NANOFABRICATION FACILITY

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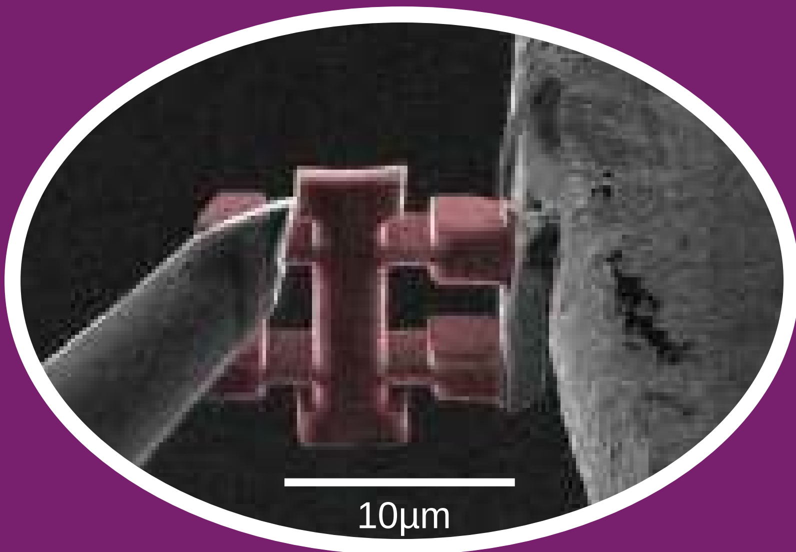
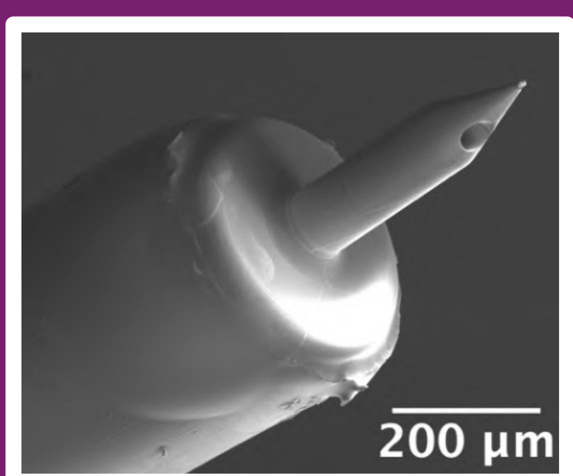
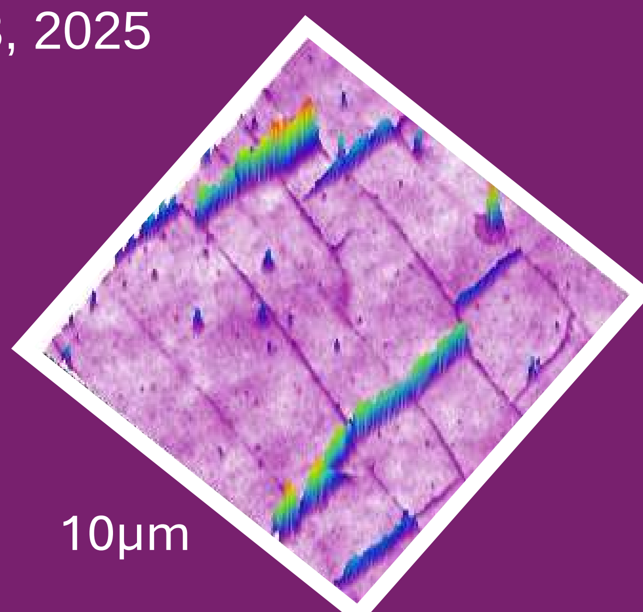


2nd Annual ASRC Nanofabrication Facility Research Showcase Day

November 13, 2025





Acknowledgements for the cover images [with abstract page]**:**

Upper Left – Federico Balduini, Aravind Devarakonda, Columbia University **[p. 40]**
Single crystal Hall bar fabricated using Focused Ion Beam (FIB) at the ASRC Imaging Suite.

Upper Right – Kwanghee Han, Vinod Menon, et al., City College of New York **[p. 20]**
Moiré superlattice of twisted hexagonal boron nitride (hBN). Images taken using Kelvin Probe Force Microscopy (KPFM) at the ASRC Surface Science Suite.

Lower Left – Aykut Aksit, Haystack Medical, Inc. **[p. 48]**
SEM images of microneedle and flexible polyimide tubing extending from a 23Ga deployment tube fabricated on the ASRC Nanofabrication Facility Nanoscribe 3D Lithothography tool.

Lower Right – Alexis Vidals, Maya Narayanan Nair et al., CCNY and ASRC **[p. 29]**
AFM topographic view of monolayer $SnSe_2$ after 1st deposition of Co and its corresponding 3D image taken at the ASRC Nanofabrication Facility on the Bruker AFM.

NANOFABRICATION FACILITY
ADVANCED SCIENCE RESEARCH CENTER

2nd Annual
ASRC Nanofabrication Facility
Research Showcase Day

A Day of Connection, Collaboration and Celebration

November 13, 2025

City University of New York
Advanced Science Research Center
85 Saint Nicholas Terrace
New York, NY 10031

Email: nanofab@gc.cuny.edu
Website: https://asrc.gc.cuny.edu/facilities/nanofabrication/

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Without the dedicated hard work of these colleagues, this event would not have been possible. Thank you!

Morning Program

9:00 AM - 9:30 AM	**Registration and Coffee**
9:30 AM - 9:45 AM	**Opening Remarks**
9:30 AM	**Samantha Roberts** - *Nanofabrication Facility Director, ASRC*
9:35 AM	**Stephen O'Brien** - *Interim Dean of Science, Professor, Chemical Engineering, CUNY City College of New York*
9:45 AM - 11:00 AM	**Session 1: Frontiers in Photonics and Quantum Devices** Session Chair: Viktoriia Rutckaia, ASRC
9:45 AM	**Andrea Alù** - *Distinguished Professor, City College of New York Director, Photonics Initiative, Advanced Science Research Center* **"Tricking Light with Nanostructured Materials"**
10:10 AM	**Michele Cotrufo** - *Assistant Professor, Institute of Optics, University of Rochester* **"Optical Metasurfaces for Linear and Nonlinear Control of Light"**
10:35 AM	**Javad Shabani** - *Professor, Dept of Physics, New York University* **"Epitaxial Superconductor-Semiconductor for Quantum Information Processing"**
11:00 AM - 11:15 AM	**Break**
11:15 AM - 12:15 PM	**Session 2: Collective Intelligence – AI and Community** Session Chair: Samantha Roberts, ASRC
11:15 AM	**Yingli Tian** - *Distinguished Professor, Electrical Engineering, City College of New York, Computer Science, Graduate Center, CUNY* **"How Open Data Builds Stronger Scientific Communities in Computer Vision"**
11:40 PM	**Samantha Roberts** - *Nanofabrication Facility Director, ASRC* **NanoKnow Community KickOff**
12:10 PM - 12:25 PM	**Sponsor Remarks** **Elionix STS | SAMCO Inc. | Oxford Instruments | VyirTech Inc.**
12:30 PM - 1:45 PM	**Lunch | Dessert | Coffee**

Afternoon Program

1:45 PM - 3:00 PM	**Session 3: Lab to Fab – Pathways to Industry** Session Chair: Jacob Trevino, CNI, Columbia University
1:45 PM	**Marissa Beatty** - *CEO, Turnover Labs* **"From Research to Venture: Decision-Making in Transitioning from Academia"**
2:10 PM	**Bryant Colwill** - *Manager, 200 mm Innovation Lab, Albany NanoTech State University of New York at Albany* **"Decoding the Albany NanoTech Ecosystem"**
2:30 PM	**Industry Panel Discussion**
	James Scholtz, *CEO, VyirTech Inc.*
	Marissa Beatty, *CEO, Turnover Labs*
	Arash Nemanti, *CEO, TuneWave Inc.*
3:00 PM - 3:15 PM	**Break**
3:15 PM - 4:30 PM	**Session 4: Expanding Discovery through Nanofabrication** Session Chair: Maya Narayanan Nair, ASRC
3:15 PM	**Alexander Khanikaev** - *Endowed Professor, College of Optics and Photonics, University of Central Florida* **"Advanced Nanofabrication for Topological Photonics and Polaritonics"**
3:40 PM	**Prachi Thureja** - *Postdoctoral Researcher, CUNY ASRC, (PI: Andrea Alu)* **"Wavelength-Tunable Metasurface Filters for Analog Image Processing"**
3:50 PM	**Reaz Uddin Bhuiyan** - *Graduate Student, CUNY CCNY, (PI: Bruce Kim)* **"Fabrication of SiNW-based Nano Sensor Device Using Silver Metal"**
4:00 PM	**Shlok Joseph Paul** - *Graduate Student, New York Univ. (PI: Ayaskanta Sahu1)* **"There is Plenty of Room at the Bottom and the Top for Colloidal Quantum Dot Infrared Photodetectors"**
4:10 PM	**Volkan Arslan** - *Graduate Student, Columbia University, (PI: Ken Shepard)* **"High Density CMOS-based Ultrasound Phased Array with Monolithically Integrated PVDF Transducers for Photoacoustic Imaging "**
4:30 PM - 4:35 PM	**Closing Remarks**
4:35 PM	**Poster Walkthrough, Cocktails, and Networking Social**
6:15 PM	**Award ceremony**
6:45 PM	**End of Day**

Introductory Remarks

Stephen O'Brien

Interim Dean for the Division of Science,
Professor of Chemical Engineering
The City College of New York

Samantha Roberts

Nanofabrication Facility Director
Assistant Research Professor
Advanced Science Research Center
City University of New York

Invited Speakers and Panelists

Andrea Alù

Andrea Alù is a Distinguished Professor at the City University of New York (CUNY), the Founding Director of the Photonics Initiative at the CUNY Advanced Science Research Center, and the Einstein Professor of Physics at the CUNY Graduate Center. He received his Laurea (2001) and PhD (2007) from the University of Roma Tre, Italy, and, after a postdoc at the University of Pennsylvania, he joined the faculty of the University of Texas at Austin in 2009, where he was the Temple Foundation Endowed Professor until Jan. 2018. Dr. Alù is a Fellow of the National Academy of Inventors (NAI), the American Association for the Advancement of Science (AAAS), the Institute of Electrical and Electronic Engineers (IEEE), the Materials Research Society (MRS), Optica, the International Society for Optics and Photonics (SPIE) and the American Physical Society (APS). He is a Highly Cited Researcher since 2017, a Simons Investigator in Physics, the director of the Simons Collaboration on Extreme Wave Phenomena Based on Symmetries, and the Editor in Chief of Optical Materials Express. He has received several scientific awards, including the NSF Alan T. Waterman award, the Blavatnik National Award for Physical Sciences and Engineering, the IEEE Kiyo Tomiyasu Award, the ICO Prize in Optics, the Max Born Award, the Brillouin Medal and the URSI Issac Koga Gold Medal.

Marissa Beatty

Marissa Beatty is the Founder and CEO of Turnover Labs - an early-stage climate tech company building carbon utilization solutions for the chemicals industry. She holds a Ph.D. in Chemical Engineering from Columbia University, and has researched sustainable chemistries at institutions including Battelle Memorial Institute and Lawrence Berkeley National Lab. She now applies her technical expertise at Turnover Labs, which is building the next generation of ultra-durable, low-cost electrolyzers for industrial carbon upcycling. For her work as a researcher and entrepreneur, Dr.

Beatty has been recognized on the Forbes 30 under 30 list (2024), been awarded the prestigious Activate Fellowship (2022), and raised more than $1.5M in non-dilutive and venture capital from state agencies, strategic investors, and climate accelerators.

Bryant Colwill

Bryant currently serves as the 200mm Innovation Lab Manager at the State University of New York at Albany. In that role, he oversees the daily operations of the facility and technical staff. His responsibilities also include expanding the cleanroom's scope and breadth in managing the acquisition, installation, and facilitation of new equipment, materials and processes. Prior to his role at SUNY Albany, Bryant filled the role of Process and Design Engineer, General Manager and Director for Rensselaer Polytechnic's academic cleanroom. Bryant began his career by joining IBM's research and development group working on low power memory devices. In 2002, he moved into IBM's microelectronics division working as a process integration and yield engineer for 180nm through 65nm node technology.Bryant is a Rensselaer Polytechnic alumnus, receiving his chemical engineering degree in 2000. He holds five US patents in the microelectronics field and has co-authored several published technical articles.

Michele Cotrufo

Dr. Michele Cotrufo is an Assistant Professor at the Institute of Optics, University of Rochester, USA. He received his B.S. and M.S. degrees in Physics from the University of Bari, Italy (2010) and the University of Padova, Italy (2012), respectively. In 2012 he joined the Eindhoven University of Technology (Netherlands) as a doctoral student, where he investigated light–matter interactions in nanophotonics and hybrid optomechanical systems. After graduating in 2017, he performed postdoctoral research at the University of Texas at Austin and at the CUNY Advanced Science Research Center, before joining the University of

Rochester as a faculty in 2023. Dr. Cotrufo's research focuses on the investigation of metamaterials—artificially structured materials that manifest optical properties not available in bulk materials—for a broad range of applications in classical and quantum optics, such as analog computation, electromagnetic nonreciprocity, and control of light emission. He has authored or coauthored more than 45 journal articles and 2 book chapters, and he is the co-inventor of 3 patents. In 2018, Dr. Cotrufo was awarded a postdoctoral Rubicon Fellowship by the Dutch Research Council. More recently, he has been awarded the MDPI Photonics Young Investigator Award (2023) and the 2024 ISSNAF Young Investigator Strazzabosco Award.

Alexander Khanikaev

Dr. Khanikaev received his PhD degree in Physics from the M. V. Lomonosov Moscow State University in 2003. After his graduation Dr. Khanikaev spent five years at the Department of Electrical and Electronic Engineering of Toyohashi University of Technology, Japan, as a postdoctoral scholar and then as a senior researcher, where he worked on the topics of photonic crystals and plasmonic nanostructures. From 2009 Dr. Khanikaev held a position of a research associate at the Department of Physics, University of Texas at Austin, where he contributed to the fields of infrared photonics and plasmonic and all-dielectric metamaterials, biosensing, and graphene photonics. In 2012 Dr. Khanikaev introduced the concept of symmetry protected photonic topological insulators. In 2015 he pioneered the field of acoustic topological insulators. In 2013 Dr. Khanikaev joined the City University of New York as a faculty member. Since 2024 Dr. Khanikaev has been an Endowed Professor, Cobb Family Eminent Scholar Chair, at CREOL, College of Optics and Photonics, University of Central Florida. He is a Fellow of the Optical Society of America (Optica), a recipient of the NSF Special Creativity Award (2021), and the Clarivate Highly Cited Researcher. His current interests and research directions include quantum phenomena and light-matter interactions in engineered optical nanomaterials and metamaterials for topological photonics and acoustics.

Arash Nemati

Dr. Arash Nemati is the Co-founder and CEO at TuneWave Inc., a technology startup developing advanced passive and tunable metasurfaces for next-generation optical and electromagnetic devices. A scientist and inventor with more than a decade of experience in tunable optics, metasurfaces, and electromagnetic device engineering, he earned his Ph.D. in Electrical and Computer Engineering from the National University of Singapore in 2020, where his research produced several high-impact publications and patent filings in tunable nanophotonic systems. Before founding TuneWave, Dr. Nemati served as a Research Scientist at the Agency for Science, Technology and Research (A*STAR) in Singapore, where he designed, fabricated, and characterized metasurface-based optical components, including tunable lenses, beam-steering devices, and optical modulators. His work contributed to a multi-million-dollar industry R&D program and multiple U.S. patent filings. At TuneWave, Dr. Nemati leads efforts to translate cutting-edge metasurface research into scalable, commercially viable technologies bridging the gap between advanced nanophotonics and real-world applications.

James Scholtz

James Scholtz is the founder and CEO of Vyir (pronounced Vie-er). He is a physicist and laser and optical engineer with over 20 years of experience designing and building complex optical systems and sensors. He combined his passion for science, innovation, and entrepreneurship with his grit and resourcefulness to develop Vyir's Optical Infrared Camera and its proprietary Nano EnCoater Technology. He is an alumnus of Stony Brook University and The City College of New York, and is an alumni of the Activate Fellowship.

