., ψ and Δ). This method is compatible with various kinds of patterning techniques and different resists.

Poster Start-Up

P10-1 Poster Start-Up

OG Sense submission for Startup contest - EIPBN 2023, Valters Slava

Our team has developed a new technology for NH3 measurements. OG Sense uses a passive optical sensor that absorbs gas and detects it through light interaction with absorbing media. A single device will consist of multiple sensors to ensure both concentration and gas-type detection.

P10-2 Poster Start-Up

High-Sensitivity Point-of-Care Cardiac Troponin Testing Device for Non-ST-Elevation Myocardial Infraction Diagnosis, Seungjun Ki, Mingze Chen, Xiaogan Liang (University of Michigan)

Our target is to develop point-of-care (POC) cTn testing module with comparable sensitivity and specificity to the CLT for the prehospital NSTEMI diagnosis.

P10-3 Poster Start-Up

Holographic photolithography tools for industrial-scale nanomanufacturing, Joseph Geddes (Photia Incorporated)

Photia Incorporated is developing methods based on holographic photolithography for industrial-scale manufacturing of micro- and nano-structured materials. These materials have a variety of applications, including optical coatings and metamaterials, filtration and separations, batteries and electrochemistry, and template patterning (molds and shims).

P10-4 Poster Start-Up

Fabrication of Ultra-low refractive index nano-lattice material, Saurav Mohanty, Chih-Hao Chang (University of Texas at Austin)

3D Nanotech proposes a scalable, airgap-based 3D multi-layer porous nanolattice structure that can be integrated into AR/VR hardware, exhibiting a refractive index as low as 1.025, with precise index tuning, and high structural stiffness in the GPa range. Applications of this include efficient photonic waveguides, and optical sensing technologies.

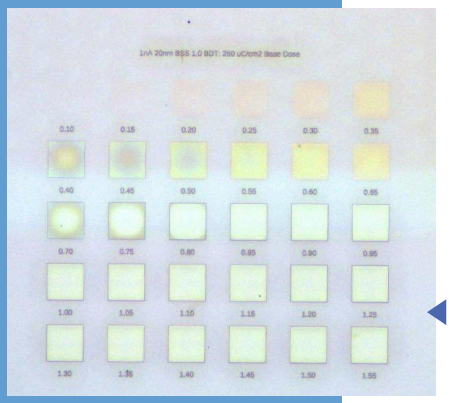
DisChem

CHEMISTRY FOR ADVANCED LITHOGRAPHY

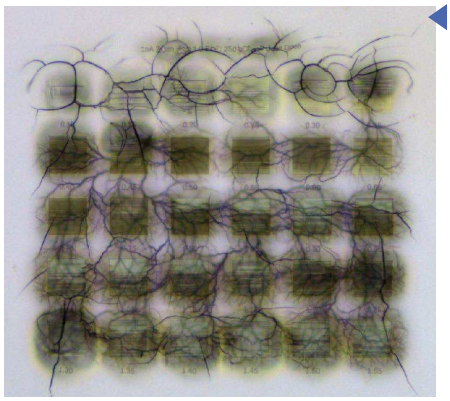
DisCharge+

EBL ANTI-CHARGING AGENT

- Improved shape fidelity and positional accuracy for EBL resist patterning on insulating substrates such as fused silica, quartz, glass, PDMS, etc.
- Water based w/ excellent wetting properties. Spin coat application provides conductive film for anti-charging.
- Suitable for nondestructive SEM imaging of nonconductive materials.
- Easy residue free removal w/ water or IPA.
- Competitively priced. Ideal for both research and industrial applications.
- Two-year shelf life at room temp. Highly stable permanently charged non-polymer formulation.
- Ready to use. No filtration required prior to use.



WITH DisCharge: no charge accumulation, resulting in expected image with no harm to PDMS layer.



