POLYTECHNIC INSTITUTE

STATE UNIVERSITY OF NEW YORK

2022 Research Report

OFFICE OF RESEARCH
SUNY POLYTECHNIC INSTITUTE

March 1, 2023

Dear Friends –

Congratulations to the faculty, staff and students of SUNY Polytechnic Institute on the success of their research, scholarly and creative work during 2022. SUNY Poly prides itself on the diversity of the research and creative activities performed across our five colleges, spanning both our Albany and Utica campuses. This report is organized by colleges, which include the College of Arts & Sciences, College of Business, College of Engineering, College of Health Sciences, and College of Nanoscale Science & Engineering. The faculty at SUNY Poly are committed to training the next generation of engineers, scientists, humanitarians, health care professionals, entrepreneurs, and leaders capable of developing the next generation of emerging solutions. Research and creative activities at SUNY Poly range from semiconductor manufacturing to adaptive behavior and cognition, power electronic design, the study of lemurs in Madagascar, data mining, and more. Our world-class faculty perform much of their research with the assistance of undergraduate and graduate students, providing experience in basic research and solving real-world problems. It is my sincere hope that you enjoy reviewing the exciting innovative research and activities that our faculty completed during 2022.

Sincerely,

Nathaniel Cady
Interim Vice President of Research
SUNY Polytechnic Institute

CONTENTS

College of Business

CONTENTS

College of Engineering

CONTENTS

College of Health Sciences

CONTENTS

College of Nanoscale Science & Engineering

CONTENTS

College of Nanoscale Science & Engineering (cont.)

POLYTECHNIC INSTITUTE
STATE UNIVERSITY OF NEW YORK

College of
Arts + Sciences

OFFICE OF RESEARCH
SUNY POLYTECHNIC INSTITUTE

OFFICE OF RESEARCH
SUNY POLYTECHNIC INSTITUTE

Understanding the neurobiological determinants of parental behavior: When parents see their child, how does their brain see their child?

Project Summary

This study investigated whether mothers' hemispheric activation patterns while viewing images of their child are similar to the activation patterns while viewing positive *or* negative images. Central to this project is the hypothesis that parental behavior is guided not only by consciously recognizing their child's needs but also by neurologically identifying their child as a *target* to approach to or withdraw from, following the well-established characterization of left (approach/positive) vs. right (withdrawal/negative) hemispheric activation patterns. No research has examined the neurological indicators of parental sensitivity. Secure/insecure parents' EEG response to their child's images are expected to be significantly associated with their EEG response to positive/negative images. Mothers' attachment security will be judged by the well-validated, Adult Attachment Interview (AAI) and standard questionnaires, including a commonly utilized depression scale questionnaire, and temperament questionnaires for the adult (mother) and for the child. This project is innovative because EEG data may help explain certain parental behaviors that cannot be fully explained by existing parental behavioral measures

Highlights

• Research has shown that mothers who have secure states of mind with regard to their own attachment experiences are likely to recognized their children needs correctly and attend their children's needs sensitively and adequately. These children are expected to develop optimally.

• Mothers who have insecure states of mind regarding their own attachment experiences may not view their children's needs correctly and thus may not attend and fulfill their children's needs. These children's developmental outcomes are likely to be less optimal.

• Where do these differences come from? What would make them want to, or not want to, attend to their child? Examining their brain activation patterns, as were designed in this study, may shed light in better understanding these interactive behaviors.

• Once we understand how mothers' brains see their child, predicting their behaviors toward their child, appropriate intervention programs can be offered to those who can benefit from these programs to ensure their children's well-being.

Publications

Weldon, R. B., **Behrens, K. Y**., Jones, D. K., Drake, E. A., & Fragetta, J. R. (2022). Anxiety and Avoidance in Close Relationships Are Associated with Responses to Negative and Positive Stimuli, *Psychological Reports*, Advance online publication.

Note: This publication is based on the preliminary data obtained from a pilot study conducted to test the effectiveness of the EEG study design. It was necessary because of the novelty of this study. The main data are expected to be analyzed within 2023. Based on a set of new analyses, two new manuscripts will be submitted for publication

Acknowledgements

Kazuko Y. Behrens

behrenk@sunypoly.edu

The first longitudinal study of intergenerational transmission of attachment security in Japan

Project Summary

- This is the first longitudinal study in Japan to examine the continuity of attachment security over the 5-year period. We also explored whether mothers' attachment security assessed when children were one year of age would still show the correlates to their children's attachment security five years later. This is the second 6-year olds' attachment data collected in Japan, using the Main-Cassidy reunion procedure, more than a decade after the first Adult Attachment Interview (AAI)-6th-year reunion data were reported (Behrens et al., 2007). This is the first study, however, that tested whether mothers' states of mind with respect to attachment assessed five years earlier could still be meaningfully related to their now 6-year-olds' attachment security.

- No continuity of child attachment security assessed at age one and security assessed at age six was found. However, mothers' secure status significantly matched to their children's secure patterns. Although the sample size has reduced over the 5-year period, this study makes important contributions to the field because this is the first longitudinal attachment study in Japan but also because mothers' states of mind with respect to attachment (assessed by the AAI) have maintained their significant correlates to children's attachment security at age six. This study has demonstrated the continuous effect of mothers' states of mind in fostering or maintaining the attachment relationship. Cultural effects on the findings, utilizing the measures developed in western cultures in non-western culture, will be further investigated and discussed.

Highlights

- Attachment theory, one of the most influential developmental theories, led to develop a number of measures of attachment. Most notably the Strange Situation Procedure (SSP) to assess attachment security of infants and the Adult Attachment Interview (AAI) to assess adults' states of mind with respect to attachment, known as the gold standard measures of attachment.

- These measures produced numerous studies but were mostly conducted in the U.S. and western Europe. Attachment studies in non-Western cultures, especially in Asia are still scarce. Thus, to further validate this evolutionary-based attachment theory and attachment measures, devised in the US., more studies in non-Western cultures must be conducted.

- Therefore, this study is important because this is the first follow-up study in Japan that investigated the AAI-SSP association five years earlier and examined whether the quality of the mother-child attachment relationships remained stable.

- Interestingly, child's attachment security did not retain for five years, but the match between the mother's attachment security and the child attachment security remained significant.

Publications

Behrens, K. Y., Kondo-Ikemura, K., & Jones-Mason, K. (in preparation). *The first longitudinal study of intergenerational transmission of attachment security in Japan*.

Acknowledgements

Kazuko Y. Behrens

behrenk@sunypoly.edu

Information Geometric Complexity of Pure and Mixed Qubit Geodesic Paths on Curved Manifolds

OFFICE OF RESEARCH
SUNY POLYTECHNIC INSTITUTE

Project Summary

It is known that mixed quantum states are highly entropic states of imperfect knowledge (i.e., incomplete information) about a quantum system, while pure quantum states are states of perfect knowledge (i.e., complete information) with vanishing von Neumann entropy. In this project, we propose an information geometric theoretical construct to describe and, to a certain extent, understand the complex behavior of evolutions of quantum systems in pure and mixed states. The comparative analysis is probabilistic in nature, it uses a complexity measure that relies on a temporal averaging procedure along with a long-time limit, and is limited to analyzing expected geodesic evolutions on the underlying manifolds. More specifically, we study the complexity of geodesic paths on the manifolds of single-qubit pure and mixed quantum states equipped with the Fubini-Study metric and the Sjöqvist metric, respectively. We analytically show that the evolution of mixed quantum states in the Bloch ball is more complex than the evolution of pure states on the Bloch sphere. We also verify that the ranking based on our proposed measure of complexity, a quantity that represents the asymptotic temporal behavior of an averaged volume of the region explored on the manifold during the evolution of the systems, agrees with the geodesic length-based ranking. Finally, focusing on geodesic lengths and curvature properties in manifolds of mixed quantum states, we observed a softening of the complexity on the Bures manifold compared to the Sjöqvist manifold.

Highlights

- Schematic description of physical systems in pure and mixed quantum states in terms of purity, von Neumann entropy, and temperature.

State	Purity	Entropy	Temperature
Pure	Maximal	Minimal	Low
Mixed	Not maximal	Not minimal	High

- Information geometric complexity of geodesic paths on Fubini-Study and Sjöqvist manifolds.

State	Metric	Complexity
Pure	Fubini-Study	Lower
Mixed	Sjöqvist	Higher

- Path length and information geometric complexity of geodesic paths on Sjöqvist and Bures manifolds.

Metric	Path Length	Complexity
Sjöqvist	Longer	Stronger
Bures	Shorter	Weaker

Publications

- C. Cafaro and P. M. Alsing, *Complexity of pure and mixed qubit geodesic paths on curved manifolds*, Phys. Rev. **D106**, 096004 (2022).

- C. Cafaro, S. Ray, and P. M. Alsing, *Complexity and efficiency of minimum entropy production probability paths from quantum dynamical evolutions*, Phys. Rev. **E105**, 034143 (2022).

Acknowledgements

Carlo Cafaro

https://sunypoly.edu/faculty-and-staff/carlo-cafaro.html

cafaroc@sunypoly.edu

Project Summary:
We use generalized continuum theories and structure preserving numerical discretizations to model elastic (Cosserat) shells.

Many phenomena in physical, engineering, and biological systems are modeled by elastic shells.

From a mechanics perspective, elastic shells can be modeled as two-dimensional elastic bodies with a reference shape not necessarily flat and that can withstand both membrane (in plane) and bending (out-of-plane) effects.

In contrast to classical continuum theory where the smallest constitutive element of media is the point-particle, Cosserat theory, takes shell media to be a two-dimensional medium with rotating micro(polar) structure, that has translational (displacement) and rotational (microrotation) degrees of freedom, i.e. each 'grain' transforms like a rigid-body.

Differential geometric Cosserat theories define a Cosserat body as the principal frame bundle of a material body. The material response is specified by the deformation of the base manifold and the gradients (jets) of the deformable frame attached to each point.

Cosserat shell models could be the key for deriving structure preserving numerical discretizations of shell elasticity.

Highlights

- Fully structure preserving discretization schemes for shell elasticity have not yet been discovered. A major challenge is that it requires deep concepts from mathematics and from theoretical mechanics.

- A long-term goal is to include deformation of the retina or of other parts of the eye which can be modeled as a thin shell. This is a nice application framework to investigate the potential of the advances of structure preserving numerical methods.

- Both research areas (shells and retina) have lead to projects in advanced undergraduate mathematics courses and for undergraduate research.

Acknowledgements

Andrea Dziubek

dziubea@sunypoly.edu

http://people.sunypoly.edu/~dziubea

Non-inertial torques and the Euler equation

Project Summary

Despite the monumental power of classical mechanics (within its limited domain of modest speeds and macroscopic scales), one area in this domain that deserves further contemplation is continuum mechanics which deals with the classical dynamics of real-life rigid objects with finite size and dimension (such as the spinning top shown in Fig. below). The standard approach to the dynamics of objects in continuum mechanics, which is known to work very well, is to invoke the Euler equation formulated by Leonhard Euler (1707-1783). At first, this equation seems to be a straightforward consequence of the Newton's laws of motion, however, a deeper look raises a subtle question which has not been sufficiently investigated in the literature. This subtle question potentially renders the Euler equation to be an axiomatic equation rather than a clear cut consequence of the laws of classical mechanics. As a result, understanding the Euler equation from different perspective becomes a crucial endeavor. One such study is recently conducted by A. Fariborz in which it is shown how Euler equation can be understood on the basis of non-inertial torques, a complete mathematical proof of which is given in a recent paper published by A. Fariborz in the European Physical Journal Plus [1].

Highlights

The work presented in this paper is a novel derivation of Euler equation based on non-inertial torques which has not been presented in the past literature. This method provides a potential alternative to the formulation of Euler equation, written by an inertial observer in the fixed coordinate system (xyz system in Fig. below). The method of this paper allows applying this equation directly by the non-inertial rotating observer (such as the one in $x''y''z''$ system in Fig. below), if the non-inertial torques are properly taken into account. The mathematical details include vector and tensor analysis of Euler equation in a manner that disentangles the characteristics of rigid body from its kinematical formulation. This provides an alternative approach to rotational dynamics of rigid bodies such as in the example shown below.

Publications

A. Fariborz, *"Non-inertial torques and the Euler equation,"* Eur. Phys. J. Plus, **137**:1343 (2022); https://doi.org/10.1140/epjp/s13360-022-03558-x.

Amir Fariborz

fariboa@sunypoly.edu

Elementary Particle Physics & Hadronic Physics

Dept. of Math & Physics, https://sunypoly.edu/physics

Chiral nonet mixing in πη scattering
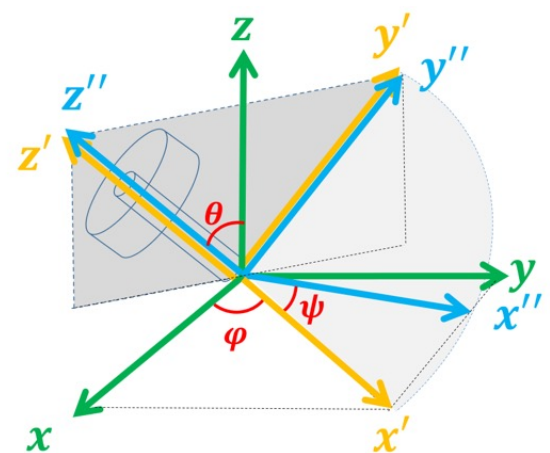
Project Summary

At this stage in the evolution of the Universe (about 14 billion years after the big bang) there are four fundamental forces in action that cause interactions among the constituents of matter: Gravity, electromagnetic, strong and weak nuclear forces. The last two forces are confined within the nucleus of atoms (distances around 10^{-15} m or smaller) and are traditionally referred to as "nuclear forces." Strong nuclear force is responsible for keeping the nucleus intact by bonding its protons and neutrons together. The protons and neutrons are members of a large family of composite particles called hadrons, and all of these family members are made of elementary particles called quarks. The theory that describes the strong interaction of quarks is called Quantum Chromodynamics (QCD), according to which, the quarks engage in strong interaction by exchanging mediating particles called gluons.

In this paper [1] published in the European Physical Journal C the generalized linear sigma model of QCD (developed by Fariborz et al) is applied to the scattering of two special type of hadrons called pion (π) and eta (η). Understanding the quark substructure of scalars sheds light on the strong interaction of quarks and gluons. This recent work has confirmed that the light scalar mesons contain a significant four-quark component, a feature that puts scalar mesons in the challenging category of exotic hadron spectroscopy.

Highlights

The scattering of π and η is calculated through the Feynman diagrams shown below. The intermediate states a_j and f_j can be seen in the figure :
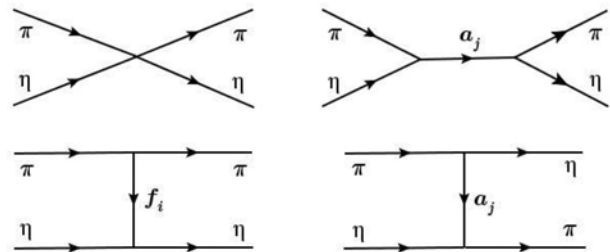
The results of this calculation are in close agreement with experiment. One of these results is shown in Fig. below in which the highlighted band is the experimentally measured mass of the intermediate state $a_0(980)$, and is compared with its theoretical prediction in this paper:

Publications

A. Fariborz, S. Zarepour, E. Pourjfarabadi and S.M. Zebarjad, *"Chiral nonet mixing in πη scattering,"* Eur. Phys. J. C **82**:1133 (2022), https://doi.org/10.1140/epjc/s10052-022-11103-4

Amir Fariborz

fariboa@sunypoly.edu

Elementary Particle Physics & Hadronic Physics

Dept. of Math & Physics, https://sunypoly.edu/physics

The Functions of Yawning
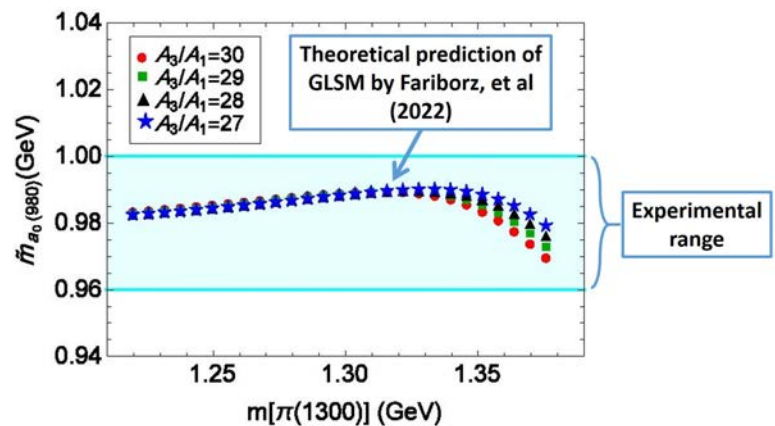
Project Summary

- Much of the ongoing research in the Adaptive Behavior & Cognition Lab is aimed at improving our understanding of the proximate and ultimate mechanisms of yawning (see below). Yawning is characterized by a powerful gaping of the jaw with inspiration, a temporary period of peak muscle contraction, and a passive closure of the jaw with shorter expiration. Evolutionarily conserved, yawning has been observed in all classes of vertebrates and is even contagious among humans and some other highly social species. Despite its ubiquity, the functions of this basic, everyday behavior are relatively unknown.
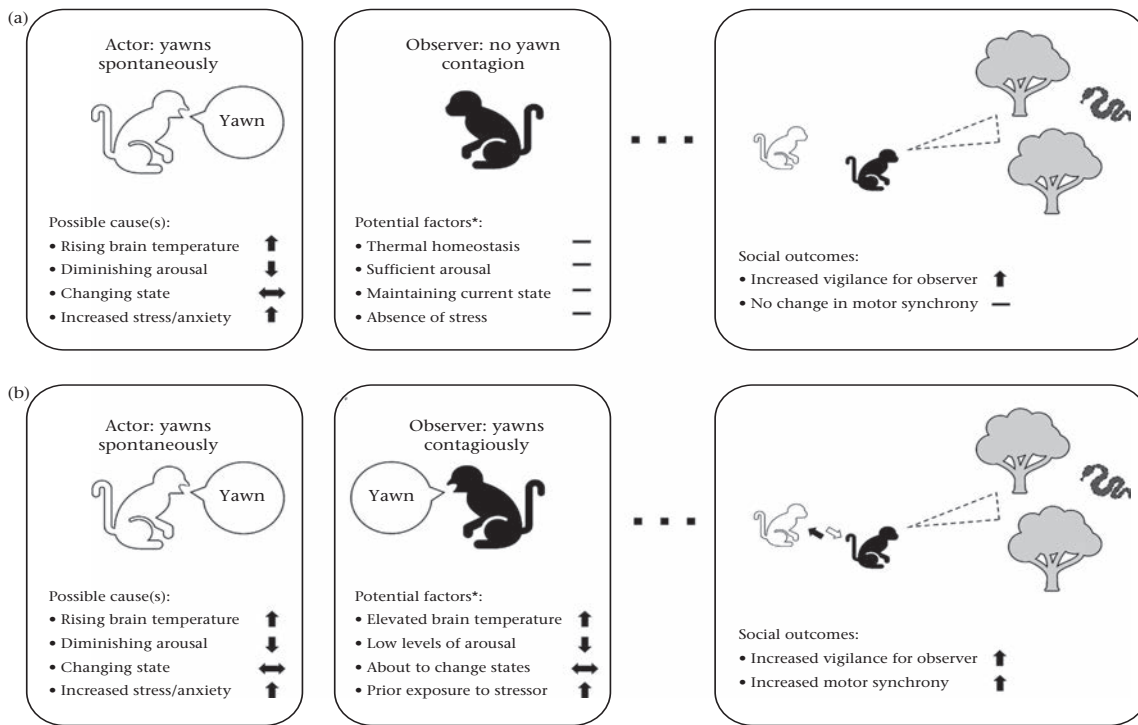
Recent Publications

- Gallup, A.C. (2022). The causes and consequences of yawning in animal groups. *Anim. Behav.* 187, 209-219.
- Gallup A.C., & Meyers K. (2021). Seeing others yawn selectively enhances vigilance: an eye-tracking study of snake detection. *Anim. Cogn.* 24, 583-592.
- Gallup, A.C., Kret, M., Eldakar, O.T., Folz, J.* & Massen, J.J.M. (2021). People that score high on psychopathic traits are less likely to yawn contagiously. *Scientific Reports* 11, 23779.
- Massen J.J.M. et al. (2021). Brain size and neuron numbers drive differences in yawn duration across mammals and birds. *Comm. Biol.* 4, 503.
- Gallup A.C. (2021). On the link between emotional contagion and contagious yawning. *Neurosci. Biobehav. Rev.* 121, 18-19.

Acknowledgements

- Key collaborators: Jorg J. M. Massen (Utrecht University) and Omar Tonsi Eldakar (NSU Florida)

Andrew C. Gallup   https://sunypoly.edu/research/andrew-c-gallup.html

gallupa@sunypoly.edu

Project Summary

This project examines an archive of Time magazine containing 3,389 issues ranging from 1923 to 2014, focusing on images of human faces. We extracted faces from this archive, and tagged them by visual characteristics, including gender, race, age, expression, and context. The research examines how representations of human faces evolved and reveals relationships between the images and their corresponding socio-political contexts. For example, we found that the percentage of female faces peak during eras when women have been active in public life, and wane in eras of backlash against women's rights. The goal is to develop a web resource that makes our data and research findings accessible to the public through visualizations and interactive narratives.

Highlights

- We have developed a page that lets users explore over 8700 faces from our archive using an AI clustering algorithm developed at Yale's Digital Humanities lab.
  https://magazineproject.org/sandbox/pixplot/output/

- We have developed a page that lets users interactively explore our data to reveal trends over time.
  https://magazineproject.org/sandbox/trendlines/

Publications

"Dataset: Faces extracted from Time Magazine 1923-2014", Ana Jofre., Berardi, V., Bennett, C., Reale, M., Cole, J. Journal of Cultural Analytics. March 16, 2020, https://doi.org/10.22148/001c.12265 (2020)
"What's in a Face? Gender representation of faces in Time, 1940s-1990s", Ana Jofre., Cole, J., Berardi, V., Bennett, C., Reale, M. Journal of Cultural Analytics. March 16, 2020 https://doi.org/10.22148/001c.12266 (2020)

"Crowdsourcing Image Extraction and Annotation: Software Development and Case Study" Ana Jofre, Vincent Berardi, Kathleen Brennan, Aisha Cornejo, Carl Bennett, and John Harlan. Digital Humanities Quarterly Vol 14, Issue 2 (2020)

"A Cultural Analytic Study of Facial Imagery in Time Magazine 1923–2014", Ana Jofre and Josh Cole. In review.

Acknowledgements

Ana Jofre
https://anajofre.com/
jofrea@sunypoly.edu

Project URL: https://magazineproject.org

Beta release:
https://magazineproject.org/sandbox/

CITE: The Collaborative Interactive Table for Education

Project Summary

- The Collaborative Interactive Tabletop for Education (CITE) allows users to manipulate on-screen data visualizations through the manipulation of hand-held tabletop objects. The system includes sound and touch features that considers users with visual impairments.

- Research has shown that interacting with tangible user interfaces (TUI), such as CITE, enhances collaborative behavior, strengthens learning, and improves user experience. While many TUI rely on specialized hardware, our approach is to create a system, a set of verified instructions along with software packages, for adapting standard computer hardware into a highly customizable tangible interactive tabletop.
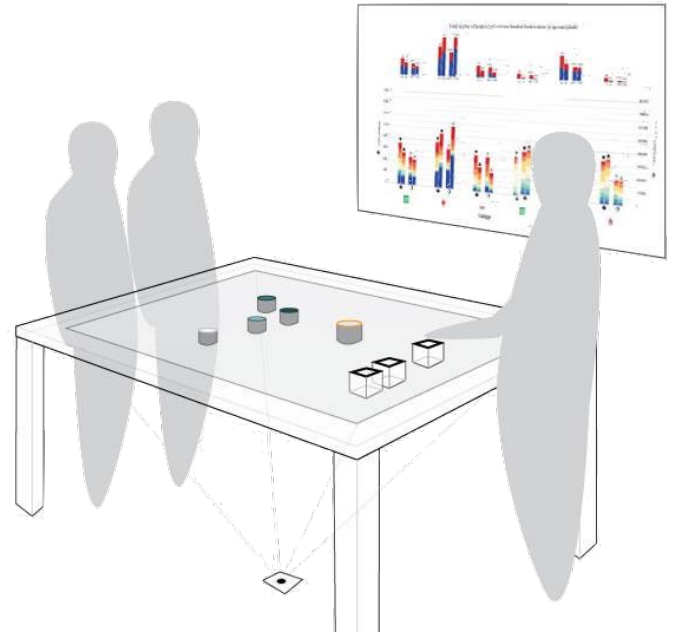
Publications

"Desarrollo de Herramientas de Educación Convivencial en el Siglo XXI." Jofre, Ana, Kristina A. Boylan, and Ibrahim Yucel. Espacio, Tiempo y Educación 9.1 (2022): 6-26.

"Countering Patterns of Educationalization: Creating Digital Tools for Critical Evidence-based Thinking," Ana Jofre, in Schooling through Time and Place: Religion, Politics, Technology and Educationalization, pp.355-382 (2019) Toronto: University of Toronto Press.

"Manipulating Tabletop Objects to Interactively Query a Database" Jofre, A., Szigeti, S., Tiefenbach-Keller, S., Dong, L.-X., Diamond, S. (2016) CHI'16 Extended Abstracts (Chi 2016 San Jose May 7-12).

Acknowledgements

Ana Jofre

jofrea@sunypoly.edu

https://anajofre.com

Project url: https://datablocks.org/

Nova Explosion Mechanism and its Gamma-ray signature

Project Summary

- Nova is the thermonuclear runaway on the surface of a white dwarf. In a binary system, a white dwarf accretes H-rich matter from its main-sequence companion star. The matter is unstable can lead to an outburst of the surface matter.

- Classical nova models predict that these outburst can release an observable amount of gamma-ray photons. The prediction is in tension with recent gamma-ray surveys (e.g. INTEGRAL/SPI) that no gamma-ray from novae in the Galaxy is observed.

- We built a new set of nova models using the stellar evolutionary code MESA. We show that the updated microphysics (radiative opacities) can significantly reduce the level of gamma-ray signal, which conforms with the observational constraints. We also show that these gamma ray signals and its implied chemical composition can reveal the progenitor of these novae.

Highlights
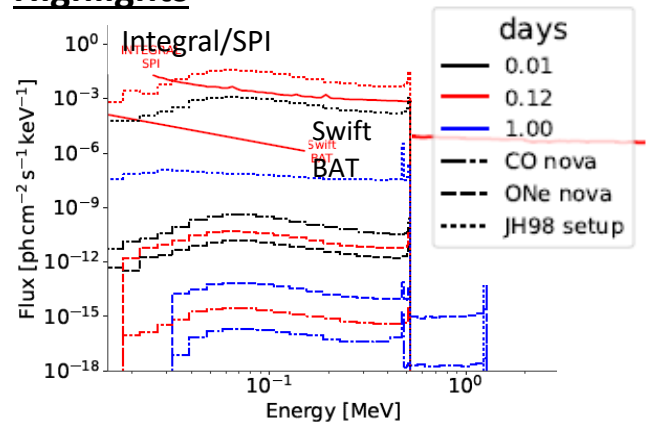
The new models are consistent with the observational limits posed by the telescopes.
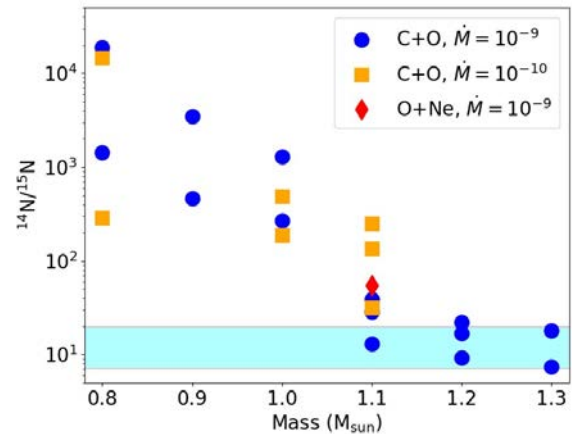
Matching the data from planetary nebular K4-47 by our nova catalogue.