Javad Shabani

Prof. Shabani received his PhD from Princeton University in 2011. After two years of research on semiconductor-based qubits at Harvard University, he joined UC Santa Barbara. There, he worked closely with Microsoft research on hybrid semiconductors/ superconductors heterostructures to study topological superconductivity. He is an expert in quantum materials and devices for computation technologies. He is currently a professor of Physics at New York University. His current research interests are 1) Novel states of matter at interfaces with focus on hybrid superconductor -semiconductor systems 2) Mesoscopic and nanoscale physics with emphasis on low dimensional semiconductors with focus on new materials/device development for quantum information 3) Physics of integer and fractional quantum Hall effect and 4) Epitaxial growth of compound superconducting metals-semiconductor, including high mobility two-dimensional electron systems and nano-plates using molecular beam epitaxy.

Yingli Tian

Dr. YingLi Tian is a CUNY Distinguished Professor in the Department of Electrical Engineering at the City College and in the Department of Computer Science at the Graduate Center of the City University of New York. She is a Fellow of the Institute of Electrical and Electronics Engineers (IEEE), the International Association of Pattern Recognition (IAPR), the American Association for the Advancement of Science (AAAS), and the Asia-Pacific Artificial Intelligence Association (AAIA). Dr. Tian is a pioneer in automatic facial expression analysis, human activity understanding, and assistive technology. Her research on facial expression analysis and database development has made significant contributions to the research community and received the "Test of Time Award" at the IEEE International Conference on Automatic Face and Gesture Recognition in 2019. Before joining CCNY in 2008, Dr. Tian was a research staff member at the IBM T. J. Watson Research Center, where she led the video analytics team. Her research interests include computer vision, machine learning, artificial intelligence, assistive technology, medical image analysis, and remote sensing. She has published more than 260 peer-reviewed papers in journals and conferences and holds 29 issued patents.

Jacob Trevino

Jacob Trevino is the Senior Director of the Columbia Nano Initiative (CNI) Labs at Columbia University, where he leads a shared research environment supporting interdisciplinary advances in nanoscience and engineering. He also serves as Chief Innovation Officer at Chemeleon, a Brooklyn-based startup developing colorimetric sensors for medical, environmental, and defense applications. There, he oversees R&D strategy and drives the integration of nanotechnology, photonics, and molecular recognition. Jacob has previously directed nanofabrication facilities at the University of Pennsylvania, NYU, and the CUNY Advanced Science Research Center, managing cleanroom operations serving diverse academic and industrial communities. He is the Founder and President of Nanotech NYC, a regional initiative that connects researchers, students, and entrepreneurs to foster collaboration and accessibility in nanotechnology. Bridging academia, industry, and community, Jacob is dedicated to advancing impactful science and cultivating ecosystems where innovation can thrive. He holds a PhD in Materials Science and Engineering from Boston University and teaches graduate-level micro- and nanofabrication at Columbia.

Abstract Index

** Highlighted Abstracts have been selected for talks **

Physics and Quantum

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Quantum confinement of excitons in phase-patterned channels of monolayer semiconductors

Ashok Adhikari

Photonics Initiative, CUNY Advanced Science Research Center, New York, USA

Controlling excitons, electron-hole pairs, at the nano and atomic scale offers opportunities to explore exotic quantum phases, strong exciton-exciton interactions, nonlinear optical phenomena, and long-range transport. Monolayers of transition metal dichalcogenides (TMDs) naturally provide strong exciton binding energies and intrinsic 2D confinement, making them an ideal platform for such studies. Here, we engineer one-dimensional exciton channels by phase-patterning WS2 and MoSe2 monolayers, achieving widths as narrow as 10 nm and enabling quantum confinement of excitons. Low temperature optical measurements reveal a blueshift of the neutral exciton, linear polarization of confined states, and higher energy excitonic states. By tailoring the channel geometry, we control the polarization of emitted light, demonstrating the influence of spatial confinement on valley hybridized excitons and providing a platform to study exciton interactions, nonlinear optical behavior, and novel phenomena in low-dimensional TMD systems.

Keywords: Excitons, Transition metal dichalcogenides (TMDs), Quantum confinement, Phase-patterned monolayers, Valley hybridization, Nonlinear optics, Polarization control

Magneto-Optic Studies of Spin Orbit Torques

Ahmet Koral Aykin and Andrew D. Kent

Center for Quantum Phenomena, Department of Physics, New York University, New York, New York 10003, United States

Spin orbit torques (SOT), originating from spin orbit coupling effects which is either intrinsic to the non-magnetic layer or develop at non-magnetic/ferromagnetic interface, offers efficient control of magnetization for spintronic devices. However, since these torques are exerted by the spin polarized current injected from the non-magnetic layer which penetrates only a few nm into the material, they only cause small deflections of magnetization from the equilibrium alignment. By electrical methods, one can quantify SOT in the dynamic regime where RF current is injected to drive the resistance of material, resulting in voltage rectification. Quantifying current induced torques not only in conventional metallic ferromagnets but also insulating systems where electrical characterization is not possible is crucial for the development of spintronic device-based applications.

Here, we report on high sensitivity optical measurement of the current-induced torques in transition metal multilayer structures using Zero-Area Loop Sagnac Interferometer (ZALSI) based Magneto-Optic Kerr Effect. Our ZALSI features a pair of reciprocal optical paths facilitated within a strand of polarization maintaining fiber in which two circularly polarized light beams with opposite polarity counterpropagating. When the two beams recombine at the detector, any time-reversal-symmetry breaking effect will result in destructive interference. In a magneto-optic based ZALSI, this interference gives information about Kerr effect. We achieved a sensitivity of ~50 nrad in Kerr angle which enabled us to probe magnetization deflection induced by the spin orbit torques. In addition, we study how lithographically defined special geometries can be utilized to probe spin orbit torques in 2D magnetic materials.

Keywords: Spintronics, Spin Orbit Torques, Sagnac Interferometry, Magneto-Optic Kerr Effect

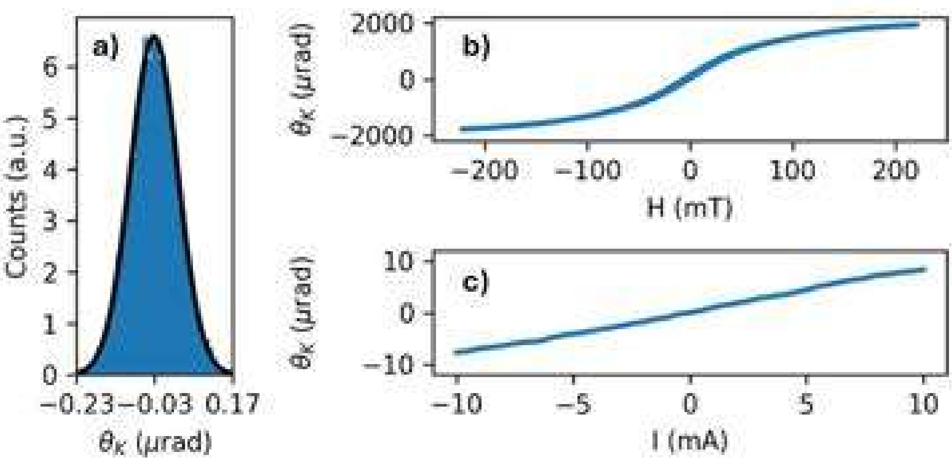


Figure 1: (a) 12-hour-run distribution of zero-signal Kerr angle. (b) Hard axis hysteresis loop. (c) Kerr angle versus I_{DC}. Spin orbit torques are in 1st order in Kerr angle.

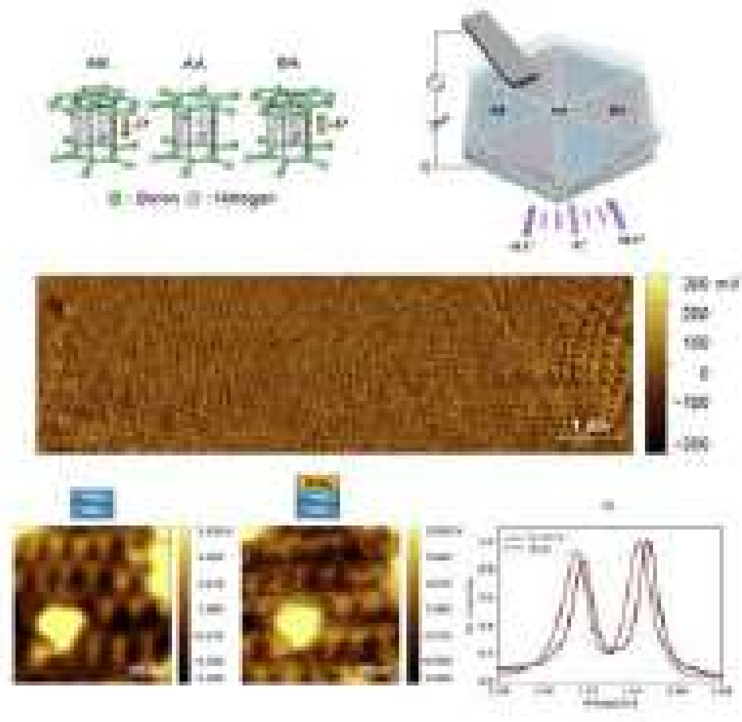
Highly Tunable Moiré Proximity System in Twisted Hexagonal Boron Nitrides Heterostructure

Kwanghee Han[1,2*], Minhyun Cho[1,2], Abhishek Budarapu[2], Taehyung Kim[1], Seung Tae Kim[1], Suk Hyun Kim[1,3], Sang Hwa Park[4], Sang Mo Yang[4], Kenji Watanabe[5], Takashi Taniguchi[6], James Hone[7], Young Duck Kim[1,3,8*] and Vinod Menon[2*]

[1]Department of Physics, Kyung Hee University, Seoul 02447, South Korea
[2]Department of Physics, City College of New York, New York 10031, United States
[3]Department of Information Display, Kyung Hee University, Seoul 02447, South Kore
[4]Department of Physics, Sogang University, Seoul, 04107 Republic of Korea
[5]Research Center for Electronic and Optical Materials, NIMS Japan
[6]Research Center for Materials Nanoarchitectonics, NIMS, Japan
[7]Department of Mechanical Engineering, Columbia University, New York,USA
[8]KHU-KIST Department of Converging Science and Technology department, South Korea
**Corresponding e-mail: ydk@khu.ac.kr, vmenon@ccny.cuny.edu*

Moiré superlattice in twisted van der Waals materials have emerged as a promising platform for emulating strongly correlated physics due to the tunability of many-body interactions via external stimuli such as gate, strain, and twist angle. In the twisted Hexagonal Boron Nitrides (hBN) heterostructure with a small angle mismatch, nanoscale ferroelectric domains are formed due to their dipole polarization difference and minimize the interlayer configurations energy. Here, we report various types of moiré potentials such as the quasi 1-dimensional moiré structure and cumulative moiré superlattice. In addition, we introduce an approach for programming the moiré potential using femtosecond laser. Furthermore, we confirm the moiré proximity effect using Kelvin Probe Force Microscopy (KPFM) even after transferring monolayer MoSe2. The twisted hBN platform could pave the way for remote engineering of moiré potentials on demand and use it for Hamiltonian simulators.

Keywords: Moiré superlattice, Hexagonal Boron Nitrides, Cumulative Moiré potential, Femtosecond laser, Proximity effect.



Advanced Nanofabrication for Room-Temperature Polariton Condensate Lattices and Metasurfaces

Rishabh Kaurav[1,2*,#], Ravindra Kumar Yadav[1,5*,#], Daegwang Choi[1], Serena Zachariah[1], Vinod M. Menon[1,2*]

[1]Department of Physics, City College of New York, NY, USA.
[2]The Graduate Center, City University of New York, NY, USA.
[3]Photonics Initiative, ASRC, City University of New York, NY, USA.
[4]Department of Chemistry, Indiana University, Bloomington, IN, USA.
[5]Indian Institute of Technology, Mandi, HP, India. Equal contribution[#].

Contact information: *rkaurav@gradcenter.cuny.edu, ryadav@ccny.cuny.edu, *vmenon@ccny.cuny.edu

This study investigates exciton–polariton systems, focusing on new nanofabrication meth-ods for building advanced polariton lattices and photonic structures. We use small-molecule ionic isolation lattices (SMILES) as the active medium, which makes it possible to embed highly emissive organic dyes into well-defined microcavity platforms. This approach offers excellent optical quality and tunability, allowing precise control over the photonic environment and exciton–photon interactions.

Using a top-down fabrication method based on Focused Ion Beam (FIB) etching, we directly pattern polariton lattices inside planar microcavities containing SMILES films. Unlike traditional bottom-up assembly, this technique provides strong refractive index contrast, high design flexibility, and the ability to engineer diverse geometries—such as periodic, quasi-periodic, and disordered lattices—with precisely placed defect sites.
Building on these capabilities, we fabricated both Bound State in the Continuum (BIC) and moiré lattice structures to study their unique mode symmetries and polaritonic band behavior. Momentum-resolved spectroscopy reveals distinct dispersion features and evidence of polariton condensation within these engineered potential landscapes.

Overall, this work shows how combining SMILES-based materials with advanced FIB nanofab-rication enables highly controllable polaritonic architectures, opening new possibilities for photonic and quantum technologies

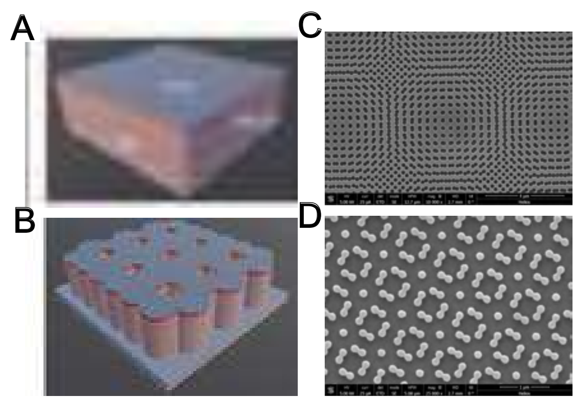


Figure 1. (A) Schematic of micro cavity, (B) patterned honeycomb organic exciton-polariton lattice
(C and D) Moire photonic lattice of R3B-SMILES .

References

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2. Deshmukh, Prathmesh, et al. "Plug-and-Play Molecular Approach for Room Temperature Polariton Con-densation." ACS Photonics 11.2 (2024): 348-355.

3. Yadav, Ravindra Kumar, et al. "Di-rect Writing of Room Tempera-ture Polariton Condensate Lattice." Nano Letters 24.16 (2024): 4945-4950.

