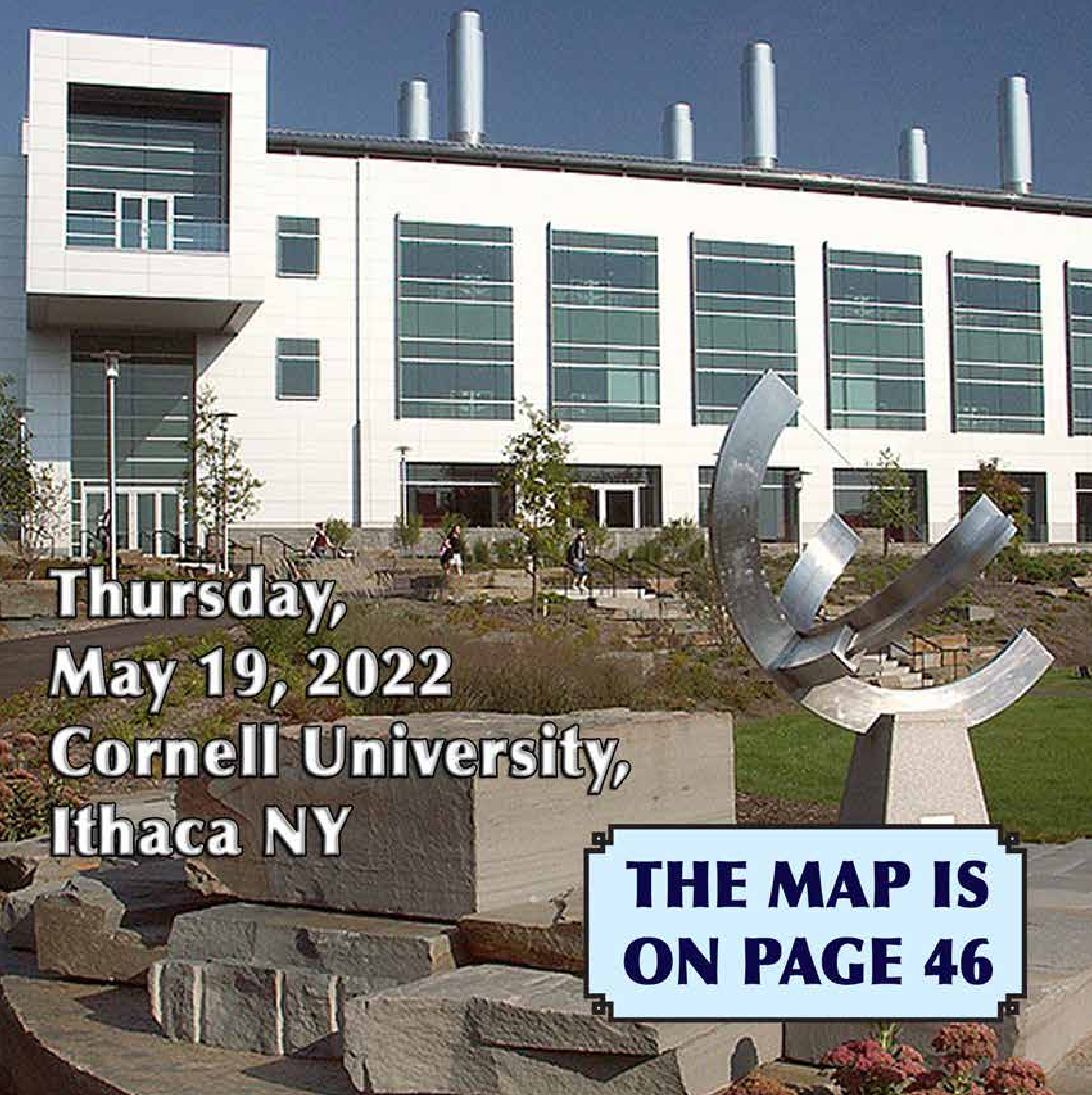
NNN Symposium
"Bridging the Workforce Gap"



Thursday, May 19, 2022 Cornell University, Ithaca NY

THE MAP IS ON PAGE 46

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:: NNN SYMPOSIUM SCHEDULE ::

:: Thursday, May 19, 2022 :: Cornell University, Ithaca NY ::

8:30-9:00 a.m. Registration & Continental Breakfast (Biotechnology Building Foyer)

9:00-9:20 Welcome & Introduction to Symposium (G10 Biotech)

Christopher Ober, Lester B. Knight Director, CNF .... *page 6*

Session Chair: Chris Ober

9:20-10:00 Industry Presentations

9:20-9:40 **GlobalFoundries;**

George Gifford, Distinguished Member of GF Technical Staff (Cornell Grad)

"Differentiated Silicon Technology Solutions-GlobalFoundries" *7*

9:40-10:00 **TEL:**

Gert Leusink, VP of Technology Development, TEL Technology Center

"Challenges and Opportunities of Atomic Layer Processes in Semiconductor Manufacturing" *8*

10:00-10:15 break

Session Chair: Mark Poliks, SUNY Distinguished Professor at Binghamton

Student Presentations, Session One; Featured Talks

10:15-10:25 **Dylan Richmond**, Center for Advanced Microelectronics Manufacturing (CAMM), Binghamton University

"Additive Fabrication of Aluminum Antennas on Flexible Glass"* *11

10:25-10:35 **Richa Agrawal**, Meinig School of Biomedical Engineering & Weill Institute for Cell and Molecular Biology, Cornell University

"Survival of the Fittest: Fabrication and Use of Microfluidic Devices to Study the Consequences of Confined Migration in Cancer Cells"* *12

10:35-10:45 **Julia D'Rozario**, Microsystems Engineering, Rochester Institute of Technology

"Thin-Film Multijunction Inverted Metamorphic Solar Cells with Light Management for Space Applications"* *13

10:45-10:55 **Tristen Head**, College of Nanoscale Science and Engineering, SUNY Polytechnic Institute

"Engineering a Novel **in vivo** ***Preclinical Cancer Assay Platform"* *14***

10:55-11:05 **Trevor McDonough**, Department of Electrical Engineering, SUNY University at Buffalo

"Ballistic Switching in Y-Shaped Nanostructures with Independent MOS Gates"* *15

11:05-11:15 **Tianna McBroom**, Department of Physics, Syracuse University

"Coupling Transmon Qubits Through a Left-Handed Metamaterial Ring Resonator Bus"* *16

11:15-11:30 break

11:30-11:45 Jonathan Cardinal, Economic Development Director for Senator Chuck Schumer, 9

Session Chairs: Xinwei Wu, CNF Tech Staff 2nd Floor Labs and Thin Films,
& Melanie-Claire Mallison, CNF Administrative Staff

Student Presentations, Session Two; Speed Talks

11:45-11:48 **Wenwen Zhao**, Applied & Engineering Physics, Cornell University

"Overcoming Acoustoelectric Material Limits of Piezoelectric Resonators using Epitaxial Aluminum Nitride" 17

11:48-11:51 **Tushar Mahajan**, College of Nanoscale Engineering and Science, SUNY Poly Tech

"Design and Development of InAs Quantum Dots in GaAs Matrix – A Novel Scintillator Material with Monolithically Integrated InGaAs Photodetector" 18

11:51-11:54 **Giancarlo D'Orazio**, Mechanical and Aerospace Engineering, Cornell University

"Development of Engineered Gas Diffusions Layers via Micro-Scale Manufacturing" 19

11:54-11:57 **Brad Cole**, Physics Department, Syracuse University

"Characterization of the Capacitance of Small Joseph Junctions from DC Superconducting Quantum Interference Device (SQUID) Resonances". 20

11:57-12:00 **Christine Harper**, Meinig School of Biomedical Engineering, Cornell University

"Bacterial Signaling System VxrAB is Activated by Diverse Mechanical Stimuli" 21

12:00-12:03 **Maximilian Liehr**, College of Nanoscale Science and Engineering, SUNY Poly Tech

"Reliability and Operation of HfOx ReRAM Devices and Neuromorphic Applications Under Real-World Conditions" 22

12:03-12:06 **Konrad Hedderick**, Materials Science & Engineering, Cornell University

"Elucidating Metal Ion-Copolymer Coacervate Attachment Design Rules via Microcontact Printing of Self-Assembled Monolayers" 23

12:06-12:09 **Emuobosan Enakerakpo**, CAMM, Binghamton University

"Fabrication of Flexible Antenna Using a Semi-Additive Process" 24

12:09-12:12 **Anjana Jayaraman**, Chemical and Biomolecular Engineering, Cornell University

"Demonstrating the Combined Effects of Shear and Surface Roughness on Thrombosis in Ventricular Assist Devices (VADs)"................................. 25

12:12-12:15 **Rajas Mathkari**, College of Nanoscale Science and Engineering, SUNY Polytechnic Institute

"Influence of Oxygen Exchange Layer and Dopants on Transition Metal Oxide Resistive Random-Access Memory (ReRAM) Performance" 26

12:15-12:30 break

Session Chairs: Xinwei Wu & Melanie-Claire Mallison

Student Presentations, Session Three; Speed Talks

12:30-12:33 **Amir Mokhtare**, Food Science, Cornell University

"Selective Single-Beam Acoustic Tweezers for Cell Manipulation" 27

12:33-12:36 **Emily Kessler-Lewis**, Microsystems Engineering, Rochester Institute of Technology

"Demonstration of a Monolithically Integrated Hybrid Electroabsorptive Modulator/Photovoltaic Device for Bidirectional Free Space Optical Communication at 1.55 µm" *28*

12:36-12:39 **Wei Wang**, LASSP, Cornell University

"Cilia Metasurfaces for Electronically Programmable Microfluidic Manipulation" .. *29*

12:39-12:42 **Jialun Luo**, Department of Physics, Cornell University

"Fabrication of Nanophotonic Optical Cavity Device from Inverse Design" *30*

12:42-12:45 **Vito Iaia**, Physics Department, Syracuse University

"Mitigation of Quasiparticle Poisoning in Superconducting Qubits using Normal Metal Backside Metallization" *31*

12:45-12:48 **Samantha Norris**, Department of Physics, Cornell University

"Optically Powered Bubble-Propelled Microswimmers" *32*

12:48-12:51 **Rubab Ume**, Nanoscale Engineering, SUNY Polytechnic Institute at Albany

"Phase Change Memory (PCM) with Multilevel Resistance States Based on Group III-Sb Binary Alloys" *33*

12:51-12:54 **Kyuin Park**, Human Centered Design, Cornell University

"Polymer Nano/Microfiber as Solar Reflector or Absorber" *34*

12:54-12:57 **Riadh Al-Haidari**, Systems Science and Industrial Engineering, Binghamton University

"Reliability Study of a Magnetically Aligned Anisotropic Conductive Epoxy for Interconnecting Stretchable Conductors to Various Surfaces" *35*

12:57-1:00 **Young Joon Suh**, Biological and Environmental Engineering, Cornell University

"Development of a 3D Microfluidic Platform for Dynamic Compression of Tumor Spheroids" *36*

1:00-1:15 Travel Time to Duffield Hall

1:15-2:00 Lunch (Bag Lunches Available in Baum Atrium Section)

2:00-2:15 Set Up Time for Poster Session

2:15-4:15 Poster Session & Career Fair

4:15-4:30 Awards and Closing Remarks

4:30-5:00 Future of New York State Nanotechnology Network Establishment (*340 DH*)

PRESENTATION ABSTRACTS BEGIN ON PAGE 6

POSTER ABSTRACTS BEGIN ON PAGE 37

Cornell University
Cornell NanoScale Science and Technology Facility

Christopher K. Ober
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May 12, 2022

Dear Attendee,

On behalf of all the organizers, I wanted to welcome you to the first meeting of the New York State Nanofabrication Network. The theme is "bridging the workforce gap"and is one of the goals of NNN, which was formed to build local relationships, solve common problems and grow awareness of the state's capabilities as they pertain to Micro and Nanotechnology.

Please enjoy the meeting and let us know what you liked and what we can do better. We expect to continue these meetings and rotate them around the state. For those of you who come from neighboring areas, welcome and thanks for joining us. Our hope is to make this a regional activity.

Warmest regards,

Christopher Ober
Director, Cornell Nanoscale Facility

Differentiated Silicon Technology Solutions - GlobalFoundries

George Gifford, DMTS,
Silicon Photonics Technology Program Manager

George.Gifford@globalfoundries.com

Synopsis:

GlobalFoundries (GF) is a leading full-service semiconductor foundry providing a unique combination of design, development, and fabrication services to some of the world's most inspired technology companies. The GF portfolio offers a wide range of differentiated technology platforms, including industry-leading RF SOI solutions, high-performance FinFET, feature-rich CMOS, proprietary FDX™ FD-SOI, high-performance silicon-germanium and silicon photonics. These platforms enable demanding application designs, leveraging an extensive patent portfolio and deep technical expertise in digital, analog, mixed-signal, RF and embedded memory.

Today's highlight is GF Fotonix™, the 2nd generation 300 mm silicon photonics technology running in Fab 8, Malta NY. Transporting enormous volumes of data within and between data centers fuels an insatiable demand for more bandwidth. To address this, power efficient, high-speed systems are needed and photonics leverages the power efficiency of photons; effectively supercharging fiber-optic networks.

GF Fotonix™, monolithically integrates high performance RF, digital and silicon photonics circuits, enabling customers to integrate more functions on the same chip while leveraging the scale and efficiencies of 300 mm manufacturing. Key photonics features include low loss passive components (such as WGs, tapers, MMIs), high performance active components (such as MZM, MRM, GePD), and V-grooves supporting passive fiber attach, for example. Combined with 2.5D or 3D stacking solutions, this enables ultra-high integration of electrical, optical and communication capabilities into a single monolithic design.

GF is collaborating with industry leaders and breakthrough photonic computing leaders to deliver unique, innovative solutions to some of the biggest challenges facing data centers. GF's electro-optical Process Design Kit (PDK) offers a co-design environment with access to a comprehensive photonics device p-cell library to help customers start designing. Reference designs, a digital standard cell library, design services and post-fab services will be available.