Publications

- Shing-Chi Leung and Thomas Siegert, "Gamma-ray light curves and spectra of classical novae", Monthly Notices of the Royal Astronomical Society, 516, 1008 (14 pages), 2022

Acknowledgements

Shing Chi Leung

leungs@sunypoly.edu

https://sunypoly.edu/faculty-and-staff/shing-chi-leung.html

https://sites.google.com/view/scleung

Project Summary

- Exploration of nostalgic and existential media, to understand their encouragement or discouragement of adaptive and reflective media consumers.

Highlights

- *Existential Science Fiction*, Lexington Press (2022).

- *Subjective Experiences of Interactive Nostalgia* (editor), Peter Lang Publishing, (2019).

- *Nostalgic Generations and Media: Perception of Time and Available Meaning*, Lexington Press (2017).

- *Mediated Nostalgia: Individual Memory and Contemporary Mass Media*, Lexington Press (2014).

Publications

- "*Death Stranding,* Connections, Timefall, and Our Interactive Past," In *END GAME: Apocalyptic Video Games, Contemporary Society, and Digital Media Culture* (Editors DiTommaso, Crossley, Lockhart, and Wagner), De Gruyter Oldenbourg (forthcoming 2023).

- "The Fucntions of Contemporary Mediated Nostalgia," In *Routledge Handbook on Nostalgia* (Editors Becker, and Trigg), Routledge (forthcoming 2023)

- *Existential Science Fiction*, Lexington Press (2022).

Ryan Lizardi

lizardr@sunypoly.edu

OFFICE OF RESEARCH
SUNY POLYTECHNIC INSTITUTE

Assessing the importance of CpG sites in the promoter regions of genes related to aging.

Project Summary

- In collaboration with Dr. Christopher Faulk of the University of Minnesota and Dr. Lauren Endres of SUNY Polytechnic Institute I am leading a project to investigate CpG Density in the promoter regions of genes associated with aging and life-long health in multiple primate species across three age cohorts (juvenile, sexually mature, elderly). The goal of this research, which is funded by an R21 from the National Institutes of Health/National Institute on Aging (NIH/NIA) is to determine the importance of CpG sites in the buffering of these regions, which are effectively "on-off switches" for genes, against things like aging-related genetic mutations. To this end over the past year we have been collaborating with the University of Wisconsin to sequence the genomes of the individual primates, with data analysis slated to begin this year. This will building on a computational project from several years ago.

Highlights

- This project promises to enrich current understanding into the genetic mechanisms that underlie the aging process.

- We are generating a sizeable and high-coverage dataset that should be a fountain of publications and future grant-writing, in addition to the publications that will stem from the original proposal.

- The ultimate goal is an application for an R01 to expand this research outside of the primate radiation to other species, in particular very long-lived organisms like Galapagos tortoises and bowhead whales, elephants, Greenland sharks, etc.

Acknowledgements

https://sunypoly.edu/news/news-release-suny-polytechnic-institute-announces-more-105000-funding-national-institute-aging.html

Preliminary publication from 2018 that led to the grant: https://pubmed.ncbi.nlm.nih.gov/29661983/

More details on the initial project here: file:///Users/mclaina/Downloads/2018-04-genes-unrecognized-role-aging-intervention.pdf

Adam McLain

mclaina@sunypoly.edu   https://sunypoly.edu/faculty-and-staff/adam-mclain.html

OFFICE OF RESEARCH
SUNY POLYTECHNIC INSTITUTE

Determining the species status and evolutionary history of the isolated Nosy Hara dwarf lemur population

Project Summary

- In the summer of 2022 I led a research expedition in coordination with the University of Antananarivo and MICET to the remote, uninhabited island of Nosy Hara off the northwestern coast of Madagascar for the purpose of collecting DNA samples from a cryptic and isolated population of dwarf lemurs. Over the course of the expedition we collected fecal and hair samples, photographed the animals, and explored the island ecosystem. Nosy Hara was formerly part of a peninsula that became an island after the Last Glacial Maximum and the subsequent rise of sea level. It is likely these animals have been on the island since this time. In the coming year I will be sequencing the genomes of several animals using Nanopore sequencing technology for analysis and comparative phylogenetics with other dwarf lemur populations, to determine their species status and population-wide genetic diversity.

Highlights

- This will be the first time this population of lemurs have had their genome sequenced and analyzed.

- They may represent a new species or subspecies.

Acknowledgements

Adam McLain

mclaina@sunypoly.edu

www.thelemurguy.net

Sequencing the genome of Pallas's cat, an Asian wild cat species

Project Summary

- Working in collaboration with the University of Minnesota, the University of Miami, the Miller Park Zoo and the Utica Zoo we sequenced the genome of Pallas's Cat (*Otocolobus manul*), also called a manul cat. Pallas's cat is a small wild cat endemic to Asia and predominantly found at higher altitudes. They are solitary hunters and a part of the taxonomic family Felidae along with other cats.

Highlights

- This study will provide key genomic information about the Pallas's cat, and also resolves existing questions about the relationships between species in the taxonomic subfamily family Felinae. Felinae are the smaller cats, and this subfamily also includes the domesticated cat *Felis catus* as well as species like the ocelot, cheetah bobcat, lynx and cougar.

Tater the Pallas's cat, photo courtesy of the Utica Zoo
https://www.uticazoo.org/pallasscat/

Publications

- https://www.biorxiv.org/content/10.1101/2022.11.30.518596v2.full.pdf

- Chromosome-level, nanopore-ony genome and allele-specific DNA methylation of Pallas's cat, *Otocolobus manul.* Flack, N, Drown, M, Walls, C, Pratte, J, McLain, Adam and Faulk, C. *In press*. bioRxiv, 2023. (link is to preprint, in-press not yet posted as this paper just finished review this week).

Acknowledgements

- Thanks to the Tate, the Pallas's cat from the Utica Zoo for generously allowing us a sample of his genomic DNA.

Adam McLain

mclaina@sunypoly.edu   https://sunypoly.edu/faculty-and-staff/adam-mclain.html

Mechanisms of production and perception of chemical signals in social insects

Project Summary

Social insects live in large colonies and by their sheer numbers produce a significant ecological and economic impact. Social structure of these colonies relies on efficient communication achieved via chemical signals, with queen pheromones being especially important as they regulate reproductive division of labor. These signals are still poorly studied in most species and their physiological basis is still largely unknown. My research program endeavors to uncover the physiological mechanisms regulating the synthesis of chemical signals, the role of cognitive mechanisms in their perception and the divergence of these mechanisms across species with different social structure.

Highlights

- Fertility signaling in insects is regulated by conserved mechanisms that predate insect sociality and operate across exocrine sources.

- In social insects these mechanisms have been co-opted to serve a social communication function.

- Chemical signals operate only in social context suggesting a role for cognitive mechanisms
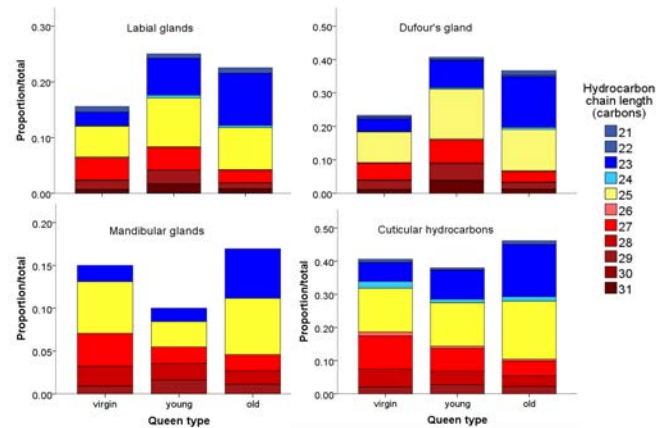
Fig.1 Chain-length profile of hydrocarbons across exocrine sources changes consistently with age in bumblebee queens.

Publications

Orlova M., Villar, G., Hefetz, A., Millar, J., & Amsalem, E., A gland of many uses: a diversity of compounds in the labial glands of the bumble bee Bombus impatiens suggests multiple signaling functions. Journal of Chemical Ecology, 48.3 (2022): 270-282..

Orlova, M. and Amsalem, E., 2021. Bumble bee queen pheromones are context-dependent. Scientific reports, 11(1), pp.1-7.

Acknowledgements

Margarita Orlova

orlovam@sunypoly.edu

Design and Synthesis of Functional Materials using Supramolecular Chemistry

Project Summary

- We are interested in developing a new methodology for Mechanically interlocked molecules (MIMs) such as rotaxane and catenane. With the supramolecular chemistry as a core, we want to develop a method to modify late-stage drug molecules.

Highlights

- Macrocyles

Cyclodextrin   Crown ether   Cucurbituril

Publications

Selected Publications:

- Unravelling supramolecular photocycloaddition: Cavitand-mediated reactivity of 3-(Aryl) Acrylic acids. A Kashyap, V Balraj, V Ramalingam, M Pattabiraman
  Journal of Photochemistry and Photobiology A: Chemistry 425, 113695, 2022.

- Magnesium pyrophosphates in enzyme mimics of nucleotide synthases and kinases and in their prebiotic chemistry P Gopinath, V Ramalingam, R Breslow
  Proceedings of the National Academy of Sciences 112 (39), 12011-12014, 2015

- Chloride sensing via suppression of excited state intramolecular proton transfer in squaramides M Porel, V Ramalingam, ME Domaradzki, VG Young, V Ramamurthy, ...
  Chemical Communications 49 (16), 1633-1635, 2013

- Cucurbit [8] uril rotaxanes
  V Ramalingam, AR Urbach
  Organic Letters 13 (18), 4898-4901, 2011

- Nanomolar binding of peptides containing noncanonical amino acids by a synthetic receptor LA Logsdon, CL Schardon, V Ramalingam, SK Kwee, AR Urbach
  Journal of the American Chemical Society 133 (42), 17087-17092, 2011

SUNY Polytechnic Undergraduate Research Students:

- Eh Thaw (2022-23)
- Ohmida Dahab (2022-23)
- Dinah Bell (2022-23)
- Htoo Shee (2022-23)
- Ayuong Arop (2020-21)
- Maja Bajic (2019-20)

Vijay Ramalingam

https://sunypoly.edu/faculty-and-staff/vijay-ramalingam.html

ramaliv@sunypoly.edu

OFFICE OF RESEARCH
SUNY POLYTECHNIC INSTITUTE

EyeDEC-ML - Mathematical Modeling of the Blood Flow in the Retina of the Eye

Project Summary

- The eye is the window into the body and anomalies in blood flow in the retina of the eye are an important factor in various eye pathologies including the open angle glaucoma. In addition, many systemic diseases, including diabetes, manifest themselves in the retina of the eye. The project aims at developing a standard model of the blood flow in the retina of the eye using scientific machine learning. While much work has been done on the application of machine learning to fundus image analysis, to the best of our knowledge, nobody has been able to bridge the gap between physically based mathematical modeling and machine learning in this context. Our team hopes to be the first to achieve this goal. In addition to advancing fundamental knowledge, the model will be helpful to medical professionals in studying the dynamics of diseases, in early detection of pathologies, and in designing better treatments.

Highlights

- The physically based modeling part, called EyeDEC, developed in collaboration with Giovanna Guidoboni and Anil Hirani, is based on fundamental physical principles.

- The numerical solution of the model involves discrete exterior calculus (DEC) – a cutting edge structure preserving method for solving partial differential equations. This enables us to preserve Stokes law exactly, which results in blood volume conservation.

- Our model predicts that changes in the curvature of the retina of the eye lead to significant changes in the blood flow. These changes may play a significant role in the primary open-angle glaucoma.

- The image analysis part uses convolutional neural networks - Deep Learning.

- Current work includes: connecting the two parts, parallelizing the code, experimenting with model reduction – speed tradeoff.

Acknowledgements

Edmond Rusjan

edmond@sunypoly.edu

http://people.sunyit.edu/~edmond/EyeDEC/

Long-term Consequences of Forced Migration on Resettled Refugees in the U.S.

Project Summary

- This long-term anthropology research agenda revolves around the lived experience of resettled refugees currently living in Utica, New York. Areas of interest include employment, status of statelessness, and visual representations of life in refugee camps and post-resettlement.

- The project is connected with the Refugees Starting Over project through the College of Arts and Sciences, which involves the collection, archiving, analysis, and showcasing of photographs that refugees have taken of their own lives.

Example of images from refugee photo collection

This photo represents a Karen family from Burma and was taken in a refugee camp in Thailand in the early 2000s.

Recent Publications

- Highlights of the photo collection are located on the New York Heritage Digital Collections website: https://nyheritage.org/collections/refugees-starting-over-collection

- Stam, K. (2022). "Building a Multicultural Community with Resettled Refugees: A case study of the Midtown Utica Community Center in Utica, NY." in Watson, M. and Gopalan, P. (Eds.) Oxford, U.K.: Routledge.

- Nelson, A.& Stam, K. (2021). "Bhutanese or Nepali: The Politics of Ethnonym Ambiguity. South Asia: Journal of South Asian Studies.

- Stam, K. (2019). "Perspectives on Religious Identity, Caste, and Culture for Bhutanese-Nepali Refugee Families in the United States." *Proceedings of the Annual Conference on Nepal and the Himalayas*. Summer 2018.

- Stam, K. (2019). "Refugee Perspectives on Identity and Community After Resettlement to the United States." *The Crux of Refugee Resettlement,* Lanham, MD: Lexington.

Acknowledgements

Kathryn Stam

https://sunypoly.edu/research/kathryn-stam.html

stamk@sunypoly.edu

https://kathrynruthstam.wordpress.com/

OFFICE OF RESEARCH
SUNY POLYTECHNIC INSTITUTE

Off-line signature verification with data-driven approaches

Project Summary

- A signature is a legally accepted key to use in document authentication and personal verification

- Off-line signature verification methods have been used to identify a real signature

- In this study, a novel approach for off-line human signature verification using Reduced Order Modeling (ROM) based on Proper Orthogonal Decomposition (POD). Is used

- This is a data-driven statistical approach and converts the high dimensional data into a lower dimensional model, which extracts the most important features that represent the characteristic features of the training phase signatures

- The required basis functions for the ROM are obtained by using the proper orthogonal decomposition.

Highlights

- The reduced order model was created with the 30 basis functions

- The basis functions are selected considering the dominant eigenvalues in the Eigenvalue spectrum of the training data set

- The reduced order model is able to successfully reconstruct the signatures and identify a given signature as a genuine or forgery.

- The quality of the signature is tested by the Structural Similarity Index Measure

- The signature is tested as a genuine or fake using an statistical index and the overall accuracy of the method is calculated as 64%

Input image | Reconstructed test image when L=30
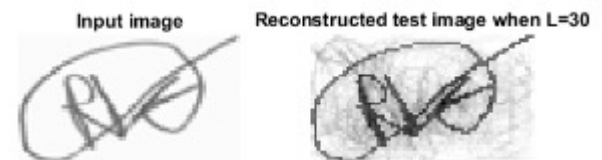
Publications

- Subawickrama H.D.A.W., Nishantha S.A.A., Mohamed M.A.M., **Udagedara U.G.I.G.K**, *Off-line signature verification by using proper orthogonal* decomposition, RITSCON 2023, Sri Lanka

Indika Udagedara

https://sunypoly.edu/faculty-and-staff/indika-udagedara.html

udagedi@sunypoly.edu

Human decision making, emotion, and cognitive control

Project Summary

Humans are generally aware of the negative consequences of drinking too much alcohol, using drugs, or eating unhealthy foods, all behaviors that can lead to detrimental health outcomes. Despite knowledge of these risks, however, humans tend to have difficulty making choices that are optimal for their health. My research aims to understand more about why people make poor health decisions.

Cognitive psychology research has been fundamental in furthering our understanding of how we inhibit our automatic tendency to pursue a rewarding item, such as a drug, an alcoholic beverage, or a sugary food. In my lab, we use survey, behavioral, and neuroscience techniques to expand our knowledge of inhibition and cognitive control, the set of processes devoted to selecting task-relevant information while filtering out task-irrelevant distractors.

Most recently, my collaborators and I have worked on answering questions related to emotion and cognitive control. Prior research has shown that experiencing conflict can facilitate responses to negative stimuli, suggesting that detecting conflict is aversive, but we have some findings that suggest that resolving conflict is associated with a positive emotional response. We have also found that emotion can affect cognitive performance, and we are currently working on understanding the underlying mechanism. Other recent work is focused on individual differences in the emotional appraisal of neutral and emotional stimuli (Weldon et al., 2022). The ultimate goal of this research is to lend insight into improving cognitive control, which could enhance cognitive performance and reduce risky decision making.

Highlights

- Positive valence facilitates cognitive control (Tae, Weldon et al., 2021).

- Anxiety and avoidance in close relationships predict responses to neutral and emotional stimuli (Weldon et al., 2022).

Recent Publications

- **Weldon, R.B.,** Behrens, K.Y., Jones, D.K., Drake, E., & Fragetta, J. (2022). Anxiety and avoidance in close relationships are associated with responses to negative and positive stimuli. *Psychological Reports,* 00332941221129133.
- Tae, J., Almasi, R. C., **Weldon, R. B.,** Lee, Y., An, C., & Sohn, M. H. (2021). Perceived conflict may be negative but resolved conflict is not. *Brain and Cognition*, *150*, 105721.
- Tae, J., An, C., Lee, Y., **Weldon, R. B.,** Almasi, R. C., & Sohn, M. H. (2021). Cognitively demanding stimuli can acquire positive valence. *Psychological Research*, *86(2),* 585-596.
- Tae, J., **Weldon, R. B.,** Almasi, R. C., An, C., Lee, Y., & Sohn, M. H. (2021). Stimuli with a positive valence can facilitate cognitive control. *Memory & Cognition*, *50(5),* 911-924.
- **Weldon, R.B.,** Patai, E.Z., Sohn, M.-H., & Tae, J. (2021). How working memory capacity relates to top-down and bottom-up components of the trial-by-trial modulation of the Simon effect. *The Korean Journal of Cognitive and Biological Psychology, 33(2),* 95-106.

Acknowledgements

Rebecca Weldon

weldonr@sunypoly.edu

College of
Business

Project Summary

- In this analysis we find evidence that credit default swap (CDS) purchases increase bank safety. Specifically, we show banks which were net buyers of CDS had smaller increases in loan loss reserves in response to the COVID-19 crisis. Previous research had speculated that bank CDS purchases caused increased risk-taking by banks which offset the effect of the hedge. This analysis contributes to this literature on the effect of hedging on bank risk taking and capital structure. Moreover, since our results are consistent with CDS being effectively used to hedge, our results have implications for systemic risk.

Publications

- Brigida, M. (2022)."Credit Default Swaps and Bank Safety "Applied Finance Letters, 11, 19–27. https://ojs.aut.ac.nz/applied-finance-letters/article/view/594

Matthew Brigida

matthew.brigida@sunypoly.edu

Project Summary

Our research initiative further develops the sociotechnical theories and practices by which collectives assemble and mobilize to tackle society's most pressing and intractable creative challenges, ranging from grand opportunities such as the commercialization of interplanetary space to wicked problems including intensifying climate change. We theorize that entrepreneurial acumen may be transformed into a socially beneficial creative change capacity for these challenges through the interdisciplinary synthesis of ontologies from the humanities and design thinking. Our work contributes theory development and testing of the microprocesses and institutional arrangements that enable social creativity capacity as a collective means for conceptualizing and implementing solutions. Those who research, practice, and make policy for sociotechnical transformations should find our observations and analysis useful.

Impact

Our tested theory indicates that exposing young adults to interdisciplinary design culture treatments induces heightened levels of prosocial entrepreneurial capabilities and civic engagement resulting in social creativity capacity.
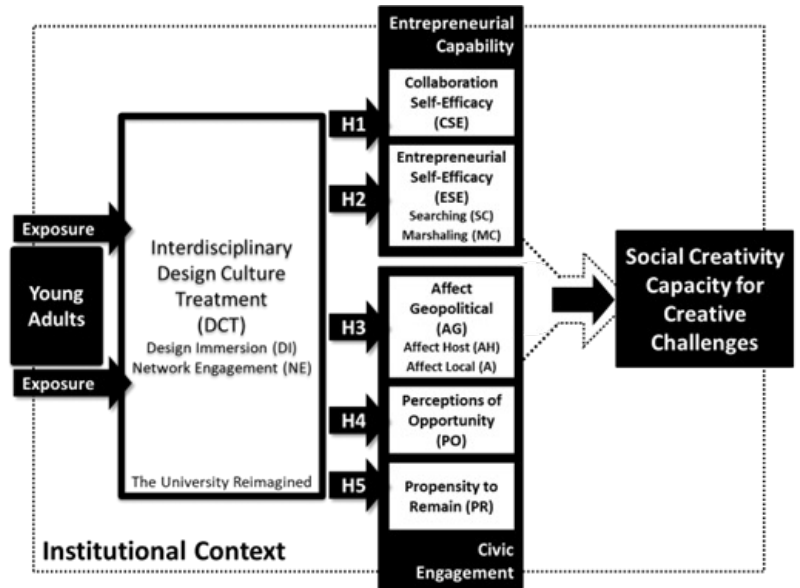
Publications

Edgell, R. A., and Lee, D. (2023). Theorizing creative challenges: Why are social creativity and reimagined universities necessary for tackling society's problems? *Journal of Creativity*, forthcoming.

Edgell, R. A., and Olney, J. (2023). The sociotechnical imaginaries of contemporary commercial space: Explicating Homo Galacticus, Techno-Utopianism, and Capitalistkind. *AIAA SciTech Forum*, 2023(1), 1-24. https://arc.aiaa.org/doi/10.2514/6.2023-2396 .

Edgell, R. A., (2022) Grand challenges: The theoretics of discursive engagement, socio-temporal dilemmas, and impact. *Academia Letters*, Article 5164. https://doi.org/10.20935/AL5164

Edgell, R. A., and Olney, J. (2021). Institutionalizing Outer Space: A sociotechnical explication of the Comsat-Intelsat actor-network. *Academy of Management Proceedings*, 2021(1), 10228.

Edgell, R. A., and Olney, J. (2021). Interplanetary institutionalization: Should humans become space faring? *Academia Letters*, Article 531. https://doi.org/10.20935/AL531

Berardino, L., Edgell, R. A., Fronmueller, M., Olney, J., Peterson, D., and Zeina, E. (2019). Design culture, immersion, and visuo-spatial learning: Re-envisioning training. *Business Education Innovation Journal*, 11(2), 110-118.

Edgell, R. A.. Khasawneh, F., and Moustafellos, J. (2018). Reimagining entrepreneurship: Design culture exposure as a positive mediator for entrepreneurial capacity. *Journal of Creativity and Business Innovation*, 4, 60-77

Robert A. Edgell

edgellr@sunypoly.edu

www.robertedgell.com

ssrn.com/author=460242

A systematic review on green hydrogen for off-grid communities: Technologies, advantages, and limitations

Project Summary

- In this project, we analyze the literature on green hydrogen research, its technologies, and potential implementation in off-grid communities. First, a quantitative bibliometric approach to size and make sense of the green hydrogen research literature is developed. Then, an in-depth review of the literature is performed following a framework that categorizes hydrogen research into production, storage, use, and safety. This review unveils green hydrogen's most promising technologies for off-grid applications. It identifies their advantages, limitations, and barriers to widespread dissemination.

Highlights

- Few studies (8%) explored green hydrogen implementation in off-grid contexts.

- An extensive bibliometric analysis of green hydrogen to address SDG 7 is performed.

- Green hydrogen production, storage, use, and safety technologies are analyzed.

- Results show that PEM and MH are promising technologies for off-grid communities.

- Green hydrogen should be part of the energy portfolio of off-grid communities.

Publications

- A manuscript is currently under the revise and resubmit stage for publication in the International Journal of Hydrogen Energy.

Acknowledgements

Juan Felipe Henao Piza

henaoj@sunypoly.edu

Non-market Strategies of domestic and foreign firms

Project Summary

- Corporate Social Responsibility (or CSR) — one strand of nonmarket strategies - is known to be a context-dependent concept. The complexities of this strategy's interaction with the institutional environment of a country challenges researchers understanding of underlying causalities and multi-level antecedents, mechanisms, and outcomes of nonmarket strategies. My colleagues and I employ a wide array of qualitative research techniques, such as case studies, computer-aided text analysis, and fuzzy Qualitative Comparative Analysis, but also analyze large panel data sets to better understand firms' nonmarket strategies and interdependencies with formal and informal institutions in emerging and developed countries. This research contributes not only to the development of Strategy research, but also to correlate fields such as political science, economics, and sociology, and informs business practitioners and public policy development.

Highlights

- Based on a large data sample from 34 Latin American countries, over the period of 2005-2018, our research shows that when firms assume state-like roles through CSR strategies, the perception of a government's capacity to design and implement effective solutions for social, economic and environmental issues is harmed.

- We collected over 400 interviews in 2020, conducted with different actors as well as small business owners located in the seven New England States, in the U.S., to discuss the role of firms and safeguarding preparedness in the case of extreme events. We discuss that through the engagement of several societal actors, firms can actively contribute to building community resilience and achieving sustainability tenets.

- Firms are relevant actors in a society. We provide evidence that whether by building preparedness to fight climate change or addressing land use issues for the surrounding population, firms can help strengthen community services and promote the necessary basis for resilience building.

Publications

STOCKER, F.; SAJJAD, A.; RAZIQ, M.M.; PACHECO, L.M. (2022). Innovation and business strategy for sustainability. Innovation & Management Review, 19(3), 174-179.

CEZARINO, L.D.; LIBONI, L.B.; HUNTER, T.; PACHECO, L.M.; MARTINS, F.M. (2022). Corporate social responsibility in emerging markets: opportunities and challenges for sustainability integration. Journal of Cleaner Production, 362, 132224.

CALDANA, A.C.F; PACHECO, L.M.; ALVES, M.F.R.; EUSTACHIO, J.;. SANTOS, N. (2022). Strategy Implementation for the 2030 Agenda: Insights from Brazilian companies. Business Ethics, the Environment & Responsibility, 31(2), p.296-306.

Larissa Marchiori Pacheco

pachecl@sunypoly.edu

Google Scholar

LinkedIn Profile

Security Breaches in Healthcare Organizations: A Mixed-Method Study

Project Summary

- Security breaches in the healthcare industry have become a growing problem. This exploratory study employed a mixed-methods research design to investigate security breaches in healthcare organizations using a public data set maintained by the U.S. Department of Health and Human Services (HHS). The Office of Civil Rights (OCR) of the HHS investigates the security breaches in healthcare organizations and provides a description capturing their investigation. This text data was analyzed using qualitative and quantitative techniques.

Highlights

- The number of security breaches in healthcare organizations has increased over the years. Compared to the growth in security breaches in the period 2010 – 2018, there has been sharp rise in recent years.

- Three categories of security incidents: internal, external, and natural disasters

- Type of breach influences type of exposed information and also influences organizational response

Publications

- Jani, A., and N. B. Peddibhotla (2022) "Security Breaches in Healthcare Organizations: A Mixed Methods Study". Presentation at the Seventeenth Annual Symposium on Information Assurance, Albany, NY, June 7-8, 2022

- Jani, A. and N. B. Peddibhotla (2022) "Challenges in combining computational and manual analysis techniques: A mixed-methods study of security breaches in healthcare organizations", Presentation at the Professional Development Workshop on "Computational methods for theory building: Practices and Struggles", at the 82nd Annual Meeting of the Academy of Management, August 7, 2022.

Acknowledgements

- Collaborator: Dr. Arpan Jani, Associate Professor, University of Wisconsin at River Falls

Naren Peddibhotla

peddibn@sunypoly.edu

Role of Culture in Website Designs

Project Summary

Although culture-laden website design is increasingly relevant to successful online marketing, its measurement has not been examined. We review prior conceptualizations of Culture-Laden Website Design in Marketing and introduce various fit dimensions, in terms of fit to the target population, fit to the product category, and fit to brand positioning. We then describe the development and validation of a three-dimensional scale measuring the three fit dimensions of culture-laden website design. The scale is applied to show that the three fit dimensions elicit various mental processes in terms of consumers' perceptions of authenticity, familiarity, self-congruency, informativeness and confusion that positively or negatively influence affective, attitudinal, and behavioral consumer responses. Applying the scale in marketing practice provides marketers with a new way to understand how and why consumers respond to specific elements of culture-based website design and offers guidelines for successful website design.