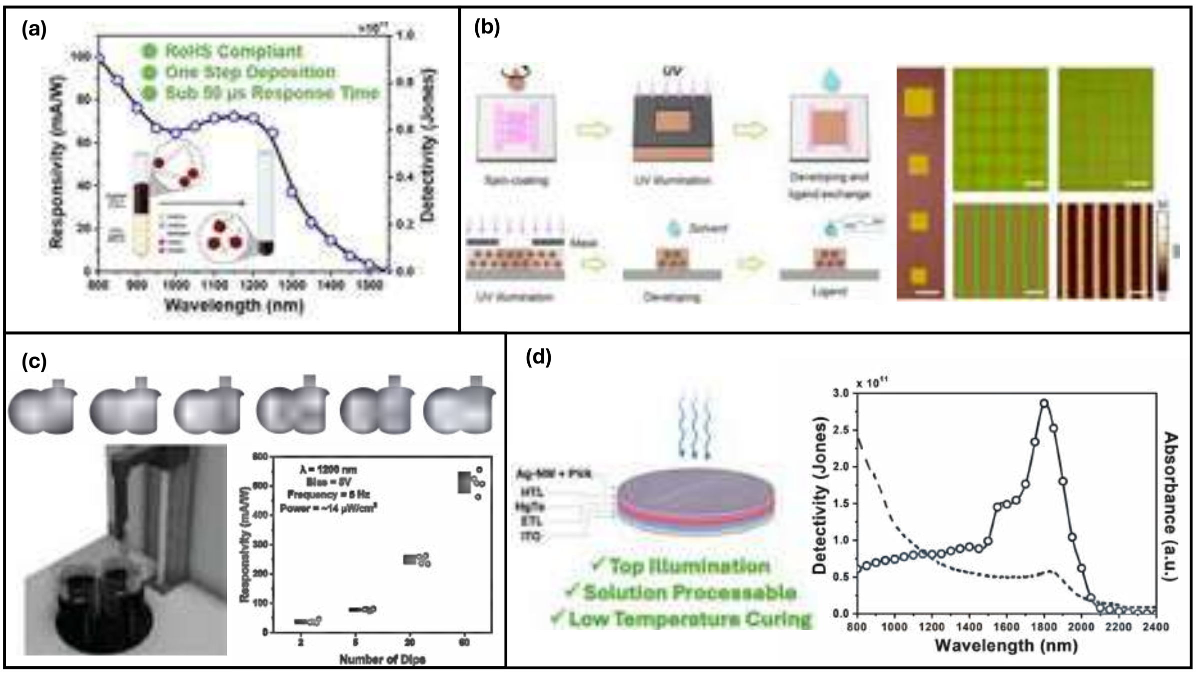
There is Plenty of Room at the Bottom and the Top for Colloidal Quantum Dot Infrared Photodetectors

Shlok Joseph Paul[1], Se Young Park[2], Prof. Moon Sung Kang[2] and Prof. Ayaskanta Sahu[1]

[1] New York University, New York, USA
[2] Sogang University, Seoul, Republic of Korea

Infrared (IR) photodetectors enable night vision, situational awareness, and UAV reconnaissance. While HgCdTe and InGaAs deliver excellent performance, they remain costly, fabrication-intensive, and difficult to scale. Solution-processed colloidal quantum dots (cQDs) are attractive alternatives, but the most mature systems (PbS, HgTe) face hazardous-substance restrictions that hinder commercialization. Here we report advances in **cQD chemistry, patterning, deposition, and device design** that collectively address these barriers. We develop a **RoHS compliant solution-phase Ag_2Se infrared ink** that yields crack-free photodiodes with detectivities above 6×10^{10} Jones and sub-50 µs response times. Then we establish **direct cQD lithography** with **2 μm resolution**, enabling patterned Ag_2Te devices including a quad-band photodetector for multispectral NIR–SWIR imaging. Acknowledging that **PbS and HgTe still provide benchmark performance**, we focus on improving process efficiency through **an automated layer by layer dipcoating apparatus**, that reduces waste and cQD consumption while producing uniform, large-area films compatible with high-throughput manufacturing. Finally, to overcome the lack of suitable IR-transparent contacts, we demonstrate a top illuminated SWIR photodiode with an **Ag-nanowire/polyvinyl alcohol (Ag-NW/PVA) electrode** with **~11 Ω sq⁻¹ sheet resistance** and **>70% transmission from NIR to MWIR**, surpassing the brittleness and spectral limits of conventional oxides.

Keywords: Infrared Detectors, Colloidal Quantum Dots, Sustainable, Patterning



Polariton–polariton interactions in microcavities with 2D Perovskites

Serena Zachariah[1,2], Cankut Tasci[1,2], Jessica Kline[3], Daegwang Choi1, Arka Majumdar[4], David Ginger[3], Johannes Flick[1] and Vinod M.Menon[1,2]*

[1]Department of Physics, City College of New York, New York, NY 10031, USA
[2]Graduate Center, City University of New York, New York, NY 10016, USA
[3]Department of Chemistry, University of Washington, Seattle, WA 98195, USA
[4]Department of Physics, University of Washington, Seattle, WA 98195, USA

Hybrid light–matter systems based on metal–halide perovskites offer a versatile platform for realizing nonlinear photonic and quantum functionalities at ambient conditions. Their strong excitonic resonances and structural tunability enable pronounced optical nonlinearities at low excitation powers. Here, we demonstrate the emergence of exciton–polaritons and their interaction-induced energy shifts in a layered perovskite thin film embedded within a microcavity. Under optical excitation, a distinct blueshift of the lower polariton branch is observed, reflecting the strength of the underlying polaritonic interactions. This highlights the potential of perovskite-based microcavities for room-temperature implementation of nonlinear and reconfigurable photonic elements, including optical logic, switching, and neuromorphic computing architectures. Structural and optical characterizations confirm high-quality film formation and well-defined cavity modes, achieved through solution processing and standard thin-film deposition techniques.

Keywords: Exciton–polariton; Microcavity; Excitons; Perovskite; Nonlinearity

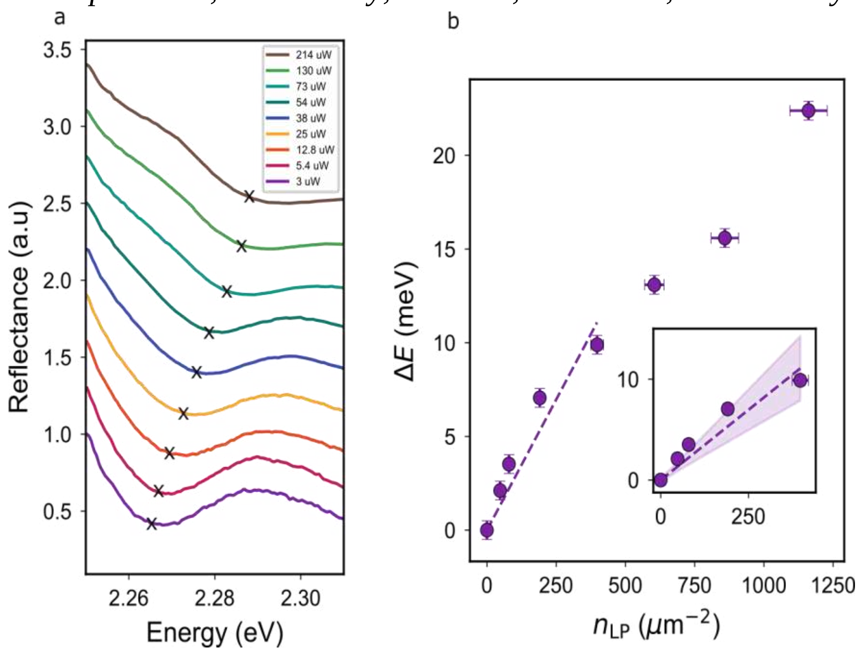


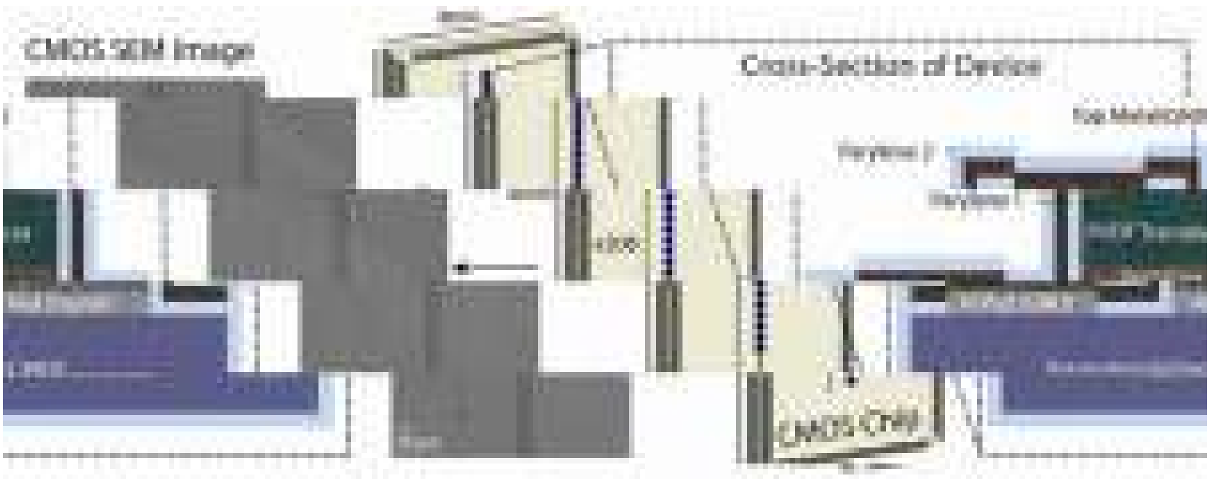
FIG: Non-linear blueshift of the lower polariton in the cavity. (a) Normal–incidence reflectance spectra recorded at room temperature, while the average incident power goes from 0-75 μW. Each trace is vertically offset for clarity; black 'x' symbols mark the energy minimum of the lower-polariton (LP) branch, which shifts to higher energy as the excitation density increases. (b) Extracted LP blueshift versus polariton density. The dashed purple line is a weighted least-squares fit to the linear regime, whose slope gives the nonlinear interaction constant

High Density CMOS-based Ultrasound Phased Array with Monolithically Integrated PVDF Transducers for Photoacoustic Imaging

Volkan Arslan, Kenneth L. Shepard
Columbia University, New York, NY, USA

Recent developments in ultrasound imaging have improved spatial resolution while reducing device form-factors, opening new possibilities for wearable and high-density imaging systems. To further advance these trends and achieve even more aggressive miniaturization, seamless integration of ultrasound transducers with complementary metal–oxide–semiconductor (CMOS) circuits is essential for realizing compact, high-density phased arrays. In this work, we introduce a custom CMOS platform that monolithically combines polyvinylidene fluoride (PVDF) transducers with on-chip front-end electronics tailored for high-resolution imaging. The co-design strategy shortens interconnect paths, suppresses parasitic capacitances, and minimizes the input capacitance of the receiver amplifiers, thereby enabling high-fractional-bandwidth operation suitable for advanced ultrasound imaging applications. The fabricated array consists of 206 receiver elements, each with dimensions of 30 µm × 25 µm × 5.5 µm—representing more than a two-order-of-magnitude volumetric reduction compared to conventional ceramic-based piezoelectric transducers. The system's performance is validated through both in-vitro and *in-vivo* photoacoustic imaging, achieving lateral and axial resolutions of better than 30 µm and 15 µm, respectively.

Keywords: CMOS, PVDF, Ultrasound Imaging, Photoacoustic Imaging



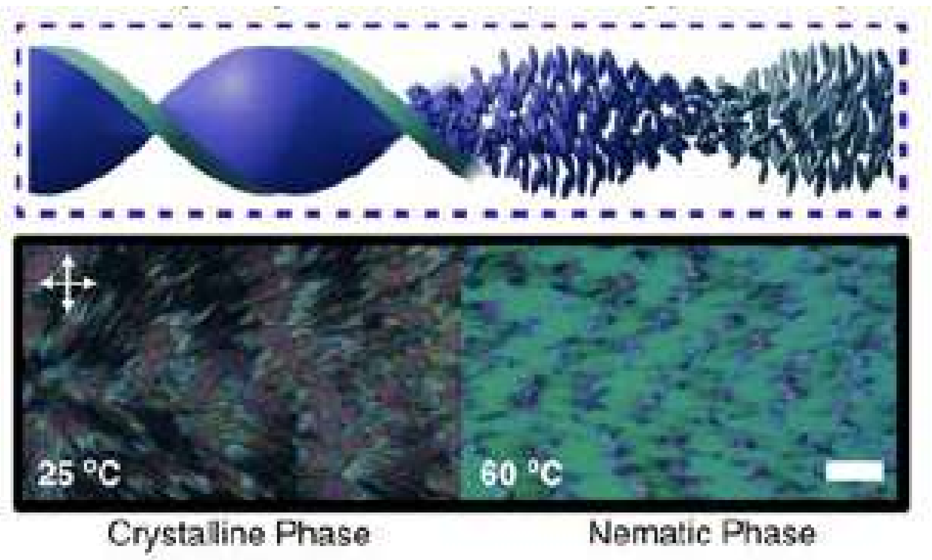
In situ Monitoring of Optical Properties Through the Crystal–Liquid Crystal Phase Transition

Justin Bendesky, Arturo Gracia, Bart Kahr[§], Stephanie S. Lee[§]
Graduate Student, New York University Molecular Design Institute, U.S.A
Undergraduate Student, New York University Molecular Design Institute, U.S.A
Professor, New York University Molecular Design Institute, U.S.A[§]

Crystal twisting in organic molecules is most often observed during crystallization from the melt as banded spherulites comprising of bundles of helicoidal fibers rotating in concert about the growth direction. When viewed between cross-polarizers, concentric rings of interference colors appear due to continuously rotating refractive indices. In addition to modulating materials properties, crystal twisting, either clockwise or counterclockwise about the growth direction, also introduces chirality to films. Here, the preservation of the twist in banded spherulites of 4-heptyloxy-4'-cyanobiphenyl (7OCB) through the crystal-to-nematic phase transition is monitored. When crystallized from the melt at temperatures between 0 – 25 ºC, 7OCB forms banded spherulites with pitch (i.e. spacing between colored bands) ranging from 2 – 300 µm. In situ petrographic imaging during thermal cycling through the crystal-to-nematic phase (54 ºC) and nematic-to-isotropic phase (75 ºC) transitions preserved the interference bands. Mueller-Matrix Imaging (MMI), a complete polarimetry method to spatially map the linear retardance (LR), linear extinction (LE), circular retardance (CR), and circular extinction (CE) in films, demonstrated that CR was preserved on traversing into the LC phase. The magnitude of the CR signal increased through the phase transition, suggesting that the orientations prescribed by crystal twisting are preserved through the crystalline-to nematic phase transition (T_{CrN}). We hypothesize that the initial formation of chiral mesostructures in the crystalline phase are a promising strategy to introduce optical activity in films from centrosymmetric liquid crystals.

Keywords: crystal twisting, liquid crystals, optical activity, chiral templating

Schematic illustration of crystal twisting across T_{CrN} (above) and crossed-polarized micrograph of 70CB twisted crystals (below)



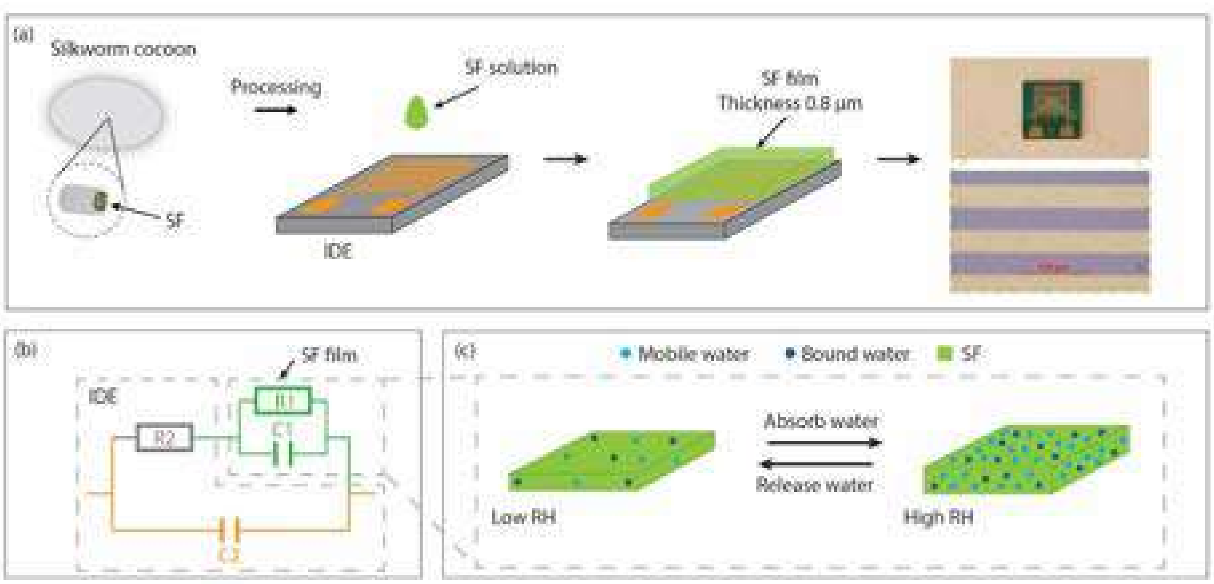
Ultra-Fast Silk-Based Humidity Sensor Enabled By Water-Induced Impedance Modulation

Shuo Fang, Yuchen Zhang, Maheen K. Khan, Xi Chen, Ioana Voiculescu
The City College of New York, U.S.A

In this study, we present a simple predictive model for a relative humidity (RH) sensor that uses silk fibroin (SF) as the sensing material and impedance spectroscopy for measurement. The model is based on the effect of water on the material and is represented by an equivalent circuit with four elements: R_1 and C_1, the resistance and capacitance of the SF film; R_2 , the contact resistance between the SF film and the electrode; and C_2, the capacitance of the electrode. R_1 and C_1 are analyzed to find out the relation between the values and RH levels based on the water structure in the material. Each component in the model has a clear physical meaning. This model provides insight into the working principle of the sensor and can be used to predict performance before fabrication. Experimental results show that the sensor has very fast response and recovery times of 0.015 s and 0.221 s; respectively.