With a global manufacturing footprint spanning three continents, GlobalFoundries makes possible the technologies and systems that transform industries and give customers the power to shape their markets. Fab 8, operational since 2011, is home to nearly 3,000 employees and currently focuses on smart mobile device, data center and personal computing market segments leveraging 12/14/45 nm and silicon photonics process technology capabilities.

Biography:

George Gifford is a Distinguished Member of Technical Staff and Silicon Photonics Technology program manager at GlobalFoundries. George graduated from Cornell University with a BS, ChE and a Meng, MSE. His application-focused-studies included reactive ion etched surfaces, light sensitive polymers and an early demonstration of 100 nm gate length GaAs FETs. These studies provided a solid foundation for his contributions to a career portfolio of leading edge, differentiated technologies and products, at General Electric, IBM, and GlobalFoundries. Now on his 16th silicon technology, George continues to find important technical and program gaps to address, problems to solve, and colleagues with whom to collaborate.

Challenges and Opportunities of Atomic Layer Processes in Semiconductor Manufacturing

Gert Leusink, Ph.D.
VP of Technology Development
Materials Deposition and Modification

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NanoFab 300 South
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Cell: 518-269-5853

Synopsis:

With ever increasing complexity in process technologies, chemically selective and/or area-selective processes can be an efficient way to enable future manufacturing requirements. Novel process technologies are needed for deposition, etch, and cleans with atomic level precision to enable area-selective-processing in complex 3-dimensional structures with ever increasing aspect ratios.

In this talk we will review and discuss trends in Atomic Layer Processing technologies including atomic layer deposition (ALD), atomic layer etching (ALE), area selective deposition and surface preparation. We will provide examples how these novel technologies can be used to enable advanced interconnect and patterning applications.

Biography:

Gert Leusink Ph.D. is a Fellow and Vice President of Technology Development at TEL Technology Center, America, LLC. In his current role, he is responsible for the Materials Deposition and Modification R&D. The scope of his role includes driving cross-functional alignment across various departments and business units to proactively identify technology gaps, managing the engineering organization to resource and execute on developing innovative technology solutions.

Dr. Leusink received his master's degree in Metallurgy and a Ph.D. in Applied Physics from Delft University of Technology. He has over 35 years of semiconductor experience, and he has directly contributed to process and hardware development in TEL for over 25 years. Dr. Leusink has more than 130 patents, written more than 100 peer-reviewed publications, and has contributed to over 100 conference presentations.

Jon Cardinal

Director of Economic Development at United States Senate Democratic Leader Charles E. Schumer

Biography (from LinkedIn):

With over a decade of experience on Capitol Hill working on economic development, Jon has expertise in federal policy to revitalize distressed communities, including issue areas focused on innovation, entrepreneurship, manufacturing, job training, worker empowerment, rural development, telecom, and trade. He has successfully led the passage of several bills into law. This includes legislation that created new federal rural economic development, entrepreneurship, and broadband deployment programs at the U.S. Department of Agriculture and that reformed the U.S. Small Business Administration's programs to support employee-owned businesses like cooperatives. His successful legislative efforts have also updated federal career and technical education programs to focus on high-tech skills and launched a new U.S. Department of Defense manufacturing communities program.

Jon is currently Director of Economic Development for United States Senate Democratic Leader Charles E. Schumer. He advises Leader Schumer on various economic and community development policy areas, manages the Senator's relationships with CEOs and the broader private sector, and leads an outreach operation that implements the Senator's economic development goals. Jon previously served in a similar role for more than a decade with U.S. Senator Kirsten Gillibrand, and prior to joining Senator Gillibrand's office, Jon was an aide on the staff of former U.S. Senator Hillary Rodham Clinton.

He has also been active in presidential politics, advising on economic policy for Senator Gillibrand's 2020 presidential campaign, and leading the rural policy working group for Hillary Clinton's 2016 presidential campaign.

Jon was selected as a 115th Congress Stennis Center Senior Fellow in recognition of his leadership on Capitol Hill. His work in the field of economic and workforce development was honored with the 2015 Statewide Leadership Award by the New York Association of Training and Employment Professionals.

He graduated from St. Lawrence University in 2008 Summa Cum Laude and Phi Beta Kappa with an honors degree in Government. He shared the honor of being the first recipient from St. Lawrence of the Harry S. Truman Scholarship, a highly competitive national award recognizing future leaders in public service.

From 2013 to 2017, Jon served a term on the St. Lawrence University Board of Trustees. He currently is an adjunct professor for City College of New York's Colin Powell School's Washington, DC semester, teaching a class on social policy, inequality, and Congress.

Student Speaker Abstracts

in order of Presentation

Additive Fabrication of Aluminum Antennas on Flexible Glass

Authors: Dylan J. Richmond, Ashraf I. Umar, Mohammed Y. Abdelatty, Mark Schadt

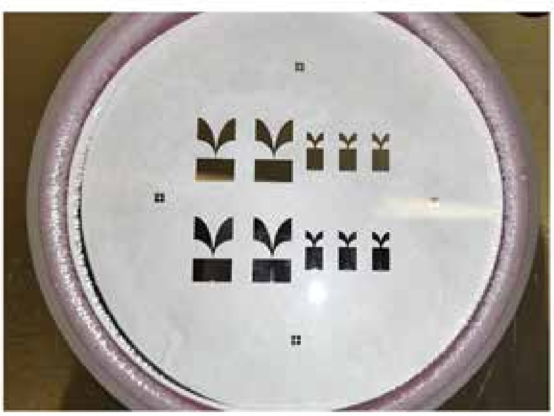
Faculty Advisor: Mark D. Poliks
Department and Institution: Center for Advanced Microelectronics Manufacturing (CAMM),
State University of New York at Binghamton
Contact Email: drichmo2@binghamton.edu, mpoliks@binghamton.edu

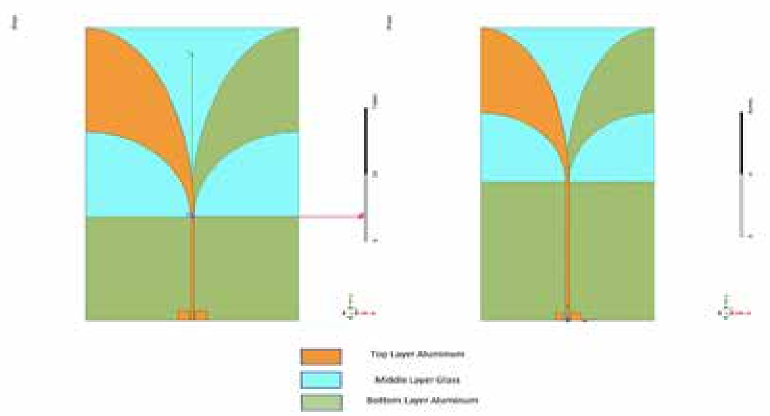
ABSTRACT

There is a persistent need for internet-of-things (IoT) devices, such as self-driving cars, mobile, and wearable devices to be networked and reliant on rapid signal transmission and processing. Flexible glass has emerged as a strong candidate for the fabrication of high quality roll-to-roll (R2R) transparent antennas at low cost. Previously we have demonstrated subtractive and semi-additive techniques for fabricating transparent copper antennas on flexible glass sheets as prototypes for R2R manufacturing.[1] We aim to reduce costs further by employing entirely additive processes and a lower cost base metal, such as aluminum. The fabrication of double-sided aluminum Vivaldi antennas is demonstrated on flexible glass wafers using only additive processes. Exposure to contamination, defects, and damage are reduced, relative to semi-additive and subtractive techniques, as the total number of process steps have been minimized. 28 GHz and 39 GHz 5G mm-wave Vivaldi antennas are designed using ANSYS high-frequency structure simulator (HFSS). Validation of the designs is done by measuring the return loss of the antennas using the Rohde and Schwarz ZNB-40 Vector Network Analyzer (VNA) and comparing the results to those obtained during the simulations. While a R2R manufacturing process is developed in tandem, the wafer scale prototypes have been made using standard materials, processes, and facilities to allow a facile translation to R2R.

REFERENCES

1. J. Lombardi et al., "Copper transparent antennas on flexible glass by subtractive and semi-additive fabrication for automotive applications," in Proc. IEEE 68th Electron. Compon. Technol. Conf. (ECTC), May/Jun. 2018, pp. 2107–2115.





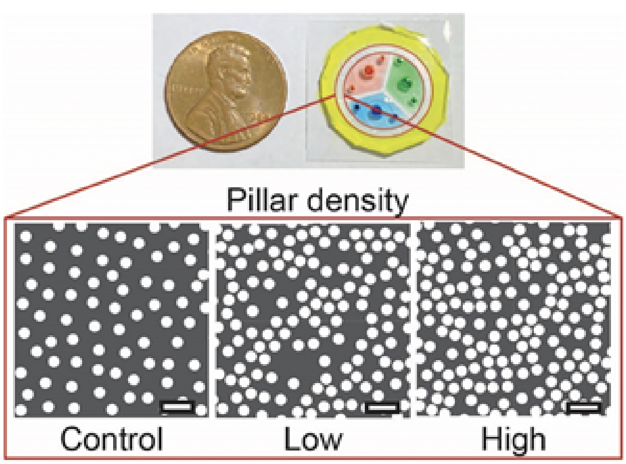
Survival of the Fittest: Fabrication and Use of Microfluidic Devices to Study the Consequences of Confined Migration in Cancer Cells

Authors: Richa Agrawal, Aaron Windsor, Jan Lammerding

CNF Project Number: 2065-11
CNF Principal Investigator: Jan Lammerding
Department and Institution: Meinig School of Biomedical Engineering & Weill Institute for Cell and Molecular Biology; Cornell University
Contact Email: ra664@cornell.edu, jan.lammerding@cornell.edu

ABSTRACT

Cancer metastasis, i.e. the spreading of tumor cells from the primary tumor to distant sites, requires cancer cells to travel through pores substantially smaller than their cross section. This 'confined migration' requires substantial deformation by the cell and the relatively large and rigid nucleus. The associated mechanical stress can disrupt nuclear envelope integrity, cause DNA damage, and increase genomic instability in the tumor cells, but to date it remains unclear whether confined migration affects cell function and survival. In order to study how cancer cells perform and respond to confined migration, we designed polydimethylsiloxane (PDMS) microfluidic devices utilizing HBr reactive ion etching, which allows resolution of the fine features (<2 µm), is more durable than the traditional SU-8 devices, and reduces cost and time compared to other etching methods. In the microfluidic devices, cells migrate through precisely-controlled constrictions, composed of 'fields of pillars', that closely mimic the intermittent confinement of tumor microenvironments and interstitial spaces (Fig. 1). These devices provide several advantages over previous versions as they not only are more physiological in design and enable time-lapse microscopy, but also allow the straightforward assessment of cellular fitness for confined migration based on the distance traveled through the constriction area over several days, without continuous imaging (Fig. 2). The novel migration devices therefore provide a high-throughput way to monitor cells in both the short-term and for longer-term of the mechanical stress due to confined migration on tumor cells. Our preliminary data suggest divergent behavior within a heterogeneous cell populations, with some cells stalling in their proliferation following repeated passage through tight spaces, whereas other cells able to tolerate the stress of confined migration.



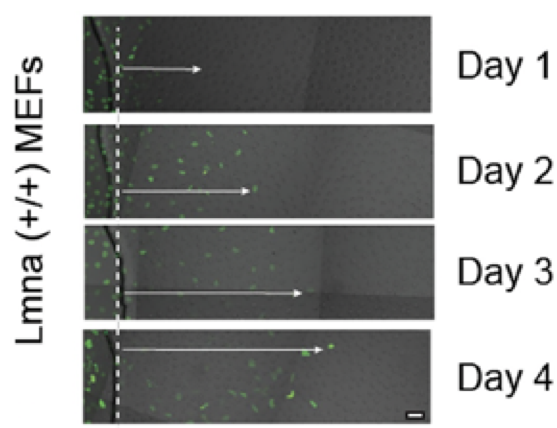


Figure 1 LEFT Microfluidic device design. PDMS device with food coloring to mark seeding ports (red, blue, green) and collection port (yellow). Constriction area marked with red lines populated with either control, low, high density 15-µm diameter pillars. Scale bar: 30 µm. **Figure 2 RIGHT** Assessing distance traveled by cells over several days. Wild-type mouse embryonic fibroblasts (MEFs) with green fluorescent protein with a nuclear localization sequence (NLS-GFP) to mark the nucleus traveling through the control density of pillars over 4 days. Distance traveled from seeding port (dotted line) assessed as distance of furthest or "leading edge" of cells (white arrows). Scale bar: 50 µm.

Thin-Film Multijunction Inverted Metamorphic Solar Cells with Light Management for Space Applications

Authors: Julia D'Rozario, Steve Polly, Rao Tatavarti, Seth Hubbard

Faculty Advisor: Seth Hubbard
Department and Institution: Microsystems Engineering, Rochester Instute of Technology
Contact Email: jrd4466@rit.edu, smhsps@rit.edu

ABSTRACT

Thin-film III-V space photovoltaics (PV) present an attractive solution for lightweight, radiation-tolerant technology as the dependence on the minority carrier diffusion length reduces with the absorber thickness. To match the current output realized in optically thick PV, light trapping structures in the form of back surface reflectors (BSR) can enhance the photogenerated current by increasing the photon path length inside the thin solar cell. This work focuses to improve the radiation tolerance and end-of-life efficiency of conventional multijunction inverted metamorphic (IMM) solar cells for space-related applications. Specifically, the bottom 1-eV InGaAs subcell is thinned to the sub-μm regime and facile texturing processes demonstrate effective light trapping through high diffuse reflectance in the thinned devices. The textured BSRs show an increased haze in reflectance compared to the planar BSRs, indicating a higher degree of angular photon scattering. The lifetime enhancement factor, which describes the extended photon lifetime inside the solar cell cavity due to effective light trapping, is larger in the solar cells with textured reflectors compared to the solar cell without light trapping. The illuminated JV measurements for the solar cells with textured BSRs show no degradation in the V_{OC} while exhibiting an increased J_{SC} due to the photon scattering. The increase in diffuse reflectance and current output in the thin-film IMM solar cells make them promising candidates for radiation-tolerant solar power sources in the space environment.