Highlights

We offer new theoretical ideas about how people may mentally categorize the world around them. In particular, we have suggested that people categorize culture-laden website designs in terms of four knowledge categories (or CLF dimensions). Hence, we considered categorical learning, a process of multiple mental categorizations of a single stimulus. This differs from the more classic view of multi-attribute stimuli categorization, based on the idea that "information that has multiple interpretations […], or that implies multiple possible categorizations is nondiagnostic" (Herr et al., 1991, p. 457). Against this idea, our index measure suggests the diagnosticity of multiple mental categorizations (the four CLF dimensions) in relation to one single source of information (one website). We thus observe meaningful variation in the four CLF dimensions.

Publications

Bartikowski, B., Gierl, H., **Richard, M.O.**, & Fastoso, F. (2022). "Multiple mental categorizations of culture laden website designs," *Journal of Business Research,* 121 (March), 40-49. doi.org/10.1016/j.jbusres.2021.11.076.

Bartikowski, B., Gierl, H., & **Richard, M.-O.** (2020), "Effects of 'feeling right' about website cultural congruency on regular and mobile websites," *Journal of Business Research*, 121 (December), 420-428. DOI: 10.1016/j.jbusres.2018.11.036.

Bartikowski, B., **Richard, M.O.**, & Gierl, H., "Fit or misfit of culture in advertising? Development of the Culture-Ladenness Fit Index (CLF)" (revise & resubmit by the *Journal of Business Research*).

Acknowledgements

Marie-Odile Richard

richarm3@sunypoly.edu

Using Vlogs and Blogs in Graduate International Business Case Studies to Impact Learning Outcomes

Project Summary

This study explores the learning impact of introducing vlogs and blogs to graduate international business case studies. Data were collected over a four-year period from graduate business programs to compare assignment performances from students when case studies were presented with versus without the inclusion of vlogs and blogs. A rubric measuring six criteria was used to evaluate case study submissions and identify areas drawing upon specific learning skills. A crosswalk between the rubric and Bloom's taxonomy of cognitive levels linked student performance and these skills. Group comparisons of the 535 observations showed the inclusion of vlogs and blogs led to statistically significant improvement in students' learning outcomes in overall scores, failing rates, and high-score achievements. A performance examination of the international business case studies against the six specific grading criteria also showed marked advances in students' higher-level thinking skills of analysis, evaluation, and synthesis or creation, which have been linked to developing cross-cultural awareness. The study indicates that instructors should thoughtfully curate sets of vlogs and blogs pertaining to products, services, values, cultures, and economic systems from multiple diverse origins to use in administering international business case studies used in their course curricula.

Highlights
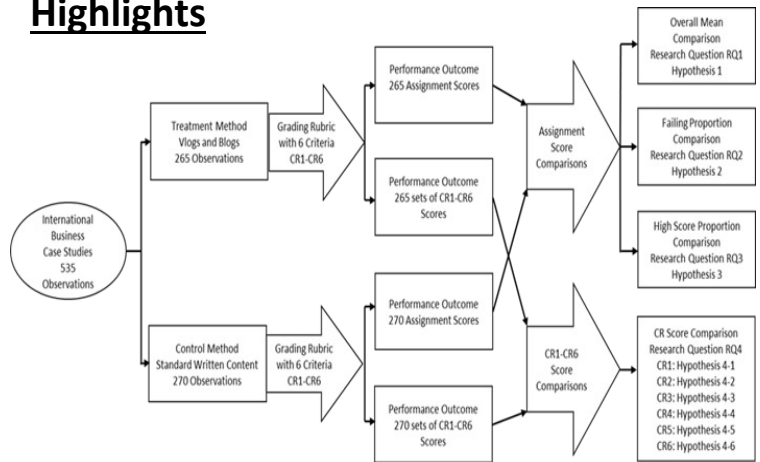
Grading Criterion in Rubric shown in Appendix C	Corresponding Components for the Six Levels of Cognitive Activity in Learning - 1956 Taxonomy	Corresponding Components for the Revised Six Levels of Cognitive Activity in Learning – 2001 Revised Taxonomy
CR1: Demonstrates understanding of new concepts	Knowledge and Comprehension	Remember and Understand
CR2: Links new knowledge to the empirical case	Application and Analysis	Apply and Analyze
CR3: Integrates previously learned content with new	Application and Synthesis	Evaluate and Create
CR4: Seeks relevant information from other sources	Knowledge and Comprehension	Understand and Apply
CR5: Identifies potential problems	Comprehension and Analysis	Analyze and Evaluate
CR6: Evaluates and selects feasible solutions	Analysis, Synthesis, and Evaluation	Evaluate and Create

Publications

Acknowledgements

Robert Yeh

https://sunypoly.edu/faculty-and-staff/robert-yeh.html

yehr@sunypoly.edu

College of
Engineering

OFFICE OF RESEARCH
SUNY POLYTECHNIC INSTITUTE

Project Summary

Different design parameters are discussed and simulated to understand how nanoscale electrode size, spacing, and structure would affect a model biosensing assay.
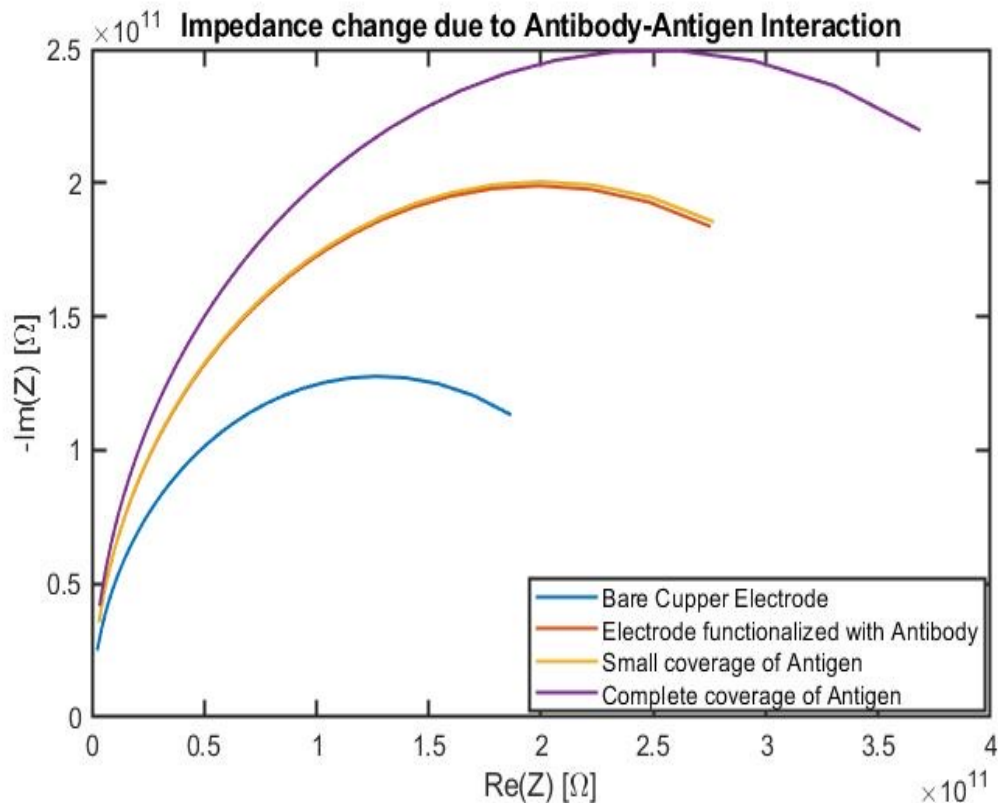
Publications

- M. Abdallah, "PROOF OF CONCEPT: DESIGN PARAMETERS FOR NANOSCALE INTERDIGITATED ELECTRODE SENSOR FOR COVID-19 DETECTION," International Journal of Modern Engineering | Volume 22, Number 2, Spring/Summer 2022

Mohammed Abdallah

abdallm@sunypoly.edu

Using Geosynthetics to Reduce Freeze-Thaw Induced Distress

Project Summary

Pavement deterioration due to frost action is a challenge for transportation infrastructure in the northern part of United States. Combination of the variation of subgrade temperature, moisture and soil type leads from minor to severe frost damage. Accumulated water causes the differential frost heave during freezing temperature followed by settlement in subsequent thawing days in seasonally frozen areas. While the classical solution suggests using granular materials up to freezing depth which comes with substantial cost, insulation can be an effective alternative to prevent the frost action reaching the frost susceptible soil. With an attempt to moisture and temperature adjustment, geo-composite insulation layer was modeled in numerical environment.

Highlights

Geosynthetics layers consisting a geonet sandwiched between geotextiles at top and bottom was placed before the subgrade. The top and bottom geotextile layers acted to prevent both downward and upward moisture flow in the pavement. The numerical modeling results yielded to less moisture variation following precipitation. In addition, it was also found that the maximum freezing depth was reduced after using the geosynthetics layer. As such, the study suggests insulation using geosynthetics layer can be an effective solution for reducing frost damage risk in frost susceptible areas.

Publications

- Ahmed, A., & Islam, M. A. (2020, February). Effect of Using Geosynthetics in Mitigation of Freeze-Thaw through Numerical Analysis. In *Geo-Congress 2020: Geotechnical Earthquake Engineering and Special Topics* (pp. 436-445). Reston, VA: American Society of Civil Engineers.

Acknowledgements

Asif Ahmed

asif.ahmed@sunypoly.edu

https://asifahmed3.wixsite.com/asif/research

https://www.linkedin.com/in/asif-ahmed-phd-pe-leed-ap-8116a834/
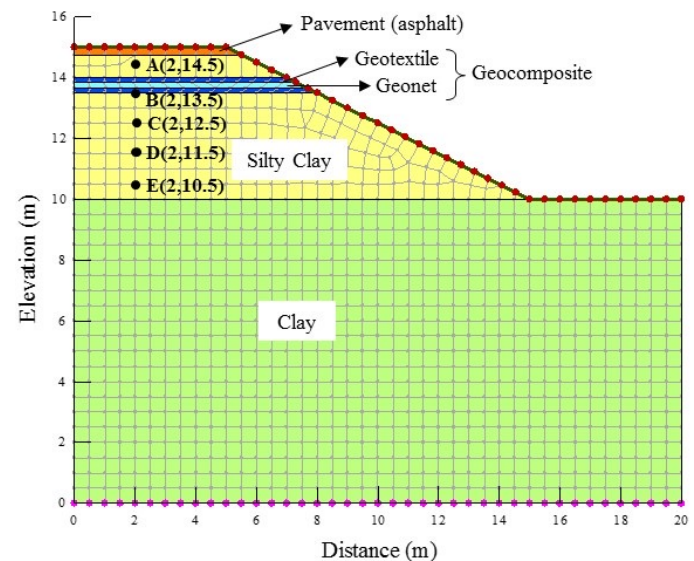
Project Summary

- Today's world is highly network interconnected owing to the pervasiveness of small personal devices (e.g., smartphones) as well as large computing devices or services (e.g., cloud computing or online banking), and thereby each passing minute millions of data bytes are being generated, processed, exchanged, shared, and utilized to yield outcomes in specific applications. Thus, securing the data, machines (devices), and user's privacy in cyberspace has become an utmost concern for individuals, business organizations, and national governments. In recent years, machine learning (ML) has been widely employed in cybersecurity. However, ML algorithms are vulnerable to attacks, which usually leads to remarkable performance decreases and security breaches. It is imperative to systematize recent works related to cybersecurity using ML to seek the attention of researchers, scientists, and engineers. Therefore, in this work, we provided a comprehensive survey of the works that have been carried out most recently on ML in cybersecurity.

Highlights

- An enormous amount of data is daily being produced, processed, stored, and traded throughout cyber-enabled networks

- Securing data and cyber networks has become of paramount importance for small-to-large organizations as well as from individuals to nations

- Use of ML to secure cyber-space has shown great improvement by ensuring the robustness of a network and maintaining the integrity of the data

- Attackers have also figured out the adversarial way of using ML to twist the performance of cybersecurity measures

- In this work, we provided a comprehensive overview of ML algorithms in cybersecurity, adversarial ML, including the security characteristics of deep learning methods, and open issues
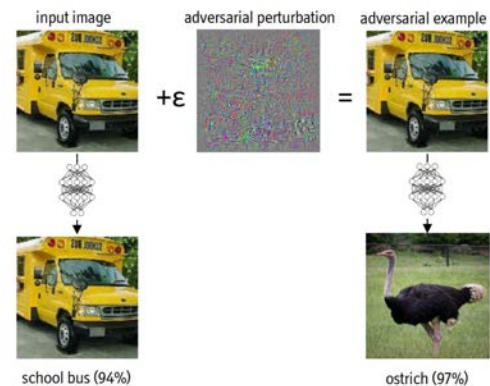

Figure: An adversarial sample generated with Fast Gradient Sign Method (FGSM)

Publications

- D. Dasgupta, **Z. Akhtar**, S. Sen, "Machine Learning in Cybersecurity: A Comprehensive Survey", The Journal of Defense Modeling and Simulation, SAGE Publishing, pp. 1-50, 2022.

Zahid Akhtar

https://sites.google.com/site/zahidakhtarhome/home

akhtarz@sunypoly.edu

DeepFakes and Fake News Detection

Project Summary

- In this project, our main goal is to develop next generation deepfake and fake news detection frameworks. In particular, we propose a deepfake detection method called HCiT, which combines Convolutional Neural Network (CNN) with Vision Transformer (ViT). The HCiT hybrid architecture exploits the advantages of CNN to extract local information with the ViT's self-attention mechanism to improve the detection accuracy. In this hybrid architecture, the feature maps extracted from the CNN are feed into ViT model that determines whether a specific video is fake or real. Experiments were performed on Faceforensics++ and DeepFake Detection Challenge preview datasets, and the results show that the proposed method significantly outperforms the state-of-the-art methods. In addition, the HCiT method shows a great capacity for generalization on datasets covering various techniques of deepfake generation.

Highlights

- Number of new falsified video contents is dramatically increasing, making the need to develop effective deepfake detection methods more urgent than ever

- Even though many existing deepfake detection approaches show promising results, the majority of them still suffer from poor generalization

- We proposed a deepfake detection method called HCiT, which combines Convolutional Neural Network (CNN) with Vision Transformer (ViT)

- The HCiT method shows a great capacity for generalization on datasets covering various techniques of deepfake generation
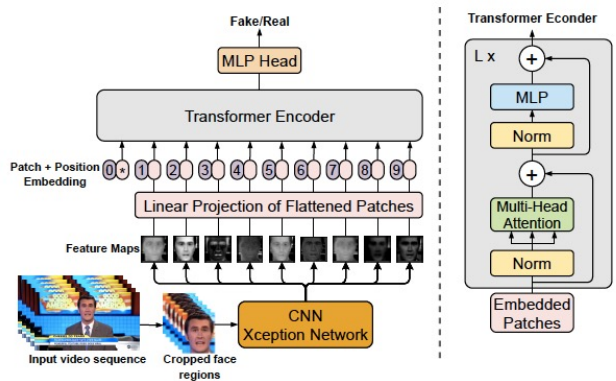
Fig. The proposed HCiT method for deepfake video detection. In HCiT (CNN-ViT), the features extracted by the CNN module are used as inputs by ViT for the binary classification task.

Publications

- Z. Akhtar, et al., "Future Trends in Digital Face Manipulation and Detection", in Handbook of Digital Face Manipulation and Detection From DeepFakes to Morphing Attacks, pp. 463-482, C. Rathge, R. Tolosana, R.V. Rodriguez, C. Busch (Eds.), Springer, 2022.

- B. Kaddar, S.A. Fezza, W. Hamidouche, Z. Akhtar, A. Hadid, "HCiT: Deepfake Video Detection Using a Hybrid Model of CNN features and Vision Transformer", IEEE Visual Communications and Image Processing (VCIP), pp. 1-5, Munich, Germany, December 5-8, 2021.

Zahid Akhtar

https://sites.google.com/site/zahidakhtarhome/home

akhtarz@sunypoly.edu

Project Summary

- The project is focusing on leveraging Cryptography, Blockchain, and Machine Learning/Deep Learning (ML/DL) for achieving security and privacy preservation for Cyber-physical Systems, including Smart Grids, Autonomous Electric Vehicles, Intelligent Transportation Systems, 5G Networks, and E-Health. It is also focusing on Machine Learning in Cyber Security including: 1) Attacks on Machine Learning Models and Countermeasures (Adversarial Machine Learning). 2) Privacy-preserving Training and Evaluation of Machine Learning Models. 3) Using Machine Learning to Launch Attacks and Counter Security Threats. 4) Secure and Efficient Federated Learning (FL).

Highlights

- To the best of our knowledge, our work is the first that investigates energy forecasting in net-metering systems using FL.

- We first proposed a multi-data-source hybrid DL-based predictor to accurately predict future readings.

- Then, we developed a novel data aggregation scheme based on Functional Encryption cryptosystem to preserve the customers' privacy by encrypting their models' parameters during the FL training.

- To address communication efficiency, we leverage a change and transmit (CAT) approach. Instead of sending all the updated models' parameters in each round, only the parameters that have sufficiently been changed from previous round are transmitted.

- Our extensive studies demonstrate that our approach accurately predicts future readings while providing privacy protection and high communication efficiency.

Publications

- **M. M. Badr** et al., "Privacy-Preserving and Communication-Efficient Energy Prediction Scheme Based on Federated Learning for Smart Grids," in IEEE Internet of Things Journal, doi: 10.1109/JIOT.2022.3230586. **[IF: 9.936]**

Acknowledgements

Mahmoud Badr

https://scholar.google.com/citations?user=1NaIEkoAAAAJ&hl=en

badrm@sunypoly.edu

# Seismic Resiliency of Structures Using Rocking Foundations: Predictive Modeling Using Machine Learning

Project Summary

- Recent experimental research findings reveal that properly designed shallow foundations, with controlled rocking during earthquakes, possess many desirable characteristics such as beneficial seismic energy dissipation in soil and reduced force and ductility demands transmitted to structures.

- The overarching goal of this research is to develop a predictive framework for the performance of rocking structure-foundation-soil systems by combining scientific knowledge (mechanics-based models) with the knowledge discovered from big data (machine learning models).

- The objective of this study is to develop predictive models for the performance parameters of rocking foundations (acceleration, energy dissipation, settlement, peak rotation, and tipping-over stability) using ensemble machine learning algorithms and deep learning models.

Highlights

- Multiple machine learning models have been developed for the prediction of maximum acceleration transmitted to the structure (AAR) during earthquake loading.

- The figure below shows the results of mean absolute percentage error (MAPE) in predictions of AAR using different machine learning models: k-NN, SVR, Random Forest, Adaptive Boosting, Gradient Boosting, and Artificial Neural Networks (ANN).
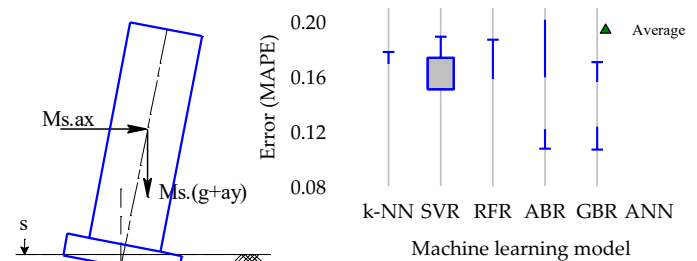
5-fold cross validation results (mean and variance) of MAPE in AAR for different ML models: The average MAPE is around 0.14 for most ML models, with ANN being the most accurate.

Publications

- Gajan, S. (2022). "Data-driven modeling of peak rotation and tipping-over stability of rocking shallow foundations using machine learning algorithms." *Geotechnics*, Vol. 2 (https://doi.org/10.3390/geotechnics2030038)

- Gajan, S. (2021). "Application of machine learning algorithms to performance prediction of rocking shallow foundations during earthquake loading." *Soil Dynamics and Earthquake Engineering*, Vol. 151 (https://doi.org/10.1016/j.soildyn.2021.106965)

Acknowledgements

Sivapalan Gajan

https://sunypoly.edu/faculty-and-staff/sivapalan-gajan.html

gajans@sunypoly.edu

Project Summary

- Additive manufacturing is an emerging concept which is extensively used to make prototype of complex geometry. One of the primary limitation these protype having insufficient mechanical properties. To overcome this issue fiber reinforced composite is introduced in additive manufacturing. Current technologies have significant challenges in fiber placement, sizing the fiber and optimize the process parameters. In this research main objective is to fabricate fiber reinforced polymeric composite with enhanced mechanical and electrical properties. In the second steps of this research is extend the additive manufacturing concept to natural fiber instead of synthetic fiber which are biodegradable and ecofriendly.

Publications

- Kazi Imran, Jiayue Shen and Jagannath Upadhyay "Additive Manufacturing for Fiber Reinforced Composite Materials: A Review" (In Preparation).

Acknowledgements

- SUNY Poly, Tuskegee University, North Carolina A&T State University

Kazi Imran

imrank@sunypoly.edu

Project Summary

- EEG (Electroencephalography), measurement of the electrical activity in different parts of the brain

- Synchronous recording of EMG, ECG, body position, and pulse oximetry
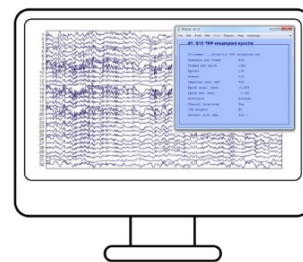
Highlights

- Sensor nets with 256 electrodes record voltage at the scalp at 1000 Hz during exposure to audiovisual stimulation

- Integrated data acquisition and analysis using NetStation, GeoSource, MATLAB, EEGLAB, E-Prime, SPSS, and PRANA

Publications

- Weldon R, Behrens K, Jones DK, Drake E, and Fragetta J, "Evaluation of Valenced Stimuli Is Associated with Anxiety and Avoidance in Close Relationships," 63rd Annual Meeting, Psychonomic Society, Boston, Massachusetts, November 2022.

- Weldon RB, Behrens KY, Jones DK, Drake EA, and Fragetta JR, "Anxiety and Avoidance in Close Relationships are Associated with Responses to Negative and Positive Stimuli," **Psychological Reports,** accepted for publication, September 2022.

Acknowledgements

Daniel K. Jones   **https://sunypoly.edu/faculty-and-staff/daniel-k-jones.html**

jonesd5@sunypoly.edu

Project Summary

- Development of assistive technology for people with physical disabilities

- Multi-disciplinary partnerships with Community and Behavioral Health, Biology, Interdisciplinary Studies, and various engineering/technology majors

Multi-disciplinary student team initiating braille block project

Highlights

- Braille blocks to help blind children to read

- Orthotics to help injured veterans golf

- Shopping carts for wheelchair users

- Urban trailers for bicycles

- Fixtures to assist manufacturing workers

- Tactile maps for blind pedestrians

- Assistive lift for tree stand

- Checkers and chess games for visual impairments

- Prosthetic leg for playing soccer

- Assistive beverage pouring device

- Motorized raising step for reaching kitchen cabinets

Publications

- Jones DK and Joseph J, "Multi-semester Projects to Improve Braille Instruction for Visual Impairments," **American Society of Engineering Education**, Middle Atlantic ASEE Section Spring 2021 Conference, Virtual April 2021.

Acknowledgements

Daniel K. Jones   **https://sunypoly.edu/faculty-and-staff/daniel-k-jones.html**

jonesd5@sunypoly.edu

Investigating Road User's Compliance of Yellow and Clearance Time Intervals for Signal Timing Design

Project Summary

- In this project, the City of Phoenix (COP) has teamed up with the University of Arizona (UArizona) and State University of New York, Polytechnic Institute to 1) identify the RLR hotspots by implementing smart sensors at 12 intersections, 2) examine whether the new ITE guideline on yellow change and red clearance intervals can enhance the safety of signalized intersections, and 3) evaluate the potential countermeasures for reducing the frequency of RLR.

Highlights
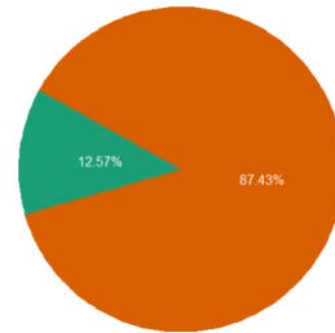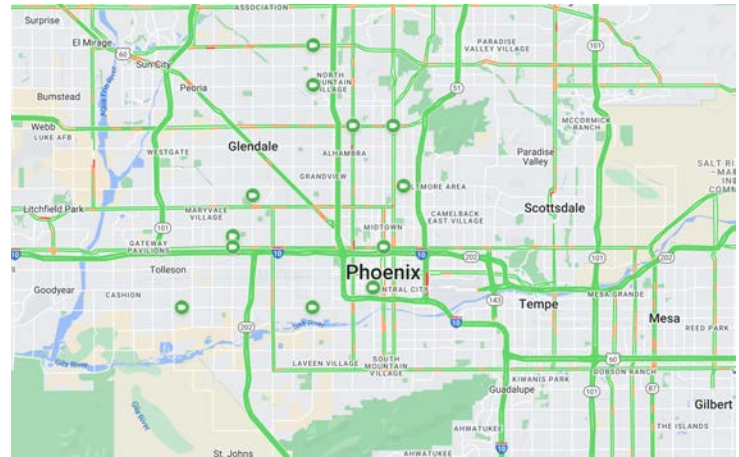
RLR frequency comparison (during all-red vs. after all-red)

Acknowledgements

Abolfazl Karimpour

karimpa@sunypoly.edu

https://www.karimpour.org

Project Summary

• This project aims at designing and implementing a blockchain-based zero-trust framework to secure and protect 6G network resources, services, and their users from cyberattacks. The proposed project will lead to the following innovative research contributions:

1. Develop an innovative approach to use blockchain, and Non-Fungible Token (NFT) smart contracts to implement zero-trust methodology to secure and protect 6G network resources in a scalable and decentralized manner.
2. Demonstrate how the smart contracts for 6G network slices can be used to evaluate the SLA violations among the 6G stakeholders.
3. Develop an innovative machine learning based approach to quantify the end-to-end trust of 6G entities and actors.
4. Demonstrating the capabilities of the research results on a federated 5G testbed available at SUNY Poly and UArizona.
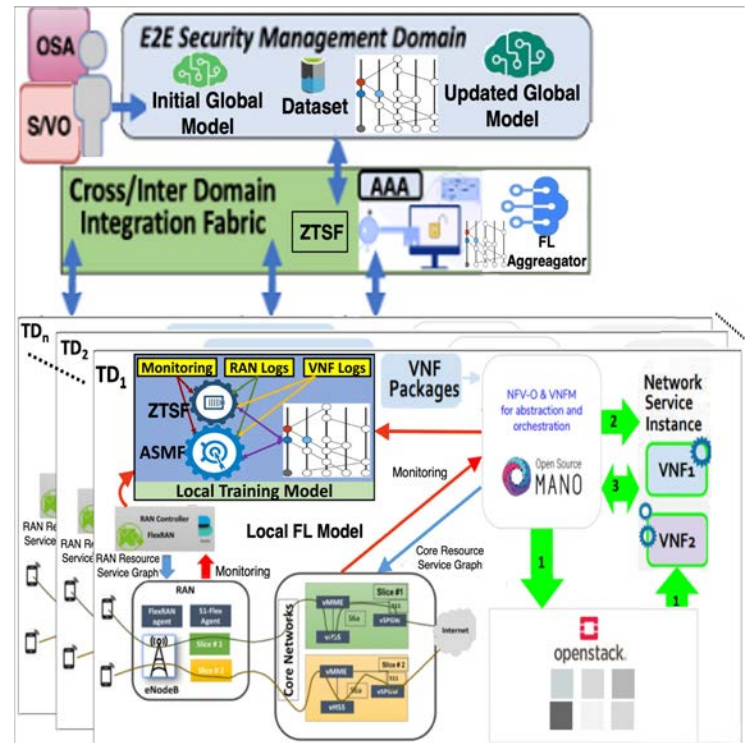
Publications

• Hisham A. Kholidy, "Multi-Layer Attack Graph Analysis in the 5G Edge Network Using a Dynamic Hexagonal Fuzzy Method", Sensors Journal 22, no. 1: 9. https://doi.org/10.3390/s22010009. (IF: 3.576).
• Hisham A. Kholidy, Andrew Karam, James L. Sidoran, Mohammad A. Rahman, "5G Core Security in Edge Networks: A Vulnerability Assessment Approach", the 26th IEEE Symposium on Computers and Communications (the IEEE ISCC 2021), Athens, Greece, September 5-8, 2021. https://ieeexplore.ieee.org/document/9631531
• Hisham A. Kholidy, Fabrizio Baiardi, Salim Hariri, "DDSGA: A Data-Driven Semi-Global Alignment Approach for Detecting Masquerade Attacks", in IEEE Transactions on Dependable and Secure Computing, DOI 10.1109/TDSC.2014.2327966, May 2014.the (IF: 6.791) https://ieeexplore.ieee.org/document/6824813
• Hisham A. Kholidy, "Detecting impersonation attacks in cloud computing environments using a centric user profiling approach", Future Generation Computer Systems, Volume 115, issue 17, December 13, 2020, Pages 171-187, ISSN 0167-739X, (IF: 7.307). https://www.sciencedirect.com/science/article/abs/pii/S0167739X20330715
• Hisham A. Kholidy, Abdelkarim Erradi, Sherif Abdelwahed, Fabrizio Baiardi, "A risk mitigation approach for autonomous cloud intrusion response system", Computing, Springer, DOI: 10.1007/s00607-016-0495-8, June 2016. (IF: 2.420). https://link.springer.com/article/10.1007/s00607-016-0495-8

Acknowledgements

Hisham Kholidy

kholidh@sunypoly.edu

http://people.sunypoly.edu/~kholidh/

Our ACRL Lab: https://sunypoly.edu/research/centers-programs/acrl.html

A Highly Scaled Multi-Modal Machine Olfaction Platform

Project Summary

- This project aims to develop the monolithically integrated novel sensor platform that consists of an array of heterogeneous components all integrated within the CMOS backend. The heterogeneity arises from variation in sensor components: i) sensing material of the sensor (MOx/2D materials), ii) sensor operating temperature, and iii) MEMS based pressure and temperature sensors. Through our novel use of standard techniques, such as ALD and standard CMOS/MEMS process, we can create these variations through monolithically enabling seamless integration. This sensor array can have numerous applications ranging from chemical sensors, gas e-nose arrays and industry safety. It is anticipated that the successful completion of this project will lead to a platform technology for high-density gas sensing which utilizes both CMOS and MEMS processing to create new applications for the semiconductor industry while advancing nanomanufacturing in semiconductor foundries.