Keywords: relative humidity (RH) sensor, silk fibroin (SF), impedance modeling, equivalent circuit model

Schematic illustration of the manufacturing and water-induced modelling of a silk-based humidity sensor

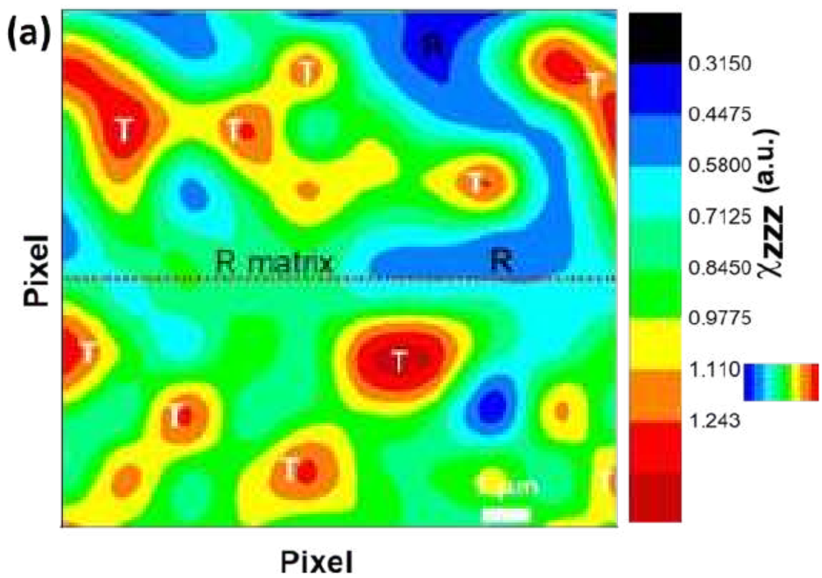


Visualization of Intertwined Heterophase Polydomains in BZT Films

Ying Wang[1,2], Yinxiu Xue[1,2], and Yuhang Ren[1,2]
[1]Physics & Astronomy, Hunter College, the City University of New York, 695 Park Avenue, New York, NY 10065
[2]The Graduate Center, the City University of New York, 365 5th Ave., New York, NY 10016

Understanding the evolution of multiple ferroelectric phases and their domain structures is vital for optimizing thin-film performance and uncovering underlying mechanisms. Yet, directly resolving local strain and nanoscale defects remains challenging. Here, we present the azimuth- and polarization-resolved second harmonic generation (SHG) approaches for distinguishing tetragonal and rhombohedral domain variants in the ferroelectric $BaZr_{0.2}Ti_{0.8}O_3$ (BZT) thin films grown on $LaTiO_3$ (LAO) substrates. Spatial mapping of SHG intensity reveals polymorphic nanodomains and elastic strain fields within the BZT/LAO heterostructure. The competition between tetragonal and rhombohedral phases generates anisotropic nanodomains with coupled elastic–electrostatic interactions. These results demonstrate that SHG imaging spectroscopy provides a powerful, non-destructive approach to probe microstructural and phase inhomogeneities in ferroelectrics, offering key insights for next-generation memory, actuator, and energy-storage devices.

Keywords: Ferroelectric thin films; Optical SHG imaging; SHG spectroscopy; Polymorphic domain structures; High-energy-storage density



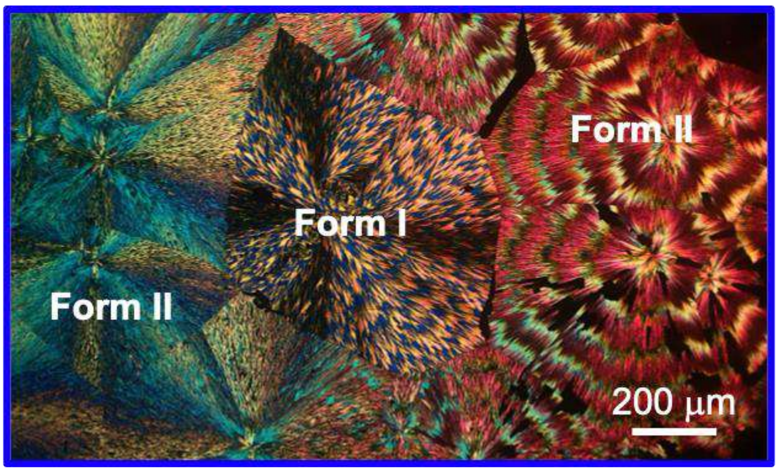
Polymorphism in Singlet Fission Materials: Discovery of a New DPND6 Crystal Form with Enhanced Optoelectronic Properties

Rochelle B. Spencer,[1] Karamoko Soumahoro,[2,3] Shixuan Wei,[4] Alexander G. Shtukenberg,[1] Matthew Sfeir,[2,3] Luis M. Campos,[4] Stephanie S. Lee[1]
[1]Molecular Design Institute, Department of Chemistry, New York University, USA
[2]Department of Physics, Graduate Center, City University of New York, USA
[3]Photonics Initiative, Advanced Science Research Center, City University of New York, USA
[4]Department of Chemistry, Columbia University, New York, USA

Crystal polymorphism plays a fundamental role in determining optoelectronic properties of organic semiconductors, with molecular packing directly controlling processes such as charge transport, light absorption, and emission. Here, we report a new polymorph, Form II, of DPND6 (6,12-dihexyl-5H,11H-dipyrrolo[1,2-b:1',2'-g][2,6]naphthyridine-5,11-dione), a chromophore previously demonstrated to exhibit singlet fission. Discovered through additive-free melt-processing of thin films, both polymorphs of DPND6 form banded spherulites with remarkable temperature-dependent selectivity: Form I crystallizes exclusively below 50°C while Form II forms at 50-120°C, with twist pitch increasing from ~50-200 μm with crystallization temperature. Single-crystal X-ray diffraction revealed a dramatic structural change: Form II adopts the lower-symmetry $P\bar{1}$ space group, enabling close π-π stacking between pyridine and pyrrole rings at 3.35-3.38 Å, while these interactions are completely absent in Form I (*C*2/c space group). This structural reorganization yields substantial optoelectronic enhancement: Form II exhibits 1.5x stronger absorbance (λ_{max} = 483 nm) and 4x stronger photoluminescence (λ_{exc} = 546 nm) compared to Form I. The helical crystal architecture produces distinctive optical signatures observable through Mueller matrix microscopy, with periodic oscillations in linear retardance and extinction, and bi-signate circular retardance and extinction. Given the enhancement in light absorption and emission of DPND6, this work employs crystal polymorphism as a powerful design strategy for tuning optoelectronic properties without molecular redesign, with implications for optimizing materials toward next-generation photovoltaics.

Keywords: crystal growth, polymorphism, melt-processing, banded spherulite

Polarized optical micrograph of DPND6 banded spherulites grown from the melt.



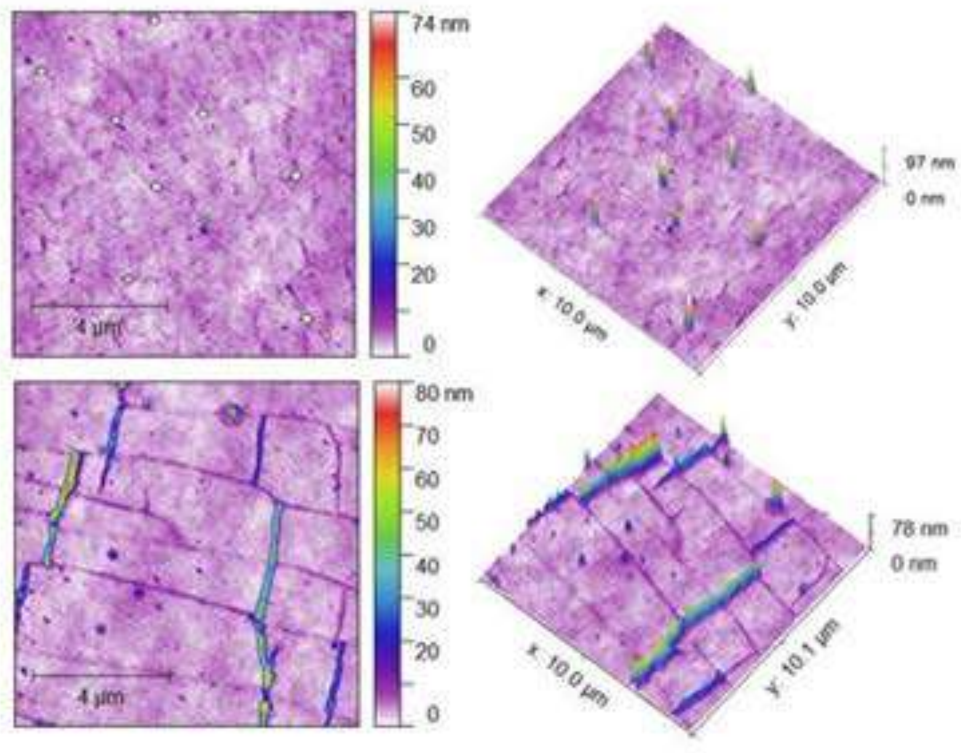
Magnetic Doping of Transition Metal Dichalcogenides for Spintronics Applications

Alexis Vidals Gonzalez[1,2], Candice Forrester[1], Maria Tamargo[1] and Maya Narayanan Nair[2]
[1]*City College of New York, CUNY*
[2]*Advanced Science Research Center, Graduate Center, CUNY*

Tin diselenide ($SnSe_2$), a layered transition metal dichalcogenide (TMD), has emerged as a promising two-dimensional semiconductor for applications in optoelectronics and spintronics. In this work, Cobalt (Co) was introduced as a dopant to modify the electronic and magnetic properties of $SnSe_2$. Monolayer $SnSe_2$ films were first synthesized via chemical vapor transport and then doped with Co via electron beam evaporation, followed by a thermal annealing. The presence of Co and its chemical state were confirmed by X-ray photoelectron spectroscopy (XPS). Atomic force microscopy (AFM) revealed changes in surface morphology and formation of wide grain boundaries after doping, and Hall resistance measurements indicated magnetic interactions in the temperature range of 120–150 K. This preliminary study highlights how magnetic doping can enhance the properties of $SnSe_2$ monolayers, making them promising candidates for future spintronic and nanoelectronics technologies.

Keywords: 2d semiconductor material, deposition, annealing, grain boundaries, spintronics

Figure: (TOP): AFM topographic view of monolayer $SnSe_2$ after 1st deposition of Co and its corresponding 3D image. (Bottom) AFM topography of 2nd deposition after annealing at 300° C.



Monolithic stacking of metalenses using plasma enhanced chemical vapor deposition

Melanie Choca[1], Federico De Luca[2], Andrea Alù[2], Samantha Roberts[2], Viktoriia Rutckaia[2]
[1] La Guardia Community College, City University of New York, New York, NY
[2] Advanced Research Science Center, City University of New York, New York, NY

Multilayer metalenses enable compact optical systems capable of multifunctional and three-dimensional light control. This work explores the fabrication of vertically stacked metalenses separated by silicon-dioxide (SiO_2) spacers deposited via plasma-enhanced chemical vapor deposition (PECVD). The goal is to identify the minimum spacer thickness that preserves surface smoothness and ensures reliable layer integration. SiO_2 layers with varying thicknesses of 100 – 1000 nm were deposited on patterned surfaces and analyzed by scanning electron microscopy (SEM) to assess morphology. Distinct overgrowth mechanisms were observed depending on the lateral dimensions of the underlying patterns, influencing surface uniformity and interlayer adhesion.

A two-layer metalens stack with a 500 nm SiO_2 spacer was fabricated and characterized through optical transmission measurements, confirming consistent focusing performance. These results establish guidelines for achieving uniform, low-defect interfaces in multilayer metalenses, advancing the development of compact and multifunctional photonic devices.

Keywords: multilayer metalens, SiO_2 spacer, surface morphology, SEM characterization, optical measurement, photonic applications

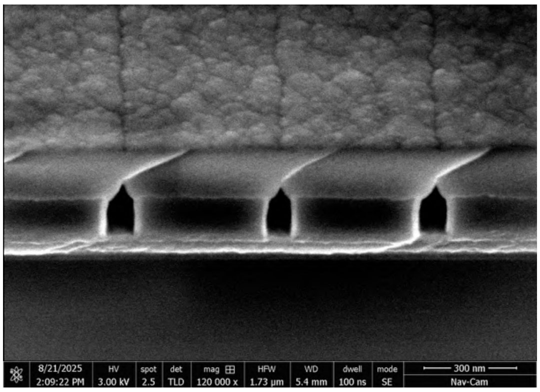


Fig 1. SEM image of a cross section showing a 250nm SiO_2 deposition on top of a patterned Si layer with 100nm feature width and 400nm period

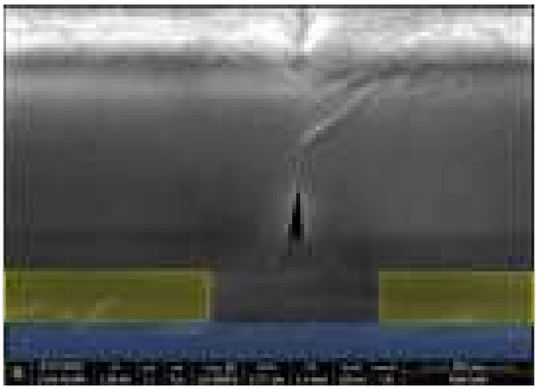


Fig 2. SEM image of the cross section showing a 1000 nm SiO_2 deposition on top of a 500 nm wide hole etched in Si layer (yellow false color). Blue false color represents SiO2 substrate.

Optical Switching on TFLN Micro-ring Resonator

Nirmal Dangi, Jiaxing Liu, Daniel Lopez, Yuping Huang
Department of Physics, Stevens Institute of Technology, New Jersey

We demonstrate an optical switch on a periodically poled thin-film lithium niobate (TFLN) microring resonator, operating through the quantum Zeno blockade (QZB) effect. The switching is driven by a nonlinear sum-frequency generation (SFG) process, where a pump wave controls the routing of an optical signal between the through and drop ports without generating carriers or heat. The experiment implies synchronized optical pulses with a 5 MHz signal and a 2 MHz pump, allowing interaction-free modulation of the signal path. The results confirm stable and reversible switching performance under both quasi-continuous and pulsed operation, demonstrating a purely parametric, low-loss, and thermally stable approach to on-chip optical routing. This work establishes a scalable platform for integrated all-optical and quantum photonic information processing.

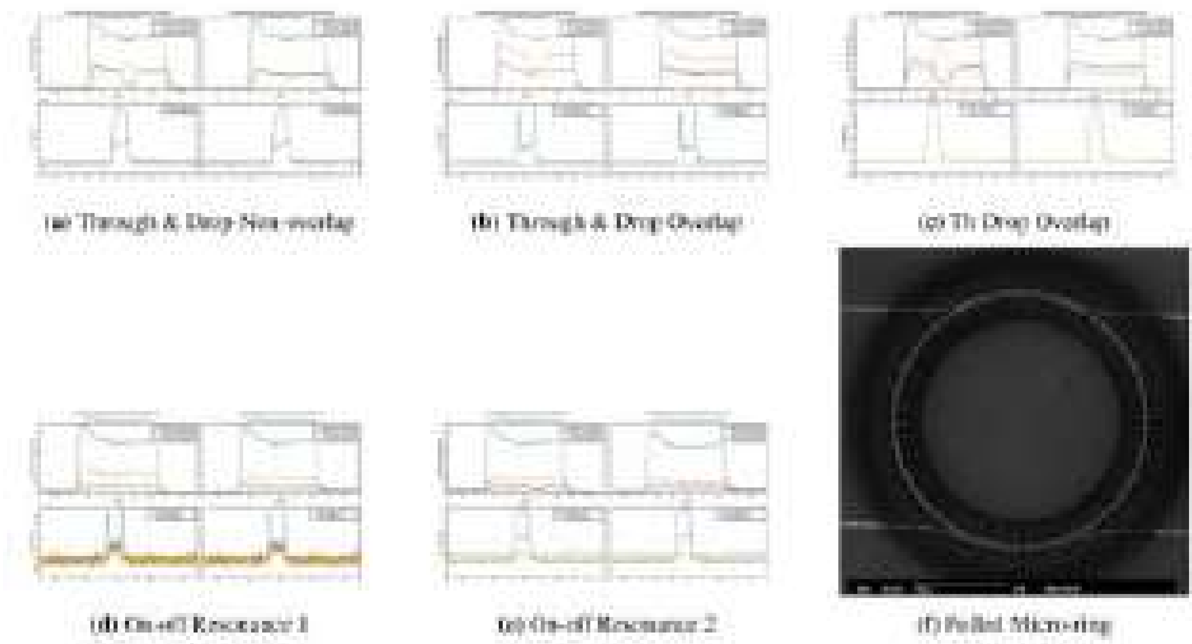


Figure 1: Normalized signal power at on/off resonance under different conditions and micro-ring image

City Tech – ASRC Summer Research and Education Program: Exploring Optical Fundamentals and 2D Materials for Quantum Photonics

Students: Tonatiuh Fitzgerald, Tomas Gonzalez, Lucy Lin, Eva Rubano, and Sean Sinclair
Faculty Mentors: Vitaliy Dorogan, Lufeng Leng, German Kolmakov, and Victoriia Rutckaia[*]

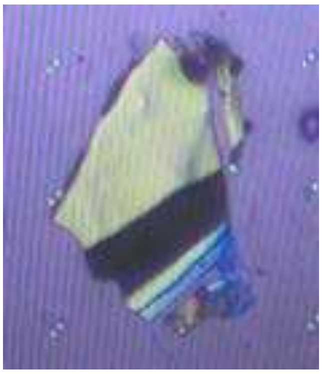
Physics Department, NYC College of Technology, CUNY, Brooklyn, NY
[*]Photonics, Advanced Science Research Center, CUNY, New York, NY

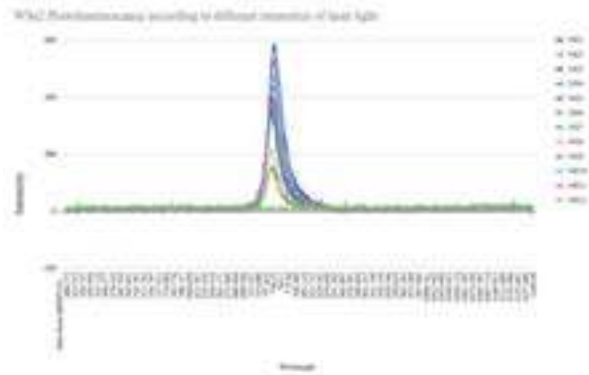
This summer internship involved three undergraduate students and two high school students. The program was divided into two separate, sequential phases. The first phase took place in the optics lab at City Tech, where students received intensive foundational training in optics, lasers, fiber optic communication, and interferometers.