Engineering a Novel *in vivo* Preclinical Cancer Assay Platform

Authors: Tristen Head, Xianjun Ye, Natalya Tokranova, David Entenberg, and Nathaniel C. Cady

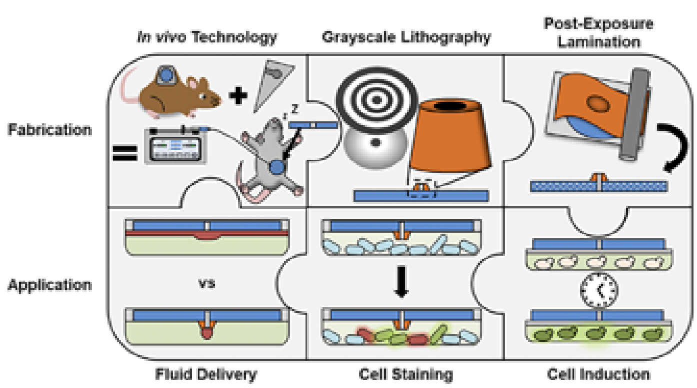
Faculty Advisor: Nathaniel C. Cady
Department and Institution: College of Nanoscale Science and Engineering, SUNY Polytechnic Institute
Contact Email: headtm@sunypoly.edu, cadyn@sunypoly.edu

ABSTRACT

Despite decades of research and billions of dollars in funding, cancer has maintained its epidemiological prominence as the second leading cause of death in the US for nearly 90 years. Currently, the clinical trial success rates for oncologic drugs is ~3%, and approved drugs often have a modest impact on overall survival. This is due in part to the tumor microenvironment (TME) which promotes cancer development and mitigates therapeutic response[1]. To better understand the role of the TME, we have utilized microfabrication techniques to develop the microfluidic imaging window (MFIW), an implantable platform for the observation and manipulation of *in vivo* TMEs. This technology provides unique opportunities for assessing the pharmacologic effects of therapeutics within the intact, living target tissue. Here, we report the integration of tapered SU-8 micro-nozzles into the MFIW using proximity-based grayscale photolithography of dry-film photoresist prior to substrate application. Micro-nozzles were shown to reduce lateral dye dispersion in agarose tissue mimics by as much as 68% and improve axial dye delivery by 134%[2]. Work focused on localized delivery of small molecules *in vitro* and *in vivo* to demonstrate spatiotemporal control during drug delivery is ongoing.

REFERENCES

1. *Head, T. & Cady, N. C. Monitoring and modulation of the tumor microenvironment for enhanced cancer modeling. Exp. Biol. Med. (2022). doi:10.1177/15353702221074293*
2. *Head, T., Tokranova, N. & Cady, N. C. Lithographically patterned micro-nozzles for controlling fluid flow profiles for drug delivery and in vitro imaging applications. MRS Commun. 11, 584–589 (2021).*



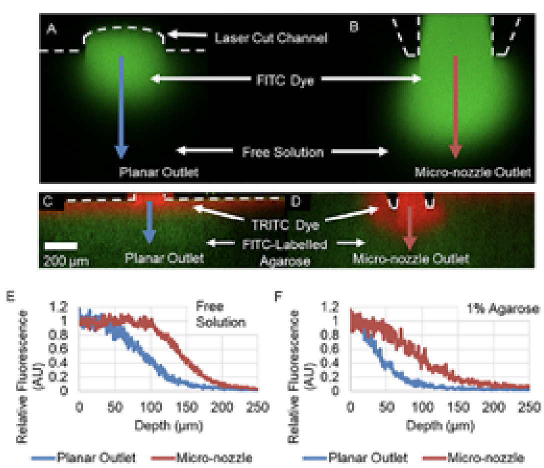


Figure 1 LEFT: Overview of key research areas for the MFIW. The combination of microfluidic technology, grayscale lithography, and a novel post-exposure lamination process enables simultaneous imaging and delivery of reagents for various biological applications in the TME. **Figure 2 RIGHT:** Cross-sectional confocal images of dye delivery in free solution (A and B) and 1% agarose tissue mimics (C and D) for comparing planar outlets and micro-nozzles. The relative fluorescence intensity of the delivered dye is plotted as a function of depth from the device outlet for both models (E and F).

Ballistic Switching in Y-Shaped Nanostructures with Independent MOS Gates

**Authors: Trevor McDonough[1], Vladimir Mitin[1],
Vadim Tokranov[2], Michael Yakimov[2], Serge Oktyabrsky[2]**

CNF Project Number: 2883-20
CNF Principal Investigator: Vladimir Mitin
Department and Institution:
1 Department of Electrical Engineering, SUNY University at Buffalo, USA
2 Department of Nanoscience, SUNY Polytechnic Institute at Albany, USA
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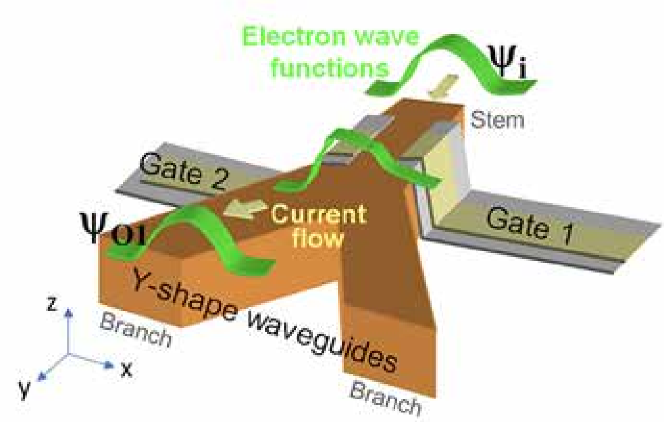
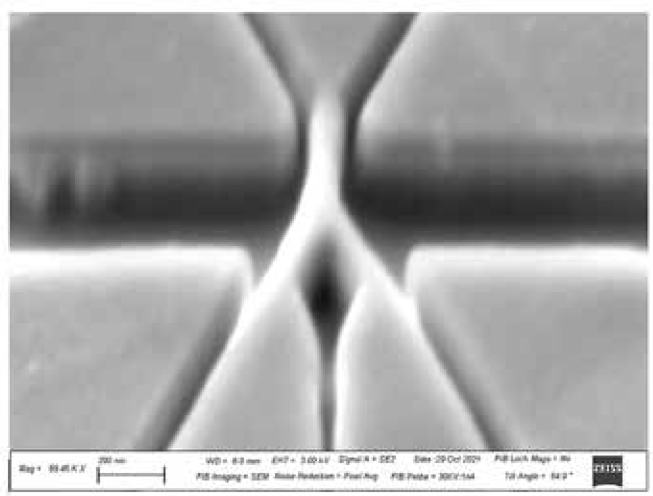
ABSTRACT

Using the Schrödinger-Poisson electrostatic solver in tandem with the non-equilibrium Green's function transport simulator included with Silvaco Atlas, we demonstrated low-power switching in a gated Y-shaped one-dimensional ballistic junction prepared from a GaAs/InGaAs quantum well structure. Modulation doping was applied with 5 nm spacer layers similar to experimental structures. With a source-drain voltage of 1 mV, current was switched to the desired branch at gate voltages as low as 10 mV. We also fabricated the devices on similar structures grown on GaAs and InP via molecular beam epitaxy. The technologies for fabrication of the quasi-one-dimensional electron waveguides and obtained results were developed using electron-beam lithography (EBL) and reactive-ion etching with a hard mask. While initial tests utilized in-plane proximity gates, we developed a novel process for the fabrication of intrinsically separated, self-aligned independent sidewall MOS gates with Al_2O_3 oxide. The gate stack was grown via atomic layer deposition of the dielectric followed by glancing angle metal deposition of each of the gates separated by an additional dielectric layer. Any location with narrow trenches would only result in the deposition of gate metal on the hard mask due to shadowing during deposition, allowing the length of the gate to be controlled using "access trenches" in the waveguide EBL pattern. The results on processing and associated ballistic current control in the structures are presented.





Coupling Transmon Qubits Through a Left-Handed Metamaterial Ring Resonator Bus

Authors: Tianna A. McBroom, Jaseung Ku, Bradley G. Cole

CNF Project Number: 1735-08
CNF Principal Investigator: B.L.T. Plourde
Department and Institution: Department of Physics, Syracuse University
Contact Email: tamcbroo@syr.edu, bplourde@syr.edu

ABSTRACT

Left-handed metamaterial transmission line resonators made with arrays of superconducting lumped circuit elements have unique dispersion relations resulting in densely grouped mode spectra, with mode spacing as low as tens of MHz scale. Forming these transmission lines into a ring allows access to these densely grouped resonances, but with a compact footprint allowing for flexible design. Superconducting qubits can be coupled to multiple modes in these left-handed metamaterial ring resonators, with promising applications for coupling qubits together and implementing a quantum memory. We have fabricated such a device with two superconducting transmon qubits coupled to a left-handed metamaterial ring resonator, and we present results characterizing this system.

*We acknowledge support from AFOSR grant No. FA9550-21-1-0020.

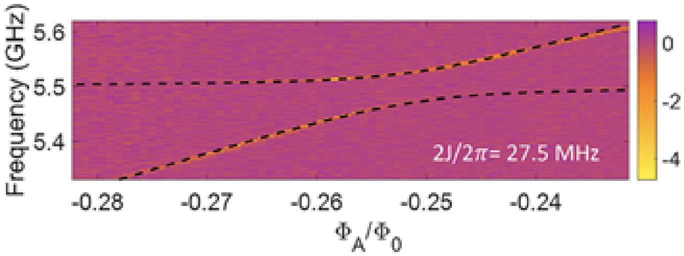


Figure 1. Qubit to qubit anti-crossing with overlaid fit and extracted J coupling. Color scale is background subtracted transmission.

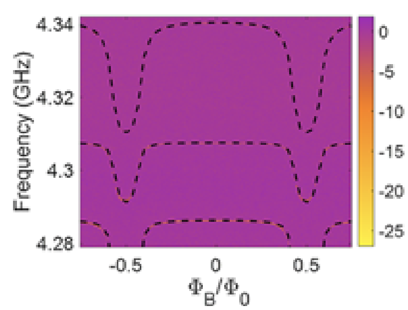


Figure 2. Vacuum Rabi splitting data with overlayed fit for a qubit crossing three left-handed line metamaterial ring-resonator modes. Color scale is background subtracted transmission.

Overcoming Acoustoelectric Material Limits of Piezoelectric Resonators using Epitaxial Aluminum Nitride

Authors: Wenwen Zhao[1], Mohammad Javad Asadi[2], Lei Li[2], Reet Chaudhuri[2], Kazuki Nomoto[2], Huili Grace Xing[2,3,4], James Hwang[2,3], and Debdeep Jena[2,3,4]

CNF Project Number: 2801-19
CNF Principal Investigator: Debdeep Jena
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ABSTRACT

High-speed communication systems require efficient and compact filters in the 10-40 GHz frequency window. These frequencies are beyond the capacity of conventional surface-acoustic wave resonators, and are challenging with bulk acoustic-wave resonators. The acoustic properties of piezoelectric aluminum nitride deposited by conventional sputtering degrade for sub 500 nm thicknesses. Since the higher frequencies require thinner layers, by taking advantage of epitaxial aluminum nitride developed for UV photonics or high-speed electronics, we have explored aluminum nitride thin-film bulk acoustic resonators (FBAR) which can operate in the longitudinal mode in the 8-20 GHz window. A unique RF front end can be enabled by the convergence of the FBAR and HEMT material layers, and such FBARs can enable integration with epitaxial nitride superconductors for microwave filters for quantum computing.