Highlights

- Successfully fabricated monolithically integrated array sensor platform

- Demonstrate the low power consumed micro-heater array and highly sensitive gas sensing characteristics

Publications

- B. Lee and V. Misra, "Monolithically integrated and densely packed array sensor platform or ultra-low power gas sensing applications", US Patent Application No. US2022/0349871 A1, November 2022

Acknowledgements

Bongmook Lee

leeb1@sunypoly.edu
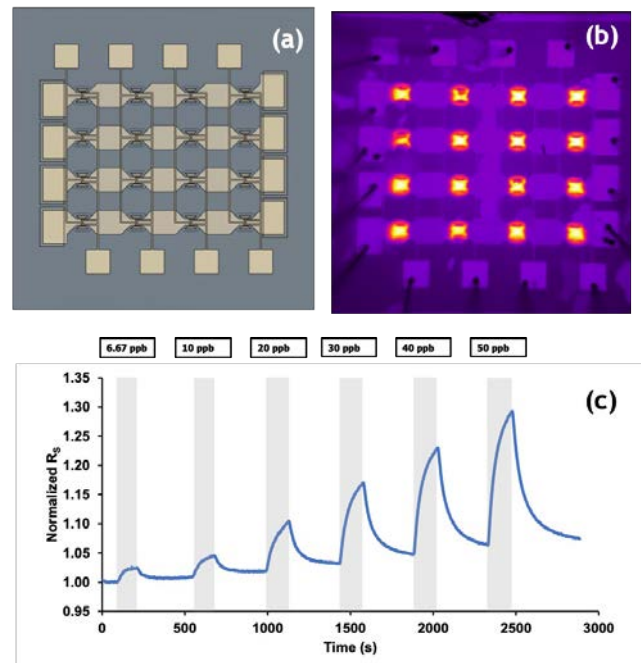
Project Summary

- This collaborative project aims to develop scalable, manufacturable, and robust technology for SiC power integrated circuits (SMART SiC Power ICs). To realize this goal, disruptive designs and processes will be developed to achieve integrated circuits of large scale (> 1 cm2) SiC Complementary Metal-Oxide-Semiconductor (CMOS) and high voltage (400 – 600 V) lateral power MOSFETs (HV-LDMOS) on 150 mm 4H-SiC substrates. The SMART SiC Power ICs will enable many applications requiring wide ranges of voltages and power ratings such as automotive, industrial, electronic data processing, energy harvesting, and power conditioning. It is expected that SiC power IC technology will extend the performance to 10x higher power levels compared to Silicon power ICs and will revolutionize all aspects in energy applications.

Highlights

- Demonstrate highly reliable SiC n-ch and p-ch MOSFETs for high temperature CMOS application

- Time dependent dielectric breakdown and lifetime evaluation
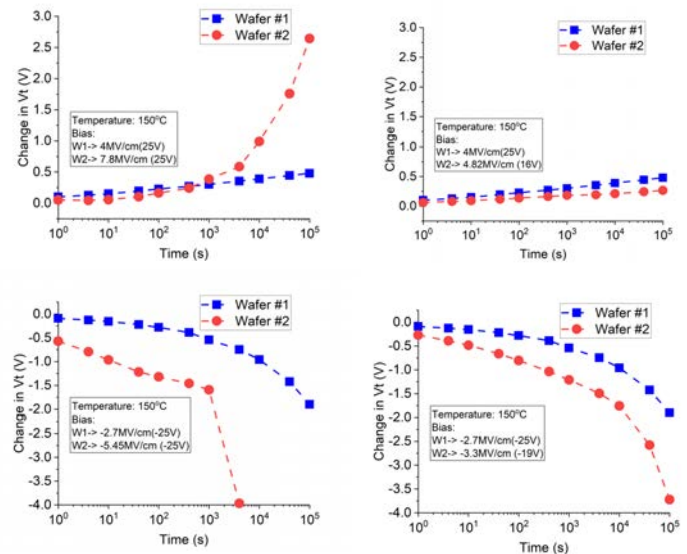
Publications

- T. Liu, H. Zhang, S. Isukapati, E. Ashik, B. Lee, A. Morgan, W. Sung, Marvin H. White, A. Fayed, and A. Agarwal, "Spice modeling and circuit development of a SiC power IC technology," IEEE Journal of the Electron Devices Society, vol. 10, pp. 129-138, 2022.

- E. Ashik , S. Isukapati, H. Zhang, T. Liu, , A. Morgan, V. Misra, W. Sung, A. Fayed, A. Agarwal, and B. Lee, " Bias temperature instability on SiC n- and p-channel MOSFETs for high temperature CMOS applications," Proceedings of IEEE International Reliability Physics Symposium (IRPS), 3B, 4.1-4.8 2022.

Acknowledgements

Bongmook Lee

leeb1@sunypoly.edu

Sympathetic Nerve Activity (SNA) via Wearable Armband

Project Summary

- In this project, we explore a sympathetic nerve activity (SNA) as an additional sensing modality by measuring the electrocardiogram (ECG) and the electro-dermal activity (EDA) simultaneously using our recently developed wearable armband system. SNA can provide new insight into the assessment of many systemic diseases (diabetes, hypertension, heart failure), emotion/pain status, and other pathophysiological conditions (drowsiness, obesity, and so on) in the body. The proposed work is significant as there are currently no devices implemented to measure both ECG and EDA simultaneously in wearable form. In addition, the use of wearable technologies in this space is still in its nascent stages but has the potential to lead to significant insight into physical and psychological conditions of human body.

Highlights

- Develop and demonstrate wearable armband physiological sensing system.

- Simultaneously measure ECG and EDA from left-arm and observe co-relation
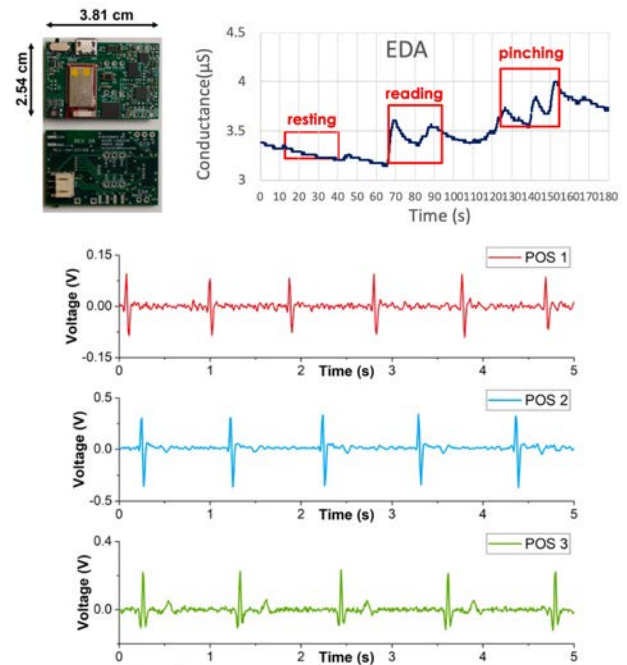
Publications

- Y. Zhou, F. Mohaddes, C. Lee, S. Rao, A. Mills, A. Curry, B. Lee*, and V. Misra, "A wearable electrocardiography armband resilient against artifacts", IEEE Sensors Journal, vol. 22 (19), 18970, 2022, doi: 10.1109/JSEN.2022.3197060

Acknowledgements

Bongmook Lee

leeb1@sunypoly.edu

Development and Validation for Member-Level Analysis-Based Testing

Project Summary

Computational modeling has been greatly advanced in recent years. High-fidelity computational modeling that has been validated has a great advantage in providing reliable prediction of structural behaviors and yet saves a lot of costs compared to full-scale experimental tests. Particularly for cold-formed steel (CFS) member analysis, sophisticated shell models have been greatly validated in the past with tests for nonlinear collapse analyses. However, there are lots of modeling parameters involved in the analysis:

- Geometric imperfections for CFS members
- Residual stress/strain for CFS members
- Material modeling for CFS steel
- Boundary conditions – particularly warping
- Solution schemes
- Element choices
- Mesh sensitivity

All of these require a guidance and provisions to efficiently yet reliably conduct computational modeling for CFS members. As a commencing effort for possible codification of testing by analysis in the AISI standards, the objective of the project, by starting from the member level, is to provide the needed background work for stub column by analysis, provide a guidance for conducting computational modeling of CFS members through a series of numerical examples, and then summarize the recommended provisions related to all the modeling parameters above.

Publications

Li, Zhanjie; Peterman, Kara; Buckholt, Josh; Glauz, Bob; Schafer, Benjamin, *Development and Validation for Member-Level Analysis-Based Testing*, CFSRC Colloquium 2022, 17-19 October 2022

Acknowledgements

Highlights

For local buckling behavior, the model development need to justify all the modeling parameters, e.g., the stub column test of Advanced High Strength Steel (AHSS).

The impacts of some of the modeling parameters are highlighted against the test:

- The impact of the material modeling
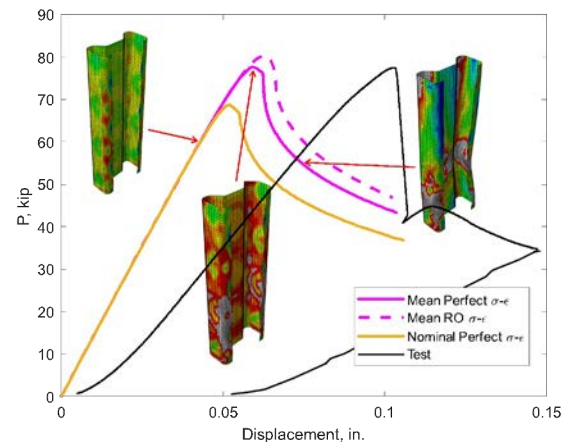
- The impact of geometric imperfections

Zhanjie Li

https://sunypoly.edu/faculty-and-staff/zhanjie-li.html

zhanjie.li@sunypoly.edu

Generative Adversarial Networks for Vehicle Transformation in Overhead Imagery
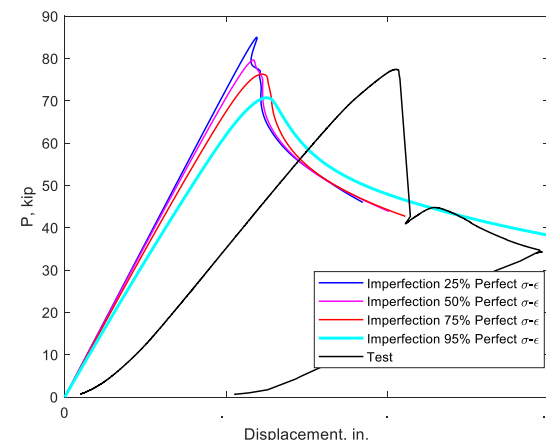
Project Summary

- Synthetic video creation is important for scene understanding, data augmentation, and improvement of adversarial approaches

- *Problems:*
    - Transformation of scene elements in overhead imagery is a unique application
    - Bounding-box-only labels contributes to background confusion
    - Data is challenging with amount/quality limited

- *Approach:*
    - Image to Image Translation with GANs [1][2]
    - Adaptive Data Augmentation [3]
    - Synthetic Data Augmentation
    - Attention-Based Mask Input to Generator

References

- J.-Y. Zhu et al., "Unpaired Image-to-Image Translation using Cycle-Consistent Adversarial Networks," arXiv:1703.10593 [cs], Aug. 2020.
- Y. Choi et al., "StarGAN: Unified Generative Adversarial Networks for Multi-domain Image-to-Image Translation," https://arxiv.org/abs/1711.09020. 8789-8797. 10.1109/CVPR.2018.00916.
- T. Karras et al., "Training Generative Adversarial Networks with Limited Data," arXiv:2006.06676 [cs, stat], Oct. 2020.

Highlights

- Car-to-Truck transformation
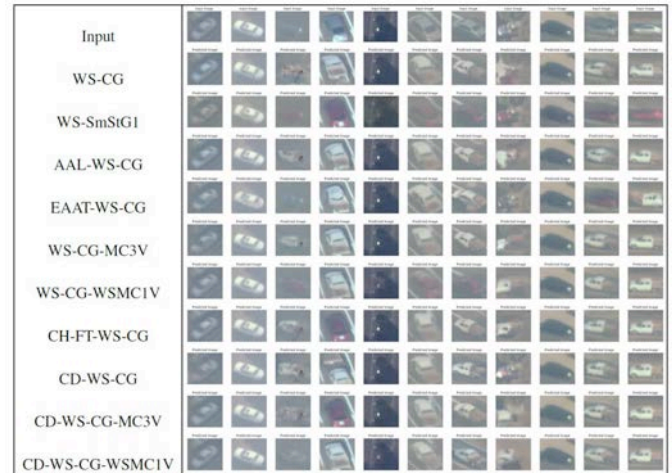
- Truck-to-Car transformation

Publications

- M. Reale, P. Nichols, E. Schneider, M. Bishop, and M. Cornacchia. "Generative Adversarial Networks for Vehicle Transformation in Overhead and Satellite Imagery," Oral presentation and full paper, IEEE Applied Imagery Pattern Recognition Workshop (AIPR'22), Oct. 2022.

Acknowledgements

Michael James Reale

realemj@sunypoly.edu

https://web.cs.sunypoly.edu/~realemj/

Identification of Fecal Indicator Bacteria and their Sources in the Mohawk River

OFFICE OF RESEARCH
SUNY POLYTECHNIC INSTITUTE

Project Summary

Surface water bodies provide drinking water, recreation, and socioeconomic benefits to the communities around them. However, water bodies can become unsafe due to bacterial contamination associated with animal waste. Researchers commonly use the bacteria *E. coli* and *Enterococci* as fecal indicator bacteria (FIB), and their presence indicates potential contamination of the water body and elevated risk to human health. However, it is usually not known where the FIB came from, since FIB are found in all types of animal waste (e.g. human, bovine, canine, avian). When high levels of FIB are found, it is important to determine the source in order to develop a good strategy to mitigate the problem. In this work, detection of source-specific markers via quantitative Polymerase Chain Reaction (qPCR) is used to identify the likely source-type of fecal contamination. Water quality sampling was conducted to quantify the presence of FIB and source-specific markers along the Mohawk river in Utica and Rome, NY and along the regional tributaries of Sauquoit and Oriskany creeks.

Highlights

- FIB concentrations were statistically different between Rome, NY and Utica, NY with higher values in Utica

- More significant positive correlations exist between FIB and rainfall in the Utica region which utilizes a combined sewer system

- Samples downstream of an active combined sewer overflow (CSO) resulted in a 2-log or greater increase in FIB compared to dry weather conditions

- Human source markers were detected in 50% of all samples confirming the presence of human sources of fecal contamination in the region

Publications

Lininger, K., Ormanoski, M., and C.M. Rodak. 2022. Observations and Correlations from a 3-year study of Fecal Indicator Bacteria in the Mohawk River in Upstate NY. Water, 14, 2137. https://doi.org/10.3390/w14132137

Rodak, C.M., and L. Endres 2019. Validation and application of pPCR-MST of fecal contamination in the Mohawk River Watershed. New York State Water Resources Institute Final Report. https://cals.cornell.edu/water-resources-institute/resources/wri-research-reports

Acknowledgements

Carolyn Rodak

rodakc@sunypoly.edu

Simulation of the SiConi Preclean Process to Predict Uniform Oxide Removal from Si Wafers

Project Summary

Semiconductor wafers are an essential component in modern-day electronics typically used for photovoltaics or ICs. Before these wafers can be used in such components, they must endure several phases of processing. The SiConi etch is one such remote plasma-assisted dry etch process that involves the simultaneous exposure of the wafer substrate to H_2, NF_3, and NH_3 plasma by-products. As a result, fluorosiliciate salts are generated through the reaction of the NH_4F reactive species with the SiO_2 film which is followed by an annealing process where volatile sales are transformed to SiF_4 and NH_3. The combined process allows for a damage-free removal of surface impurities, resulting in increased contact resistance and reliability of middle-of-the-line interconnections. While the SiConi is one of the more popular dry preclean processes, the specific role of various physical parameters throughout the process remains to be determined. The current study focuses on carrying out numerical simulations of the etch process to determine conditions necessary for a uniform oxide removal. A 300mm Si wafer is set up under a showerhead that delivers reactants from a remote plasma and the final thickness of the oxide layer is measured. We closely evaluate the influence of temperature and reactant rate and predict oxide removal for both blanket and patterned wafers.

Highlights

While this is an ongoing effort but the temperature (left panel , in K) and velocity (right panel , in m/s) contours show the variations in the flow over the domain indicating preferential removal of the SiO_2 layer.

Chamber temperature – 85°C , Velocity 0.02m/s

Chamber temperature – 65°C , Velocity 0.04m/s

Publications

- Sekaran A., Taber M., Ferrer-Luppi D., "Simulation of the SiConi preclean process to predict uniform oxide removal on Si wafers", American Physical Society Division of Fluid dynamics meeting, November 2022, Indianapolis, U.S.A.
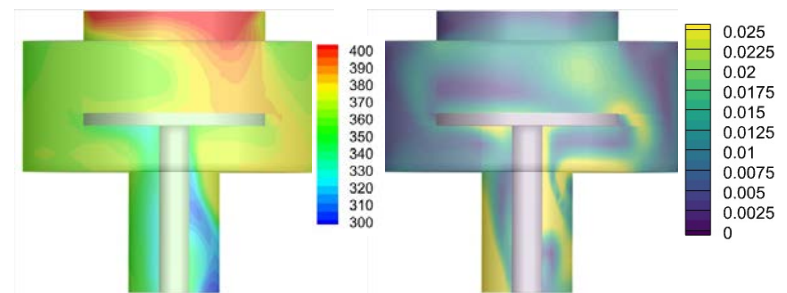
- Sekaran A., Taber M., Ferrer-Luppi D, "Simulation of the SiConi preclean process to predict uniform oxide removal from 300 mm Si wafers" , Albany Nanotechnology Symposium, November 2022, Albany, U.S.A.
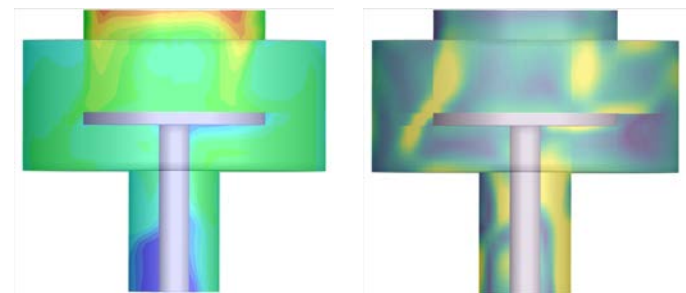
Acknowledgements

Aarthi Sekaran

sekaraa@sunypoly.edu

https://sunypoly.edu/research/aarthi-sekaran.html

https://aartisekaran.wixsite.com/aarthi-sekaran

Low-cost Internet of Things Based Real-Time Pavement Monitoring System

Project Summary

- A low-cost IoT-based data collection apparatus for pavement monitoring systems was developed and tested in this study. The proposed system consists of various components, and each part requires a specific design. Therefore, the complete system is partitioned into five modules (Sensor, power, IoT, LTE/4G, and UI/WebApp modules), and each module is developed according to the project specification. While designing the modules, rough environmental conditions alongside pavements in rural areas are considered. Therefore, the final product can be used in rural areas to collect real-time data as long as there are LTE connections in the area. The final product allows users to collect real-time, dense data such as strain, pressure, temperature, and humidity without traveling to the site. In addition, the data is accessible anywhere in the world as long as an internet connection is available. The developed apparatus is tested through the sensors embedded under the heavy vehicle simulator (HVS) at the Accelerated Pavement Testing (APT) facility located at Blacksburg, Virginia. The continuous data streaming to the Cloud, as well as even more dense data, is collected and recorded in the local microprocessor Raspberry-pi memory and Cloud at the same time. The sample data both from local R-pi and Cloud is presented in this paper.

Highlights

- This study has developed and tested a low-cost, wireless IoT-based data collection apparatus for pavement monitoring systems

- The final product can be used on the roadside to collect real-time data as long as there are LTE connections in the area.

- The final product allows road engineers to collect realtime, dense data such as strain, pressure, temperature, and humidity without traveling to the roadside.

- The developed apparatus is tested in the heavy vehicle simulator (HVS) located in Virginia Tech Transportation Institute.
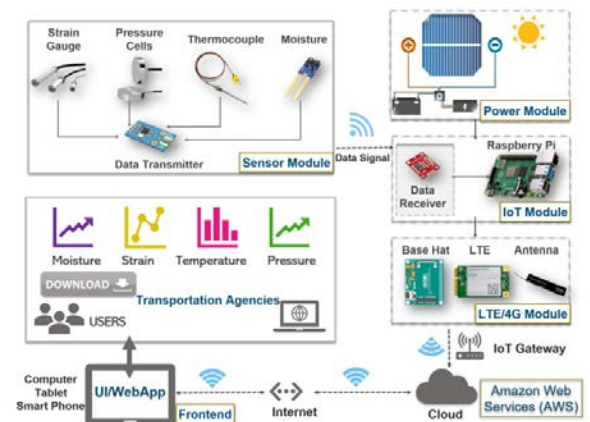
Fig. 1. IoT modules for pavement monitoring system

Publications

- Shen, J., Bekiroglu, K., Tekeoglu, A., Boz, I., Chen, W., & Geng, M. (2022). Numerical Study of a PVDF-Based Strain Sensor for Damage Detection of an Asphalt Concrete Pavement Subject to Dynamic Loads. Engineering Proceedings, 27(1), 31. (https://doi.org/10.3390/ecsa-9-13318)
- Bekiroglu, K., Tekeoglu, A., Shen, J., & Boz, I. (2021, December). Low-Cost Internet of Things Based Real-Time Pavement Monitoring System. In 2021 IEEE International Conferences on Internet of Things (iThings) and IEEE Green Computing & Communications (GreenCom) and IEEE Cyber, Physical & Social Computing (CPSCom) and IEEE Smart Data (SmartData) and IEEE Congress on Cybermatics (Cybermatics) (pp. 17-22). IEEE.
- Jiayue Shen, Minghao Geng, Abby Schultz, Weiru Chen, Hao Qiu, and Xianping Wang (2019, November). Numerical study of a multi-layered strain sensor for structural health monitoring of asphalt pavement. 6th International Electronic Conference on Sensors and Applications, 15–30 November 2019. (Best Contribution Award) (doi:10.3390/ecsa-6-06527)

Acknowledgements

Jiayue Shen

shenj@sunypoly.edu

https://scholar.google.com/citations?user=DvEVIlgAAAAJ&hl=en

https://www.researchgate.net/profile/Joyce-Shen-5

Deployable Communication Systems at Terahertz Frequencies Through Joint Wavefront and Waveform Engineering

Project Summary

- The objective of the proposed research is to demonstrate a targeted breakthrough of a 100 Gbps wireless link at THz frequencies. Since the THz-band has abundant bandwidth and very small wavelengths, a communication system that is expected to function at these frequencies and provide unprecedented capabilities is likely to be (i) Near-field and (ii) Ultra-wideband. Thus, on the one hand, near-field valid wavefronts are required for improved propagation of THz signals. In conjunction, on the other hand, such wavefronts must be customized and designed keeping in mind that the underlying waveform is no longer narrowband, and thus the effects on the signal propagation and the required aspects of the THz channel cannot be accounted for through prior work.

Highlights

- Targeted breakthrough of a 100 Gbps wireless link.

- Utilization of near-field wavefronts including Bessel beams and Airy beams that provide significant improvements on link conditions compared to canonical beamfocusing.

- Accounting for waveform distortions through multi-carrier modulations and implementing a joint hardware / software mitigation algorithm.

- Increase the participation of undergraduate students in cutting edge research and drive growth in industry relevant and pioneering fields.

Publications

- A.Singh, V. Petrov, H. Guerboukha, I.V.A.K. Reddy, E. Knightly, D.M. Mittleman, J.M. Jornet "Wavefront Engineering: Realizing Efficient Terahertz Band Communications in 6G and Beyond," submitted to IEEE Wireless Communications Magazine, 2022.

- I. V.A.K. Reddy, D. Bodet, A. Singh, V. Petrov, C. Liberale, J. M. Jornet, "Ultrabroadband Terahertz band Communications with Self-healing Bessel Beams," (Nature) Communications Engineering, revised2023..

- A.Singh, V. Petrov, and J.M. Jornet, "Utilization of Bessel Beams in Wideband Sub Terahertz Communication Systems to Mitigate Beamsplit Effects in the Near-field," to appear in proceedings of the 48th IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP), 2023.

- A.Singh, I.V.A.K. Reddy, D. Bodet, and J.M. Jornet, "Bessel Beams for 6G - A performance Analysis," in proceedings of the 56th Asilomar Conference on Signals, Systems, and Computers, November 2022.

- A.Singh, A. Alqaraghuli, and J.M. Jornet, "Wavefront Engineering for Terahertz Communications,"in proceedings of the 22nd IEEE International Workshop on Signal Processing Advances in Wireless Communications (SPAWC), May 2022.