In the second half, students worked on a dedicated research project in the photonics labs at the Advanced Science Research Center (ASRC). The main goal of this project was to study the photoluminescence (PL) response of advanced two-dimensional (2D) chalcogenides, including Tungsten Diselenide (WSe_2) and Indium Selenide (InSe). This research aimed to examine a new material's ability to modulate a PL signal through a radio-frequency (RF) input, a crucial feature for linking the RF-emitting output of future quantum computers to the global industrial fiber-optic network.

Students used mechanical exfoliation to produce mono-, bi-, and multilayer samples, followed by precise thermal transfer onto silicon substrates. Characterization was performed with a micro-PL spectrometer setup, which consistently confirmed that WSe_2 exhibited a characteristic PL peak around 750 nm, while InSe showed a direct correlation between the number of layers and its photoluminescence signal (PL peak at 1000 nm for multilayers), supporting the viability of these materials for novel quantum communication applications.

Keywords: optics, exfoliation, photoluminescence, two-dimensional materials, WSe_2, InSe





Bilayer nonlocal metasurface for arbitrarily polarized wavefront engineering

Mingze He[1,2], Lin Jing[2], Wei Wang[1], Yihao Luo[1], Andrea Alù[1#]

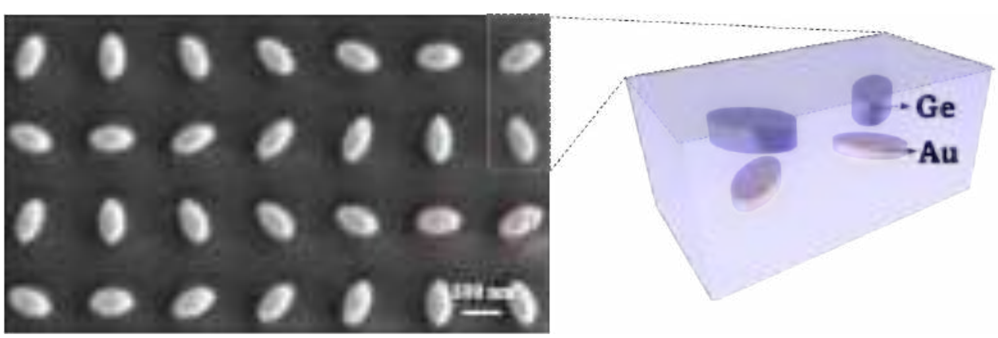
[1]Photonics Initiative, Advanced Science Research Center, City University of New York, New York, NY, 10031, USA

[2]Those authors contribute equally

[#]Email: aalu@gc.cuny.edu

Symmetry-driven phenomena emerging in nonlocal metasurfaces that support quasi-bound states in the continuum (q-BICs) have opened new avenues for tailoring light–matter interactions through perturbative design strategies. The concept of geometric phase is particularly powerful in nonlocal metasurfaces, as it allows local modulation of the q-BIC scattering rate and phase across the aperture while preserving the delocalized nature of the q-BIC resonance. However, this control typically imposes stringent limitations on efficiency and polarization operation in single-layer platforms. In our previous work[1], we addressed this challenge using a nonlocal bilayer metasurface with additional tunning variables, where we tuned the relative scattering strengths of its top and bottom interfaces to enable highly efficient phase manipulation for any custom polarization. While promising, the challenges associated with fabrication hinder its application at optical frequencies, limiting our prior demonstrations to the radio frequencies. Here, we overcome these nanofabrication challenges with a rationally designed double lift-off process, experimentally validating the bilayer metasurface's performance in the near-infrared (~3 μm). We demonstrate highly efficient nonlocal phase gradients that route prescribed polarization states—linear, circular, and elliptical—to distinct diffraction orders/angles, confirming independent, spatial control of phase and polarization with high Q-factor. This polarization-agnostic geometric phase offers new opportunities in wavefront manipulation, multifunctional operation and light emission, with applications in augmented reality, secure communications, wireless systems, imaging, lasing, nonlinear and quantum optics.

Keywords: Bilayer nonlocal metasurface, Wavefront engineering, Arbitrary polarization



Acknowledgement: ASRC Nanofabrication Facility and all staff members!

1. Overvig, Adam, et al. *arXiv preprint arXiv:2302.13215* (2023).

Topological Photonic Metasurfaces for Light Manipulation

Daria Kafeeva[1], Filipp Komissarenko[1,2], Yuma Kawaguchi[1], Dmitry Yasnov[2], Ceren Babayigit[2], Alexander Khanikaev[1,2]
[1]City College of New York, New York, NY
[2]University of Central Florida, Orlando, FL

This study explores the application of the geometrical phase, a fundamental concept borrowed from topological insulators, to create novel optical devices. The research centers on using artificial gauge fields, implemented by carefully designing the lattice geometry of photonic crystals (PhCs), to control the geometrical phase. These metasurfaces are realized as high-refractive-index slabs (like silicon) patterned at the nanoscale via electron beam lithography. A theoretical model was developed in Comsol Multiphysics to predict field distribution of a topological cavity mode. We employed custom-built near- and mid-IR spectroscopy set-up to image modes of cavities in both real- and Fourier-space domains. Results demonstrate the resonance frequency invariant with respect to the resonator's macroscopic shape and length. This robustness against geometry makes this a new and highly promising class of resonator for applications requiring ultra-stable spectral tuning.

Keywords: topological photonics, photonic crystal, geometrical phase, optical resonators

Schematic illustration of resonator design by mixing two of the most widely used topological photonics platforms – the pseudo-spin-Hall-like (SH) and valley-Hall (VH) photonic topological insulators

Designing Hyperbolic Metamaterials using Ellipsometry

Samhita Kattekola, Alexander Couzis, Ilona Kretzschmar
Department of Chemical Engineering, City College of New York, New York

Metamaterials exhibiting hyperbolic dispersion (Hyperbolic Metamaterials or HMMs) of light have applications in super resolution imaging and spontaneous emission control. However, they have sparingly been used due to difficulty in identifying versatile design parameters and characterization using accessible techniques. In this work, spectroscopic ellipsometry is used to characterize films comprising alternating layers of alumina and silver to identify threshold for the onset of hyperbolic dispersion. Numerical simulations are then used to extend the design space for HMMs using four interdependent parameters: metal thickness, dielectric thickness, transition wavelength and number of periods and summarized into a design chart.

Keywords: Metamaterials, Design, Ellipsometry

Two-way Design Flow of all-optical switching

Jiaxing Liu, Jack Mock, Cosmo Gallaro, Nirmal Dangi,
Daniel Lopez Martinez, Yuping Huang
Department of Physics, Stevens Institute of Technology, New Jersey
Center for Quantum Science and Engineering, Stevens Institute of Technology, New Jersey

This study presents a two-way design flow for all-optical switching based on ring resonators fabricated by periodically poling lithium niobate (PPLN). The design methodology connects structural parameters to switching performance through a combination of simulation, theoretical modeling, and fabrication data.

In the forward direction, the flow enables prediction of switching performance—such as extinction ratio and response time—from known fabrication parameters and simulated device behavior, allowing performance assessment prior to fabrication. In the backward direction, given target performance metrics, the required coupling conditions and geometric parameters can be derived to guide device design.

Future work will involve validating this design flow through fabrication and experimental testing. By integrating artificial intelligence (AI) and machine learning (ML) tools, the proposed framework aims to facilitate inverse design in integrated photonic systems, accelerating the development of next-generation optical switches.

Keywords: design flow, all-optical switching, periodically poling lithium niobate

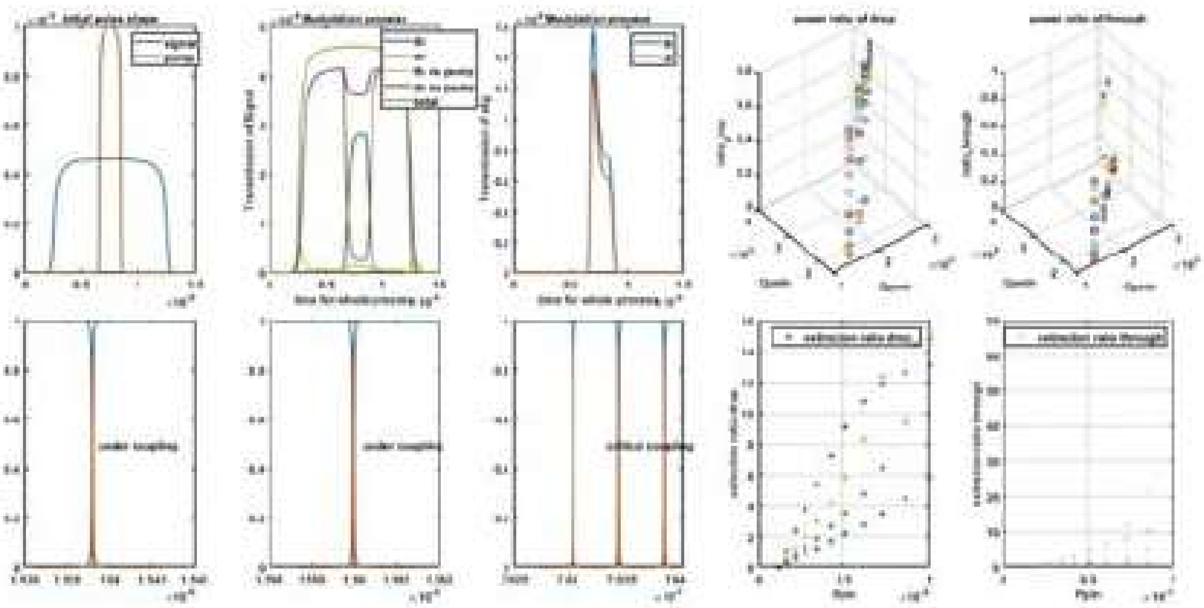


Figure 1. Backward design flow example

Wavelength-tunable metasurface filters for analog image processing

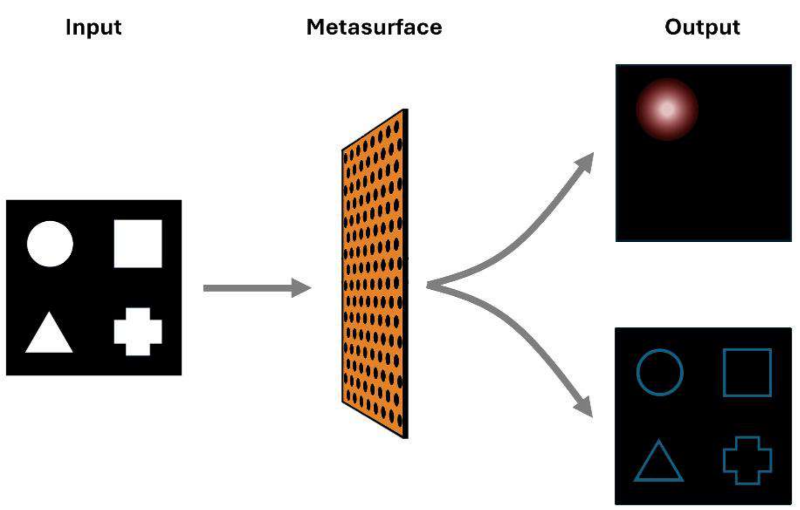
Prachi Thureja, Mehdi Kiani, Lin Jing, and Andrea Alù
Photonics Initiative, CUNY Advanced Science Research Center, New York, USA

Analog, task-specific optics offers a promising route to offload image processing tasks at far lower latency and energy than digital pipelines. We demonstrate a passive metasurface – an ultrathin amorphous silicon film patterned with a nanohole array – that performs shape or edge detection in the near-infrared by acting as a spatial-frequency filter. In shape-detection mode, the metasurface implements an azimuthally symmetric *low-pass filter* that transmits light incident within a target numerical aperture (i.e., angular bandwidth) while suppressing higher spatial frequencies. Changing the illumination wavelength tunes the effective numerical aperture and thus selects the target object size. By detuning the wavelength, the same metasurface transitions into a *high-pass*, edge-detection regime, enabling task switching without physical reconfiguration. Using fabricated samples, we detect micrometer-scale circular features (4-20 μm) and analyze key trade-offs that impact performance. This single-device, wavelength-tunable approach provides a compact, low-power optical front end for real-time image processing.

Keywords: nanophotonics, optical metasurfaces, analog computing

Graphic Abstract.

Schematic illustration of metasurface for wavelength-tunable analog optical shape or edge detection.



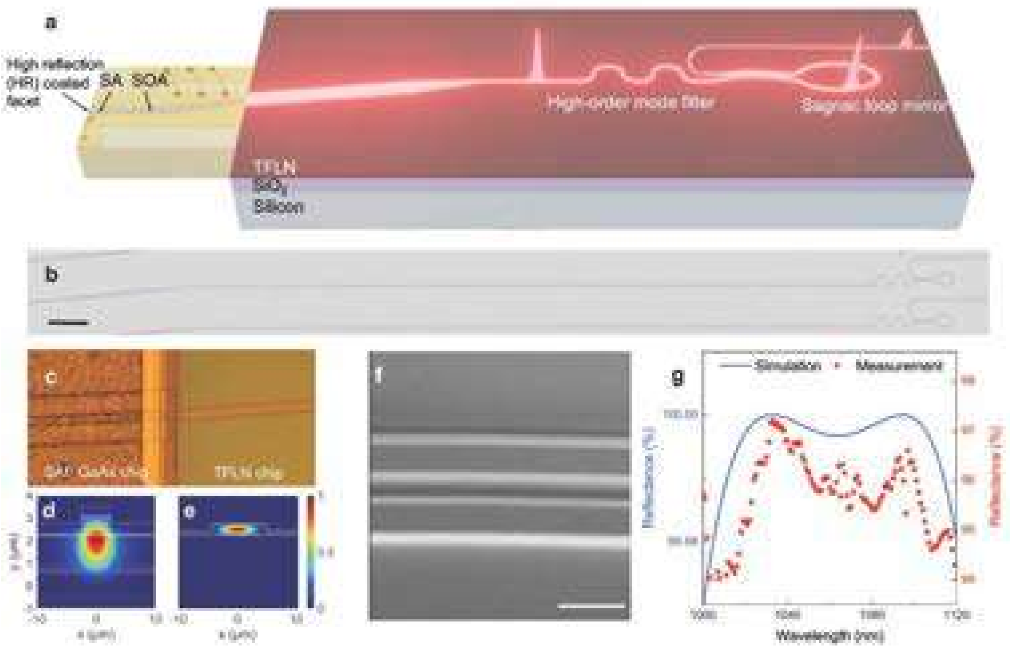
Passive Harmonic Mode-Locked Laser on Lithium Niobate Integrated Photonics

Yu Wang*[1,2], Guanyu Han*[1,2], Jan-Philipp Koester[3], Hans Wenzel[3], Wei Wang[1,2], Wenjun Deng[1,2], Ziyao Feng[1,2], Meng Tian[1,2], Andrea Alù[1,2], Andrea Knigge[3], and Qiushi Guo†[1,2]

1. Photonics Initiative, Advanced Science Research Center, City University of New York, NY, USA
2. Physics Program, Graduate Center, City University of New York, 365 5th Ave, New York, NY 10016, USA
3. Ferdinand-Braun-Institut (FBH), Gustav-Kirchhoff-Str. 4, 12489 Berlin, Germany

* These authors contributed equally to this work.
† Corresponding author: qguo@gc.cuny.edu

Mode-locked lasers (MLLs) are essential for a wide range of photonic applications, such as frequency metrology, biological imaging, and high-bandwidth coherent communications. We demonstrate the first electrically pumped, self-starting passive MLL in lithium niobate integrated photonics based on its hybrid integration with a GaAs quantum-well gain medium and saturable absorber. Our demonstrated MLL generates 4.3-ps optical pulses centered around 1060 nm with on-chip peak power exceeding 44 mW. The pulse duration can be further compressed to 1.71 ps via linear dispersion compensation. Remarkably, passive mode-locking occurs exclusively at the second harmonic of the cavity free spectral range, exhibiting a high pulse repetition rate at 20 GHz. We elucidate the temporal dynamics underlying this self-starting passive harmonic mode-locking behavior using a traveling-wave model. Our work offers new insights into the realization of compact, high-repetition-rate MLLs in the TFLN platform, with promising applications for monolithic ultrafast microwave waveform sampling and analog-to-digital conversion.