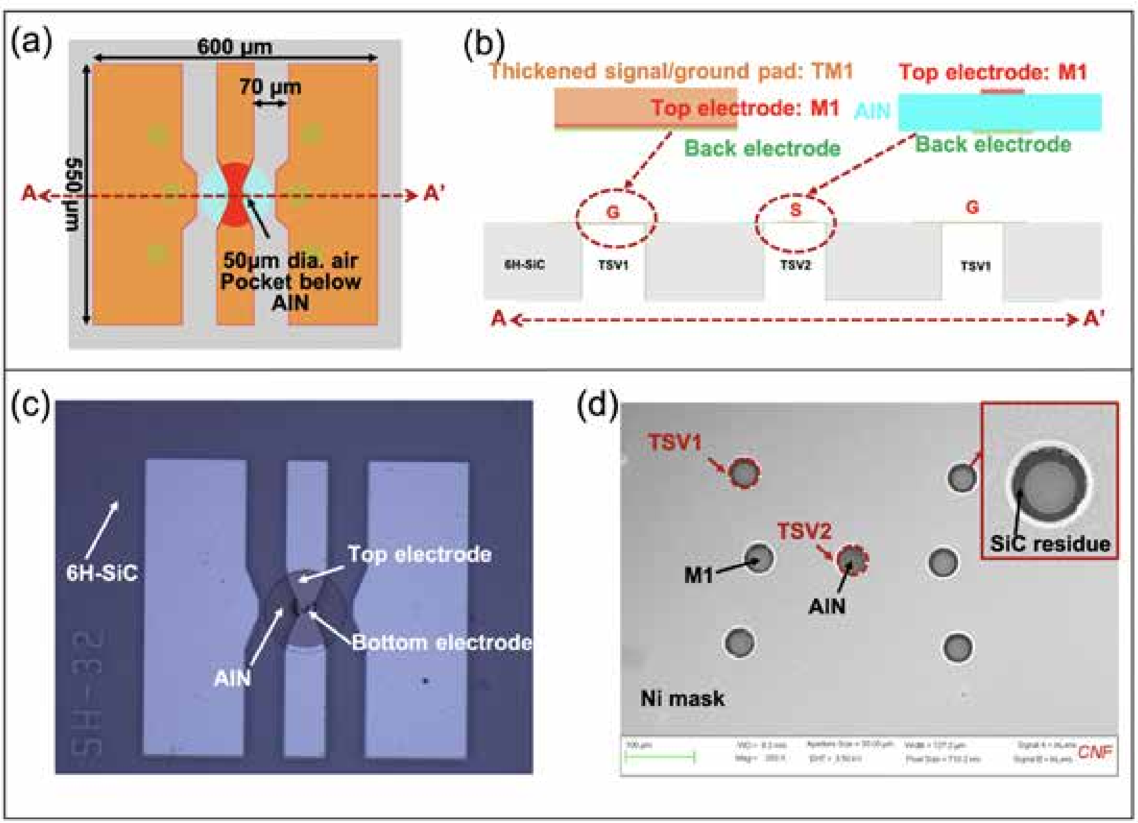

Figure 1: (a), (b) Top view and cross section-view of the designed shunt AlN FBAR device. FBAR device comprises of an MBE-grown AlN layer (blue) on semi-insulating SiC which is the same substrate platform used for RF and mm-wave AlN based HEMTs, a top electrode (red) and a back electrode (green). Deep ICP-RIE etch was performed to remove the SiC substrate under the M1 in the ground lines and AlN in the signal lines. (c) Top view of a fabricated shunt AlN FBAR. Top electrode is 50-nm-thick Ni while the back electrode is 20-nm-thick ALD Pt. (d) Bottom view of a shunt AlN FBAR (without back electrode). 100-?m-thick SiC substrate was selectively removed then the metal pad and AlN were exposed which resulted in suspended AlN layer.

Design and Development of InAs Quantum Dots in GaAs Matrix – A Novel Scintillator Material with Monolithically Integrated InGaAs Photodetector

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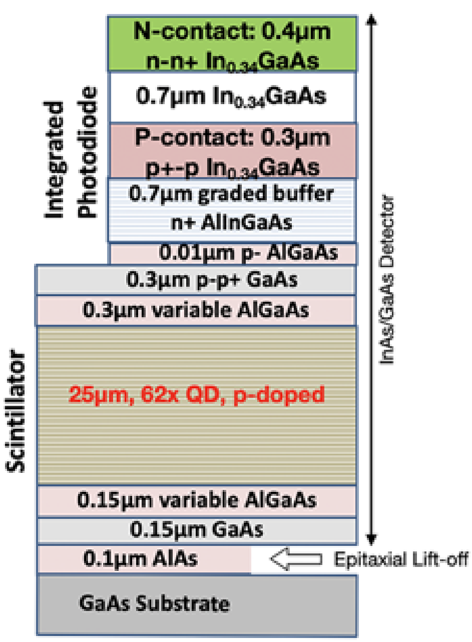
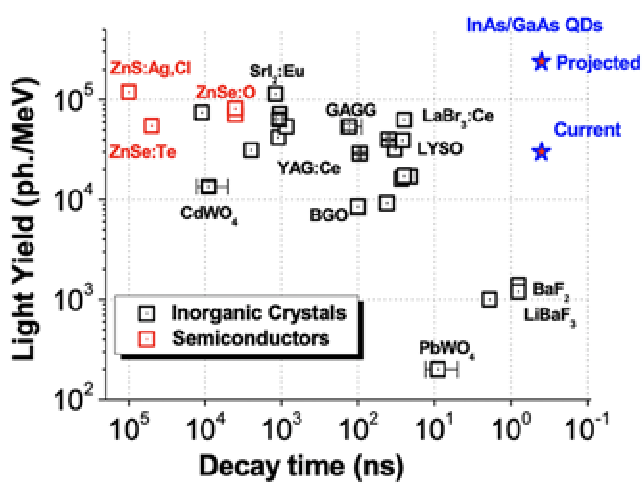
ABSTRACT

Radiation detection technology is very important in various fields such as medical imaging, high energy physics experiments and homeland security. Scintillators are the material which can convert incoming radiations into light and therefore, have been the core element of radiation detectors for more than a century. However, traditional scintillator materials often have either lower light yield or are prone to incoming radiation damage, and inefficient coupling to an external photomultipliers may further limit detector performance. Therefore, new scintillator materials are being developed to overcome these challenges. We have developed a novel semiconductor-based scintillation material composed of InAs quantum dots embedded into a GaAs matrix. The epitaxial heterostructures consisting of self-assembled InAs quantum dots (QDs) embedded within a GaAs matrix have unique luminescence properties. The structure studied was grown by molecular beam epitaxy on GaAs substrate and separated from parent substrate by epitaxial liftoff. A monolithically integrated InGaAs p-i-n photodiode matched with QDs emission was engineered to collect light efficiently. The effect of waveguide parameters such as absorption and surface scattering on detector performance is investigated using Monte Carlo (MC) simulations. The charge collection, optical journey length, and time (optical jitter) statistics obtained by MC analysis aided in the optimization of a scintillator pixel and integrated photodetector. The early measurement of responses from 5.5 MeV alpha particle from Am-241, yields estimated 38 ps noise limited timing resolution. In addition, 3×10^4 photoelectrons per 1 MeV of deposited energy were collected with an integrated photodetector, which corresponds to 13% of the theoretically achievable limit in the InAs/GaAs QD system.



Schematic of detector grown by MBE



Light yield vs. decay time of some widely used and perspective solid state scintillation materials

Development of Engineered Gas Diffusions Layers via Micro-Scale Manufacturing

Authors: Giancarlo D’Orazio, Sadeq Saleh, Joshua Krsek, Sadaf Sobhani

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ABSTRACT

The need for low carbon and carbon-neutral energy sources has become increasingly clear as CO_2 emissions have continued to increase at an impressive rate. Efforts to sequester carbon show some promise, though storage remains a major issue. Utilizing this captured CO_2 in electrochemical reduction reactors can yield valuable products, such as ethanol, propanol, formic and acetic acids, among others. As these reactors generate these products, however, the gas diffusion layer (GDL) separating the carbon dioxide gas from the cell’s electrolyte begins to wet and subsequently flood with the change in product concentration; this flooding behavior severely limits operational lifespan and cell efficiency. In this work, micro-scale additive manufacturing via two-photon polymerization enables the printing of microfluidic devices. These devices were dynamically tested for flow properties via *in operando* testing and analysis by means of high energy X-ray computed tomography. The impact of architected geometry with variable surface texturing is explored, as well as the effects of electrolyte composition and surface coatings. The results of this analysis are further used in computational fluid dynamic models to better optimize GDL design to minimize flooding in subsequent designs.

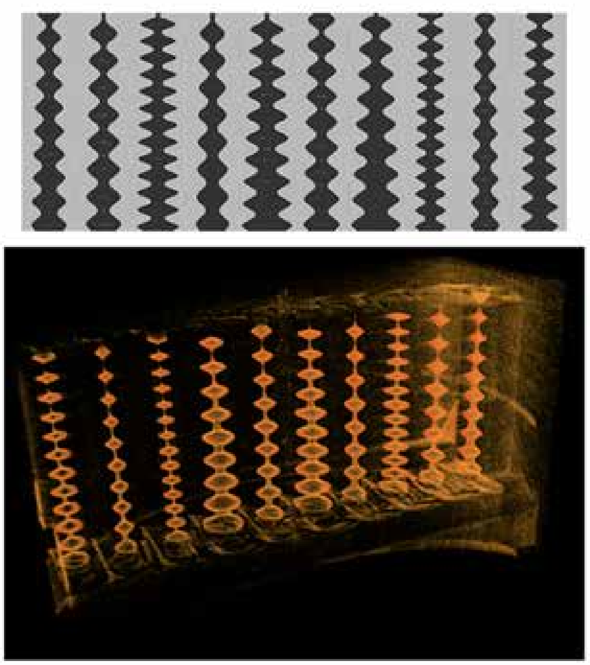

Figure 1. Left Top: Microchannel design. Left Bottom: X-ray CT reconstruction of as-printed microfluidic design.

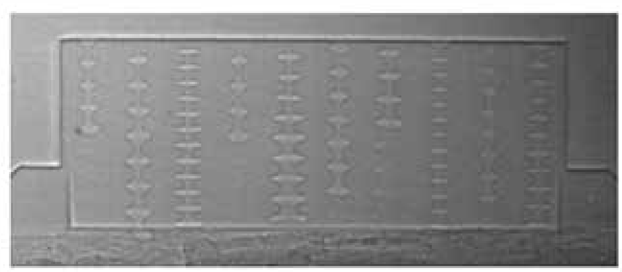

Figure 2. Above. Partially flooded microfluidic device.

Characterization of the Capacitance of Small Josephson Junctions from DC SQUID Resonances

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ABSTRACT

Developing techniques for characterizing and targeting the parameters of small-area Josephson junctions is important for implementing large superconducting qubit arrays. In particular, the self-capacitance of shadow-evaporated small area junctions is often challenging to extract, yet it plays an important role in the development of various topologically protected qubit designs. A direct current superconducting quantum interference device (DC SQUID) allows for the extraction of individual junction capacitances via the measurement of the LC self-resonance in the current-voltage characteristic. By varying the DC SQUID geometry, as well as the critical current densities of the Al-AlOx-Al junctions that make up the SQUID, we can measure the behavior of the self-resonance and characterize the specific capacitance of these small Josephson junctions.

*We acknowledge support from ARO/LPS grant No. W911NF-18-1-0106.

Bacterial Signaling System VxrAB is Activated by Diverse Mechanical Stimuli

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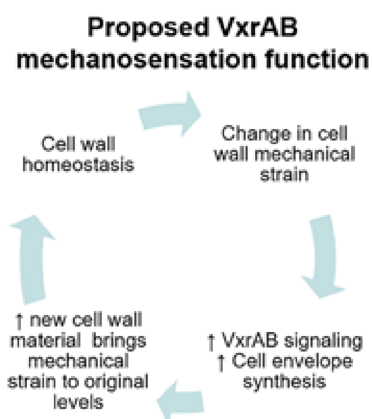
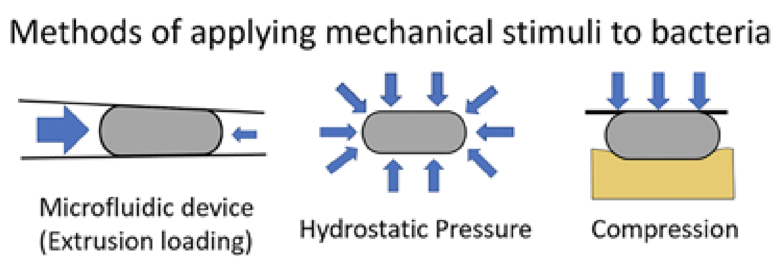
ABSTRACT

Bacteria live in an environment where they constantly experience mechanical forces, including mechanical forces from surface adhesion, osmotic shock, and motility. The integrity of the bacterial cell envelope is crucial for cell survival during these mechanical challenges. Recently, it has been shown that bacteria are capable of sensing changes in the mechanical forces in the cell envelope and responding by controlling gene expression to enhance cell fitness. While it is known that the cell envelope is critical for survival and that bacteria are capable of sensing and responding to mechanical forces in the cell envelope, it is unknown if there are any mechanosensitive mechanisms that control cell wall synthesis and repair. Here we focus on the VxrAB two component system, which is a key contributor to remodeling and maintaining homeostasis of the bacterial cell envelope in *Vibrio cholerae*. We applied three different forms of mechanical loading to the cell envelope of *Vibrio cholerae* cells using a custom fused silica microfluidic device (minimum feature size 300 nm), hydrostatic pressure, and compression. In each instance, cells experiencing greater magnitudes of mechanical loading exhibit greater VxrAB signaling ($p < 2*10^{-6}$). Our findings suggest an interplay between mechanical stress and strain in the cell envelope and VxrAB mediated cell envelope biogenesis.





Reliability and Operation of HfOx ReRAM Devices and Neuromorphic Applications Under Real-World Conditions

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ABSTRACT

Limitations related to the von Neumann bottleneck have resulted in a shift towards in-memory computing architectures that leverage non-volatile memory (NVM) devices. Resistive Random-Access Memory (ReRAM) is a strong candidate for such applications. Non-volatility and multi-level memory encoding capabilities make them amenable to compute in memory operations as well as neuromorphic computing, deep learning, and mathematical accelerators. These devices, however, suffer from stochastic switching variability that currently limits their usage and performance. To realize the full potential of ReRAM, performance and reliability analysis must be performed under different operational parameters and environments. In our work, reliability studies were performed on 65 nm CMOS/ReRAM devices fabricated on a 300 mm wafer platform [1,2]. To address the influence of switching compliance current, set/reset voltage, and pulse time on the variability of Low Resistance State (LRS) and High Resistance State (HRS), multiple parameters/conditions have been implemented, as well as the effect of temperature to mimic different use scenarios. The mechanisms of device drift, failure, and performance degradation under stress conditions were also studied, to highlight operation vulnerability in array-based operations, such as vector matrix operations for image processing and recognition.

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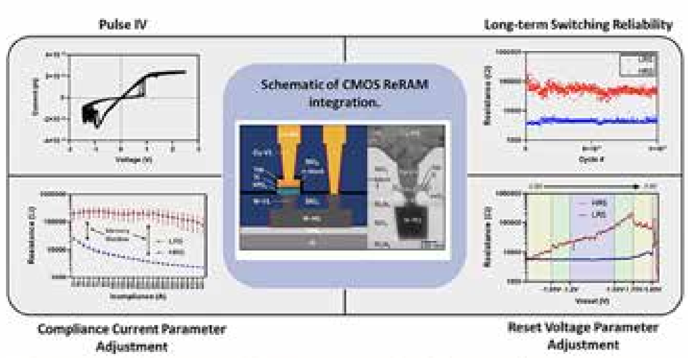

Figure 1: Ideal ReRAM device operation including Pulse IV, Long-term Switching Reliability, Compliance current parameter adjustment, and reset voltage parameter adjustment.