Acknowledgements

Arjun Singh

https://www.sunypoly.edu/faculty-and-staff/arjun-singh.html

singha8@sunypoly.edu

Project Summary

Scope: Study and formulate customer-based thiol-acrylates chemistry as a function of bulk modifiers for potential use in rapid immunoassay test

• Understanding the particulate and multi-phase transport mechanism in small scale real like complex geo/bio-structures using non-destructive mechanism

• Optimization of three-dimensional additive manufacturing processes to manufacture metal and polymer based high resolution complex surrogates resembling the natural porous structures

• Goals: 1) Devise programmable novel and stable microfluidic polymer that has wide ranges of stable hydrophilic surfaces, (2) understand the mechanical and chemical properties associated with it to develop a polymer-based platform for rapid immunoassay test

TOPIC 1: Tunable surface hydrophilicity via the in-situ tertiary-amine catalyzed Michael Addition of a multifunctional thiol to a multifunctional acrylate

TOPIC 2: Feasibility study of three-dimensional additive manufacturing of polymer based micro-channels using UV based SLA technique

Publications

• Nirmal Dhakal, Mostafa A. Elseifi, Zia U. Zihan, Zhongjie Zhang, Christophe N. Fillastre, and Jagannath Upadhyay, "Classification of Surface Pavement Cracks as Top-down, Bottom-up, and Cement-Treated Reflective Cracking Based on Deep Learning Methods", Canadian Journal of Civil Engineering, 13 august, 2021, https://doi.org/10.1139/cjce-2020-0808

• Jagannath Upadhyay, Christopher O. Bounds, Nicholas Totaro, Suman Thakuri, Leah Garber, Michael Vincent, Zhaoyang Huang, John A. Pojman, "Production and analysis of stable microfluidic devices with tunable surface hydrophilicity via the in-situ tertiary-amine catalyzed Michael addition of a multifunctional thiol to a multifunctional acrylate", European Polymer Journal, 126 (2020) 109482

Acknowledgements

Highlights

(a)   (b)
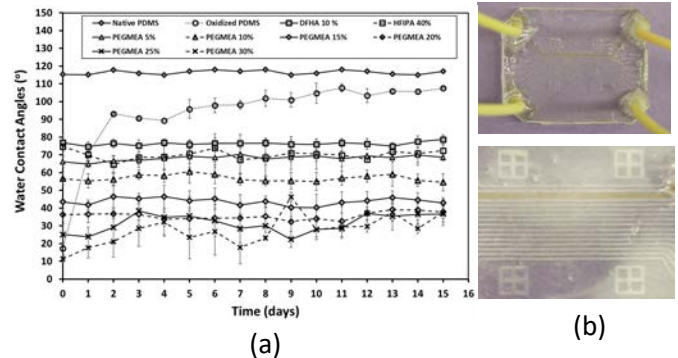
Figure 1. (a) Water contact angle library showing native PDMS; PDMS exposed to an oxygen plasma generator for 30 seconds, and PETA-co-TMPTMP materials containing, HFIPA, DFHA, and various concentrations of PEGMEA as a function of recovery time, and (b) images of the final annealed microfluidic device attached to inlet capillaries (top left and top right) and methyl orange solution being pumped through final microfluidic device.

(a)   (b)   (c)
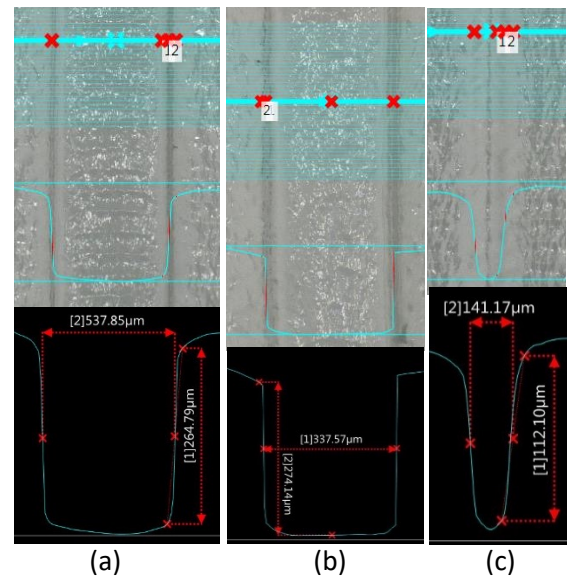
Figure 2. Optical images illustrating microchannels using UV based SLA technique. The design width of the microchannels was (a) 600 µm, (b) 400 µm, and (c) 200 µm and the depth for the channels was 300 µm. It also illustrates larger geometrical deviation in high resolution channels compared to others and the surface roughness was observed in the tens to hundreds of microns.

Jagannath Upadhyay

upadhyj@sunypoly.edu

Debugging System-Level Concurrency Faults

Project Summary

- Localizing concurrency faults that occur in production is hard because, (1) detailed field data, such as user input, file content and interleaving schedule, may not be available to developers to reproduce the failure; (2) it is often impractical to assume the availability of multiple failing executions to localize the faults using existing techniques; (3) it is challenging to search for buggy locations in an application given limited runtime data; and, (4) concurrency failures at the system level often involve multiple processes or event handlers (e.g., software signals), which cannot be handled by existing tools for diagnosing intra-process (thread-level) failures. To address these problems, we present SCMiner, a practical online bug diagnosis tool to help developers understand how a system-level concurrency fault happens based on the logs collected by the default system audit tools. SCMiner achieves online bug diagnosis to obviate the need for offline bug reproduction. SCMiner does not require code instrumentation on the production system or rely on the assumption of the availability of multiple failing executions. Specifically, after the system call traces are collected, SCMiner uses data mining and statistical anomaly detection techniques to identify the failureinducing system call sequences. It then maps each abnormal sequence to specific application functions.

Highlights

- Data Mining

- Program Analysis

- Natural Language processing

- Conducted an empirical study on 19 real-world benchmarks. The results show that ScMiner is both effective and efficient at localizing system-level concurrency faults

Publications

- Zaman, Tarannum Shaila, Xue Han, and Tingting Yu. "SCMiner: localizing system-level concurrency faults from large system call traces." *Proceedings of the 34th IEEE/ACM International Conference on Automated Software Engineering*. 2019.

Acknowledgements

Tarannum Shaila Zaman

zamant@sunypoly.edu

https://tarannumzaman.github.io

College of
Health Sciences

OFFICE OF RESEARCH
SUNY POLYTECHNIC INSTITUTE

Mental Health and Well-Being of Oneida County Teens During the COVID-19 Pandemic

Project Summary

Oneida County periodically administers anonymous and voluntary Teen Assessment Project (TAP) surveys to its middle and high school students to catalog youth opinions and behaviors, as well as identify problems and concerns among youth that should be addressed by the schools and community. In 2022, the county conducted a TAP survey that was mainly designed to assess students' mental health and well-being during the COVID-19 pandemic. Students were asked several questions, including their thoughts about suicide and running away from home, whether they intentionally hurt themselves, about being cyberbullied, and whether they often felt so sad or hopeless. The survey also inquired about who the student lived with the most, whether the family had recently been homeless, and about safety challenges and physical and sexual abuse.

Publications

Niyirora, J., Rana, A.M., Tichenor, V., & Joseph, J. (25 July 2022). *Oneida County COVID-19 Student Survey Report*.

Highlights

Despite the challenges of the pandemic, this inquiry revealed some good news, compared to the 2019 TAP survey, such as a decrease in the rate of teens who considered suicide or thought about running away from home. Besides, the majority of the respondents were not worried about economic challenges or being less socially connected due to COVID-19. Still, this survey also uncovered more mental health and educational challenges compared to the pre-pandemic era, including an increase in the rate of teens who felt so sad or hopeless almost every day for two weeks or more in a row that they stopped doing some usual activities. And nearly half of the students felt they needed help adjusting to all the changes in their lives because of COVID-19. As expected, most students had difficulties learning during the pandemic, primarily due to online and other remote teaching modalities. Aside from the statistical similarity in adverse childhood experience (ACE) between the 2019 and 2022 TAP surveys, it was observed that students with an ACE history were worse off socially and mentally during the pandemic than their counterparts.

Joanne Joseph, Ph.D.

josephj@sunypoly.edu

https://sunypoly.edu/faculty-and-staff/joanne-joseph.html

Research Interests

- My main subject areas revolve around medical education, public health, and clinical research informatics, especially EMR generated data and analytics of heterogeneous clinical information (clinical "Big Data") from large clinical databases to study data trends and improve health outcomes.

- Over the past year, I have been providing my informatics and data expertise on several research projects at Nova Southeastern University Dr. Kiran C. Patel College of Osteopathic Medicine (NSU-KPCOM) and SUNY Polytechnic Institute.

- At NSU-KPCOM, I am utilizing my data expertise to examine the effectiveness of hyperbaric oxygen treatment on veterans with mild traumatic brain injuries. During my time at Polytechnic Institute, I have been and continue to be working closely with Dr. Joanne Joseph and Dr. Veronica Tichenor as a data analyst on their award from Herkimer County as part of a Herkimer County System of Care Expansion and Sustainability Project grant funded by the Substance Abuse and Mental Health Services Administration.

Acknowledgements

Publications

- Bested, A. C., **Rana, A. M.**, Hardigan, P., Niyirora, J., Cheema, A., Antony, G., Defina, P.A., & Machado, C. (2022). A Case Series of 39 United States Veterans with Mild Traumatic Brain Injury Treated with Hyperbaric Oxygen Therapy. *Clinical and Translational Neuroscience*, 6(3), 21. doi.org/10.3390/ctn6030021

- **Rana, A.M.**, Wiggin, H., DeGaetano, H., Wallace-Ross, J., & Jacobs, R.J. (2022). Formative Evaluation of Using Action Learning in a Master of Medical Education Assessment and Measurement Course. *Cureus*, 14(7). doi.org/10.7759/cureus.26523

- Rourke, K.M., Longtin, L., Niyirora, J., **& Rana, A.M.** (2021). Assessing Basic Nutrition Knowledge of Nurse Practitioners. *International Journal of Nursing and Health Care Science* 01:2021-60.

- AlHazme, R. H., Haque, S. S., Wiggin, H., & **Rana, A. M.** (2016). The impact of health information technologies on quality improvement methodologies' efficiency, throughput and financial outcomes: a retrospective observational study. *BMC Medical Informatics and Decision Making*, 16(1), 154.

- AlHazme, R. A., **Rana, A. M.**, & De Lucca, M. (2014). Development and Implementation of a Business Intelligence System at Broward Regional Health Planning Council. *International Journal of Public Health Informatics*, 6(2).

Arif M. Rana, Ph.D.

https://sunypoly.edu/health-information-informatics.html

ranaa@sunypoly.edu

Project Summary

This doctoral research study was conducted to advance understanding of the art of nursing in clinical practice. This study involved adaptation and evaluation of the 37-item Aesthetics of Nursing Care Scale (ANCS) for use by nurses in clinical practice within the U.S. The purpose was to evaluate the psychometric properties of a modified, English-translated version, the Aesthetics of Nursing Care Scale–For Nurses (ANCS-FN). This study used two phases, each with two rounds, for adaptation and evaluation of the ANCS-FN.

The first phase utilized an expert panel for evaluation of face, content, and construct validity, and the final adaptation as the 20-item ANCS-FN. A pilot of the ANCS-FN was conducted in the second phase. The pilot used a sample of hospital-based nurses for evaluation of the instrument's validity and reliability. Exploratory factor analysis using principal component analysis was completed to evaluate the instrument's dimensionality and validity. Cronbach's alpha coefficients were calculated to determine reliability.

Publications

Acknowledgements

Highlights

In the first round of phase one, review by a four-member expert panel demonstrated appropriateness for 31 of the 37 preliminary ANCS-FN items, and readability for 15. For relevance, 20 items showed I-CVI = 1.0 and 17 items showed I-CVI = 0.25 to 0.75, revealing an average S-CVI = 0.784. Based on these results and panel recommendations, multiple items were modified to form a second 37-item preliminary version. In round two, 20 items were deemed to be essential (I-CVI = 1.0) and only those were retained for the ANCS-FN.

In phase two, the 20-item ANCS-FN was piloted with a sample of hospital-based nurses, with 48 responses returned for the first administration. EFA revealed four factors with good interpretability and the sub-scales 1) self and contextual knowing; 2) compassionate and caring approaches; 3) transpersonal connections; and 4) authentic presence. Each sub-scale demonstrated good reliability with Cronbach's coefficients 0.826, 0.835, 0.842, and 0.798, respectively. The ANCS-FN was administered as a repeated measure at two weeks with inadequate responses to calculate the ICC.

This study examined the ANCS-FN as an English-translated and adapted measure of the aesthetics, or art of nursing. Two iterations of the ANCS-FN were evaluated by an expert panel for adaptation and use by nurses in clinical practice. A pilot of the ANCS-FN was then conducted, and analysis revealed four sub-scales with good interpretability and reliability. These findings are consistent with the literature and prior analysis of the original tool. However, due to study limitations and the inability to determine the instrument's stability, further evaluation of the ANCS-FN is recommended.

Amy E. Weaver

Amy.weaver@sunypoly.edu / bankera@sunypoly.edu

College of
Nanoscale
Science +
Engineering

OFFICE OF RESEARCH
SUNY POLYTECHNIC INSTITUTE

Project Summary

- Rutherford Backscattering- Channeling (RBS)

- Nuclear Reaction Analysis (NRA)

- High Resolution Magnetic Spectrometer

- Particle induced X-ray analysis (PIXE)

- Ion implantation

- Micro-beam RBS/ PIXE Analysis

ION BEAM LABORATORY
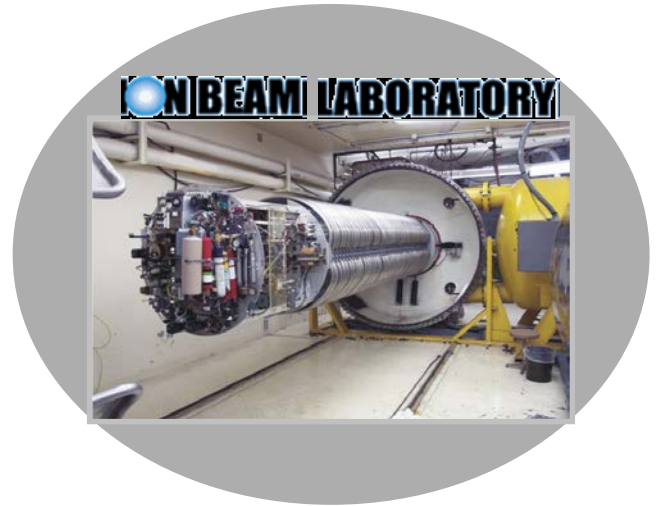
Crystal Ion slicing
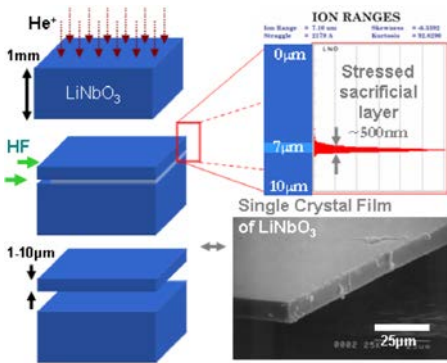
FEOL : Dopant Activation, Diffusion Studies in Si, SiGe, SOI. High resolution Depth profiling for USJ

Boron Profile (RTA 1100 annealed sample)
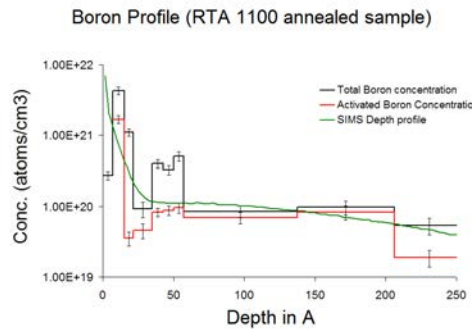
Defects in Semiconductor crystals: Ultra shallow junctions, Waveguides.
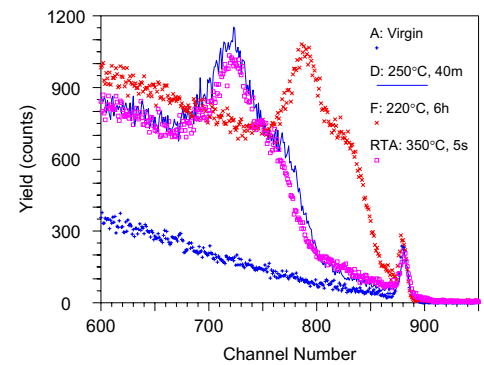
Publications

- Manana, U., Shah, K., Chaudhary, L. S., Higashiya, S., Bakhru, H. S., Gittleson, F. S., & Efstathiadis, H. Analysis of SEI Formation and Fast Charging on Lithium Loss in NMC/Graphite Cells. In ECS Meeting Abstracts (No. 4, p. 512, 2021).

- S. Higashiya, U. Manana, K. Shah, L. Chaudhary, M. Chebuske, A. Hagazy, H. Bakhru, F. Gittleson and H. Efstathiadis, "Analysis of SEI Formation and Fast Charging on Lithium Loss in NMC/Graphite Cells", Fast Charging in Electrochemical Systems - Batteries and Supercapacitors, 240 Electrochemical Society Meeting, Virtual Conference, (2021).

- M. Millares, H. Frost, M. Chebuske, K. Shah, D. Sadana, H. Bakhru and H. Efstathiadis, "Structural Analysis of Li1-xAlxTi2-x(PO4)3Thin Films for All-Solid-State Li-ion Battery Applications, Physics of Corona viruses, 122nd Topical Symposium of the New York State Section of the American Physical Society, Virtual Conference, Albany, NY (2020).

- S. Higashiya, A. Hegazy, K. Shah, L. Chaudhary, M. Chebuske, H. Bakhru, F. Gittleson and H. Efstathiadis, "Analysis of SEI Formation and Fast Charging on Lithium Loss in NMC/Graphite Cells", submitted to Chem. Acta (2022).

Hassaram Bakhru, PhD

hbakhru@sunypoly.edu

Interplay Between PTP1B Activity and Cholesterol Metabolism

Project Summary

Much remains unknown about the underlying molecular mechanisms that cause insulin resistance. However, a growing body of data supports that altered physiological levels of cellular cholesterol is an underlying condition of insulin resistance. We have recently identified protein tyrosine phosphatase 1B (PTP1B) as a cholesterol-interacting protein in cells. Given that PTP1B dephosphorylates the insulin receptor on key residues and dephosphorylates insulin receptor substrate, we propose to investigate the link between cholesterol binding to PTP1B and insulin signaling. Our preliminary results show that cholesterol binds to PTP1B in vitro and in vivo. When characterizing this interaction, we have observed that cholesterol acts as an allosteric electron donor for PTP1B and that this electron tunneling event leads to the reduction of the reversibly oxidized catalytic cysteine of PTP1B, re-activates the enzyme and attenuates insulin signaling. Given these results, our proposal is designed to test the hypothesis that cholesterol is a reductant that protects PTP1B from NOX-mediated oxidation, and that PTP1B is a central player in the molecular mechanism by which increased cellular cholesterol leads to defective insulin receptor signaling and insulin resistance.

Highlights
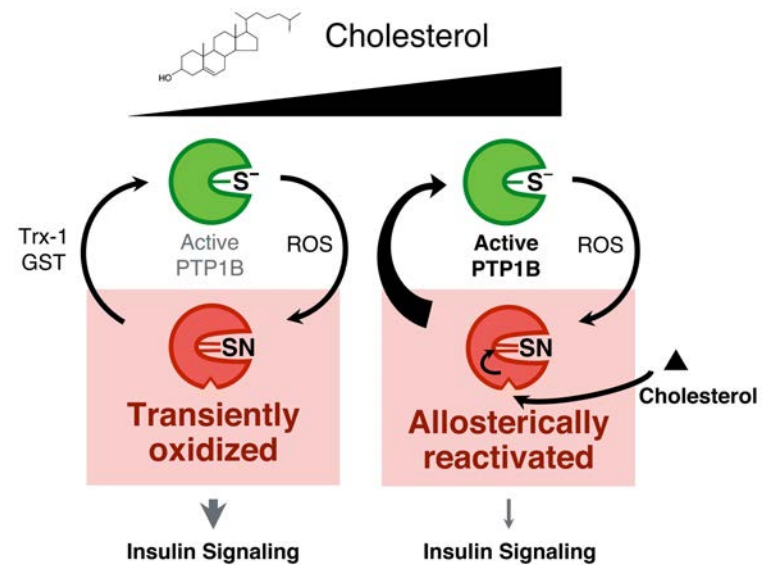
Publications

- He, P., Faris, S., Sagabala, R.S., Xu, Z., Callahan, B., Wang, C., Boivin, B., Zhang, F. and Linhardt R.J. (2022) Surface plasmon resonance cholesterol biochip for the study of cholesterol-protein interactions. Biosensors. 12(10):788

- Sagabala, R. S., Londhe, A. D., Marquart, K., Pappin, D., & Boivin, B. (2022). Role of PTP1B in the Regulation of Cholesterol Homeostasis. FASEB J., 36.

- Sagabala, S.R., Boivin, B. Role of Cholesterol and Oxysterols in Regulating PTP1B Activity. Free Radic Biol Med. 2017. 10: 223.

Acknowledgements

Benoit Boivin

bboivin@sunypoly.edu

https://sunypoly.edu/research/boivin-lab.html

Twitter: @BoivinLab

Role of the Phosphoprotein Phosphatase PTP1B in Cardiac Hypertrophy

Project Summary

Oxidative stress is associated with reduced left ventricular function and correlates with the severity of heart failure in patients. Research from many labs now highlights the importance of reactive oxygen species as mediators of cardiomyocyte hypertrophy and the development of contractile dysfunction. Despite intensive efforts, proteins targeted by ROS in hypertrophy remain mostly unknown to date. We have recently demonstrated that Protein Tyrosine Phosphatase 1B (PTP1B) becomes reversibly oxidized and inactivated in pressure overload-induced cardiac hypertrophy and that PTP1B inactivation causes profound changes in thyroid hormone responsiveness. We showed that inhibiting the synthesis of triiodothyronine rescued the exacerbated pressure overload-induced hypertrophy and improved myocardial contractility and systolic function in cardiomyocyte-specific PTP1B knockout mice (PTP1B cKO) subjected to pressure overload. We hypothesize that as hypertrophy develops, the inhibition of the cardioprotective activity of PTP1B by cellular oxidants leads to T3-mediated changes contributing to pathological hypertrophy. Based on our recently published data in which we demonstrate that breaking the interaction between 14-3-3z and PTP1B prevents its inactivation in vivo, we also hypothesize that ectopic expression of a peptide derived from PTP1B, will both prevent the oxidation and inactivation of PTP1B in myocytes, and prevent pathological thyroid hormone signaling, left ventricular hypertrophy and heart failure.

Highlights
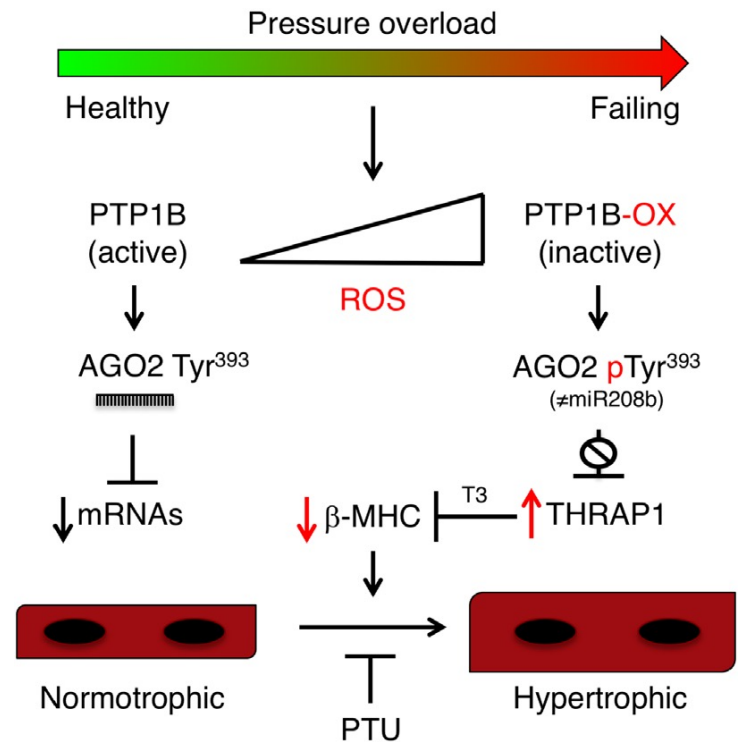
Publications

- Coulis, G. *et al.* (2022) Protein Tyrosine Phosphatase 1B Regulates miRNA-208b-Argonaute 2 Association and Thyroid Hormone Responsiveness in Cardiac Hypertrophy. Science Signaling 15(730): eabn6875.

- Londhe, A.D., *et al.* (2020) In Vitro Activity Assays to Quantitatively Assess the Endogenous Reversible Oxidation State of Protein Tyrosine Phosphatases in Cells. Curr. Protoc. Chem. Biol. 12, e84.

- Londhe, A.D., *et al.* (2020) Regulation of PTP1B Activation Through Disruption of Redox-Complex Formation. Nat. Chem. Biol. 16(2):122-125

Acknowledgements

Benoit Boivin

bboivin@sunypoly.edu

https://sunypoly.edu/research/boivin-lab.html

Twitter: @BoivinLab

Project Summary

Previous studies on the structure of PTP1B have given us important insights on the catalytic function and redox regulation of members of the PTP family. They have also revealed that the reversible oxidation of PTP1B (PTP1B-OX) leads to profound structural changes at the active site that can be taken advantage of by molecular tools such as conformation sensor antibodies to stabilize its inactive form. Although work from several labs, including ours, has clearly established that PTPs, and phosphatases from other families, are transiently oxidized by hydrogen peroxide in response to several cellular stimuli, our knowledge of the underlying mechanisms is rudimentary and inconsistent with most of the work in signal transduction from the last two decades that clearly points toward an exceptionally high level of specificity within signal transduction cascades. This research project aims to gain further insight into the molecular mechanisms that regulate the catalytic activity of PTPs to develop molecules that specifically activate phosphatases.

Highlights
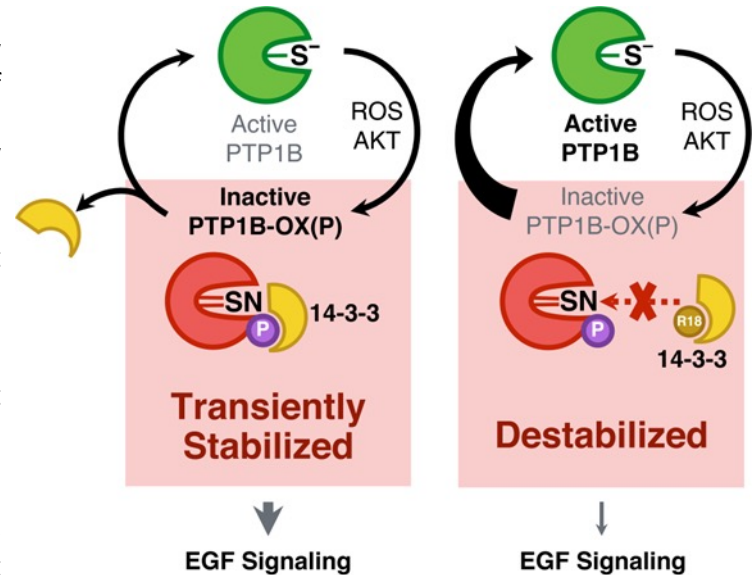
Publications

- Londhe, A.D., Bergeron, A., Rizvi, S. H., Kim, S.J., & Boivin, B. (2022). Characterization of Protein Tyrosine Phosphatase 1B activator peptides in cells. FASEB J, 36.

- Londhe, A.D., Bergeron, A., Zhang, F., Rizvi, SMH, Kim, S.J., Linhardt, R., Boivin, B. (2022) Characterization of Peptide Activators of Protein Tyrosine Phosphatase 1B, Free Radic Biol Med. 180, 63.

- Londhe, A.D., *et al.* (2020) In Vitro Activity Assays to Quantitatively Assess the Endogenous Reversible Oxidation State of Protein Tyrosine Phosphatases in Cells. Curr. Protoc. Chem. Biol. 12, e84.

- Londhe, A.D., *et al.* (2020) Regulation of PTP1B Activation Through Disruption of Redox-Complex Formation. Nat. Chem. Biol. 16(2):122-125

Acknowledgements

Benoit Boivin

bboivin@sunypoly.edu

https://sunypoly.edu/research/boivin-lab.html

Twitter: @BoivinLab

Project Summary

- The overarching goal of this proposal is to develop a self-assembly process to convert planar sheets of epithelial cell monolayers into 3D functional structures. To achieve this goal we will create trilayer stacks of photo-imageable, biocompatible hydrogels for cell growth and use differential swelling stresses to self-assemble them into tubes, intersections and spheres for cell differentiation and functional tissue formation.
- We have created a biocompatible polymeric system that self-assembles.
- The current plan is to use thermally-responsive polymers to control the timing of self-assembly so that we can vary self-assembly vs. the life-time of cell growth.

Highlights

- Figure 1 shows (A) Idealized self-assembled tube lined with cells. (B) Idealized self-assembly structure.

(A) Goal Structure

(B) Idealized Self Assembly

Highly cross-linked BL2: Less swelling.