From Si-Rich SiN to TiO2: High-NA Holographic Metasurfaces for Scalable Optical Tweezer Arrays

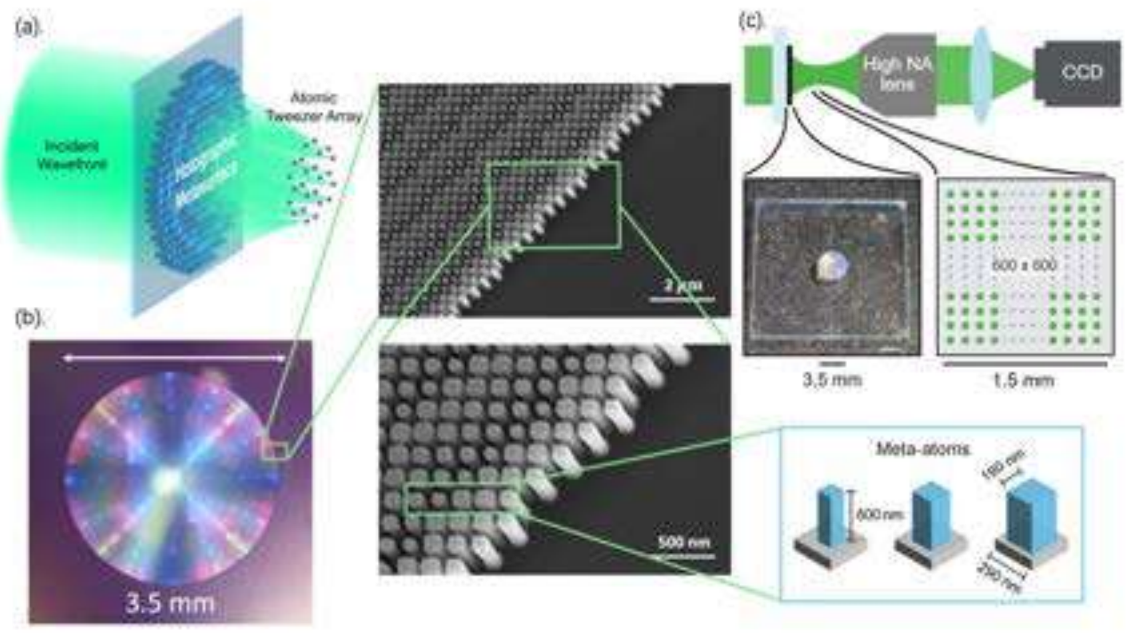
Yuan Xu[1], Aaron Holman[2], Jiahao Wu[1], **Zezheng Zhu**[1*], Ximo Sun[2], Mingxuan Wang[2], Bojeong Seo[2], Nanfang Yu[1 †], and Sebastian Will[2 ‡]

[1]*Department of Applied Physics and Applied Mathematics, Columbia University, New York, NY 10027, USA (*Presenter) and*

[2]*Department of Physics, Columbia University, New York, NY 10027, USA*

Optical tweezer arrays have emerged as a key experimental platform for quantum computation, quantum simulation, and quantum metrology, enabling unprecedented levels of control over single atoms and molecules. However, existing tweezer platforms have fundamental limitations in array geometry, size, and scalability. Holographic metasurfaces overcome these limits by integrating array generation and focusing in a single, passive element, enabling high NA, phase only beam shaping at visible wavelengths in a deployable form factor. We present a titanium-dioxide (TiO_2) metasurface nanofabrication flow optimized for short-wavelength operation, high power handling, and large-format scalability. Devices use subwavelength pixels (290-nm pitch; 100 to 190-nm pillar widths; 600-nm height) to realize effective NA > 0.6 and over 60% diffraction efficiency. Importantly, TiO_2 exhibits extreme power handling with no degradation up to over 2,000 W·mm^{-2}, making it well-suited for scaling tweezer arrays without active cooling. We validate performance via single-atom trapping in 2D arrays (1,000 atoms loaded) and, separately, the optical characterization of a 600×600 tweezer array (360,000 traps at 2.5 µm pitch) with about 92% uniformity, indicating a path to over 10^6 traps with modest aperture growth. These results establish holographic metasurfaces as a scalable, high-NA, high-power-handling neutral-atom platform.

Keywords: metasurface, TiO_2, holography, optical tweezer, quantum computing



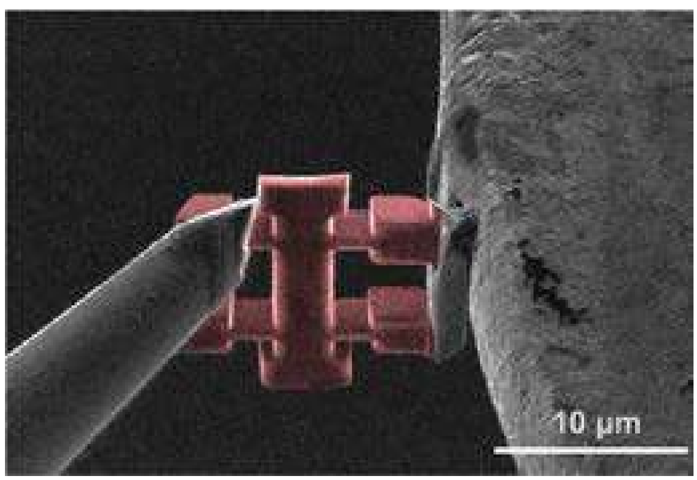
Fabrication of Functional Devices from Single Crystals using Focused Ion Beam

Federico Balduini, Shulami Oh, Aravind Devarakonda

Postdoc Research Scientist, Columbia University, New York, USA
Graduate Student, Columbia University, New York, USA
Assistant Professor, Columbia University, New York, USA

Focused Ion Beam (FIB) technology, traditionally employed for transmission electron microscopy lamella preparation and cross-section analysis, can also be used to shape high-quality single crystals into functional mesoscopic devices. In this work, we highlight FIB fabrication of Hall bar structures for electrical transport characterization of single crystal quantum materials that are too small for conventional bulk techniques. Building on this, we also illustrate how the FIB can be used to shape complex dynamic structures to engineer lattice strain. These novel structures enable access to higher strains than bulk techniques and, additionally, novel stress configurations such as bending and shear. Overall, FIB milling introduces geometry as a tunable parameter in the study of crystalline materials, expanding the experimental tools available to probe their properties.

Pick up of a Hall bar fabricated using FIB starting from a micrometer-scale single crystal.

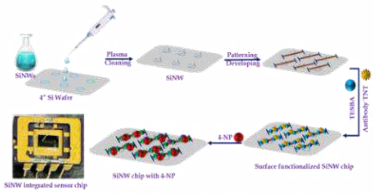


Fabrication of SiNW-Based Nano Sensor Device Using Silver Metal

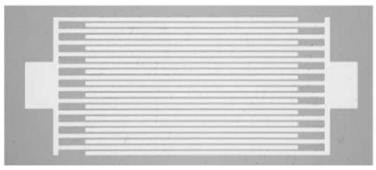
Reaz Uddin Bhuiyan, Bruce Kim
Graduate Student, The City College of New York, U.S.A
Associate Professor, The City College of New York, U.S.A

This work investigates a silicon nanowire (SiNW) based nano sensor device to detect the hazardous para-nitrophenol (P-NP) molecule. Due to outstanding electrical conductivity and high surface-to-volume ratio, metal-deposited SiNW-based nano sensor devices have attracted considerable attention. SiNWs were grown using CVD machine. Rather than the more popular gold, silver metal was deposited in this case using the E-beam metal deposition technique. Etching the silver metal took less amount time than gold metal. Inside the laboratory, the device demonstrated superior label-free detection ability with an instant response time to the target molecule, resulting in a low limit of detection (LOD). To confirm the successful surface modification using TESBA and anti-TNT, various spectroscopic techniques were employed such as Raman and FT-IR. FESEM images confirmed that SiNWs were present between the two electrodes. In the presence of P-NP molecule the conductance of the SiNWs altered which has reflected in the I-V characteristics graph.

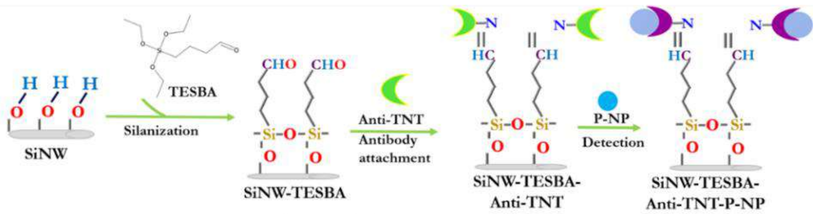
Keywords: SiNW, surface functionalization, I-V graph, P-NP, Silver



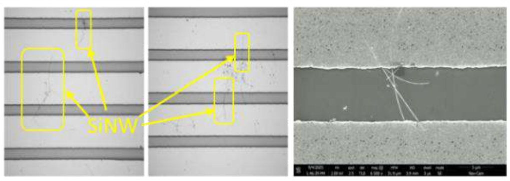
Scheme for the fabrication of SiNW-based sensor array



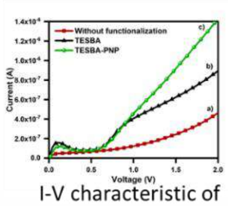
Microscopic images of SiNW-based sensor



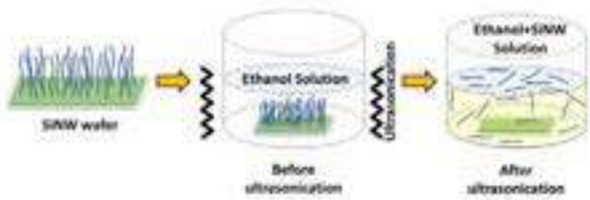
Scheme of the detection of 4-NP



Microscopic and FESEM images of SiNW based sensor array



I-V characteristic of SiNW-TESBA-4-NP



Silicon nanowire solution preparation

Development of Single Shot Electron Beam Lithography Rapid Writing Method for Photonic Crystal Arrays

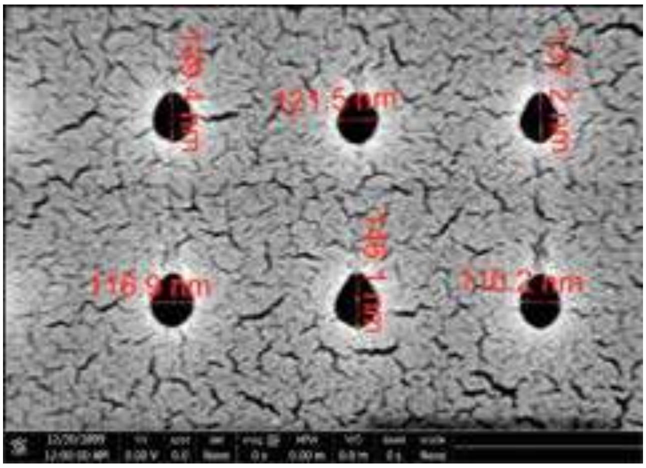
Philip Cairns[1], Viktoriia Rutckaia[2], James Scholtz[3]

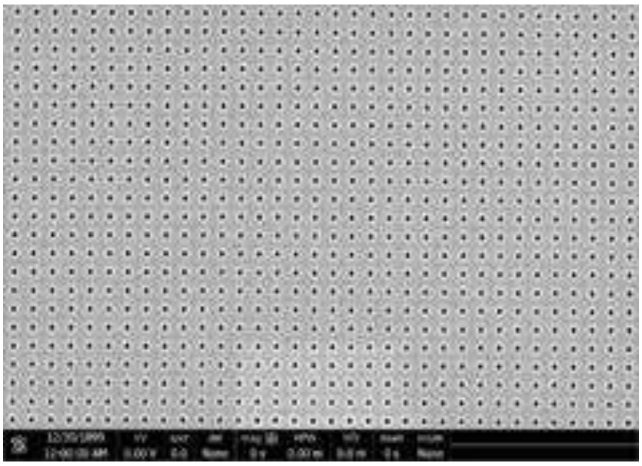
[1]Graduate Student, ASRC & VyirTech, New York, USA
[2]Director of Photonics Core Facilities, ASRC, New York, USA
[3]CEO, VyirTech, New York, USA

Traditional electron beam lithography (EBL) is a time-consuming process even when writing simple periodic structures. This is because the EBL software must fracture a structure into polygons and then expose those polygons based on the beam parameters. For applications requiring periodic arrays of circular shapes, single shot EBL offers a better solution. In this process, the feed and scan pitch are set to the desired period of the array so that with each electron beam shot one circle is exposed. This EBL process allows for the writing of periodic arrays of circles significantly faster than with the traditional process. Since each hole is formed by a single shot of the electron beam, the shape of the holes is defined by the focus, astigmatism, and dose time. This project aims to characterize the single shot EBL process for writing photonic crystals and other periodic structures and to explore how the EBL parameters can allow us to control the structures we expose. We have fabricated rectangular PhC structures with varied parameters in order to obtain fine control over the EBL system and to demonstrate the potential of this process. We have generated circle diameters from 40-200nm with array periods of 600nm and have varied the beam current to change the write speed. We have also demonstrated that changing the astigmatism of the beam allows us to control the ellipticity of the circles. Furthermore, we have successfully transferred exposed patterns onto Si/Glass substrates using reactive ion etching. Using the insights we have gained, this process promises to offer further control of the EBL system in order to allow for the writing of more sophisticated photonic structures while maintaining significantly faster write times than traditional EBL methods.

Keywords: electron beam lithography, photonic crystals, periodic structures

SEM of rectangular PhC Array, 12000X and 120000X





Developments in the Lithographic Engineering of $Bi_2Sr_2CaCu_2O_{8+\delta}$ mesa terahertz emitting devices

Sarah Elghazoly[1], Timothy Benseman[1], Naoki Tsunawaki[1,2]
[1]*Queens College, Jamaica, NY, USA*
[2]*Graduate Center, New York, NY, USA*

The high-T_c superconducting $Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi-2212) is one of the most promising materials for the development of technologies to fill the 'terahertz gap' which spans approximately 0.3 to 2.0 THz. Comparatively powerful sources of coherent THz radiation have been engineered in the form of rectangular mesas lithographically patterned in Bi-2212 which intrinsically contain stacks of Josephson junctions and can operate at a temperature of 77.4 K or more. Initial crystal thickness measurements due to topographic surface variation and inherent imprecision in the mechanical exfoliation techniques used to prepare samples for lithographic processing pose a nontrivial obstacle, as the performance of these devices is considerably impacted by the thickness of the base crystal beneath the mesa stack due to the low thermal conductivity of Bi-2212.