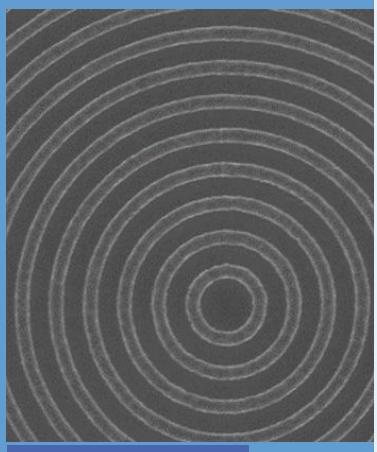
Without DisCharge: charge accumulation and sudden charge dissipation caused by exceeding the dielectric breakdown strength of the PDMS to the Si substrate resulting in significant image distortion in the resist and destruction of the PDMS surface.

anti-charging

H-SiQ *(hydrogen silesquioxane)*

NEGATIVE-TONE ELECTRON BEAM RESIST

DisChem H-SiQ is a negative tone hydrogen silesquioxane (HSQ) resist in MIBK carrier solvent for use in electron beam lithography (EBL). H-SiQ is characterized by excellent pitch resolution, sensitivity and etch resistance for direct write thin and thick film EBL applications. Immediate availability in quantities as low as 20 ml.

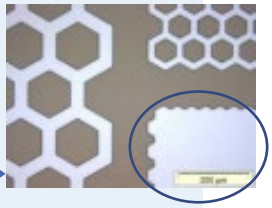


resist

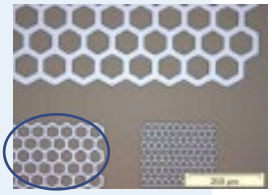
SurPass

RESIST ADHESION PROMOTERS

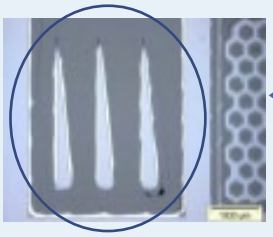
- Improved microlithographic resist adhesion on a broad range of substrate materials.
- Improved adhesion at low doses in electron beam lithography
- Improved removal of critical substrate contaminants
- Reduced z-potential for improved resist coating properties
- Improved patterned resist mold to copper seed layer for subsequent electroforming.
- Increased adhesion of evaporated metals to substrate materials
- Non-Hazardous waterborne formulation



No Adhesion Promoter: some patterns removed during resist development.



With SurPass: Complete Precision Mask



No Adhesion Promoter Resist Mask Undercut During Etching

With SurPass: Complete Precision Mask

adhesion promotion

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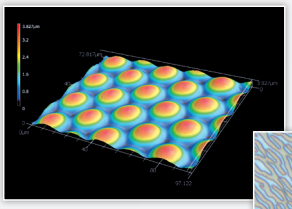
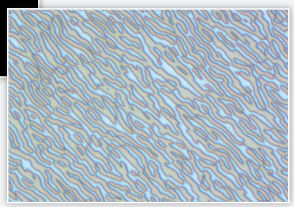
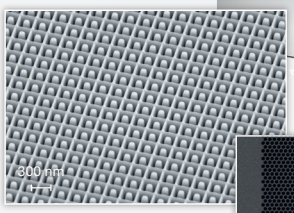