Figure 2: Influence of environmental changes, degradation from use, and device manufacturing errors leading to non-ideal operation results that require user adjustment.

Elucidating Metal Ion-Copolymer Coacervate Attachment Design Rules via Microcontact Printing of Self-Assembled Monolayers

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ABSTRACT

Employing bio-informed design principles gathered from single celled marine alga (coccolithophores) that use calcium ion – biopolymer coacervates to template intricate calcite crystal growth[1,2] (see Figure 1), we have templated various metal ion (Ca^{2+}, Fe^{2+}, etc.)-copolymer coacervates. Using established methods for photolithography and film casting, we have created PDMS microcontact printing stamps with varying size, pitch, and patterns. These stamps were then used to print self-assembled monolayer (SAMs) patterns of variously charged terminal groups (COOH, NH_2, OH) on supported gold substrates[3]. Exposing these templates to the ion- copolymer solutions formed the attachments you see in image (2) below. Based on preliminary Scanning Electron Microscopy, Energy Dispersive X-ray Spectroscopy, and Atomic Force Microscopy data, we have begun understanding the design rules that govern coacervate attachment and templating based on metal-polymer binding strengths, solution pH, and preferential ion-charged group interactions. We hope this work can be used to both further knowledge on coacervate surface interactions as well as introduce more spatially and temporally controllable crystallization pathways for use in the synthesis of functional materials.

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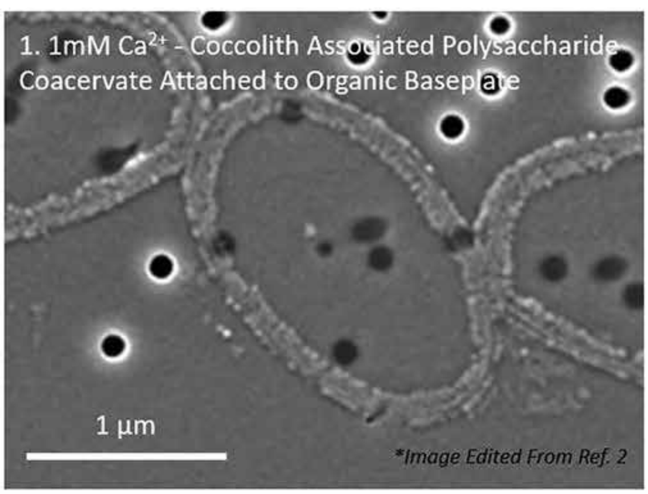

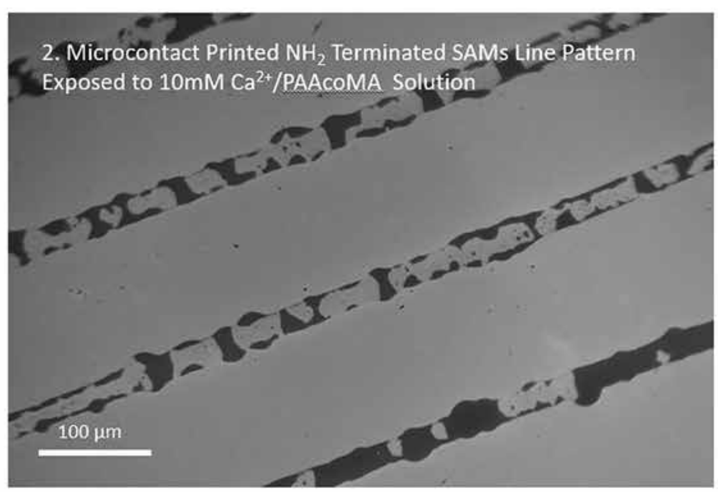

Fabrication of Flexible Antenna Using a Semi-Additive Process

Authors: Emuobosan Enakerakpo, D.J. Richmond, A. Umar, M. Alhendi, M.D. Poliks

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ABSTRACT

Flexible antennas are integral to the development of electronics for emerging applications such wearable electronics, IoT, health monitoring devices and soft robotics. Photolithography which is a conventional manufacturing process for such devices is limited in terms of the complex multi- step processes involved, the cost of the process and the associated waste. Additive manufacturing techniques employed in replacing some of these steps can be used addressing some of these limitations. Here, we show the use of aerosol jet printing (AJP) techniques to transfer patterns to a substrate in a lithographic process.

Flexible dual-band dipole antennas (2.4 GHz and 4.6 GHz) were simulated using ANSYS HFSS and fabricated using RO3003 material- a double sided copper clad substrate with LCP core- by wet etching the exposed copper. The antenna designs were patterned onto the substrate by Aerosol jet printing of the photoresist. The AJP process is a non-contact, direct write printing process in which collimated streams of the ink mist is focused on the substrate. AJP can achieve resolutions down to 10 µm. The etched resolution quality on the other hand was shown to be affected by the thickness of the photoresist, which is enhanced by increased number of layers; the duration of the etching process with shorter duration being desirable and the size of the substrate where smaller substrates are preferred. The fabricated dual band dipole antennas are assessed for their performance in relation to simulated designs.

In conclusion, the use of a semi-additive process such AJP printing eliminated the complex steps in a photolithographic process and also halving the required number of steps.

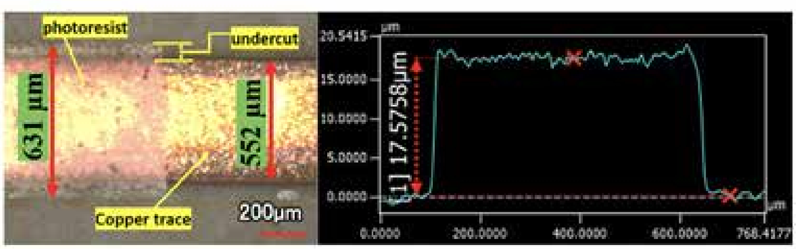

Figure 1: Profile of antenna conductor trace.

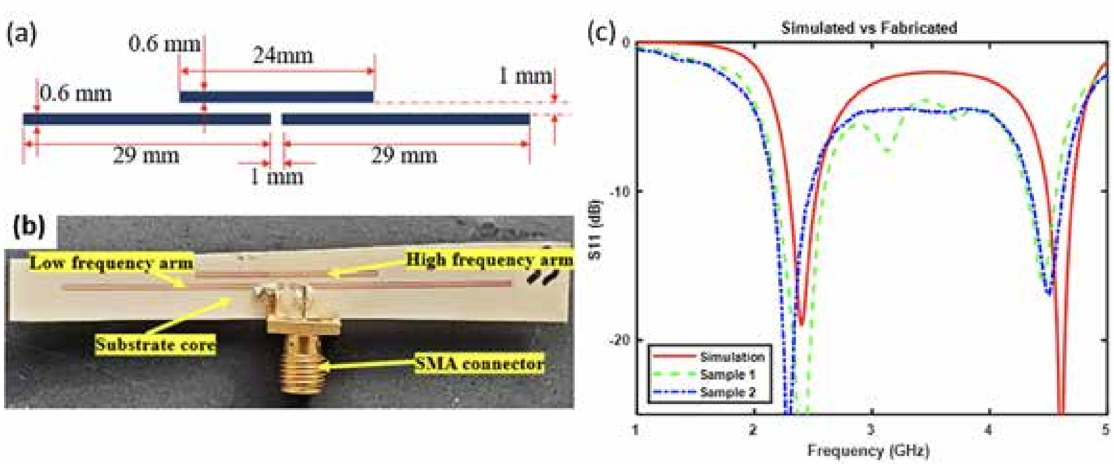

Figure 2: (a) Antenna design and dimensions (b) fabricated antenna (c) simulated antenna design vs. fabricated antennas

Demonstrating the Combined Effects of Shear and Surface Roughness on Thrombosis in VADs

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ABSTRACT

In ventricular assist devices (VADs), pathological shear enhances thrombosis, or clot formation. Their Ti-alloy surfaces are often unintentionally roughened on the submicron scale during manufacture; however, there is no consensus on how roughness affects thrombosis. We leveraged the precise control, versatility and low volumes of microfluidic systems to study shear and topography-induced thrombosis. We designed and fabricated microfluidic devices with roughened Ti_6Al_4V surfaces to create shear-controlled, clinically relevant micro- and submicron scale environments to quantify thrombus formation through platelet aggregation. A blood analog comprised of red blood cells and platelet-rich plasma with fluorescent mepacrine-labeled platelets was perfused through the microdevices. Four surface roughness levels were used: mirror finish, Ra 0.3 µm (not shown here), 0.8 µm and 2.1 µm, respectively, and at each roughness three shear rates were applied: $1000s^{-1}$, $2000s^{-1}$, and $5500s^{-1}$. Platelet aggregate properties were visualized, recorded and quantified using fluorescent microscopy. At $1000s^{-1}$ and $2000s^{-1}$, respectively, adhesion patterns demonstrated sustained growth of platelet monolayers (fig 1a) or stable, growing platelet aggregates when Ra < 2.1 µm (fig 1b). At $5500s^{-1}$, round platelet aggregates formed on all three surfaces, often connected by fibrous structures (fig 1c), with increasing intensity and density with time. Embolization was observed on all surfaces after an initial increase in aggregate intensity (in yellow, fig 2c). On the Ra 2.1 µm surface, platelet aggregates formed at all three shear rates, indicative of higher shear rates and gradients resulting from surface roughness.

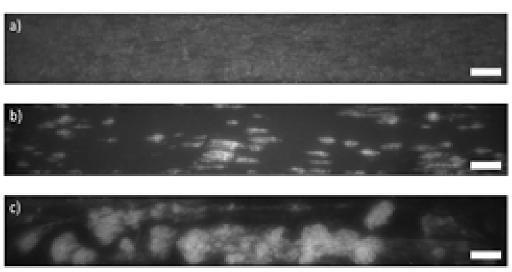

Figure 1. Scale bar is 100µm.

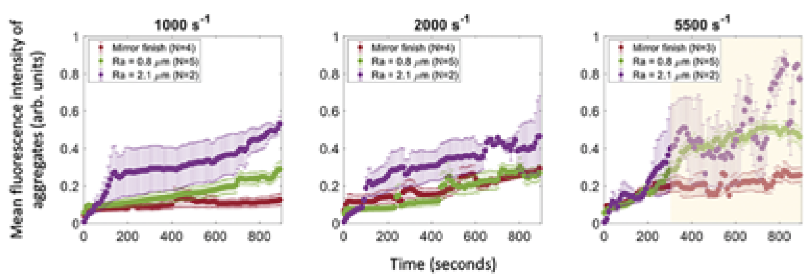

Figure 2. Mean intensity of aggregates. Error bars represent standard error of the mean.

Influence of Oxygen Exchange Layer and Dopants on Transition Metal Oxide ReRAM Performance

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ABSTRACT

Resistive random-access memory (ReRAM) is a form of non-volatile memory that has potential applications in high density memory and as embedded memory for a growing number of non-Von Neumann computing architectures. However, reliability issues of these devices are a major concern for such applications. ReRAM is generally a two-terminal device with oxide as a switching layer. In this work, we focused on TiN bottom electrodes, W top electrodes, transition metal oxides (TMOs) HfOx and TaOx as the switching layer, and multiple metals as an oxygen exchange layer (OEL). Previous studies have shown that modifying the OEL and/or doping of the switching layer can dramatically affect device switching performance. For this study we have fabricated devices by depositing TMOs on templates which have 50 nm diameter TiN bottom electrodes (Figure 1). This was followed by plasma-based doping of the TMO, and then deposition of OEL and top electrode. Device performance was evaluated by measuring current-voltage switching characteristics. Ongoing work is focused on correlating the doping conditions and the type of OEL used with switching characteristics, with the goal of improving ReRAM memory window, forming voltage, retention and endurance.

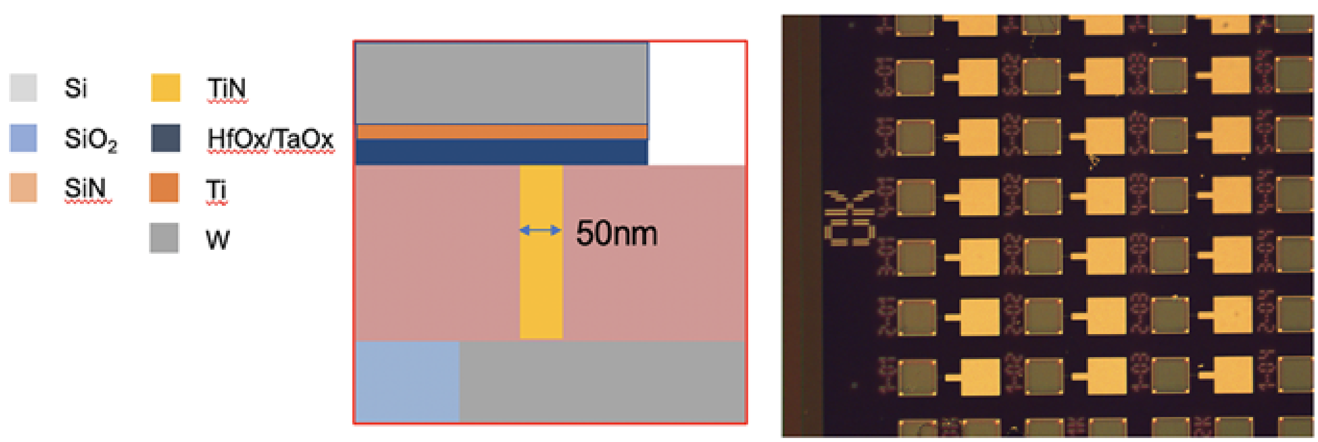

Figure 1: Left) Cross section schematic of the nanoscale ReRAM bottom electrode template being used for device development and testing. Right) Top-down view of patterned and etched ReRAM stacks (using contact lithography) fabricated on top of nanoscale bottom electrode templates.