Greater control of the final base crystal thickness can improve reproducibility for these devices. Enhanced heat-sinking, phase synchronization of the stacked Josephson junctions, and electrical contact are all paramount to maximizing the power output needed for practicable uses. Using the FEI-Helios Nanolab FIB-SEM in the Imaging Suite of the ASRC to perform energy-dispersive X-ray spectroscopy (EDAX) we are developing methodology for precise crystal thickness determination. The thickness dependence of measurements of the crystal and solder composition and the counts at energies of interest after successive millings of Bi-2212 crystals a calibration curve can be extrapolated in order to perform future thickness estimates before commencing lithographic patterning of the mesa structure from Bi-2212.

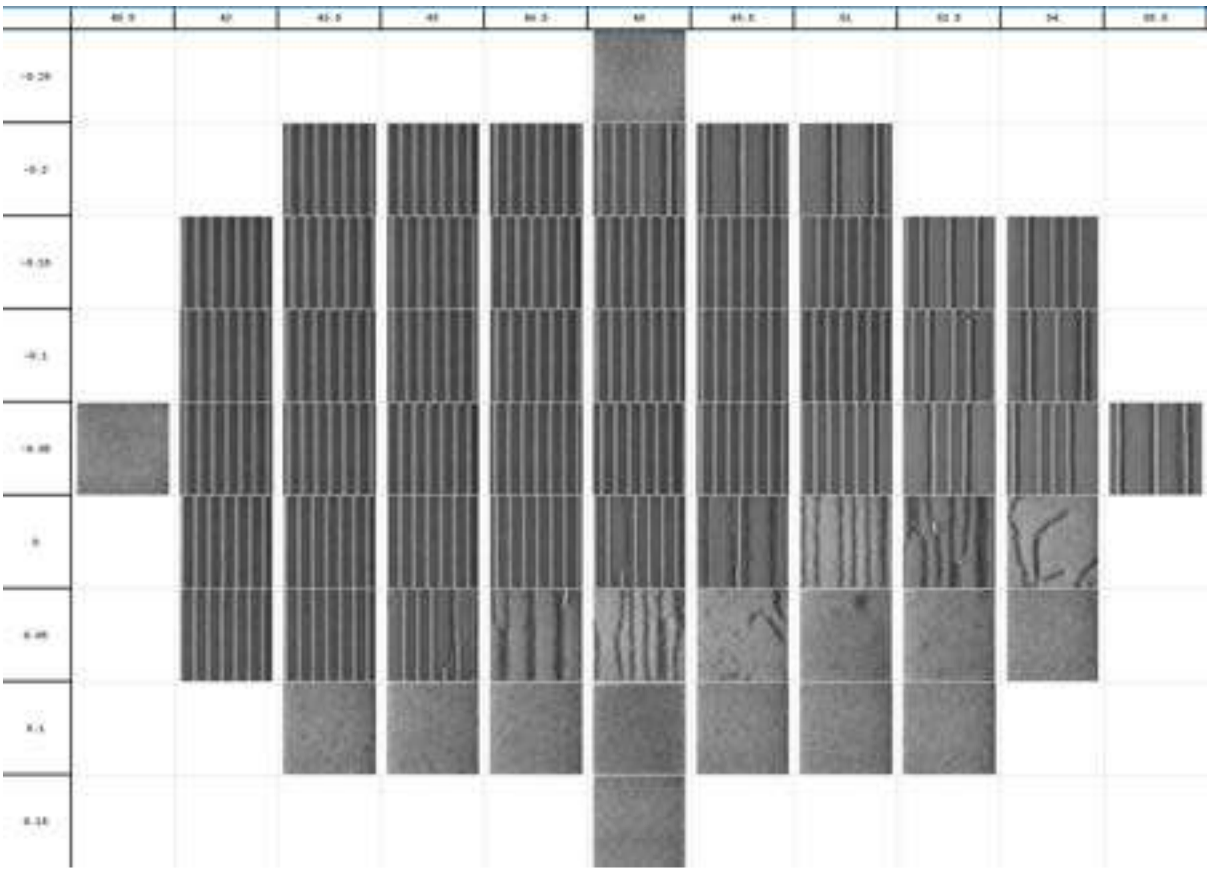
An Introduction to Integrated Wafer Patterning Workflow

Brandon Nunez
Vyir Tech, City College of New York, New York

This summer internship at NYCREATES involved practical, hands-on training in nanofabrication and the complete wafer processing workflow within a cleanroom environment. The core focus was placed on critical pattern transfer steps: photolithography and etching, where precise control over device feature size is paramount. The primary objective was to optimize the semiconductor lithography process by determining the ideal combination of focus and exposure settings for consistent results. Utilizing a stepping function test, we investigated and mapped various parameter combinations across the wafer. Post-development imaging was performed to evaluate critical feature consistency, ensuring the highest level of dimensional control for high-performance fabrication.

Keywords: photolithography, processing workflow

Focus exposure imaging including dose and focus



Ultraviolet Nanoimprint Lithography

Jake Rabinowitz, Brandon Nunez, Jame Scholtz
Vyir Technical Team, VyirTech, USA
Vyir Undergraduate Intern, ASRC, USA
CEO, VyirTech, USA

This project aims to develop a method of accurately replicating sophisticated nanoscale structures through a mechanical replication process. To date, we have demonstrated the transfer of diffraction gratings and photonic crystal arrays of varying dimensions with the capacity to etch such structures into a variety of materials, utilizing a UV curable photoresist and PDMS soft molds. The results of this method have shown mode power efficiencies of the nano-imprinted gratings within 2-8% of the values given by matching Rigorous Coupled-Wave Analysis (RCWA) theoretical models. These findings offer an efficient and cost-effective method of transferring the topography of complex nanoscale structures into a wide range of materials.

Keywords: lithography, nanoimprint

Optical microscope image of grating replication, etched into SiO2

Monolithic 2D Multilayer Laue Lens (MLL) Optics for High-resolution Hard X-ray Nanofocusing

Wei Xu [1], Weihe Xu [1], Nathalie Bouet [1], Juan Zhou [1], Zirui Gao [1], Hanfei Yan [1], Xiaojing Huang [1], Ming Lu [2], Yong S. Chu [1], and Evgeny Nazaretski [1]

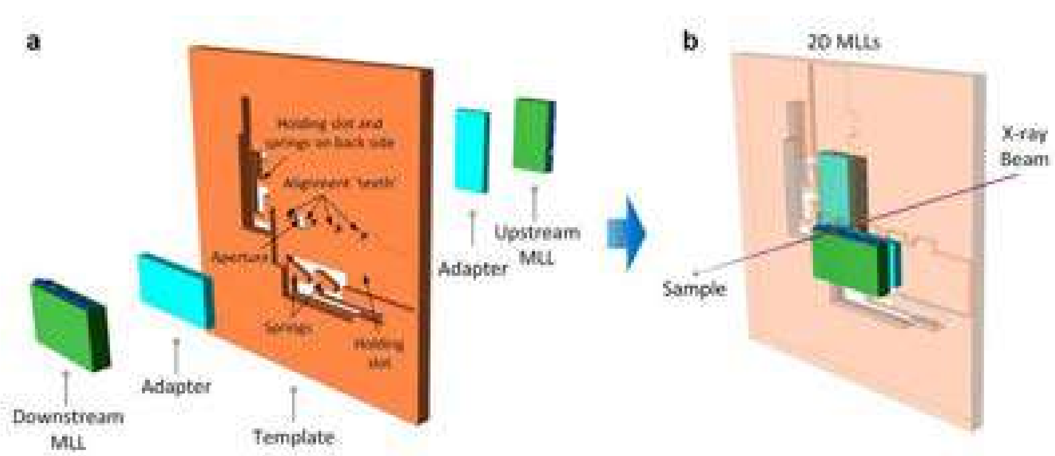
[1] National Synchrotron Light Source II, Brookhaven National Laboratory, USA

[2] Center for Functional Nanomaterials, Brookhaven National Laboratory, USA

We report recent progress in developing 2D MEMS-based multilayer Laue lens (MLL) nanofocusing optics for high-resolution hard X-ray microscopy. MLLs offer great potential for achieving high efficiency in the hard X-ray regime among various X-ray focusing optics. However, as one-dimensional focusing elements, two MLLs must be orthogonally aligned with one another to achieve point focusing. This alignment demands eight degrees of freedom with nanoscale precision and high stability, posing significant technical challenges for microscopy systems. To address this, we developed monolithic 2D MEMS-based MLL optics using a microfabricated silicon template that pre-aligns two linear MLL optics with angular misalignment below tens of millidegrees and lateral offsets within a few micrometers. Using the developed 2D MLLs, we achieved an astigmatism-free point focus of approximately 14 nm x 13 nm at 13.6 keV and applied it to 3D tomography of an integrated circuit sample. This advancement represents a significant step forward in the development of high-resolution hard X-ray microscopy and broader applications of MLL optics in the hard X-ray community.

Keywords: X-ray microscopy, multilayer Laue lenses, optics, MEMS, microfabrication

Schematic illustration of monolithic 2D MEMS-based MLL nanofocusing optics



(W. Xu et al., *Microscopy Today*, 30(6), 28-33 (2022))

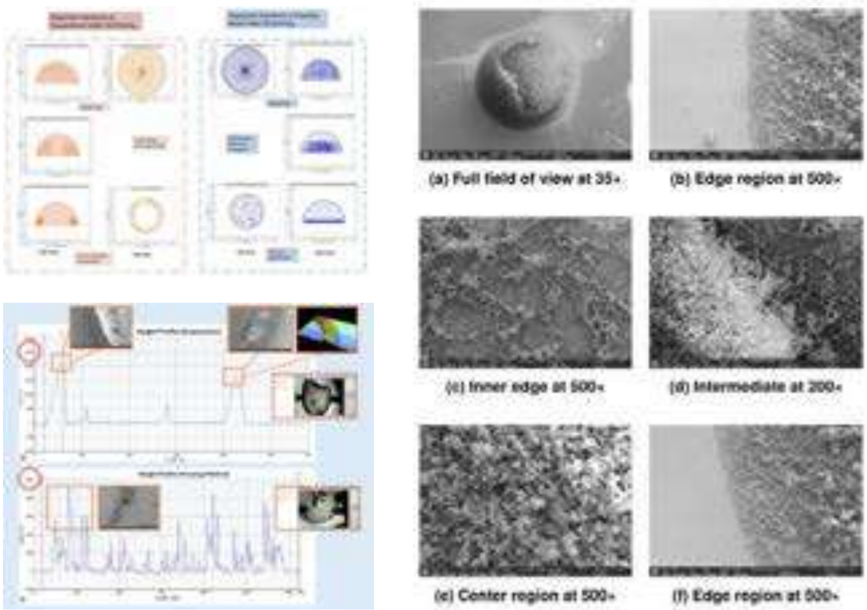
Deposition Pattern Formations in a Novel Freezing-Sublimation-Based Inkjet 3D Printing Method

Xiaoxiao Zhang[1], Haipeng Zhang[1], Jorge Ahumada Lazo[1], Tai-De Li[2], Jiazhang Chen[2], Sheng Zhang[2], Yang Liu[1]

[1]Department of Mechanical Engineering, The City College of New York, New York, NY
[2]Graduate Center of the City University of New York, New York, NY

Inkjet-based three-dimensional (3D) printing is extensively employed for rapid and efficient contactless production. A major challenge in inkjet 3D printing is its coarse resolution, primarily dictated by droplet-substrate interactions during printing, including droplet impact, deposition, and subsequent drying. To address the unwanted fluid movements and particle relocation during deposition, this study focuses an innovative freezing-sublimation-based inkjet 3D printing approach that mitigates the issues seen in the conventional evaporation based drying methods. Through the freezing technology, we can achieve even particle distributions and stabilization at impact, enhancing the printed material quality. The pattern formations and mechanical properties of the lyophilized areas were examined with advanced imaging tools including 3D laser scanning confocal microscopy, stylus profiler, Atomic Force Microscopy (AFM), and Scanning Electron Microscopy (SEM). This research laid the theoretical and technological groundwork for developing and validating the novel freezing-based inkjet 3D printing method to produce enhanced functional structures.

Keywords: Freezing rate, Phase Change, Networking, Morphology, Particle Distribution, Cold Plasma



Schematic illustration of deposition morphologies in conventional and freezing-based inkjet 3D printing (Top Left). Comparison of surface height profiles for colloidal (0.5% w/v) samples prepared by evaporation (a) and freezing based (b) methods. The freezing method significantly suppresses the coffee ring effect, reducing the edge height from 25000 nm to 5000 nm (Bottom Left). SEM images of a lyophilized droplet by freezing method and post plasma treatment, showing full and sectional views across different regions of the droplet (Right).

A Microneedle-Endoscope Platform for Minimally Invasive Access to the Inner Ear

Aykut Aksit, PhD[1], Mickie J. Hamiter, MD[3,4], Sharon J. Feng, MD[3], Stephen Leong, MD[3], Daniella R. Hammer, BE[2], Jeffrey W. Kysar, PhD[2,4], Anil K. Lalwani, MD[2,3,4], Justin S. Golub, MD[3,4]

[1]Haystack Medical, Inc., New York, NY
[2]Department of Mechanical Engineering, Columbia University, New York, NY
[3]Vagelos College of Physicians & Surgeons, Columbia University Irving Medical Center, New York, NY
[4]Department of Otolaryngology - Head & Neck Surgery, Columbia University Irving Medical Center, New York, NY

Inner-ear diseases remain among the least accessible disorders for precision diagnosis and treatment due to the lack of minimally invasive routes to the cochlea. We present a microneedle-endoscope system engineered to enable controlled perforation and fluid sampling through the round window membrane (RWM) of the inner ear under direct visualization. The device integrates a 100 µm-diameter two-photon-lithographed hollow microneedle with a flexible polyimide micro-tubing assembly and a 23 Ga deployment tube optimized for endoscopic guidance. In cadaveric temporal-bone tests (n = 7), we achieved 100% successful RWM perforations without tearing and enabled aspiration of perilymph at ~1 µL/min, yielding collected volumes of 0.89 ± 0.20 µL. The microfabricated components maintained structural integrity after each use, demonstrating robustness of the lithographic design and assembly. These results establish Haystack microneedles as the first microneedle-based platform to achieve reproducible, visually guided cochlear fluid access, laying the groundwork for clinical translation and next-generation biomarker discovery in otology.

Keywords: microneedle, endoscope, inner ear drug delivery, precision diagnostics

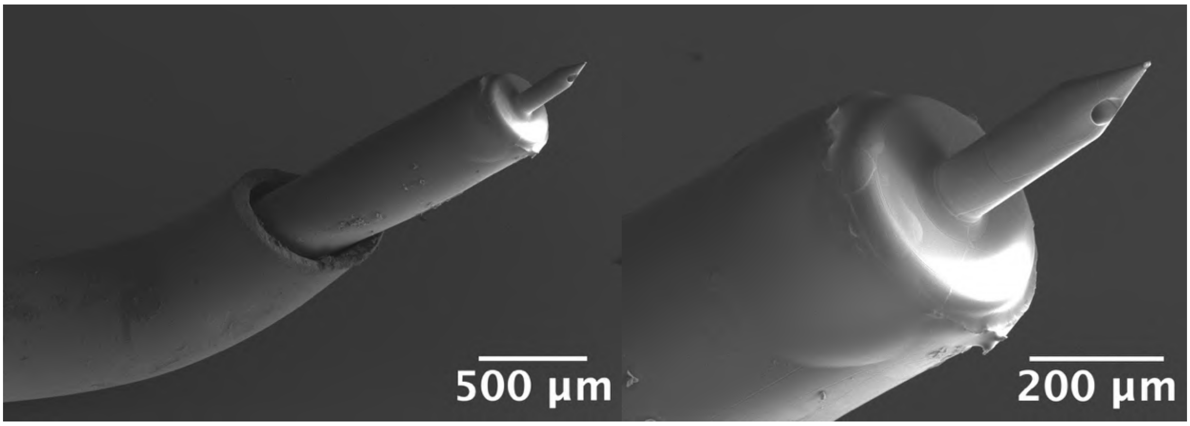


Figure 1: SEM images of microneedle and flexible polyimide tubing extending from a 23Ga deployment tube.