Grayscale Lithography

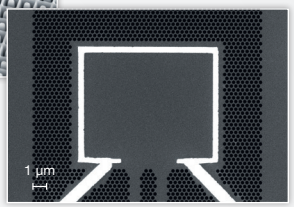


Augmented/ Virtual Reality

FIB

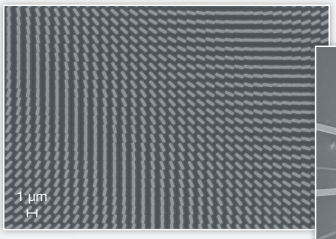


Metasurfaces

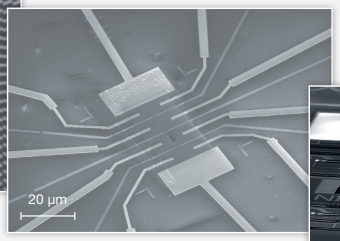


Phononic Engineering

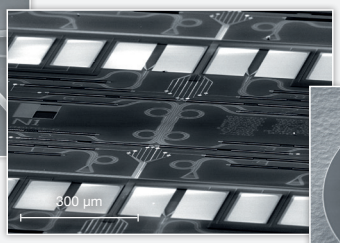
E-BEAM



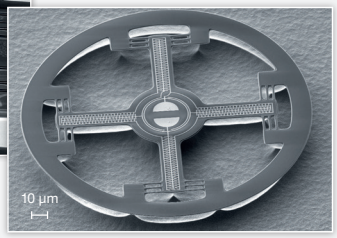
Photonics



Nanoscale Science



Quantum Technologies



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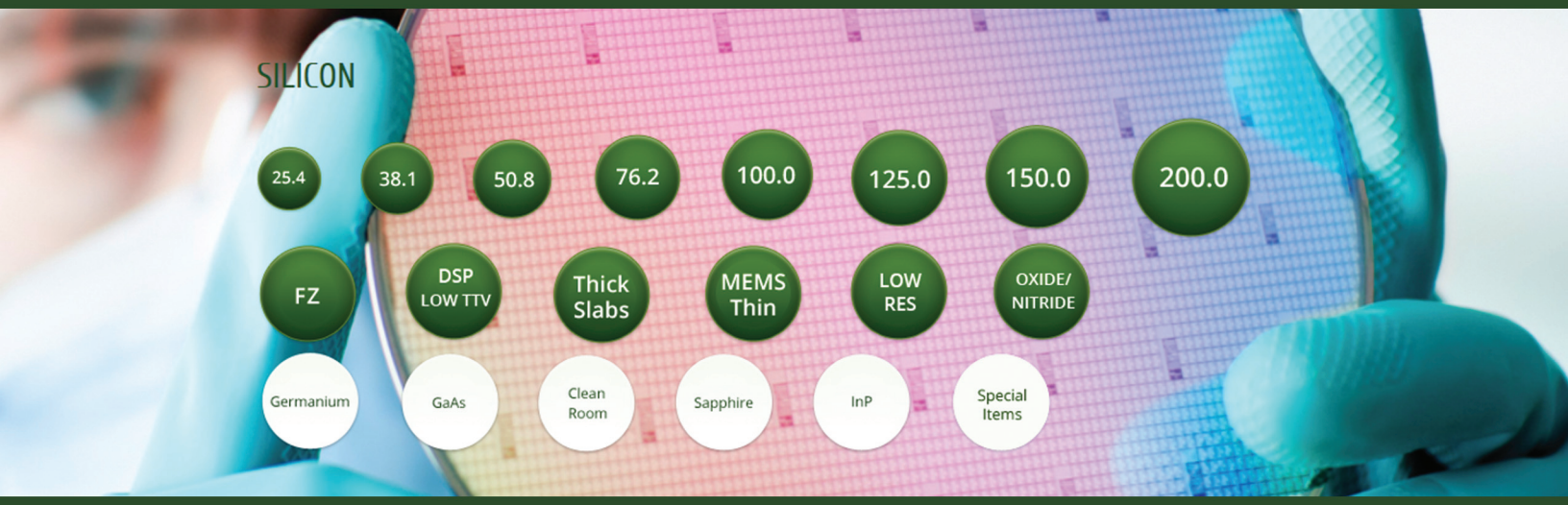

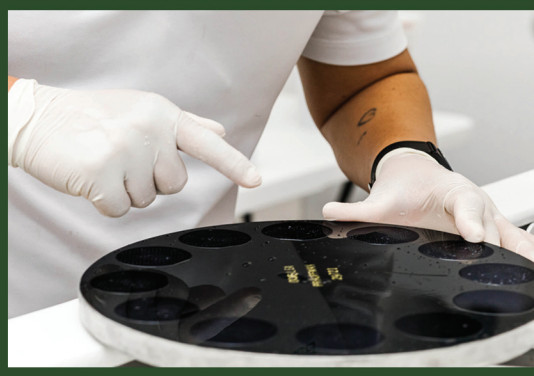

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