Selective Single-Beam Acoustic Tweezers for Cell Manipulation

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ABSTRACT

Structured sound waves, mechanical waves carrying energy and momentum flux, are frontiers in advancing our understanding of cell mechanobiology. The acoustic tweezers enable biocompatible, contact, and label-free manipulation of single cells and microorganisms. Focused sound beams can exert acoustic radiation force and torque that can be used to precisely manipulate the position and orientation of cells and probe their mechanical properties at powers much lower than their optical counterpart.[1,2]

This work will discuss focalized acoustic vortices for creating a phase singularity around the beam axis for selective and individual microparticle/cell manipulation inside a microfluidic device fully compatible with standard microscopy environments. (Figure 1). These miniaturized acoustic tweezers are achieved by folding the phase of an acoustic vortex on a piezoelectric substrate following the principles of Fresnel lenses. Similarly, a single pair of curved interdigitated transducers on an active substrate is used to capture the equiphase lines of various acoustic fields instead of using an array of transducers to produce stiff localized traps with reduced acoustic power.

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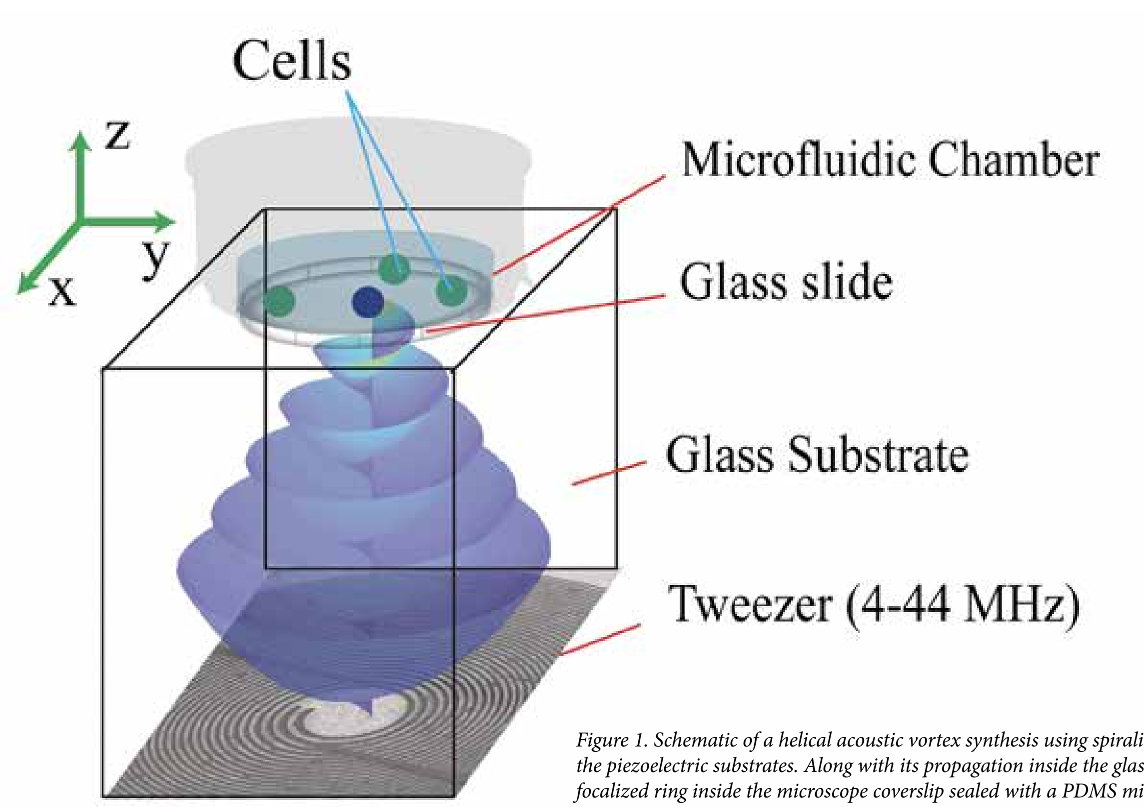

Figure 1. Schematic of a helical acoustic vortex synthesis using spiraling electrodes deposited on the piezoelectric substrates. Along with its propagation inside the glass, the acoustic field forms a focalized ring inside the microscope coverslip sealed with a PDMS microchamber to trap a cell.

Demonstration of a Monolithically Integrated Hybrid Electroabsorptive Modulator/ Photovoltaic Device for Bidirectional Free Space Optical Communication at 1.55 μm

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ABSTRACT

One of the major drivers in satellite research is the reduction of the size, weight, and power (SWaP) of mission critical subsystems, such as power generation systems and communication systems. III-V semiconductors are the class of materials typically used for photovoltaic (PV) arrays for satellites due to their exceptional efficiencies of upwards of 35% and ability to be made thin, flexible, and lightweight. This is contrasted with the high SWaP communication systems, which utilizes a radio frequency (RF) transceiver in order to communicate with a ground station. A low SWaP alternative is to transmit data using free space optical (FSO) communication, a line of sight communication technique that uses a laser to transmit data, and to integrate the optical communication device with the PV system.

A three-terminal, monolithically integrated device is presented combining both power generation via an indium phosphide (InP) PV device and optical communication at 1.55 μm via an indium gallium arsenide (InGaAs) based multiple quantum well (MQW) electroabsorption modulator (EAM), shown in Figure 1. The InP PV device achieved an AM0 efficiency of 12.8 % (without an anti-reflection coating), and the InGaAs based EAM exhibited peak modulation near 1.55 μm. Simultaneous power generation and data communication via FSO has been achieved (Figure 2), with the PV device illuminated with LEDs at 750 nm and the EAM modulating a 1.55 μm laser with a driving signal of 5 V.

Figure 1: Photograph of the three-terminal, monolithically integrated PV/EAM device.

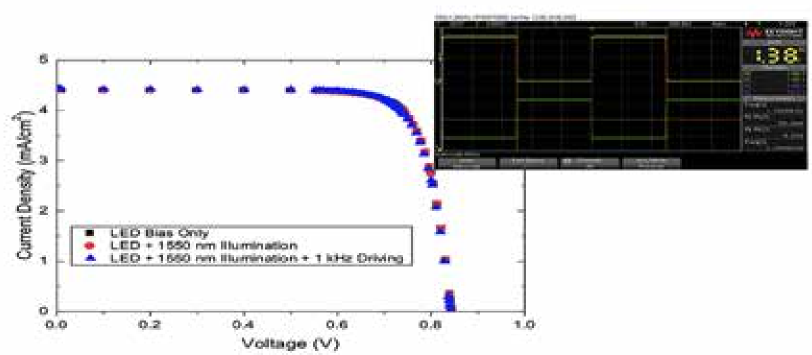

Figure 2: LED illuminated current density versus voltage for the InP PV device while the InGaAs-based EAM is being driven with a 1 kHz, 5 V peak-to-peak signal under 1.55 μm laser illumination, with the modulated signal shown in the oscilloscope capture.

Cilia Metasurfaces for Electronically Programmable Microfluidic Manipulation

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ABSTRACT

Cilial pumping is a powerful strategy used by biological organisms to control and manipulate fluids at the microscale. Despite numerous recent advances in optically, magnetically, and electrically driven actuation, however, development of an engineered cilial platform with the potential for applications has remained elusive. Here, we report on active metasurfaces of electronically actuated artificial cilia that can create arbitrary flow patterns in liquids near a surface. We first create voltage-actuated cilia that generate non-reciprocal motions to drive surface flows at tens of microns per second at actuation voltages of 1V. We then show a cilia unit cell can locally create a range of elemental flow geometries. By combining these unit cells, we create an active cilia metasurface (Fig.1) that can generate and switch between any desired surface flow pattern. Finally, we integrate the cilia with a light-powered complementary metal-oxide-semiconductor (CMOS) clock circuit to demonstrate wireless operation. As a proof of concept, we use this circuit to output voltage pulses with various phase delays to demonstrate improved pumping efficiency using metachronal waves (Fig.2). These powerful results, demonstrated experimentally and confirmed using theoretical computations, illustrate a new pathway to fine scale microfluidic manipulations, with applications from microfluidic pumping to microrobotic locomotion.

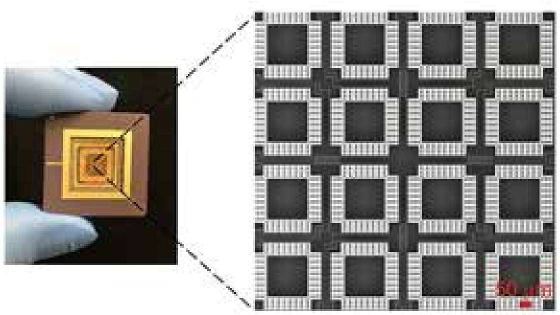

Fig.1. Cilia metasurface with 64 independently controlled arrays

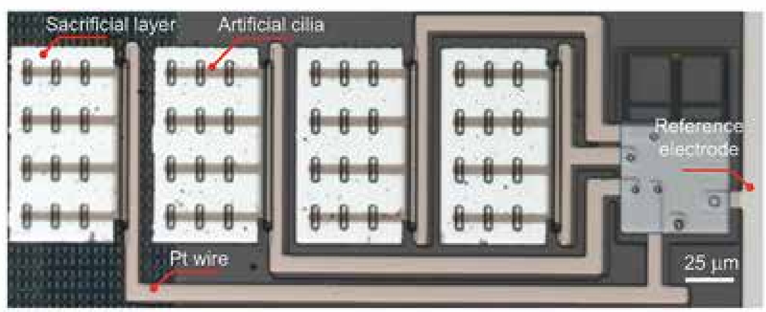

Fig.2. Optical image of CMOS integrated artificial cilia

Fabrication of Nanophotonic Optical Cavity Device from Inverse Design

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CNF Project Number: 2126-12
CNF Principal Investigators: Greg Fuchs[3], Alejandro Rodriguez[3]
Department and Institution:
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ABSTRACT

On-demand polarized single-photons are essential in realizing many photon-based quantum communication protocols [1]. We developed and fabricated a nanophotonic cavity device from aluminum nitride (AlN), whose structure was calculated from an inverse design method [2]. The structure serves as a platform for enhancing the collection of single photons from isolated defects hosted in hexagonal boron nitride (hBN). These defects can be created from ion-implantation with carbon and have a zero-phonon line fluorescence around 585 nm [3-5], at which we designed our cavities to resonate. We employed electron beam lithography to define the pattern whose minimum feature size is on the order of 10 nm, and we use a combination of ion milling and inductively coupled plasma reactive ion etch to carve out the devices that has a high aspect ratio. Here we will present a work-in-progress on the device fabrication.

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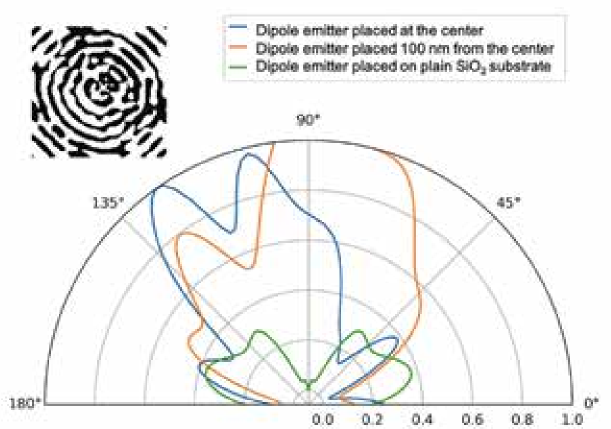

Figure 1: Far-field radiation patterns of a dipole emitter placed at the center, 100 nm from the center of the device, and on a plain SiO$_2$ substrate.

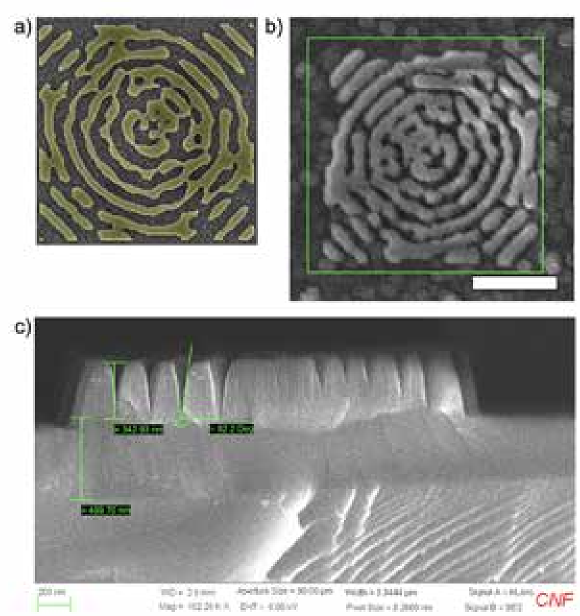

Figure 2: SEM images of: (a) top-down view of the device pattern on HSQ mask with colored design overlay; (b) top-down view of the final device; (c) cross-section view of the cleaved device showing slanted side walls.