Electrospun Mucilage-based Micronutrient-Loaded Nanofibrous Seed Coating: A Bioinspired Nanotechnological Approach for Enhanced Germination and Stress Tolerance

Dr Krishna Priyadarshini Das[a] & Prof. George John*

Department of Chemistry and Biochemistry, City College of New York (CCNY), The City University of New York (CUNY),160 Convent Avenue, New York, NY 10031, USA

The current research work aims at developing sustainable and biodegradable seed coating materials using micronutrient-loaded PVA/mucilage-based electrospun nanofibrous constructs with improved germination efficiency, micronutrient delivery, and stress tolerance of legume and corn seeds. The mucilage was extracted from okra (Abelmoschus esculentus), followed by electrospinning fabrication to prepare uniform, bead-free nanofibrous coatings. An in-depth physicochemical, morphological, thermomechanical, and adhesion properties will be carried out by conducting SEM, TGA, DSC, XRD, FTIR, contact angle and TEM. Atomic Force Microscopy (AFM) was used to provide more insights into surface roughness (Ra and Rq) and nanomechanical strength. Further, the swelling dynamics, water retention capacity, and nutrient release behavior were thoroughly evaluated under simulated soil conditions (sandy and clay soil) while the release kinetics were modelled using Higuchi, Korsmeyer–Peppas, and first-order models. Surface adhesion testing and contact angle measurements were also performed, along with the biological efficacy of coatings through germination experiments (germination percentage, germination index, mean germination time, plumule and radicle length, and seed vigour index) using legume (mung bean) and cereal (corn) seeds. Further, the stress tolerance studies under variable pH, temperature, and humidity conditions were conducted. Thus, the current study not only facilitates nutrient release, seed–soil interaction and mechanical integrity under stress conditions but also offers a promising route toward developing next-generation seed enhancement technologies for sustainable agriculture and resilient crop growth.

Keywords: mucilage; nanofiber; seed coating; nutrient delivery; sustainable agriculture.

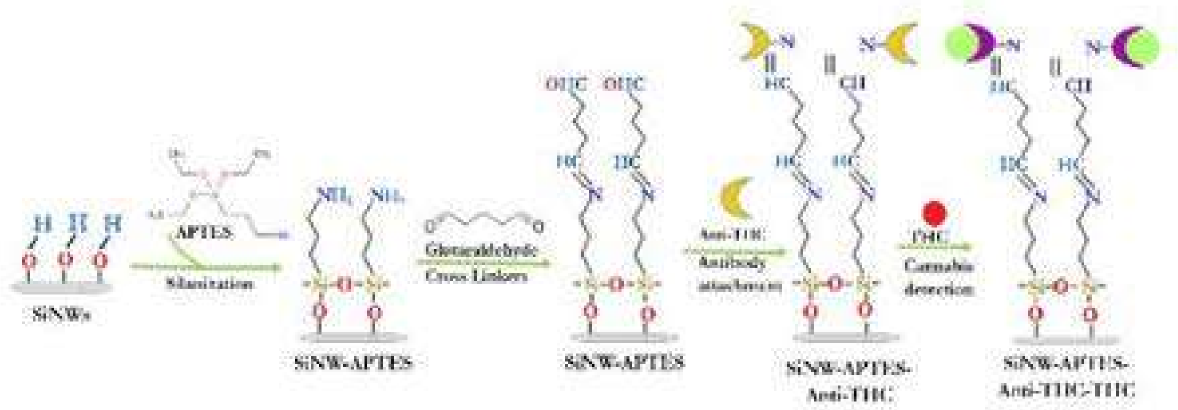
Silicon Nanowire Biosensors for Cannabis Detection

Bruce Kim, Thambiraj Selvarathinam
Department of Electrical Engineering, City College of New York, CUNY

The global rise in cannabis abuse poses a significant threat to public health and safety, emphasizing the necessity for sensitive and portable detection technologies. We developed a biosensor device that integrates silicon nanowires (SiNWs) for the selective detection of tetrahydrocannabinol (THC). UV photolithography and e-beam thermal evaporation were used in the fabrication of SiNW-integrated biosensor devices. The devices were functionalized with (3 aminopropyl) triethoxysilane (APTES) through covalent bonding (Si-O-Si) and prepared for antibody conjugation. The recombinant tetrahydrocannabinol antibody (anti-THC) was covalently conjugated to the APTES-functionalized SiNW. Sensing studies were conducted in the presence of THC derived from cannabis. The device and surface characteristics were determined using various analytical techniques, including X-ray photoelectron spectroscopy, confocal Raman spectroscopy, Fourier-transform infrared spectroscopy, UV-vis spectroscopy, and field-emission scanning electron microscopy (FE-SEM). The average SiNW measures 1.08 µm in length and 50 nm in thickness. Its electrical and sensing characteristics were assessed through IV and spectroscopic studies, revealing a lower detection limit of 1 × 10-7 M.

Keywords: silicon nanowires, cannabis, nanosensors

Schematic of the SiNW-integrated sensor device for detecting THC (cannabis).



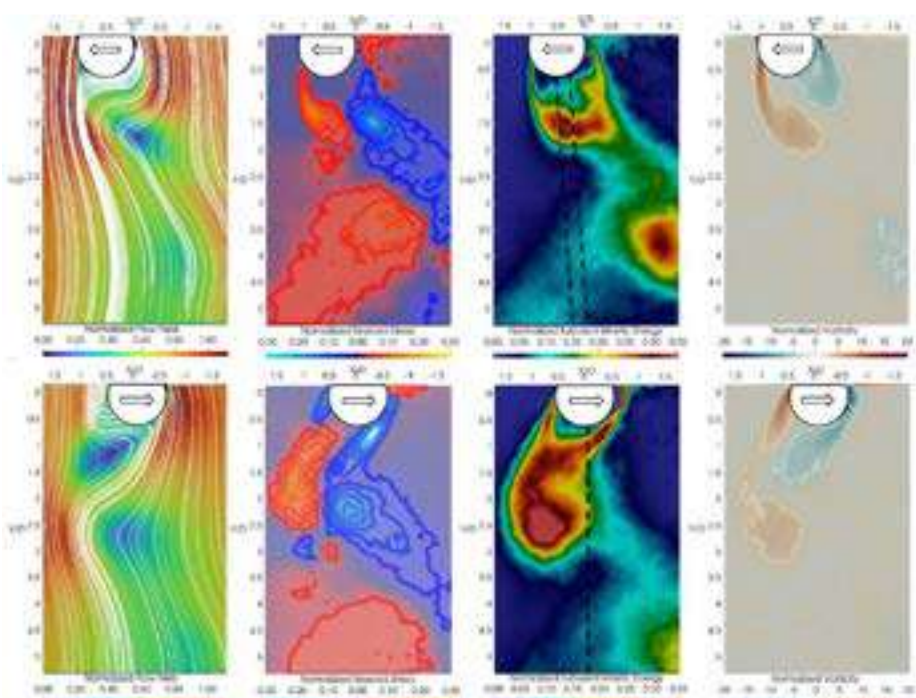
Energy Transport Mechanisms in Vortex-Induced Vibration of a Cylinder: Phase-Locked PIV and Synchronized Pressure-Strain Measurements

Jooi Albano, Reem Eldakhakhany, Andrei Fershalov, Niell Elvin, Yang Liu

Department of Mechanical Engineering, The City College of New York, NY, USA

Understanding how flow-induced forces lead to structural vibration and energy harvesting is central to the design of efficient fluid–structure interaction systems. This study investigates the energy transport process from airflow to a vibrating circular cylinder undergoing vortex-induced vibration (VIV), with emphasis on phase-resolved flow features and structural response. Time-resolved Particle Image Velocimetry (PIV) was performed in phase-locked mode across a complete lock-in cycle (0 to 2π, in $\pi/4$ increments), synchronized with simultaneous pressure and strain measurements on the cylinder surface. The strain gauge signal was used to identify the oscillation phase, enabling conditional averaging of surface pressure and flow fields at each phase point. The combined dataset reveals a coherent picture of momentum and energy transfer during lock-in, especially the interplay between vortex shedding, pressure recovery, and strain energy buildup. The findings in this study suggest distinct phase-dependent patterns in vortex dynamics and pressure variations that precede structural response, offering quantitative insight into optimal energy harvesting timing and design.

Keywords: vortex-induced vibration, cylinder, PIV, energy harvesting, pressure-strain coupling, phase-locked flow



Particle imaging velocimetry (PIV) measurements of the wake-flow field evolution of a vibrating cylinder

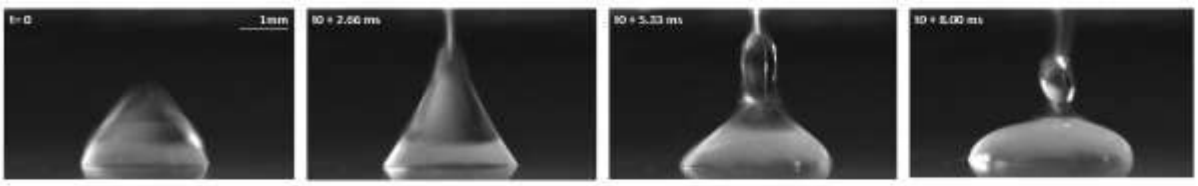
An Experimental Study on the Colloidal Droplet-Plasma Interactions and Final Deposit Formation

Sandeep Kumar, Haipeng Zhang, Yang Liu

Department of Mechanical Engineering, The City College of New York, New York, U.S.A

This study investigates the transient deformation and evaporation dynamics of sessile colloidal droplet subjected to single-streamer dielectric barrier discharge (DBD) plasma. High-speed imaging was employed to resolve the droplet's oscillatory response, contact line motion, and surface deformation under varying plasma powers. The interface (plasma-liquid) exhibited alternating forces driven by periodic charge accumulation, resulting in axial elongation, daughter droplet ejection, and stick-slip boundary transitions. Frequency-domain analysis of the contact angle revealed a dominant oscillation mode, corresponding to plasma excitation cycles. These results elucidate the role of filamentary plasma in modulating droplet morphology and pattern, providing a framework for plasma-assisted control of fluidic interfaces and colloidal deposition. These findings highlight the role of interfacial stresses in modulating wetting dynamics, offering potential for tunable deposition and surface modification in plasma-assisted printing and coating technology systems.

Keywords: Colloidal Droplet, Filamentary Plasma, Plasma-Droplet Interactions, Particle deposition



Temporally-resolved colloidal droplet dynamics in interaction with single streamer Plasma.

An Experimental Study on the Transient Processes of Droplets Interacting with Dielectric Barrier Discharge Plasmas

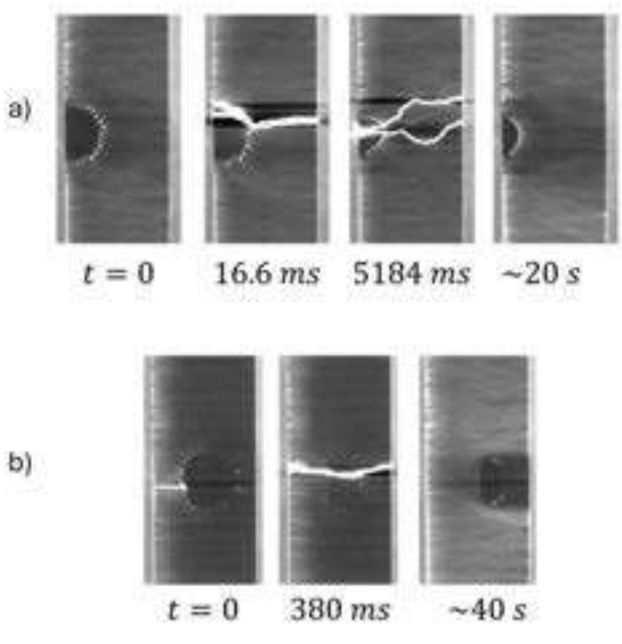
Petr Lelikov, Jorge Ahumada Lazo, MD Sohaib Bin Sarwar, Yang Liu

Department of Mechanical Engineering, The City College of New York, New York, USA

This paper presents an experimental study characterizing the dynamic and thermal behaviors of droplets interacting with Dielectric Barrier Discharge (DBD) plasmas under two typical scenarios, i.e., in-flight interaction and impinging interaction. While the evolutions of the droplet and DBD plasma fields were visualized and characterized using a high-speed imaging system, voltage and current signals of the DBD plasma actuator were collected and analyzed. As the droplet falls through the plasma field, it changes dielectric properties between the two electrodes and can induce formation of streamers between the droplet and both electrodes. Along with streamer formation and/or modification, voltage and current signals change as a reflection of the dynamic multiphase system. We have also looked at the interaction between a water droplet and its impact on a sliding plasma dielectric discharge (SP-DBD). SP-DBD known as tri-electrode dielectric barrier discharge is a derivation of the regular two electrode DBD that contains an additional exposed electrode which connects to a large negative DC voltage. This allows a uniform density of nonthermal plasma to form between the two exposed electrodes. Plasma formation from these actuators creates induced airflow and heat generation. These findings offers important insights in understanding how electric fields and plasma formation affect the droplet and many engineering systems.

Keywords: dielectric barrier discharge, volume plasma, sliding plasma, droplet interaction

Images of a water droplet on a sliding dielectric barrier discharge plasma: a) droplet impinging on the electrode edge of the sliding plasma actuator; b) droplet impinging on the center of the dielectric surface of the sliding plasma actuator.



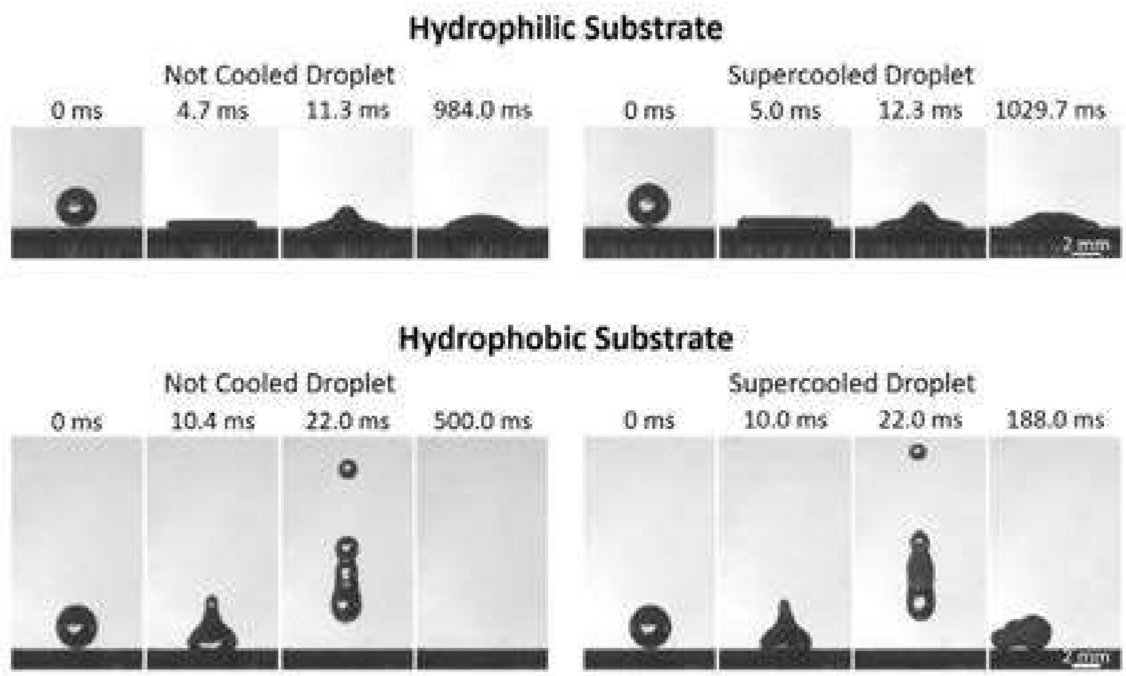
Revealing the dynamic and thermal behaviors of supercooled droplet impinging on surfaces with varying wettability

Haipeng Zhang, Jorge Ahumada Lazo, MD Sohaib Bin Sarwar, and Yang Liu
Department of Mechanical Engineering, The City College of New York, New York, USA

Icing resulting from the impingement and freezing of supercooled droplets presents a significant threat to aviation safety and various infrastructure systems. This work experimentally studied the transient dynamic and thermal behaviors of supercooled droplets impinging and freezing on substrates with differing wettability (hydrophilic and hydrophobic). High-speed and infrared imaging techniques were used to capture the detailed evolution of droplet hydrodynamics and heat transfer processes. This research focused on the competing effects between impingement dynamics and unsteady heat transfer during droplet impact and freezing, which determine the final ice structure and morphology. The findings advance the understanding of droplet freezing processes and provide valuable guidance for the development of efficient anti-icing surface designs.

Keywords: Supercooled droplet, droplet impingement, freezing, wettability, ice roughness

Time-sequence images illustrate the evolution of droplet impingement and freezing on substrates with different wettabilities.



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