Lightly cross-linked BL1: More swelling.
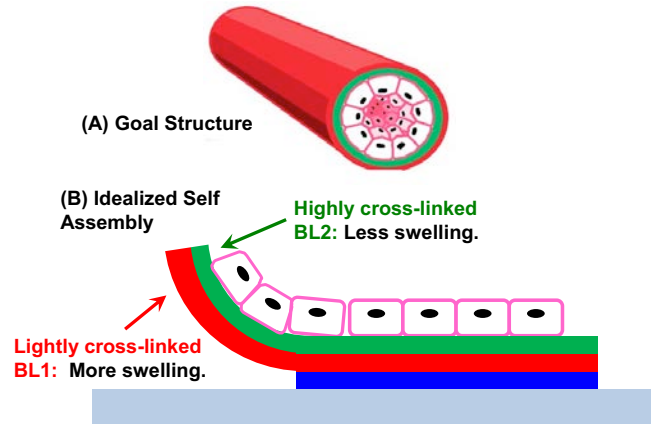
- Figure 2 shows the first self-assembly results.

250 µm

0   2   15   29   37   47 sec.
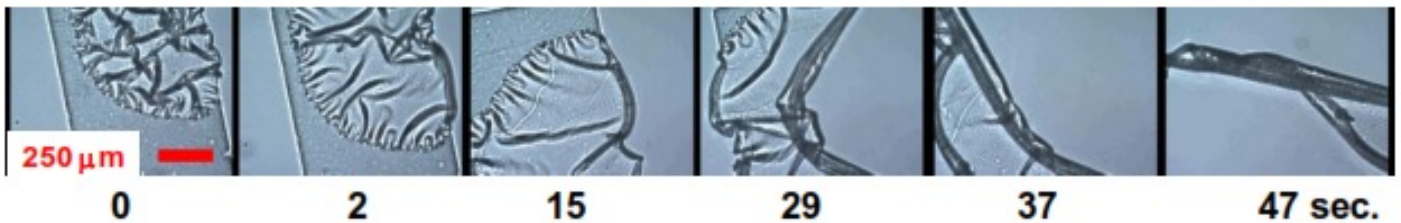
Publications

- Other than undergraduate posters, this work has intentionally been unpublished. The plan is to achieve critical results then, submit to a high-level journal.

Acknowledgements

Robert L. Brainard

rbrainard@SUNYPoly.edu

Fluorescent Plasmonic Sensors for Disease Diagnosis

Project Summary

We are developing novel approaches to disease diagnosis and evaluation of serological response to infections or vaccination, in response to the COVID-19 pandemic and other important diseases.

Using Ciencia, Inc.'s grating-coupled fluorescent plasmonic (GC-FP) platform, we have developed assays for diagnosing Lyme disease with higher accuracy than conventional testing approaches, and for determining prior infection status / vaccination status for COVID-19. This technology utilizes nanoscale plasmonic gratings fabricated at SUNY Poly.

In collaboration with the University of Rochester and other partners in the AIM Photonics program, we are working to develop rapid, label-free detection of COVID-19 serological (antibody) response using novel silicon-photonic devices fabricated in the SUNY Poly 300mm cleanroom.

Highlights

Grating-coupled fluorescent plasmonics (GC-FP) can be used to detect antibodies in human blood samples to diagnose disease or prior infection in less than 30 min.

Publications

B. Taubner et al. Dual detection of COVID-19 antigens and antibodies using nanoscale fluorescent plasmonic substrates. (2022) Experimental Biology and Medicine. https://doi.org/10.1177/15353702221113860

B. Taubner et al. Rapid and Quantitative Detection of Human Antibodies Against the 2019 Novel Coronavirus SARS CoV2 and its Variants as a Result of Vaccination and Infection. (2021) Microbiology Spectrum. 9(2): e00890-21. https://doi.org/10.1128/Spectrum.00890-21
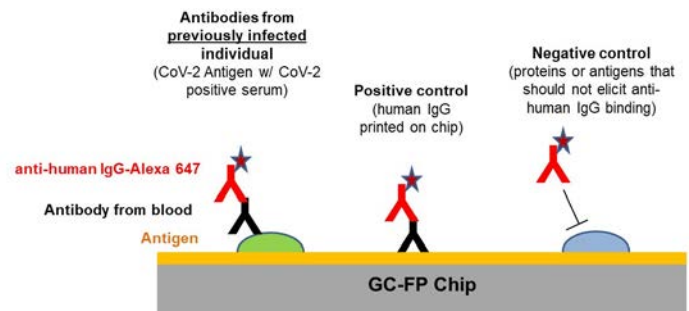
N. Cady et al. Multiplexed Detection and Quantification of Human Antibody Response to COVID-19 Infection Using a Plasmon Enhanced Biosensor Platform. (2021) Biosensors & Bioelectronics. 171:112679. https://doi.org/10.1016/j.bios.2020.112679

J.S. Cognetti et al. Disposable photonics for cost-effective clinical bioassays: application to COVID-19 antibody testing. (2021) Lab on a Chip. 21: 2913-2921 https://doi.org/10.1039/D1LC00369K

Acknowledgements

Nathaniel Cady

cadyn@sunypoly.edu

https://sunypoly.edu/research/nano-bio

Google Scholar

Nanoelectronic Hardware for Neuromorphic Computing and in-Memory Computing

Project Summary

We have established an ongoing research program on resistive memory devices (aka: ReRAM). These metal-insulator-metal (MIM) devices behave similarly to neural synapses, as their "memory state" depends on the current and voltage history of the device. This is a good example of bioinspired/biomimetic research, since the biological process of synapse formation is mimicked by a physical, electronic device. We have previously developed ReRAM as both non-volatile memory (NVM) elements, as well as devices to control the reconfigurability of CMOS circuits.

To date we have developed a full 65nm CMOS/memristor hybrid chip design and fabricate these devices in the SUNY Poly 300mm fabrication facility. This work leverages a 65nm node CMOS process design kit (PDK) that has been licensed by the Research Foundation for SUNY for design and fabrication purposes – to which we have added a ReRAM module.

We have ongoing efforts to characterize the switching mechanism of our devices, to better enable modeling and simulation of memristors in complex circuits. We are also investigating methods (both fabrication methods and testing methods) that reduce the stochastic nature of memristor device performance. This will improve reliability of these devices and make the amenable to larger scale integration with complex CMOS circuits, processors, etc.

Publications

S. Rafiq, M. Abedin, K. Beckmann and N. C. Cady, Detecting Temporal Correlation on HfO2 Based RRAM on 65nm CMOS Technology. (2022) 2022 IEEE 31st Microelectronics Design & Test Symposium (MDTS) p. 1-6, https://doi.org/10.1109/MDTS54894.2022.9826965

M. Liehr, K. Beckmann, N. Cady. Impact of Switching Variability, Memory Window, and Temperature on Vector Matrix Operations Using 65nm CMOS Integrated Hafnium Dioxide-based ReRAM Devices. (2022) IEEE 31st Microelectronics Design & Test Symposium (MDTS), 2022. https://doi.org/10.1109/MDTS54894.2022.9826924

Acknowledgements

Highlights

A TEM cross-section of an integrated transistor-ReRAM (1T1R) cell is shown at right, and full 300mm wafer map showing the memory window (high resistance vs. low resistance level) for ReRAM devices fabricated in our 300mm fabrication facility.
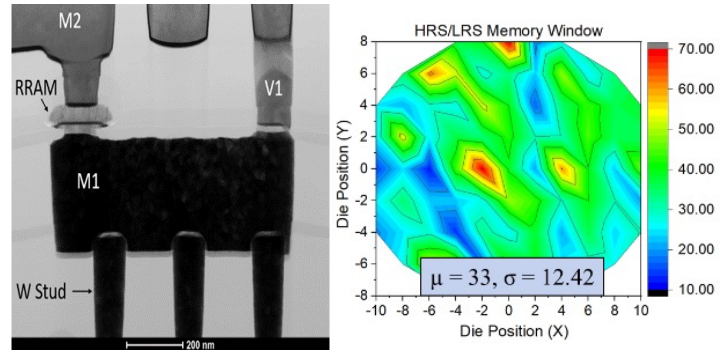
Rafiq, J. Hazra, M. Liehr, K. Beckmann, M. Abedin, J.S. Pannu, S.K. Jha, N.C. Cady. Investigation of ReRAM variability on flow-based edge detection computing using HfO2-based ReRAM arrays. (2021) IEEE Transactions on Circuits and Systems. https://doi.org/10.1109/TCSI.2021.3072210

M. Abedin, M. Liehr, K. Beckmann, J. Hazra, S. Rafiq, N. C. Cady. In-memory Computation of Error-Correcting Codes Using a Reconfigurable HfOx ReRAM 1T1R Array. (2021) 2021 IEEE International Midwest Symposium on Circuits and Systems (MWSCAS). p. 593-598, doi: https://doi.org/10.1109/MWSCAS47672.2021.9531717

J. Hazra, M. Liehr, K. Beckmann, M. Abedin, S. Rafiq, N.C. Cady. Optimization of Switching Metrics for CMOS Integrated HfO2 based Bipolar RRAM Devices on 300 mm Wafer Platform. (2021) IEEE International Memory Workshop (IMW) 2021. 1-4. DOI: 10.1109/IMW51353.2021.9439618

Nathaniel Cady

cadyn@sunypoly.edu

https://sunypoly.edu/research/nano-bio

Google Scholar

Project Summary

- The latest generation lithography technology for semiconductor manufacturing is extreme ultraviolet (EUV) lithography.

- It has begun production for advanced semiconductor devices, but still there are challenges with the photoresist used for the light sensitive pattern formation.

- We study multiple aspects related to the fundamental reaction mechanism of EUV photoresists.

Fundamentals of acid diffusion and reactions

- In the traditional chemically amplified photoresists, we study the generation of the acid from the photoacid generator and its efficiency to EUV photons.

- We study the range of the acids generated which impacts the speed and resolution of the resist.
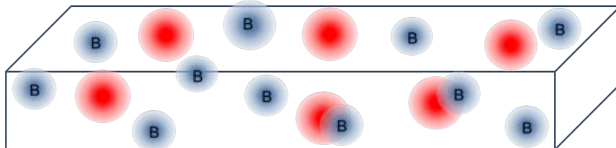
- We also study the diffusion rate and time scale of the acid diffusion.
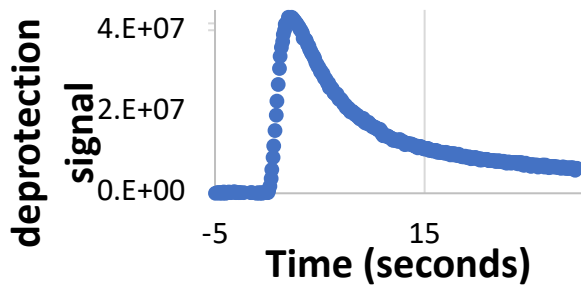
Molecular segregation

- At a small enough spatial scale nothing is uniform. For photoresists, we have approached the regime where the actual molecular distribution in the photoresists becomes a statistical challenge for repeatable and reliable lithography

- The random molecular distribution can be calculated. We are studying the non-random molecular distribution that occurs during the coating and baking of the photoresist coated wafers. This leads to local resist non-uniformities like this resist pattern on the left side from a uniform exposure process.

- Changing the chemical composition to molecules that are known to have energetically favorability to segregate makes the system even worse as shown in the right image.
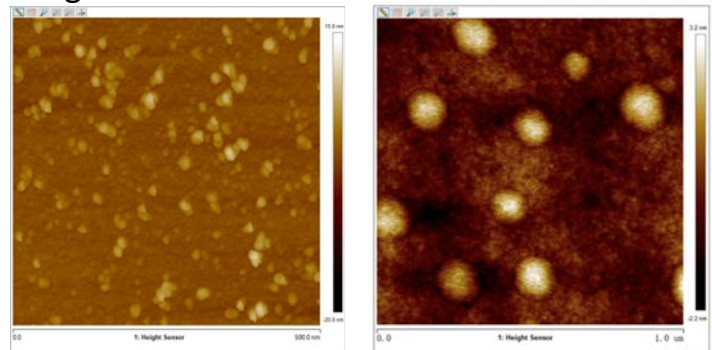
- Studying the onset of this segregation helps to understand how to control the segregation within commercial EUV photoresists where smaller numbers of segregated defects and smaller size features impacts manufacturability with EUV lithography

Acknowledgements

Greg Denbeaux and Robert Brainard

denbeag@sunypoly.edu, brainar@sunypoly.edu

Applications of Machine Learning to Materials Characterization

Project Summary

- The goal of this project is to access the ability of machine learning methods to improve the speed and accuracy of materials characterization.

- The first application is determination of crystal phase and orientation of ferroelectric HfZr oxide dielectric films used in advanced transistors.

- Data set consists of maps of electron diffraction patterns from cross-sectional samples of metal/HfZr oxide/metal samples.

- Sample provided by TEL

- Amir Kordijazi (Post-Doc)

Highlights

- First approach was un-supervised Machine Leaning.

UNSUPERVISED LEARNING

Dimensionality reduction of the diffraction patterns

Clustering of the feature vectors of the diffraction patterns

Analyzing each cluster to find information about the crystal phases and orientations

Unsupervised learning workflow

Results

(a)

(b)

(a) Phase map produced by a commercial software (Nanomegas) using template matching method, (b) preliminary result of grain map generated by the machine learning method

Publications

- In-Line Metrology for Semiconductor Manufacturing: Tutorial – 2022 Frontiers of Characterization and Metrology for Nanoelectronics (FCMN 2022)

- Poster – Amir Kordijazi - **Machine learning-assisted characterization of hafnia-based ferroelectric thin films** FCMN 2022

- Co-Author : Implementation of High-Performance and High-Yield Nanoscale Hafnium Zirconium Oxide based Ferroelectric Tunnel Junction Devices on 300mm Wafer Platform, accepted (J. Vac. Sci. Technol. B, 2022)

- Conference Co-chair for 2022 Frontiers of Characterization and Metrology for Nanoelectronics.

Alain Diebold

adiebold@sunypoly.edu

https://sunypoly.edu/research/optical-physics.html

Project Summary

- The goal of this project is to advance the ability of Mueller Matrix Spectroscopic Ellipsometry to measure 3D DRAM structures.

- Ezra Mel Pasikatan (Grad Student)

- Another goal is to characterize the multilayer single crystal epilayers of $Si/Si_{1-x}Ge_x$ using X-Ray and other methods.

- Develop scatterometry models for measuring the shape and dimensions of test structures with lithographically patterned contact holes and cavity etches.

https://semiengineering.com/will-monolithic-3d-dram-happen/

Highlights

- Superlattice effect observed in X-Ray Data ($\omega - 2\theta$) data from initial samples

- Favorable comparison between ellipsometry and X-Ray analysis of un-patterned film stack.

GOF: MAE (log10) is 0.208, Angle from -7019 to 1981
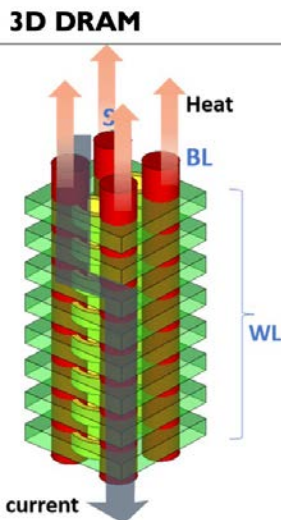
Publications

- Invited Talk : **Determination of Nanostructure Shape and Dimension using Mueller Matrix Spectroscopic Ellipsometry :** International Conference on Spectroscopic Ellipsometry 9

- Co-Author: Optical and Electrical Properties of Nanoscale Materials (Springer, Dec. 2021)

- Conference Co-chair for 2025 International Conference on Spectroscopic Ellipsometry (Boulder Co).

Acknowledgements

Alain Diebold

adiebold@sunypoly.edu

https://sunypoly.edu/research/optical-physics.html

https://link.springer.com/book/10.1007/978-3-030-80323-0

OFFICE OF RESEARCH
SUNY POLYTECHNIC INSTITUTE

Corrosion Products:
Hydrothermal Synthesis, Nanoparticle Characterization, and Transport Modeling

Project Summary

Nickel ferrite particles form when metal alloys containing nickel and iron corrode in high temperature water, and can be transported downstream to deposit in less auspicious locations. Deposition in a particular location is a function of many variables including the flow characteristics, particle size distribution, as well as particle-particle and particle-surface interactions. However, studying these deposits in the field is prohibitive due to the harsh environment in which they are formed. Instead, we synthesize model particles in a controlled laboratory setting, and evaluate surface charge and magnetic characteristics as a function of synthesis conditions and composition. Information about particle-particle or particle-surface interactions is then incorporated into a COMSOL Multiphysics model of the flow system, to predict nanoparticle transport and deposition in real environments. Controlling these material characteristics will also enable tailoring of ferrite nanoparticles for future applications in catalysis, magnetic storage systems, and the production of magnetic fluids.

Highlights

- Non-stoichiometric nanoparticles were synthesized over a range of metal cation ratios and temperatures

- Phase identification by X-ray Diffraction enabled the generation of a phase diagram with a goal of identifying the window for obtaining single phase nickel ferrite product

Nickel Ferrite Phase Diagram (Temperature & Precursor Ratio)

Legend: Precursors; Nickel Ferrite; NF + α-Fe$_2$O$_3$; NF + α-FeOOH; NF + β Ni(OH)$_2$

[Ni]/[Fe]: 0.25 0.275 0.30 0.325 0.35 0.375 0.4 0.425 0.45 0.475 0.50
Mole fraction Ni/(Ni+Fe) (single phase region, only): 0.231 0.259 0.273 0.286 0.298 0.310
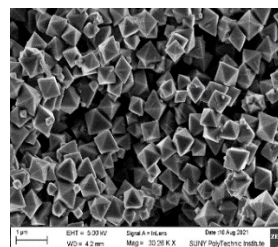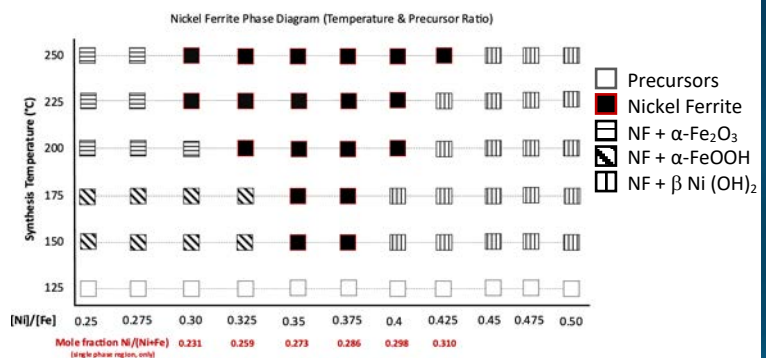
- Zeta potential measurements based on particle size & composition are used to calculate transport & deposition probability in COMSOL

Recent Publications & Conference Activity

- B.S. Nagothi, J. Arnason and K.A. Dunn, "A Hydrothermal Phase Diagram for the Low-Temperature Synthesis of Non-stoichiometric Nickel Ferrite Nanoparticles," *accepted for publication in Nuclear Technology, 2023.*

- B.S. Nagothi, J. Arnason and K.A. Dunn, "A Hydrothermal Phase Diagram for the Low-Temperature Synthesis of Non-stoichiometric Nickel Ferrite Nanoparticles," *poster presented at the 20th International Conference on Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,* Snowmass, CO, July 17-21, 2022.

- B.S. Nagothi, "Synthesis of nonstoichiometric nickel ferrites by hydrothermal method," Master's Report, College of Nanoscale Science & Engineering, SUNY Polytechnic Institute, 2022.

Acknowledgements

Kathleen A. Dunn

https://sunypoly.edu/faculty-and-staff/kathleen-dunn.html

dunnka@sunypoly.edu

Program Summary

Electroplated copper has been the conductor of choice for the semiconductor industry for twenty-five years, but faces a rapidly approaching sunset of its utility as chips and their interior wiring continue to scale to smaller sizes. My group has worked on several aspects of this issue over the last twenty years, from deposition method development for copper and its alloys, to microstructural manipulation for resistance to electromigration failure, to plasma etching and chemical mechanical polishing of alternative metals. The overarching theme is the role of defects in determining and manipulating material performance, a connection we explore with cutting-edge microscopy and spectroscopy techniques applied to blanket and patterned wafers from the 300-mm fabrication line.

Highlights

- Time-resolved Transmission Electron Microscopy confirmed microstructural transformation of ECD copper was initiated at sub-surface interface; later shown to depend on seed orientation

2.5 hours after plating   3.0 hours after plating   3.5 hours after plating   5.5 hours after plating

- Alloy development Cu(Co), Cu(Ag), Cu(Sn) for grain boundary stabilization
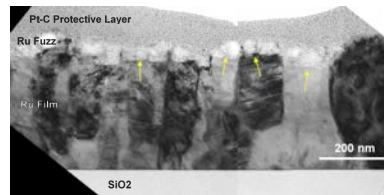
- Microstructural dependence of etch response in Ru

Select Publications & Conference Activity

- S. Rogalskyj, "Ruthenium Fuzz Growth and Surface Faceting During $O_2/Cl_2/Ar$ Plasma Processing," M.S. report, College of Nanoscale Science & Engineering, SUNY Polytechnic Institute, 2022.

- S. Rogalskyj, H. Frost, L. Melican, A. Palka, N. Joy, D.Triyoso, R. Clark, C. Wajda, G. Leusink, A. Raley, and K. Dunn, "Plasma-induced roughness and chemical modification of TiN bottom electrode and their impact on HfO_2-MIM properties," Proceedings of the *2020 International Interconnect Technology Conference*. Winner, Best Student Paper.

- C. Netzband and K.A. Dunn, "Ceria Based Chemical Mechanical Polishing Slurries," US Non-Provisional Patent Application 17/069,608, filed *October 14, 2020.*

- C. Netzband and K.A. Dunn, "Improving BEOL Metal Polishing through the Use of Ceria Abrasives," *Proceedings of the 2019 International Conference on Planarization/CMP Technology.* Winner, Best Student Presentation.

- T. Tsurumaru, L. Prestowitz, B. O'Brien and K. Dunn, "The impact of solute segregation on grain boundaries in dilute copper alloys," *Proceedings of the 2018 International Interconnect Technology Conference (IITC) ,* (2018). DOI: 10.1109/IITC.2018.8430454

Acknowledgements

Kathleen A. Dunn

https://sunypoly.edu/faculty-and-staff/kathleen-dunn.html

dunnka@sunypoly.edu

Additive Nanomanufacturing Using Charged Particle Beams

Program Summary

Focused Electron Beam Induced Deposition (EBID) and its corollary Ion Beam Induced Deposition (IBID) are direct-write techniques capable of producing three-dimensional structures with high spatial resolution, high placement fidelity, and the flexibility to deposit on non-planar surfaces. While room-temperature EBID and IBID with gas-phase precursors are commercially available options from any electron or ion microscope manufacturer, the growth rate is too slow to be viable for anything but laboratory use. Improving throughput without comprising the site-specificity or 3-dimensional capabilities of the technique are critical if this technology is to be a credible micro- or nano-manufacturing option. Using a unique custom-built cryogenic stage, my group was able to move the reaction from the typical precursor-starved regime into a precursor-rich regime where the growth rate was controlled by the electron beam current. We are the only group, globally, which employs this cryogenic assistance, which has enabled us to set (and keep) the current world record for volumetric growth rate for EBID depositions.

Highlights

- Demonstrated three orders of magnitude faster volumetric growth rates than our nearest competitor.
- Demonstrated the ability to design and build suspended structures, including stacked, free-standing bridges.
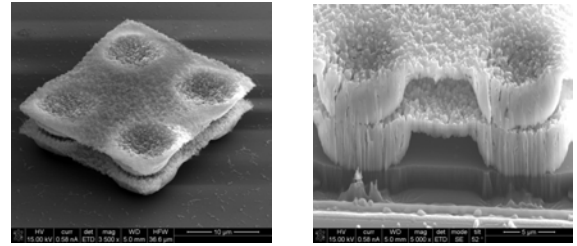
- Demonstrated morphological control in three regimes: mesh, smooth and rough surfaces.
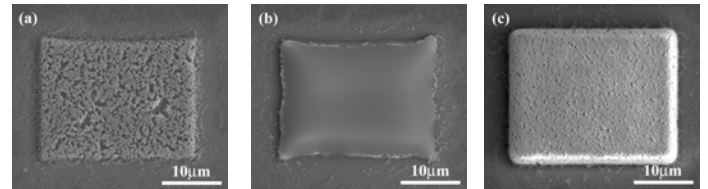
- Elastic and plastic responses are intermediate between polymer and me

Select Publications & Conference Activity

- A. Reiser, L. Koch, K.A. Dunn, F. Iwata, O. Fogel, Z. Kotler, N. Zhou, K. Charipar, A. Pique, P. Rohner, D. Poulikakos, S. Lee, S. K. Seol, I. Utke, C. van Nisselroy, T. Zambelli, J. M. Wheeler and R. Spolenak, "Metals by micro additive manufacturing: a comparison of microstructure and mechanical properties," *Advanced Functional Materials,* **2020,** 1910491. DOI: 10.1002/adfm.201910491
- M. Bresin, M. Toth and K.A. Dunn, "Direct-write 3D Nanolithography at Cryogenic Temperatures," *Nanotechnology* **24**(3), 03501 (2013). DOI: 10.1088/0957-4484/24/3/035301

Acknowledgements

Kathleen A. Dunn

https://sunypoly.edu/faculty-and-staff/kathleen-dunn.html

dunnka@sunypoly.edu

Nanoparticles for Chemical Mechanical Planarization

Program Summary

Chemical Mechanical Planarization (CMP) is the second-most costly process in the production of semiconductor wafers, and much of that cost comes from consumables such as the aqueous slurries used for material removal and surface polishing. Although the pH and solid content of slurries are adjusted during reuse to account for dilution of the liquid, very little is known about changes to the nanoparticles themselves. We design materials and methods to extend the usable lifetime of slurries, optimize their surface characteristics to increase their efficiency, and to inform occupational health strategies for ameliorating worker exposures.

Highlights

- Developed new methods and metrics for evaluating particle agglomeration in traditional slurries, and used this metric to design an AI algorithm to predict slurry replacement timing

- Broke the trade-off between speed and performance in ceria slurries by using the catalase mimetic activity of cerium to enhance the concentration of Ce^{3+} on the particle surface, independent of particle size

Select Publications & Conference Activity

- C. Netzband and K.A. Dunn, "Ceria Based Chemical Mechanical Polishing Slurries," US Non-Provisional Patent Application 17/069,608, filed *October 14, 2020.*

- C. Netzband and K. Dunn, "Improving Ruthenium Polishing Through the Use of Ceria Abrasives," Proceedings of the *2020 International Interconnect Technology Conference (virtual),* 2020.

- C. M. Netzband and K. Dunn, "Controlling the Oxidation State During Silicon Oxide CMP to Improve Material Removal Rate and Roughness," *ECS J. Solid State Sci. Tech.* **9**, 044001, 2020. DOI: 10.1149/2162-8777/ab8393

- C. Netzband and K.A. Dunn, "Investigation into the Effect of CMP Slurry Chemicals on Ceria Abrasive Oxidation State using XPS", *ECS J. Solid State Sci. Tech.* B, (10), P629-P633, 2020. DOI: 10.1149/2.0311910jss

- M. Kubota, K. Takanashi and K.A. Dunn, "Evaluation of Particle Agglomeration Level in CMP Slurry for Silicon Wafers and Investigation of these Effects on the Polishing Behaviors," *Proceedings of the 2019 International Conference on Planarization/CMP Technology*

- C. Netzband and K.A. Dunn, "Improving BEOL Metal Polishing through the Use of Ceria Abrasives," *Proceedings of the 2019 International Conference on Planarization/CMP Technology.* Winner, Best Student Presentation.

Acknowledgements

Kathleen A. Dunn

https://sunypoly.edu/faculty-and-staff/kathleen-dunn.html

dunnka@sunypoly.edu

Office of Research — SUNY Polytechnic Institute

Li-Enriched Graphite Anodes of Batteries Investigated Using Nuclear Reaction Analysis

Project Summary

Lithium-ion electrode-electrolyte interfaces remain key areas of study, even after a half-century of technological development. The physical and chemical characteristics of the solid electrolyte interphase (SEI) formed on a graphite anode surface during the initial charge cycle may have an outsized influence on cell performance. Ideally, the electrolyte selection, formation, and resulting SEI are designed to optimize cell parameters like lifetime, energy, and power while balancing the process time and its associated production cost

Non-destructive Li nuclear reaction analysis (NRA) techniques at Ion Beam Lab of the University at Albany were used to profile the Li distribution at the surface of graphitic Li-ion battery anodes. These techniques show that Li concentrations are elevated within 300 nm of the anode surface, even in fully delithiated states. The surface region, which includes the solid electrolyte interphase, contains at least 60% of the total Li irreversibly lost during formation and cycling leading to battery degradation.