Mitigation of Quasiparticle Poisoning in Superconducting Qubits using Normal Metal Backside Metallization

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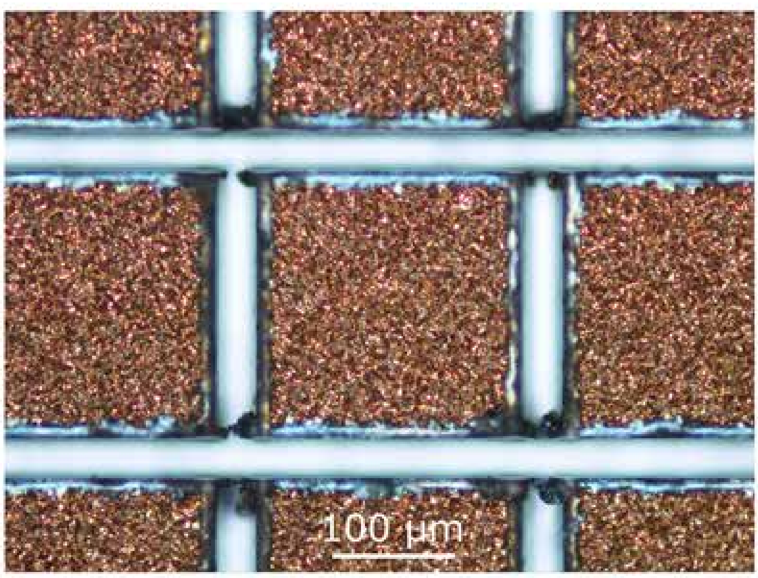
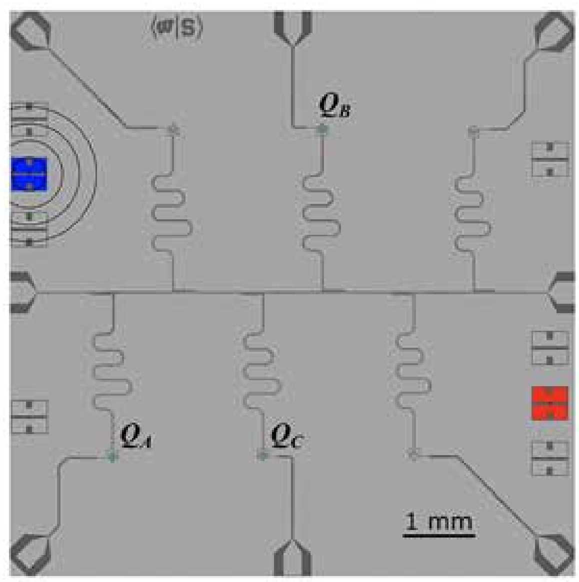
ABSTRACT

The absorption of high-energy particles, such as gammas and cosmic ray muons, in superconducting qubit chips generates pair-breaking phonons that can travel long distances and generate quasiparticles over significant areas of a device. The quasiparticle poisoning from such events can lead to correlated errors between distant qubits, resulting in the breakdown of error-correction schemes, such as the surface code. Therefore, it is critical to develop strategies for mitigating such quasiparticle poisoning to protect large qubit systems from such errors. We have fabricated devices with normal metal phonon absorbers on the opposite face of the chip from an array of charge-sensitive transmon qubits. We present measurements of devices with and without this backside metallization. We demonstrate the effectiveness of the phonon absorbers on the mitigation of quasiparticle poisoning by measuring the qubit behavior in the presence of direct quasiparticle injection by biasing on-chip Josephson tunnel junctions in both pulsed and continuous modes.





Optically Powered Bubble-Propelled Microswimmers

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ABSTRACT

The development of artificial microswimmers has attracted great interest recently, especially for biological and sensing applications. To this end, we have developed a microswimmer roughly 100 microns in size which is powered by light and propels itself in fluid by creating and ejecting bubbles. Unlike other bubble-propelled microswimmers, these devices are capable of operating in any aqueous solution without the addition of a chemical fuel. Each microswimmer consists of multiple silicon photodiodes connected in series with a hollow, tube-like electrode at each end. Under incident light, the photodiodes drive water splitting at the rocket-like electrodes, forming oxygen and hydrogen gas bubbles which are then expelled from the device preferentially in one direction, propelling the device forward. These microswimmers are fabricated and released from the substrate using traditional lithography, allowing hundreds of thousands of swimmers to be fabricated simultaneously. This process also lends itself well to integration with a wide array of materials such as magnetic thin films, which are used to steer the microswimmers *in situ* via an external magnetic field.

In this talk, we show working, steerable microswimmers with various pre-determined swimming trajectories and discuss their fabrication, mechanism, and potential applications. In addition, we demonstrate a novel method for locomotion on surfaces using bubble propulsion, resulting in locomotion more efficient than previously discussed in the literature.

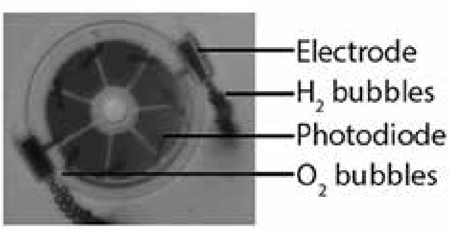

Figure 1: Labelled micrograph of optically powered microswimmer operating on a glass-water interface in 10 mM PBS solution under mercury lamp illumination.

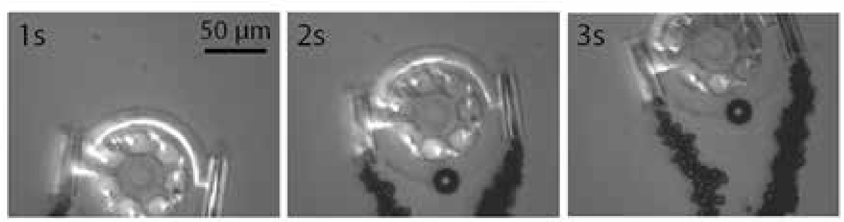

Figure 2: Time lapse of a device swimming under mercury lamp illumination at an air-water interface in 10 mM PBS solution.

Phase Change Memory (PCM) with Multilevel Resistance States Based on Group III-Sb Binary Alloys

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ABSTRACT

Phase change materials are actively being explored as analog resistive memories for neuromorphic applications. $Ge_2Sb_2Te_5$ (GST) alloys have been a primary material class for PCM technology. However, elemental redistribution and Te volatility in GST based films have been shown to cause poor endurance performance. Therefore, Te-free Sb-rich binary alloys with group III and IV doping have been of great interest and have demonstrated faster crystallization and improved thermal stability. The potential of Al-Sb and Ga-Sb binary alloys thin films for applications in multilevel PCM is presented here.

Thin films with different compositions of Al-Sb and Ga-Sb deposited in molecular beam epitaxy (MBE) reactor under ultra-high vacuum were used for bulk material properties. Films with 30% group III fraction demonstrated improved data retention of up to 150-160°C projected to 10 years as compared to ~73°C for GST. Upon transformation these alloys crystallize into rhombohedral doped Sb (A7) and cubic zinc-blende AlSb or GaSb phases. Furthermore, the results of synchrotron *in-situ* XRD and TEM analysis revealed a potential mechanism for multilevel resistance switching obtained by alloying the A7 phase with different concentrations of Ga or Al.

PCM Mushroom cells (Fig.1) demonstrated reversible switching with high resistance contrast (Fig.2) demonstrating a possibility of programming multiple discrete resistance states. Electrical and structural properties of these alloys, as well as realization of these materials on foundry templates with high dynamic resistance range and potential for analog performance by alloying control indicate that Te-free III-Sb based alloys are promising candidates for analog PCM applications.

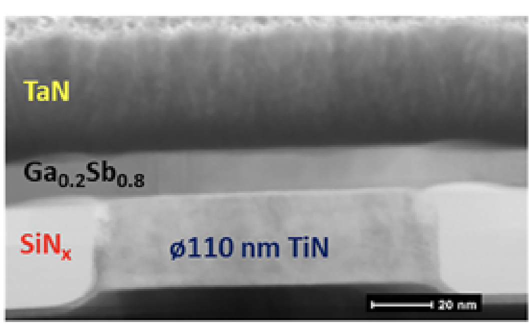

Fig. 1. Bright filed TEM of PCM cell device with ~16 nm $Ga_{0.2}Sb_{0.8}$ PCM film.

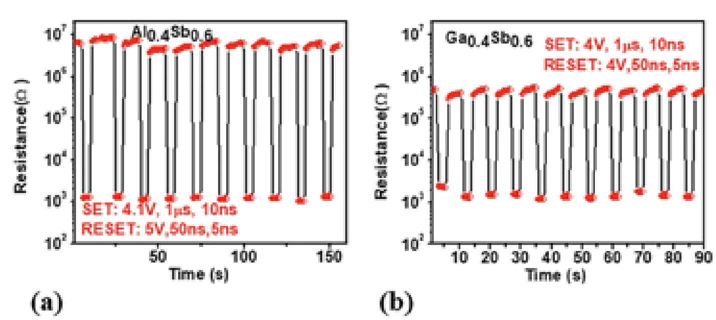

Fig. 2. Switching of 20 nm thick $Al_{0.4}Sb_{0.6}$ (a) and $Ga_{0.4}Sb_{0.6}$ (b) PCM cell. The resistance between the pulses was measured multiple times at 100 mV. Pulse voltage, pulse width, and rising and falling edge respectively are shown in red on the plots.

Polymer Nano/Microfiber as Solar Reflector or Absorber

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ABSTRACT

Smart thermal management is the key to energy conservation and efficient energy usage. When it comes to handling heat from the sunlight, "color" might be the first word that comes to mind in order to control the reflectance or absorbance of the light. However, color accounts only for half of the total solar irradiance, responsible for heating the surface, where the other half is invisible to our eyes, the Near-Infrared (NIR) region (λ=800~2500 nm). This indicates that two surfaces that have the identical color may have very different optical properties in terms of how much light energy is being absorbed or reflected. Studies demonstrating passive methods to minimize, or to rapidly cool down, the heat from the Sun focus on emissive/radiative cooling.[1] Only recently, the potential for nanofiber's NIR reflection capability has been recognized in textile applications to prevent the heating.[2] The purpose of this research is to further examine this optical phenomenon. We focus on the bottom-up method to electro-spin 1-D nanofibers that form 2-D matrices. This allows higher surface area than a 2-D polymer layer. In addition to higher surface area, fibers are air-permeable, stretchable, and, therefore, wearable. This presentation demonstrates approaches to control the optical property by controlling and optimizing fibers' structure, orientation, and composition.

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2 Kim, Gunwoo, et al. ACS Nano, 2021, doi.org/10.1021/acsnano.1c04104.

Reliability Study of a Magnetically Aligned Anisotropic Conductive Epoxy for Interconnecting Stretchable Conductors to Various Surfaces

Authors: Riadh Al-Haidari, Behnam Garakani, Mohammed Alhendi

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ABSTRACT

Stretchable wearable electronics frequently necessitate the integration of mechanically dissimilar materials in order to create functional devices that are flexible, stretchable, conformal, and sufficiently reliable. Solder and isotropic/anisotropic conductive adhesives are common methods for integrating highly stretchable conductors with other flex/rigid components. However, each of those methods has limitations for soft/much softer, rigid/soft assemblies for wearable devices due to the nature of the stretchable conductors/substrate. A magnetically aligned Anisotropic Conductive Epoxy (ACE) has several advantages over traditional interconnections, including a robust mechanically flexible to flexible/rigid connection, pressure-free assembly, low-temperature cure, and excellent adhesion to a variety of substrates. Herein, we conducted electromechanical and environmental characterization of ZTACH interconnections in five critical interfaces: e-textile to e-textile, e-textile to SMD resistor, Cu-Flex PCB/e-textile/SMD resistor to Polymerized liquid metal networks (Poly-LMNs), and e-textile to electronic module board (rigid and flex). The ZTACH demonstrates superior adhesion, low contact resistance, and robustness during electromechanical testing, which proves that the ZTACH can serve as a reliable, compliant medium between stretchable to stretchable/flex/rigid materials with high electrical conductivity. The environmental conditions showed no significant impact on direct contact joints; however, there was a permanent failure to via connections due to moisture absorption, which led to cracks/delamination.

Development of a 3D Microfluidic Platform for Dynamic Compression of Tumor Spheroids

Authors: Young Joon Suh[1], Mrinal Pandey[1], Tao Luo[1], Jeffrey E. Segall[2], and Mingming Wu[1]

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ABSTRACT

Solid tumor stress caused by the rapid growth of tumor cells and abnormality of vascular vessels has long been associated with a poor prognosis of cancer. However, understanding of tumor mechanics has been limited largely to single cells under static compressive loads. In this study, we have developed a high-throughput microfluidic platform to study tumor spheroids under well-controlled dynamic compressive loads.

This work is supported by the National Cancer Institute under grant R01CA221346.

POSTER ABSTRACTS BY LAST NAME

POSTER 1, ABOELKHEIR

Electrospun Polycyclodextrin Nanofibrous Membrane for the Scavenging of Organic Micropollutants from Aqueous Environment

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ABSTRACT
Electrospun nanofibers have a large specific surface area, a highly porous structure, and the design flexibility for surface functionalization that makes them a promising water treatment technique [1]. In the literature, there are numerous reports about the usage of nanofibrous structures in water filtration and wastewater treatment. Cyclodextrin (CD) molecules are used in separation and filtration systems because of their extraordinary capacity to trap organic pollutants by creating inclusion complexes [2]. We use electrospinning to create crosslinked polycyclodextrin (Poly-CD) molecules in the form of nanofibers. Poly-CD nanofibers can be used to scavenge contaminants from water thanks to their crosslinked CD structure that makes nanofibers insoluble in the aqueous medium [3]. Triclosan, an antibacterial agent, is so widely used that it is likely that 75 percent of the population in the United States has been exposed to it [4]. Triclosan is a major environmental hazard, thus finding a reliable way to remove it from aqueous systems is essential. In our study, we produced poly-CD nanofibers by the electrospinning of CD molecules in the presence of a cross-linker (i.e., 1,2,3,4-butanetetracarboxylic acid), followed by heat treatment to obtain insoluble poly-CD nanofibrous membranes. Here, poly-CD membranes were used for the removal of triclosan from water over time. The batch sorption experiments using UV Spectroscopy proved that the removal efficiency of triclosan was 88.3±2.07% for the 10 ppm triclosan solution. The sorption kinetics were studied using different models. The removal experiments showed the potential for using poly-CD nanofibrous membranes in the scavenging of triclosan from aqueous systems.