Highlights

- Using two Li-NRA techniques PIGE and DIPE, we obtained quantifiable ^6Li and ^7Li depth profiles of graphite anodes after SEI formation and cycling.

- These non-destructive techniques illuminate Li concentration gradients at electrode surfaces and elucidate the consequences of electrochemical irreversibility.

- Nuclear reaction analyses will continue to be useful in studies on the physical and performance impacts of SEI formation, cell aging, and fast charging in Li-ion batteries.

- PIGE ^7Li depth profile of the formed and cycled graphite anode surface. Each line indicates a representative anode from a cell subjected to a different formation procedure. A background that is consistent for each sample is indicated as a dashed line
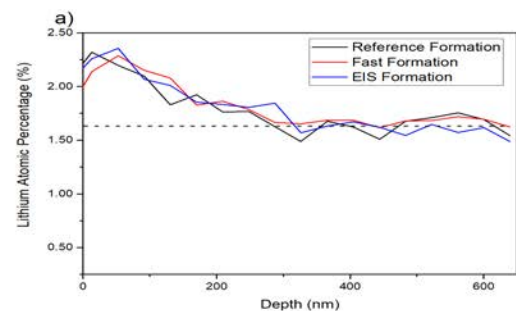
Publications

- M. Chebuske, S. Higashiya, S. Flottman, H. Bakhru F. Gittleson, B. Antonopoulos, O. Paschos and H. Efstathiadis, "Lithium-Enriched Graphite Anode Surfaces Investigated using Nuclear Reaction Analysis", Chem. Comm., 93 (2020), DOI: 10.1039/d0cc04205f
- S. Higashiya, U. Manana, K. Shah, L. Chaudhary, M. Chebuske, A. Hagazy, H. Bakhru, F. Gittleson and H. Efstathiadis, "Analysis of SEI Formation and Fast Charging on Lithium Loss in NMC/Graphite Cells", Fast Charging in Electrochemical Systems - Batteries and Supercapacitors, 240 Electrochemical Society Meeting, (2021).

Acknowledgements

Harry Efstathiadis

efstath@sunypoly.edu

- https://sunypoly.edu/faculty-and-staff/harry-efstathiadis.html
- https://sunypoly.edu/academics/majors-and-programs/nanoscale-engineering/nanoscale-engineering-renewable-energy.html

OFFICE OF RESEARCH
SUNY POLYTECHNIC INSTITUTE

Engineering Active Sites on Transition Metals as High-Performance Bifunctional Electrodes for Electrochemical Water Splitting

Project Summary

A facile method was used to prepare $MoNi_4$ particles on MoO_2 nanorods and MoVN was coated using DC-RF co-sputtering technique. Coating transition metal nitride (MoVN) on synthesized nanorods showed significant increase in the catalytic activity towards both HER and OER with measured overpotentials of 14 mV and 140 mV at 10 mA/cm^2 respectively.

Electrochemical impedance spectroscopic results also show the decreased charge transfer resistance of the synthesized electrode for both half-cell reaction.

The stability tests of the electrode were also performed for both reactions under consideration, showing that the electrode can deliver the expected current density for 12 hours without degradation.

Further, the required overpotential for overall water splitting was found as low as 320 mV and the continued electrolysis performed for 12 hours at high current density, demonstrates the applicability of the electrode synthesized in commercial H_2 production technologies.

Publications

Y. Kumaran *et al* 2022 *Meet. Abstr.* MA 2022-02 2523

Y. Kumaran, I. Gherasoiu, M. Thandavarayan, . Efstathiadis, "Engineering active sites on transition metals as high-performance bifunctional electrodes for electrochemical water splitting" submitted to ACS Catalysis (2023).

Acknowledgements

Highlights

- $MoNi4-MoO2$/Ni foam was synthesized via facile hydrothermal method.

- MoVN was coated using DC-RF co-sputtering on $NiMoO4$ nanorods.

- Fabricated electrodes performed very well for both cathodic and anodic reactions in alkaline conditions with overpotentials only 14 mV and 140 mV respectively.

- The electrodes also proved to be stable for both HER and OER for 12 hours without reduction in current density.

- Testing in flow electrode conducted reduced the bubble resistance and also increased overall efficiency.
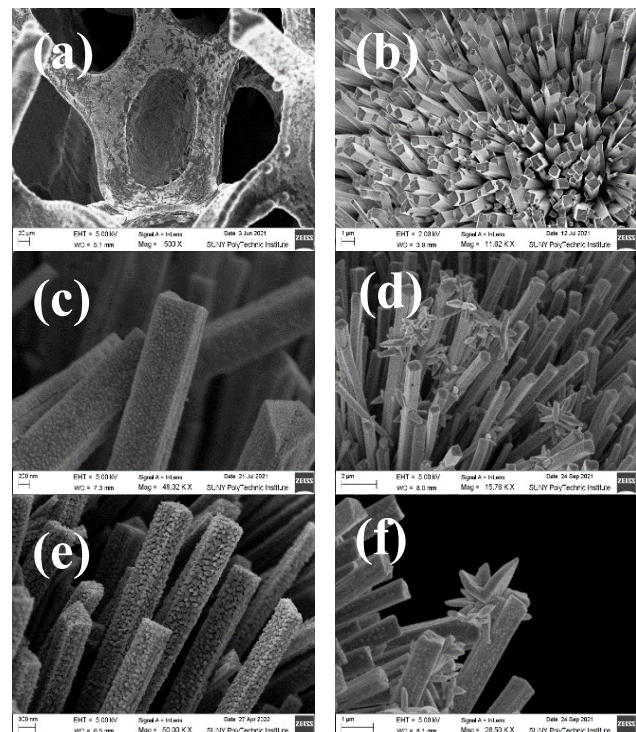
Figure above: SEM imaging (a) Ni foam (b) $NiMoO_4.H_2O$ obtained through hydrothermal synthesis (c) $MoNi_4/MoO_2$/Ni foam after annealing for 180 minutes (d)&(f) MoVN nanoflakes on $MoNi_4/MoO_2$ nanorods

Harry Efstathiadis

efstath@sunypoly.edu

- https://sunypoly.edu/faculty-and-staff/harry-efstathiadis.html
- https://sunypoly.edu/academics/majors-and-programs/nanoscale-engineering/nanoscale-engineering-renewable-energy.html

Development of Nanostructured Antireflection Coatings Technology for UV and IR Bands for Improved Detector Array and Sensor Performance

OFFICE OF RESEARCH
SUNY POLYTECHNIC INSTITUTE

Project Summary

Nanostructured antireflection (AR) coatings reducing optical reflections and maximizing radiation transmitted onto the surfaces of substrates, optics and optical devices such as detectors over ultraviolet (UV) to infrared (IR) wavebands have many potential optical applications including for NASA IR band detectors.

These AR coatings fabricated using a scalable e-beam deposition process on GaSb substrates and LWIR detector arrays provide omnidirectional suppression of light reflection and increased optical transmission over a range of incident IR angles for improved detection and sensing performance. Through nanoengineering optical layers and tuning their refractive indexes, broadband and omnidirectional suppression of light reflection and scattering is achievable with increased optical transmission for enhanced IR detector and system performance over a wide range of light incidence angles.

The growth of step-graded nanostructured layers using a process involving deposition at different tilt angles has produced single-layer AR coatings utilizing ZnS demonstrating below 4% reflectance, compared to ~34% reflectance for uncoated GaSb, across LWIR bands of interest with substantial improvement in quantum efficiency.

Highlights

- AR nanostructures were developed to create optimal AR coatings with high laser damage thresholds and high reliability, even in extreme low temperature environments and under launch conditions.
- The quantum efficiency (QE) of a focal plane array after being coated with these nanostructured AR coatings improved from 31% to 47% from 8.0-9.4 µm over the LWIR band.
- These tunable nanoengineered optical layers enable the realization of optimal nanostructured coatings with extended reliability in extreme low temperature environments and under launch conditions.

8.075-9.4 µm Band Pass Filter Quantum Efficiency

20HIL34
T = 68 K
VDETCOM = 5.2 V
Tint = 1.41 msec
Mean QE = 47 %
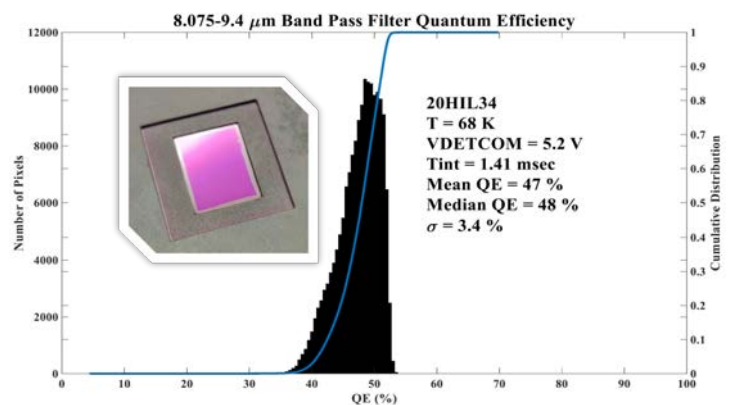Median QE = 48 %
σ = 3.4 %

Publications

- A. K. Sood, J. W. Zeller, A. W. Sood, P. Ghuman, S. Babu, S. Gunapala, A. Soibel, D. Ting, L. S. Chaudhary, and H. Efstathiadis, "Nanostructured antireflection coating technology for enhanced MWIR and LWIR band sensing performance," Proc. SPIE. 12234, 1223424 (2022).
- A. K. Sood, J. W. Zeller, A. W. Sood, R. E. Welser, P. Ghuman, S. Babu, S. Gunapala, A. Soibel, D. Ting, L. S. Chaudhary, and H. Efstathiadis, "Improved UV to IR band detector performance through advanced nanostructured antireflection coatings," Proc. SPIE 12091, 1209106 (2022).
- A. K. Sood, J. W. Zeller, A. W. Sood, R. E. Welser, P. Ghuman, S. Babu, S. Gunapala, A. Soibel, D. Ting, L. S. Chaudhary, and H. Efstathiadis, "Development of nanostructured antireflection coating technology for IR band for improved detector performance," in Proc. SPIE 11858, 1185812 (2021).

Acknowledgements

Harry Efstathiadis

efstath@sunypoly.edu

- https://sunypoly.edu/faculty-and-staff/harry-efstathiadis.html
- https://sunypoly.edu/academics/majors-and-programs/nanoscale-engineering/nanoscale-engineering-renewable-energy.html

Graphene Enhanced Charged Coupled Heterostructures for Mid-wave IR Photodetectors & Focal Plane Arrays

**OFFICE OF RESEARCH**
SUNY POLYTECHNIC INSTITUTE

Project Summary

High performance detector technology was developed for sensing over the mid-wave infrared (MWIR) band that involves the integration of graphene with HgCdTe photodetectors.

It combines the best of both materials, making them much more practical and useful for MWIR sensing applications such as remote sensing and earth observation, e.g., in smaller satellite platforms (CubeSat), for measurement of thermal dynamics with better spatial resolution. The graphene functions as high mobility channel that whisks away carriers before they can recombine, further contributing to performance. Chemical doping of the bilayer graphene lattice has provided *p*-type doping levels in graphene for high mobility implementation in high performance MWIR HgCdTe detectors. Through modeling, material development, and device optimization, room temperature graphene-HgCdTe MWIR array detectors were demonstrated.

Highlights

- High-performance graphene-HgCdTe detector technology for MWIR detection and imaging combines the best of both materials
- The successful integration of graphene into HgCdTe photodetectors provides higher MWIR detector performance as compared to HgCdTe-only detectors
- These graphene-enhanced HgCdTe detectors/arrays enable advanced earth observation measurement capabilities for NASA Earth Science applications
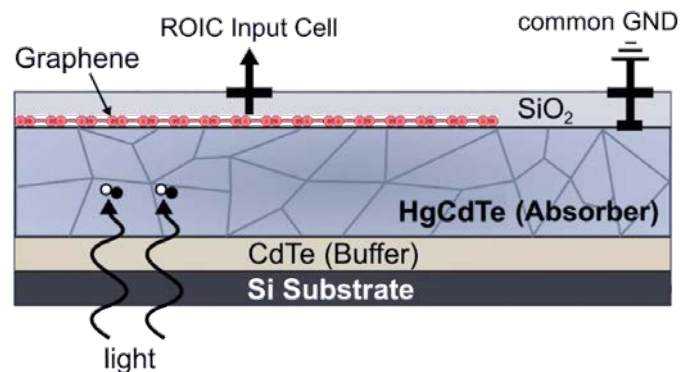
Publications

- J. W. Zeller, A. K. Sood, P. Ghuman, S. Babu, N. K. Dhar, S. Ganguly, R. N. Jacobs, L. S. Chaudhary, and H. Efstathiadis, "High-performance graphene-enhanced HgCdTe mid-wave infrared photodetector development," Proc. SPIE 12234, 1223425 (2022).
- A. K. Sood, J. W. Zeller, P. Ghuman, S. Babu, N. K. Dhar, R. N. Jacobs, S. Ganguly, S. Ahmed, F. Tonni, A. Ghosh, L. S. Chaudhary, and H. Efstathiadis, "Development of high-performance graphene-HgCdTe detector technology for mid-wave infrared applications," Proc. SPIE 12091, 1209108 (2022).
- A. K. Sood, J. W. Zeller, P. Ghuman, S. Babu, N. K. Dhar, R. N. Jacobs, L. S. Chaudhary, H. Efstathiadis, S. Ganguly, A. W. Ghosh, S. Z. Ahmed, and F. Tonni. Doping and Transfer of High Mobility Graphene Bilayers for Room Temperature Mid-Wave Infrared Photodetectors. In Nanostructured Materials—Classification, Growth, Simulation, Characterization, and Devices, P. Pham, editor. IntechOpen, 2022.

Acknowledgements

Harry Efstathiadis

efstath@sunypoly.edu

- https://sunypoly.edu/faculty-and-staff/harry-efstathiadis.html
- https://sunypoly.edu/academics/majors-and-programs/nanoscale-engineering/nanoscale-engineering-renewable-energy.html

Project Summary

- Currently, lithium-ion battery technology is dominant in many applications. While the manufacturing of such batteries is quite mature, the materials and structures employed do not provide optimal performance, extendibility, or sustainability. This research employs COMSOL Muttiphysics modeling to explore the relationship between battery system materials and structures on battery performance, including charge/discharge characteristics, battery heating, and capacity fade. Although many material systems and cell geometries may be investigated, our research is focused on designs with high manufacturing potential, so as to provide the most significant research impact on battery manufacturing and energy storage technologies.

Highlights

- The research carried out so for under this program has revealed several key structure-performance relationships for battery technologies, focusing on batteries using silicon-based anodes.

- It was determined that the nanostructure of the Si anode plays a key role in battery longevity and stability, using capacity fade as a key performance metric. Specifically, it was determined that anode nanoparticle size below a critical threshold value significantly decreases capacity fade, thus yielding longer-lasting, better-performing batteries.

- Similarly, the structure of the anode was observed to play a significant role in battery heating during charge/discharge cycling. Minimization of battery heating is crucial, as this helps to prevent ion intercalation into the electrode, which reduces the battery performance.

Publications

- H. Dasari and E. Eisenbraun, "Predicting the Effect of Silicon Electrode Design Parameters on Thermal Performance of a Lithium-Ion Battery", under editorial review at *J. Electrochem. Sci. Eng.*

- H. Dasari and E. Eisenbraun, "Predicting Capacity Fade in Silicon Anode-Based Li-Ion Batteries," *Energies* 2021, **14**(5), 1448; https://doi.org/10.3390/en14051448

Acknowledgements

Eric Eisenbraun

https://sunypoly.edu/faculty-and-staff/eric-eisenbraun.html

eisenbe@sunypoly.edu

OFFICE OF RESEARCH
SUNY POLYTECHNIC INSTITUTE

Profiling the Budding Yeast Genome For Resistance to Food Carcinogens

Project Summary

- Human susceptibility to environmental carcinogens is highly variable. This variability is partially due to genetics; however, genes that confer resistance are still unknown. Since many eukaryotic genes are conserved from yeast to humans, we used budding yeast to identify genes that confer resistance to carcinogens. We humanized the yeast barcoded deletion collection by introducing human genes that bioactivate carcinogens, and exposed yeast to 2-amino-3-methylimidazo [4,5-f] quinoline (IQ), a heterocyclic aromatic amine linked to colon cancer. By high-throughput DNA sequencing of molecular barcodes, we identified genes that confer IQ resistance. Among the human genes orthologous to yeast resistance genes, the DNA repair genes *hNTHL1* and *RAD18* are risk factors for colon cancer. Future studies are to knockdown mammalian orthologs in cell cultures and determine subsequent IQ sensitivity.

Highlights

- Expression of human CYP1B1, a cytochrome P450 gene expressed in the liver, breast, and prostate activates food carcinogens to become potent genotoxins in budding yeast.

- Among IQ resistance genes are those that participate in DNA damage tolerance, ribosome structure, histone modification, and ammonia metabolism. An interactome of gene functions is shown below.

Publications

- Perpetua, N., Kannan, A., **Fasullo, M**. CYP1B1 converts procarcinogens into genotoxins in *Saccharomyces cerevisiae.* Mutation Research, 874–875: 503440,2022.

- **Fasullo M,** Dolan M. The continuing evolution of barcode applications: Functional toxicology to cell lineage. *Experimental Biology and Medicine*. doi:10.1177/15353702221121600, 2022.

- Dolan, M, Zaidi, F., St. John, N., Doyle, F., **Fasullo**, M. High-throughput screening of the Saccharomyces cerevisiae genome for 2-amino-3-methylimidazo [4,5-f] quinoline resistance identifies colon cancer-associated genes. bioRxiv, Cold Spring Harbor Laboratory Press, 2022.
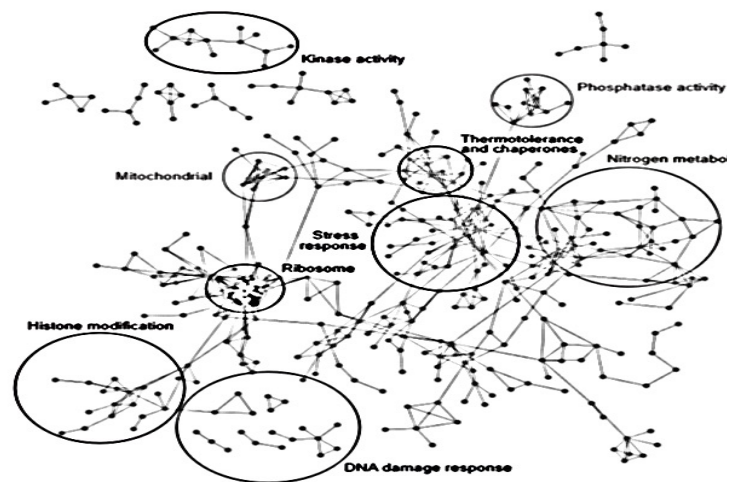
Acknowledgements

Michael Fasullo

https://sunypoly.edu/faculty-and-staff/michael-fasullo.html

fasullm@sunypoly.edu

# On-Demand Scalable Fabrication of Nanostructures

Project Summary

- The field of semiconductor nanowires (NWs) has become one of the most active research areas towards the realization of scalable on-chip devices. Progress is hindered due to the lack of development of novel scalable nanostructured materials and the ability to understand and control their properties at the nanoscale. The primary limiting fabrication challenge commonly faced, especially for feature sizes below 30 nm and bottom-up approaches, is the required deterministic (on-demand) and scalable integration, which involves control over the density, orientation, and spacing of the synthesized nanowires, parameters important for producing NW-based nanodevices.

- My group is focused on developing complementary metal-oxide-semiconductor (CMOS)-compatible fabrication strategies for nanostructured materials, for example, silicon carbide (SiC) and silicon oxycarbide NW arrays. These strategies enable the development of scalable ultrathin nanostructures, which can serve as an experimental platform to investigate NW-based emerging technologies, such as nanowire sensing/ optoelectronics, nanophotonics, and quantum photonics.

Highlights

- **Breakthrough:** My group has demonstrated novel nanofabrication for sub-10 nm one-dimensional (1D) SiC NWs at predetermined locations, using CMOS-compatible fabrication (recent publication in *Nanomaterials* with GlobalFoundries Corp.).

- This nanofabrication allows for self-aligned defect-free NWs to be fabricated without the use of a lithographic-pattern-transfer technique.
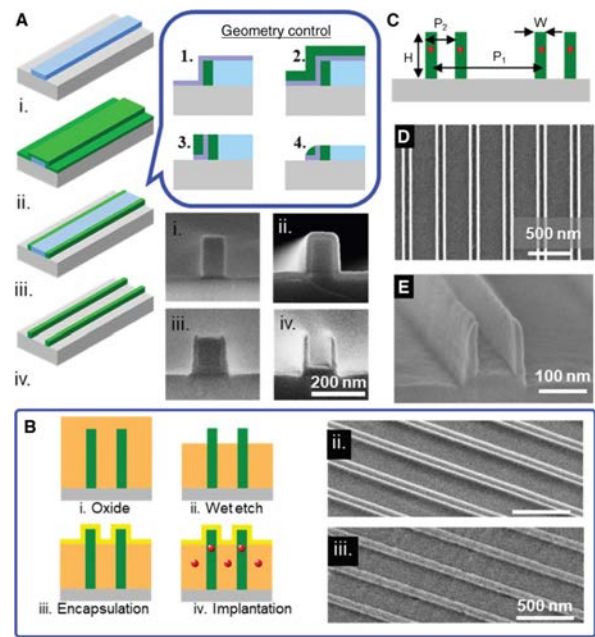
Publications

- Tabassum N., Kotha M., Kaushik V., Ford B., Dey S., Crawford E., Nikas V., and Gallis S*. On-demand CMOS-Compatible Fabrication of Ultrathin Self-Aligned SiC Nanowire Arrays. *Nanomaterials* 8, 906 (2018).

- B. Ford, N. Tabassum, V. Nikas, S. Gallis*. Strong photoluminescence enhancement of silicon oxycarbide through defect engineering. *Materials* 10, 446 (2017).

- N. Tabassum, V. Nikas, B. Ford, M. Huang, A. E. Kaloyeros, S. Gallis*. Time-resolved analysis of the white photoluminescence from chemically synthesized SiC_xO_y thin films and nanowires. *Appl. Phys. Lett.* 109, 043104 (2016).

Acknowledgements

Spyros Gallis (Spyridon Galis)

galiss@sunypoly.edu

SGNano Research - Galis Lab

sgalis@albany.edu Office #: 518-956-7048

OFFICE OF RESEARCH
SUNY POLYTECHNIC INSTITUTE

Scalable Telecom Single-Photon Emitters for Quantum Networks

Project Summary

- The realization of scalable on-chip quantum devices requires novel nanostructured materials that must be high integrable and compatible with existing electronic circuits, waveguide architectures, and current chip-scale and silicon process technology. Non-classical (single-photon) light sources emitting in the near-infrared region of the electromagnetic spectrum, where signal transmission losses in optical fibers are small, are essential for the development of long-distance optical quantum networks.

- Single-photon emission at near-infrared wavelengths has been demonstrated in several systems. Nevertheless, none of them has exhibited the necessary and required properties, such as room-temperature operation and photo-stable telecom C-band wavelength emission, radiative-limited excited state lifetimes, high photoluminescence (PL) efficiency, and compatibility with fab-friendly manufacturing technology, for practical telecom device implementation. These critical scientific and technological challenges have yet to be addressed. My research program focuses on filling these gaps and demonstrating scalable fab-friendly quantum photonic materials for the realization of chip-scale single-photon emitters.

SG Nano RESEARCH

Highlights

- **Breakthrough:** We have introduced a new class of fab-friendly nanowire-based nanophotonic structures. These nanostructures enable the positioning of emitters - **ions with an accuracy of 10 nm, an improvement on the current state-of-the-art ion implantation processes**, as reported in *Nanophotonics*[1]. Through a combination of correlation and comparison of temperature-dependence and time-resolved PL studies, my group has demonstrated a 22 times increase of the ion-induced emission in the nanophotonic structures, as compared to bulk devices, while using 20 times lower pumping power.

Scalable CMOS fab-compatible fabrication: Self-aligned SiC NW-based photonics structure

Emission engineering at 1540 nm: Polarized, efficient, and enhanced (60×) room-temperature emission

Publications

- Alex E. Kaloyeros, and Gallis S*. Polarization-dependent photoluminescence properties of fab-compatible nanowire-based nanophotonic structures. *Appl. Phys. Lett.* 120, 231104 (2022).

- [1]Natasha Tabassum, Vasileios Nikas, Alex E. Kaloyeros, Vidya Kaushik, Edward Crawford, Mengbing Huang, and Gallis S*. Enhanced Telecom C-band Emission and Controlled Positioning of Er^{3+} by Scalable SiC Nanophotonic Structures. *Nanophotonics,* 9, 1425 (2020).

- Tabassum N., Kotha M., Kaushik V., Ford B., Dey S., Crawford E., Nikas V., and Gallis S*. On-demand CMOS-Compatible Fabrication of Ultrathin Self-Aligned SiC Nanowire Arrays. *Nanomaterials* 8, 906 (2018).
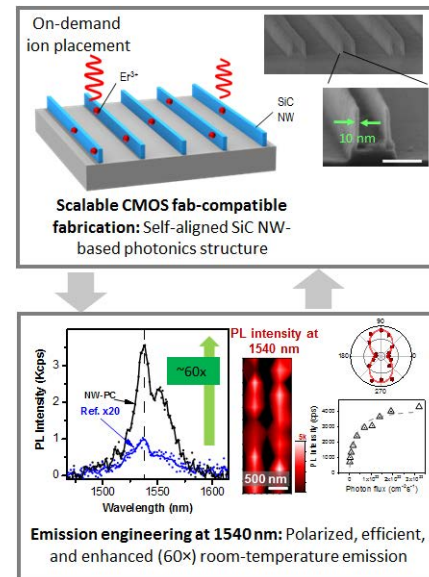
Acknowledgements

Spyros Gallis (Spyridon Galis)

galiss@sunypoly.edu

SGNano Research - Galis Lab

sgalis@albany.edu Office #: 518-956-7048

Polarization-dependent Nanophotonic Devices

Project Summary

- Emerging 2D semiconductor materials, such as gallium telluride (GaTe), are promising layered semiconductors that can serve as vital building blocks towards the implementation of nanodevices in the fields of nanoelectronics, optoelectronics, and quantum photonics. Research in this program is focused on developing environmental-stable layered GaTe and on studying the anisotropy in the optical properties of GaTe nanomaterials and nanodevices. The polarization of reflected and emitted light can offer more details about an object or scene than traditional thermal or visible imaging. The polarization anisotropy is caused by the 1D-like nature of the GaTe layer, as the layer comprises of Ga-Ga chains extending along the b-axis crystal direction. The identification of the b-axis in such anisotropic materials is imperative for the fabrication of polarization-sensitive devices based on the generation and detection of polarized light, such as polarization-sensitive photodetectors and light sources.

- My group demonstrated an effective and novel encapsulation process using ultrathin hydrogen–silsesquioxane for environmental-stable GaTe flakes. This novel strategy provides a platform for studying the anisotropic properties of pristine GaTe flakes through polarization-resolved Raman and photoluminescence (PL) spectroscopies.

SG Nano Research

Highlights

- **Breakthrough:** Polarization-resolved PL spectroscopy was used, in agreement with high-resolution transmission electron microscopy studies, to identify the b-axis crystal direction in capped GaTe flakes with various thicknesses. We observed polarization anisotropy contrast of ~0.6 at 532 nm for multilayer GaTe, which is comparable to other pseudo-1D materials like zirconium trisulfide.

Publications

- Mounika Kotha, Alex Kaloyeros, Thomas Murray, and Gallis S*. Wavelength-Dependent Anisotropic Optical Properties in Layered GaTe for Polarization-Sensitive Applications. *Adv. Photonics Res.* 2, 2100140 (2021).