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POSTER 2, AGRAWAL

Survival of the Fittest: Fabrication and Use of Microfluidic Devices to Study the Consequences of Confined Migration in Cancer Cells

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Complete abstract on page 12

POSTER 3, AL-HAIDARI

Reliability Study of a Magnetically Aligned Anisotropic Conductive Epoxy for Interconnecting Stretchable Conductors to Various Surfaces

Authors: Riadh Al-Haidari, Behnam Garakani, Mohammed Alhendi
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Complete abstract on page 35

POSTER 4, COLE

Characterization of the Capacitance of Small Joseph Junctions from DC SQUID Resonances

Authors: Brad G. Cole, Eric M. Yelton, Britton L.T. Plourde
CNF Project Number: 1735-08
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Complete abstract on page 20

POSTER 5, D'ORAZIO

Development of Engineered Gas Diffusions Layers via Micro-Scale Manufacturing

Authors: Giancarlo D'Orazio, Sadeq Saleh, Joshua Krsek, Sadaf Sobhani
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Complete abstract on page 19

POSTER 6, D'ROZARIO

Thin-Film Multijunction Inverted Metamorphic Solar Cells with Light Management for Space Applications

Authors: Julia D'Rozario, Steve Polly, Rao Tatavarti, Seth Hubbard
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Complete abstract on page 13

POSTER 7, ENAKERAKPO

Fabrication of Flexible Antenna Using a Semi-Additive Process

Authors: Emuobosan Enakerakpo, D.J. Richmond, A. Umar, M. Alhendi, M.D. Poliks
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Complete abstract on page 24

POSTER 8, GUO

Current-Induced Switching of Thin-Film α-Fe2O3 Devices Imaged Using a Scanning Single-Spin Microscope

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ABSTRACT
We image the magnetic field 110 nm above an a-Fe2O3 thin-film device using a diamond nitrogen-vacancy (NV) center scanning microscope. We study the change of the sample's antiferromagnetic state induced by electric currents and magnetic fields at the nanoscale to learn the magnetic properties and switching mechanism of a-Fe2O3.

POSTER 9, HARPER

Bacterial Signaling System VxrAB is Activated by Diverse Mechanical Stimuli

Authors: Christine E Harper, Wenyao Zhang, Jung-Ho Shin, Ellen van Wijngaarden, Junsung Lee, Emily Chou, Peng Chen, Tobias Dörr, Christopher J. Hernandez
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CNF Principal Investigator: Christopher J. Hernandez
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Complete abstract on page 21

POSTER 10, HEAD

Engineering a Novel *in vivo* Preclinical Cancer Assay Platform

Authors: Tristen Head, Xianjun Ye, Natalya Tokranova, David Entenberg, and Nathaniel C. Cady
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Complete abstract on page 14

POSTER 11, HEDDERICK

Elucidating Metal Ion-Copolymer Coacervate Attachment Design Rules via Microcontact Printing of Self-Assembled Monolayers

Authors: Konrad Hedderick, Jessica Xiang, Bill Liu, Lara Estroff
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Complete abstract on page 23

POSTER 12, HUM

Role and Migration of Chromium Adhesion in Flash Lamp Annealed LTPS

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ABSTRACT

Flash lamp annealing (FLA) is a method of quickly crystallizing large areas of amorphous silicon, which is a promising alternative to existing low-throughput laser annealing in the fabrication of low temperature polycrystalline silicon for thin film transistors in display applications [1]. However, FLA tends to promote dewetting of silicon and randomized void formation during melt-phase crystallization [2]. Chromium underlayers have been successfully used [3] to promote silicon adhesion in thicker films, but there are many potential interactions between Cr and Si, such as the formation of silicides and generation of electrical trap states, that may inhibit future transistor performance. The mechanism and effects of these interactions are not yet understood. This work investigates the efficacy of chromium adhesion layers in silicon crystallization by FLA. Various thicknesses and configurations of amorphous silicon, thin chromium, and silicon dioxide barriers were deposited on glass and subjected to FLA. The resulting material was analyzed with electron and atomic-probe microscopy and found to contain a unique repeated pattern of voids, trenches, and SEM-bright spots at the nanometer scale. Energy-dispersive X-ray spectroscopy confirmed the distribution of chromium in crystallized films to be discrete Cr-rich agglomerations 50-70 nm in diameter, with little metallic contamination outside of these isolated areas.

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POSTER 13, IAIA

Mitigation of Quasiparticle Poisoning in Superconducting Qubits using Normal Metal Backside Metallization

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CNF Principal Investigator: Britton Plourde
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Complete abstract on page 31

POSTER 14, JAYARAMAN

Demonstrating the Combined Effects of Shear and Surface Roughness on Thrombosis in VADs

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Complete abstract on page 25

POSTER 15, KESSLER-LEWIS

Demonstration of a Monolithically Integrated Hybrid Electroabsorptive Modulator/Photovoltaic Device for Bidirectional Free Space Optical Communication at 1.55 µm

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Raymond Hoheisel2, Seth M. Hubbard1
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Complete abstract on page 28

POSTER 16, KIRTANIA

Diltiazem HCl/Hydroxypropyl-beta-Cyclodextrin Inclusion Complex Nanofibrous Webs as Fast-Dissolving Oral Drug Delivery System.

Authors: Ankit Kirtania, Asli Celebioglu, Tamer Uyar
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ABSTRACT

This study aimed to create a potentially fast dissolving orally dispensable drug delivery system through polymer-free electrospinning of Diltiazem HCl/Hydroxypropyl-ß-Cyclodextrin (HPßCyD) inclusion complex nanofibers. The 180% (w/v) concentrated aqueous solution of HPßCyD was used to form an inclusion complex with Diltiazem HCl in two different molar ratios, 1/1 and 1/2 (Diltiazem HCl/HPßCyD), which contained ~21% and ~12% (w/w) of Diltiazem HCl respectively and were spun into bead-free uniform nanofibers with an average fiber diameter ~170 nm. Ultimate Diltiazem HCl/HPßCyD-IC (1/1 and 1/2) nanofiber samples exhibited an excellent fast-dissolving character in correspondence to artificial saliva within ~10 seconds and the in-vitro release test recorded ~79% and ~82% release of Diltiazem HCl respectively from the samples within 30 seconds.

POSTER 17, LARSON

Fabrication of Cu Islands to Downconvert Phonons to Protect Superconducting Qubits

Authors: Clayton Larson, Vito Iaia, Jaseung Ku, Andrew Ballard, Eric Yelton, Britton Plourde
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CNF Principal Investigator: Britton Plourde
Department and Institution: Physics, Syracuse University
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High-energy particles impacting a superconducting qubit chip generate pair-breaking phonons that spread throughout the substrate and can create quasiparticles which can poison qubits from long distances away. Here we detail the fabrication process of normal metal islands on the backside of the chip which promote downconversion of phonons below the superconducting gap so they can no longer poison qubits.

POSTER 18, LIEHR

Reliability and Operation of HfOx ReRAM Devices and Neuromorphic Applications Under Real-World Conditions

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Complete abstract on page 22

POSTER 19, LIU

Microfluidic Platform to Study Multi-Resource Controlled Growth of Photosynthetic Microorganism for a Sustainable Future

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Photosynthetic microorganisms (PSMs) such as cyanobacteria and microalgae are emerging players in developing biotechnology for a sustainable future, either creating clean energy or maintaining a balanced ecosystem. To understand how complex environmental parameters, such as nutrients and light, regulate PSM growth, we created a microfluidic platform with well controlled environmental conditions, and obtained cell growth dynamics and growth kinetics from real-time epi-fluorescence imaging. Our work revealed synergistic effects of multiple environmental factors on the growth of a model algal.

POSTER 20, LUO

Fabrication of Nanophotonic Optical Cavity Device from Inverse Design

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Complete abstract on page 30

POSTER 21, MAHAJAN

Design and Development of InAs Quantum Dots in GaAs Matrix — A Novel Scintillator Material with Monolithically Integrated InGaAs Photodetector

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POSTER 22, MATHKARI

Influence of Oxygen Exchange Layer and Dopants on Transition Metal Oxide ReRAM Performance

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Complete abstract on page 26

POSTER 23, MCBROOM

Coupling Transmon Qubits Through a Left-Handed Metamaterial Ring Resonator Bus

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Complete abstract on page 16

POSTER 24, MCDONOUGH

Ballistic Switching in Y-Shaped Nanostructures with Independent MOS Gates

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POSTER 25, MOKHTARE

Selective Single-Beam Acoustic Tweezers for Cell Manipulation

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POSTER 26, NORRIS

Optically Powered Bubble-Propelled Microswimmers

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Complete abstract on page 32

POSTER 27, OESCHGER

Waxed Printed Paper Microfluidics for Antibiotic Susceptibility Testing

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ABSTRACT
Antibiotic resistance is the second leading infectious disease worldwide, causing more deaths than HIV or malaria[1]. Estimates suggest that by the year 2050, antibiotic resistance will cause more than 10 million deaths worldwide, primarily in low and middle income countries[2]. We created the Bac-PAC or Bacterial Paper Antibiotic Susceptibility Chip to enable personalized antibiotic profiling. The assay is made using a wax printer on chromatography paper with bacteria samples loaded in the center. Bacteria diffuse radially and are exposed to three antibiotics at three concentrations in the outer wells. Colorimetric cell viability dye is converted by replicating cells to indicate that the antibiotic was not sufficient to prevent growth. The user receives in a simple readout after overnight incubation whereby more color change equals more resistance. Each test costs $0.75 and is run in a rechargeable coffee mug when a consistent power source in unavailable. 84% accuracy has been demonstrated with Carbapenem-resistant Enterobacterales and the technology is being adapted for gonorrhea. Implementation of such an assay could allow for quantification of resistance in low income countries and enable personalized prescriptions to reduce further spread and treatment failures.

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POSTER 28, PARK

Polymer Nano/Microfiber as Solar Reflector or Absorber

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Complete abstract on page 34

POSTER 29, POWELL

Indium Gallium Zinc Oxide Thin Film Transistor Backplane Integration for µLED Flat-Panel Display

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ABSTRACT
Display technologies have continuously evolved since the advent of cathode ray tube (CRT) displays in the early 1900s. Thanks to modern advancements, current display thicknesses are on the order of centimeters and their area has increased 10-fold. Modern flat panel display (FPD) systems consist of a TFT backplane that controls the filtering of a backlight or the modulation of emissive devices such as OLED or microLEDs (µLEDs). Due to their small size, µLEDs provide higher resolution and better contrast than previous display technologies, and are an active topic in FPD research and development. The primary focus of this work is the process integration of Indium Gallium Zinc Oxide (IGZO) TFTs as an active-matrix backplane for row/column addressing. A single pixel is composed of a µLED driven by an arrangement of two transistors and a storage capacitor. The pixels are then arrayed on a glass substrate to control monochrome and full color (RGB) displays from 1x1 cm (50 x 50 pixels) up to 7.6 x 7.6 cm (380 x 380 pixels). Optimization of circuit parameters considering size and scan frequency were modeled using existing TFT and µLED electrical device compact models. New process parameters and procedures were established for the hybrid integration of µLEDs with the IGZO TFT backplane. System integration with control circuitry will facilitate demonstration of a new interconnect strategy for µLED display modules.

POSTER 30, REYNOLDS

Microscopic Robots Controlled by Onboard CMOS Electronics

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ABSTRACT
Robots—autonomous systems that combine digital information processing/control with mechanical actuation—are revolutionizing everything from health care to transportation. Microscopic robots have similar potential to revolutionize fields from medicine to environmental remediation [1-5]. However, existing microscopic robots lack onboard digital control electronics to allow them to act autonomously like their macroscopic counterparts because combining microactuators and microelectronics in a fully releasable platform is a major unsolved technology integration challenge [3-5]. Here we report a fabrication process for meeting this challenge and show the first microscopic robots with onboard complementary metal oxide semiconductor (CMOS) electronics. The resulting robots are completely untethered, 100-250 micrometers in size, are powered by light, and walk autonomously at speeds greater than 10 micrometers per second. We also demonstrate a microscopic robot that responds to an optically delivered command. This work paves the way for microscopic robots that perform complex functions, respond to their environments, and communicate with the outside world.

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POSTER 31, RICHMOND

Additive Fabrication of Aluminum Antennas on Flexible Glass

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Complete abstract on page 11

POSTER 32, SINDERMANN

Progress on Substrate Reuse Using Sonic Lift-Off for GaAs-Based Photovoltaics

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GaAs-based solar cells were grown by metalorganic vapor phase epitaxy on spalled substrates and fabricated at RIT. Electrical characterization and profilometry data will be presented to illustrate progress toward substrate reuse enabled by acoustic-assisted spalling.

POSTER 33, SUH

Development of a 3D Microfluidic Platform for Dynamic Compression of Tumor Spheroids

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Complete abstract on page 36

POSTER 34, UME

Phase Change Memory (PCM) with Multilevel Resistance States Based on Group III-Sb Binary Alloys

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POSTER 35, WANG

Cilia Metasurfaces for Electronically Programmable Microfluidic Manipulation

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POSTER 36, XIE

Magnetic Field Sensor Based on Spin-Hall Nano-Oscillators

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ABSTRACT
Spin-Hall nano-oscillators (SHNOs) are magnetic bilayer devices that convert dc charge current to microwave frequency magnetic oscillations under external magnetic field. The oscillation frequency of SHNOs is tuneable with dc current and external magnetic field, enabling their applications as agile microwave signal generators and nanoscale magnetic sensors. We fabricated SHNO devices with four nano-constrictions in an array and demonstrated their ability to sense both static and low frequency magnetic fields up to kHz, with a noise floor of less than 1uT/sqrt(Hz) above 50 Hz.

POSTER 37, ZHAO

Overcoming Acoustoelectric Material Limits of Piezoelectric Resonators using Epitaxial Aluminum Nitride

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