- M. Kotha, T. Murray, D. Tuschel, and S. Gallis*. Study of Oxidation and Polarization-Dependent Optical Properties of Environmentally Stable Layered GaTe Using a Novel Passivation Approach. *Nanomaterials* 9, 1510 (2019).
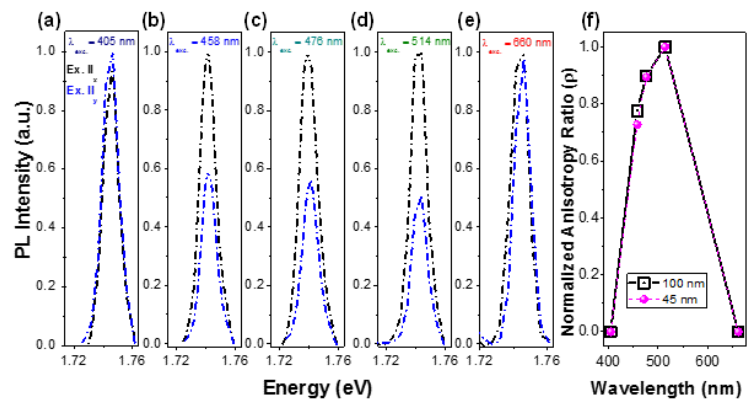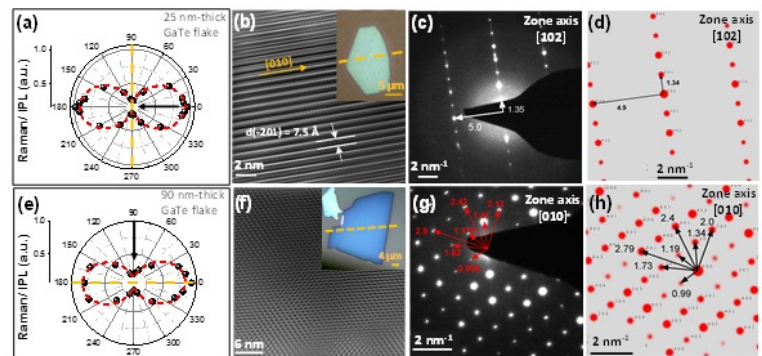
Acknowledgements

Gelest **SUNY RF** The Research Foundation for The State University of New York

Spyros Gallis (Spyridon Galis)

galiss@sunypoly.edu

SGNano Research - Galis Lab

sgalis@albany.edu Office #: 518-956-7048

Ion Beam Research on Extreme-Condition Materials and Harsh-Environment Sensing

Project Summary

- In collaboration with Lawrence Livermore National Laboratory (LLNL), we applied ion beam techniques to understand how nanoscale imperfections inhered from materials deposition and processing can impact the ability of dielectric-coated optical mirrors to resist high-power laser beams that are used in the National Ignition Facility for laser-induced inertial confinement nuclear fusion.

- With support from DARPA, we are working closely with our industrial partner to develop sapphire fiber based optical sensing capability for US hypersonic research programs.

Highlights

- The work with LLNL identified structural imperfections like nanobubbles and nonstoichiometry in hafnia coatings as important mechanisms for laser damage. The findings provide a fundamental basis for the development of potential mitigation strategies required for the realization of laser damage resistant hafnia films.

- Our work demonstrated that ion beam technology is effective in creating optical cladding and single-mode light transmission in sapphire fibers, a critical step toward optics sensing in harsh environments.

Single-mode sapphire fiber for industrial and military applications

power plants

SCR

Air Heater

ESP

ID Fan

Coal Crusher

Coal Silos

Boiler

FD Fan

gasifiers

Coal Supply

Pulveriser

Steam Turbine/Generator

Combustion engines

Fouling/slag Monitoring (650 °C)

Multi-point $CO/O_2/NO_x$ sensors for combustion Control & Optimization

Multi-point temperature sensor for Post-Comb control (1000 °C)
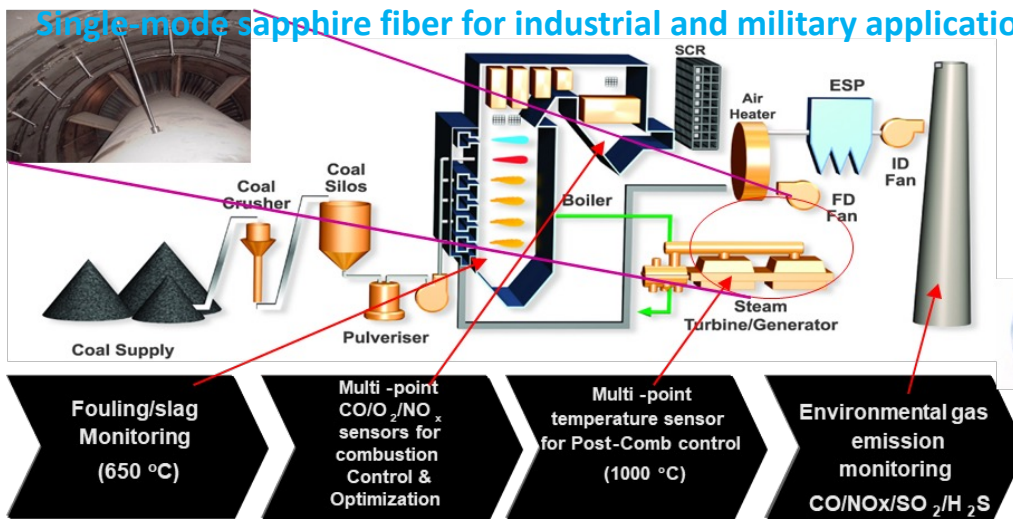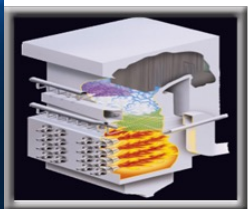
Environmental gas emission monitoring $CO/NOx/SO_2/H_2S$

Publications

- P. B. Mirkarimi et. al., Optical Materials Express 12, 3365 (2022).

- V. N. Peters et. al., Journal of Applied Physics 130, 043103 (2021).

Acknowledgements

Mengbing Huang

https://sunypoly.edu/faculty-and-staff/mengbing-huang.html

huangm@sunypoly.edu

# Nanoscale Visualization of Electrostatic Barriers Formed at Material Interfaces

Project Summary

- Electrostatic barriers at the interface between materials are the foundation of electronic and optoelectronic devices. Continued scaling below the sub-10-nm feature size is straining the ability to measure and control interface electrostatics and resulting device performance.

- The LaBella group has invented the ability to spatially resolve or visualize the electrostatic barrier at an interface between two materials to nanoscale dimensions. It utilizes a scanning tunneling microscopy (STM) technique called ballistic electron emission microscopy (BEEM). The STM tip is positioned on a regularly spaced grid with nanoscale resolution, where spectroscopy is utilized to measure the local electrostatic or Schottky barrier height as depicted.

- Computational modeling of the physics of the interface and electron transport has been developed that provides insight into the fundamental physical and chemical interactions occurring at the material interface. These interactions are the foundation of the barrier's spatial (non) uniformity

Highlights

Nanoscale map of the electrostatic barrier at metal/HfOx interface. A large 1 eV variation is observed and attributed to film nonuniformity.
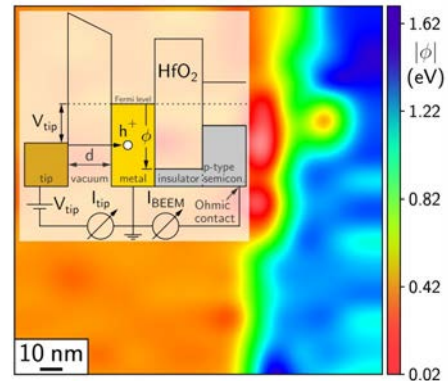
Mapping and computational modeling results of a non uniform interface, where multiple barrier heights are detected due to metal species intermixing.
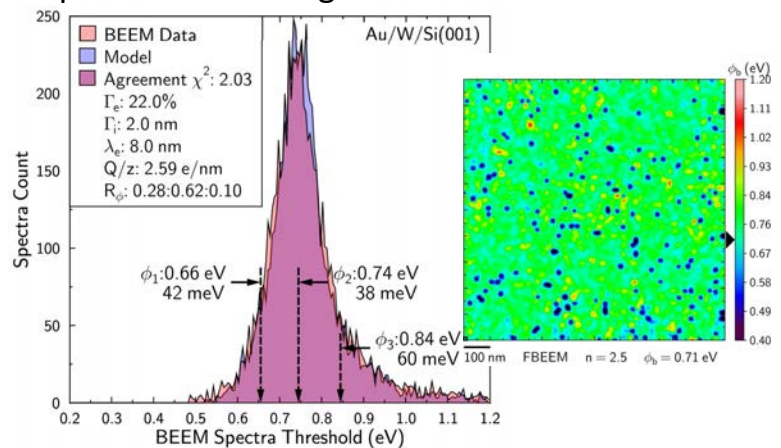
Publications

- Determination of the Energetic Resolution of Schottky Barrier Visualization via Interface Band Structure and Parallel Momentum Conservation, Jack Rogers, Westly Nolting, Chris Durcan, Robert Balsano, Vincent P. LaBella, AIP Advances, **11** 025108 (2021).
Visualizing Metal/HfO$_2$/SiO$_2$/Si(001) Interface Electrostatic Barrier Heights with Ballistic Hole Emission Microscopy, Jack Rogers, Hyeonseon Choi, Steven Gassner, Westly Nolting, Daniel Pennock, Steven Consiglio, Vincent P. LaBella, Journal of Applied Physics, **126** 195302 (2019).

Acknowledgements

Vincent LaBella

www.labellagroup.org

vlabella@sunypoly.edu

Project Summary

- Carbon nanotube solar cell devices inspired by photosynthesis.

- Topological quantum computer to allow computation that scales faster than Moore's law according to:

$$\sim e^{(Moore's\ Law)}$$

- Quantum transport modeling of ballistic nanoscale transistors.

- AI-specific hardware based on compact XNOR logic made using reconfigurable 2D transistors.

- Extensive use of our 300mm wafer line, including the integration of novel 2D materials in our line.

- The only US-based 300mm SOI radhard wafer development effort.

Highlights

All-carbon nanotube tandem solar cell devices mimic the light excitation funneling process found in photosynthetic systems. Both systems transfer photogenerated excitons to their respective energy conversion "centers" as shown below.
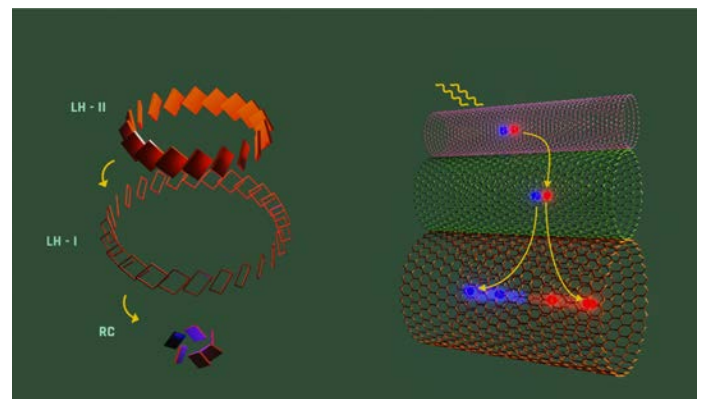
Publications

1. Andreev Reflection and Klein Tunneling in High-Temperature Superconductor/Graphene Junctions, Sharadh Jois,[1, *] Jose L. Lado,[2, †] Genda Gu,[3] Qiang Li,[3] and Ji Ung Lee, (In review)

2. Measuring the Electronic Bandgap of Carbon Nanotube Networks in Non-ideal *p-n* Diodes, *Gideon Oyibo[1], Thomas Barrett[1], Sharadh Jois[1], Jeffrey Blackburn[2], Ji Ung Lee*[1]* (In review).

3. All-carbon nanotube solar cell devices mimic photosynthesis, *Gideon Oyibo[1], Thomas Barrett[1], Sharadh Jois[1], Jeffrey Blackburn[2], Ji Ung Lee*[1]* Nano Letters, oi.org/10.1021/acs.nanolett.2c03544, (2022).

Acknowledgements

Ji Ung Lee

leej5@sunypoly.edu

https://sunypoly.edu/research/ji-ung-lee.html

Low Frequency Pulsed Power Electromigration

Project Summary

- Pulsed power electromigration was studied as a function of duty cycle and current density

- Significant relaxation observed at low current densities and little to no relaxation at higher current densities.

- Extrapolation of Pulsed Power Electromigration in engineering applications should take duty cycle of operation into consideration.

- Are these results repeatable at higher frequencies?
  The question remains unanswered.

Highlights
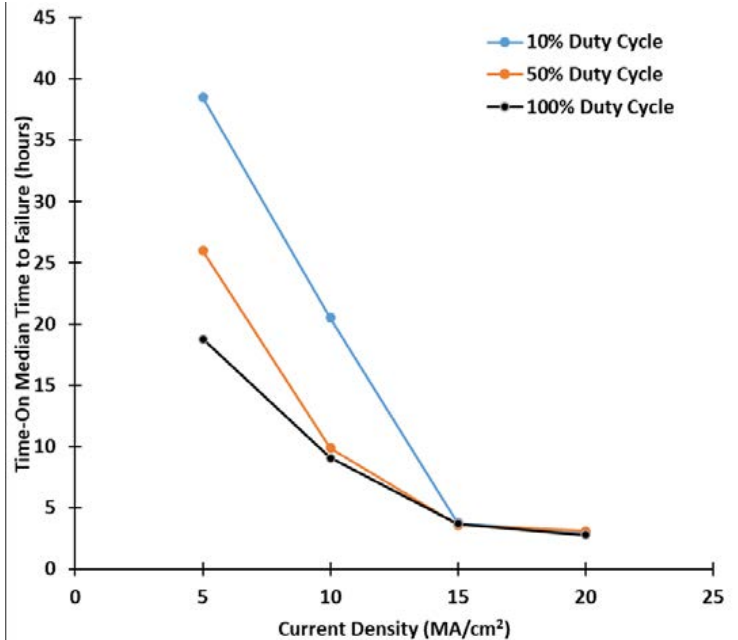
Publications

- Black's Law in Light of Low Frequency Pulsed Power Electromigration

- Mohd Mueen Ul Islam Mattoo, SUNY Polytechnic Institute

- J. R. Lloyd, SUNY Polytechnic Institute

- Proceedings 2022 International Integrated Reliability Workshop

Acknowledgements

- CATN2 Funding

- GlobalFoundries support for samples

- Siemens (Mentor Graphics)

Jim Lloyd

lloydjr@sunypoly.edu

Epitranscriptomic Control of Senescence

Project Summary

- Using human ***Alkbh8^Def* cells and mice we will test the hypothesis that senescence occurs *in vivo* because of altered epitranscriptomic signals.** Senescent cells adopt senescence-associated (***SA***) secretory phenotype (***SASP***), which includes the secretion of inflammatory cytokines, immune modulators, growth factors, and proteases, which together can damage or kill neighboring cells. **We are testing the role of senescence in initially protecting epitranscriptomic deficient mice from detrimental redox-based signaling, but that the resultant SASP signaling promotes damage and stress to cause disease pathologies.** The identification of senescent cells and their selective removal *in vivo* can be achieved using p16-3MR mice, which we have mated with *Alkbh8^Def* mice.

Highlights
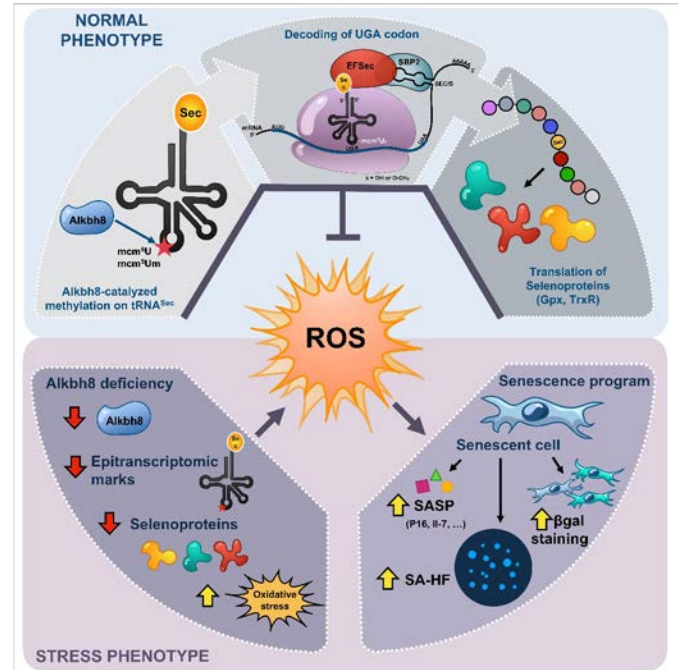
Publications

- Melendez, J. A. The therapeutic bionanoscience interface**. *Exp Biol Med* (Maywood). 2022 Dec 19:15353702221144090**

- Lee, M. Y. *et al.* Selenoproteins and the senescence-associated epitranscriptome. *Exp. Biol. Med. (Maywood).* 15353702221116592 (2022)

- Huber, S. M. *et al.* Arsenite toxicity is regulated by queuine availability and oxidation-induced reprogramming of the human tRNA epitranscriptome. *Proc. Natl. Acad. Sci. U. S. A.* **119**, e2123529119 (2022).

- Evke, S., Lin, Q., Melendez, J. A. & Begley, T. J. Epitranscriptomic Reprogramming Is Required to Prevent Stress and Damage from Acetaminophen. *Genes (Basel).* **13**, (2022).

Acknowledgements

- National Cancer Institute

- National Institute of Environmental Health and Safety

- CATNMIP

- SUNY Poly Seed Award

- Begley & Tenenbaum and Nanobioscience labs

J. Andres Melendez

https://sunypoly.edu/research/melendez-research-group.html

jmelendez@sunypoly.edu

Project Summary

The project focuses on phase-change memory (PCM) materials as a likely candidate for multilevel/analog devices due to their internal property of resistance change and retaining that allows for programming and storage of synaptic weights and execution matrix-based computations in AI hardware.
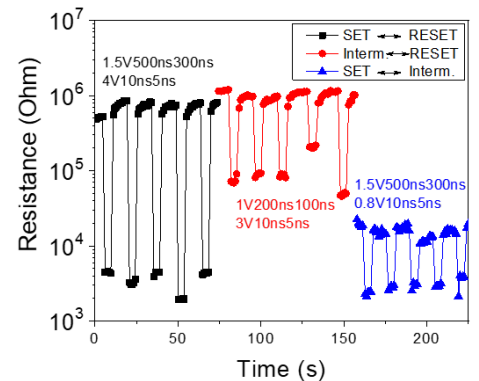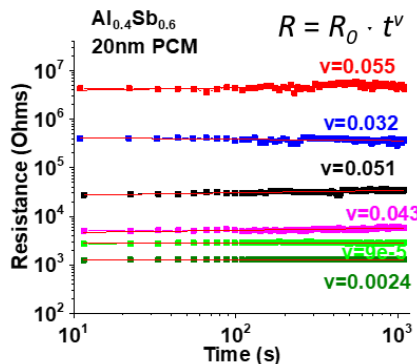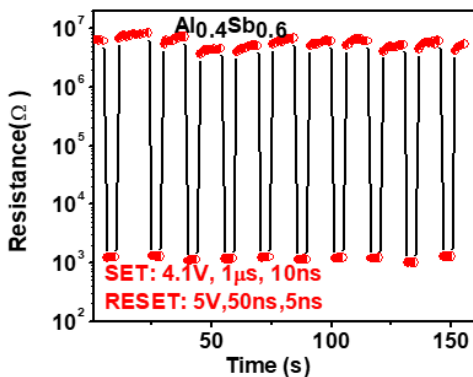
Highlights

Cross-sectional TEM image of $Al_{0.4}Sb_{0.6}$ PCM cell
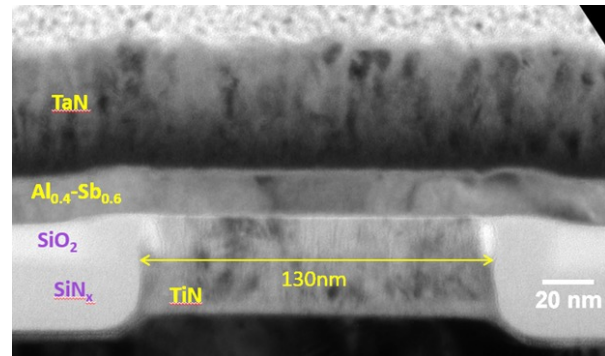
Extremely high (=5000) resistance contrast switching and low drift in 20nm thick $Al_{0.4}Sb_{0.6}$ cell

$$R = R_0 \cdot t^v$$

Three switching levels in double-layer $Ga_{0.2}Sb/AlOx/Ga_{0.3}Sb$ cell

Publications

1. R. Ume, et. al. Crystallization Properties of Al-Sb Alloys for Phase Change Memory Applications. ECS J. Solid State Science and Technology, 10(7), 075008 (2021).DOI: 10.1149/2162-8777/ac14dd.

2. H. Gong, et.al. "Bilayer Ga-Sb Phase Change Memory with Intermediate Resistance State." Device Research Conference (DRC) Extended Abstracts, pp. 1-2. IEEE, 2021. DOI: 10.1109/DRC52342.2021.9467153.

3. R. Ume, et.al. , "Electrical and structural properties of binary Ga–Sb phase change memory alloys," Journal of Applied Physics, vol. 132, p. 035103, 2022. DOI: 10.1063/5.0096022.

Acknowledgements

Serge Oktyabrsky

soktyabrsky@sunypoly.edu

Artificial Intelligence-Driven Adaptive Sensors for Autonomous Object Recognition

Project Summary

A joint project with U. Buffalo - SUNY focuses on the development, implementation and testing of an autonomous object recognition system that comprises of adaptable detectors/sensors driven by an artificial intelligence. The research focus is two-fold: (a) design and build a unique AI object recognition system with integrated IR wide band adaptive sensors (3-12 mm) based on asymmetrically doped double-quantum-well structures; and (b) exploration of the properties and potential benefits of the adaptive IR spectral sensitivity selection in changing environment.

Attributes of recognized objects in IR

Highlights

Quantum Well Infrared Photodetector (QWIP)

Band structure of QWIP period

$E4-E1= 120$ meV(10.3 μm)

Bias= -80mV

FTIR spectra: Bias-controlled IR sensitivity:

Publications

1. V. Mitin, S. Tulyakov, G. Biswal, M. Yakimov, V. Tokranov, and S. Oktyabrsky, "Tunable infrared detector for object recognition," in Workshop on Innovative Nanoscale Devices and Systems, Book of Abstracts, ed. J.Fabian et al., 2022, p. 122-123.

2. G. Biswal, M. Yakimov, V. Tokranov, S. Tulyakov, V. Mitin, and S. Oktyabrsky. "Development of Voltage-Tunable IR Photodetector." American Vacuum Society Hudson-Mohawk 2022 Fall Meeting, 2022, Albany, NY , Abstracts, p.12.
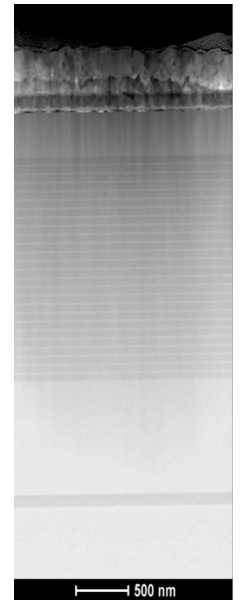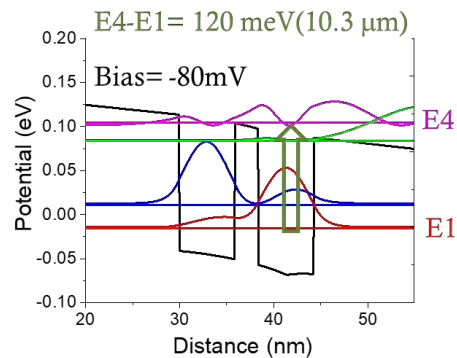
Acknowledgements

Serge Oktyabrsky

soktyabrsky@sunypoly.edu

OFFICE OF RESEARCH
SUNY POLYTECHNIC INSTITUTE

InAs/GaAs Quantum Dot Integrated Scintillation Detectors
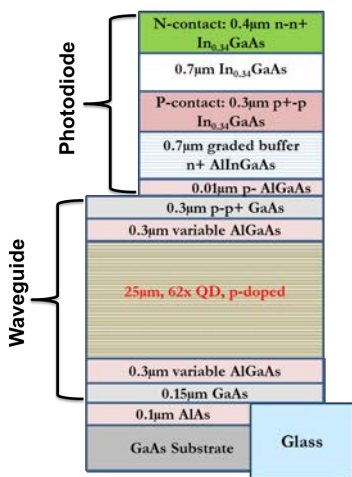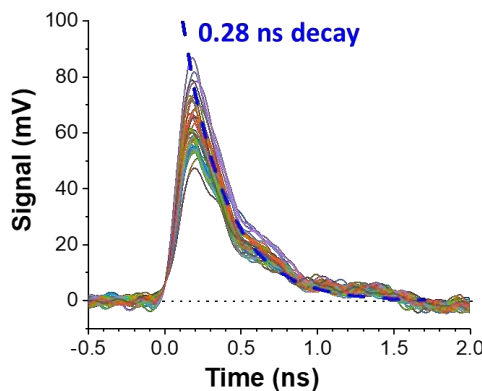
Project Summary

The project focuses on development of ultrafast high light yield scintillating detectors consisting of a quantum dot waveguiding medium with integrated wavelength-matched photodetector (PD) as an enabling technology for multiple high-energy physics applications, as well as for medical imaging and security purposes.

Highlights

Comparison of light yield and decay time of scintillators

Structure of integrated QD scintillation detector

Ultrafast decay from 4.5MeV alpha-particles
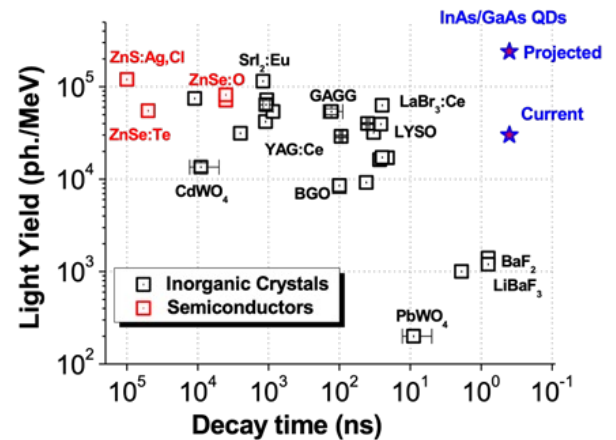
Charge histograms for 4.5MeV alpha-particles with PDs of two sizes
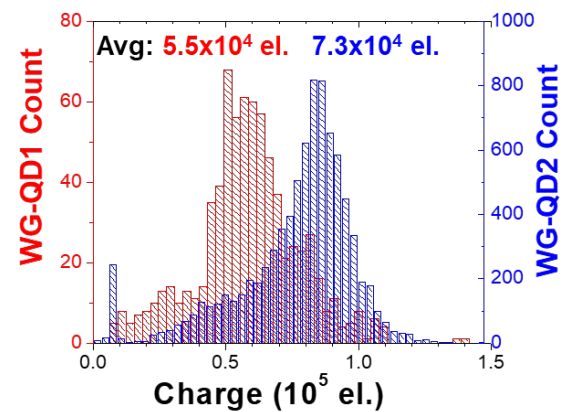
Publications

1. V. Mitin, S. Tulyakov, G. Biswal, M. Yakimov, V. Tokranov, and S. Oktyabrsky, "Tunable infrared detector for object recognition," in Workshop on Innovative Nanoscale Devices and Systems, Book of Abstracts, ed. J.Fabian et al., 2022, p. 122-123.

2. A. Minns, K. Dropiewski , M. Yakimov, V. Tokranov, M. Hedges and P. Murat, and S. Oktyabrsky, "Parameters of Fast and High-Yield InAs/GaAs Quantum Dot Semiconductor Scintillator," MRS Advances 2021, DOI: 10.1557/s43580-021-00019-y.

3.   Acknowledgements

Serge Oktyabrsky

soktyabrsky@sunypoly.edu

Quantum Control of Electron States in Ballistic Waveguides

Project Summary

A joint project with U. Buffalo is focused on the development of principles and technologies for a direct manipulation of electron quantum states in semiconductor ballistic waveguides by applied electrostatic potential. The technical approach relies on a specially designed nanoscale semiconductor structure where electrons travel as one-dimensional waves, and high-efficiency gate electrodes control the electron wave propagation in Y-shaped branching waveguides.

Simulation of electron concentration (Left plots) and current density (Right plots) for YBS with 5×10^{10} cm^{-2} doping, V_G= 12 mV, V_{DS}=1mV, T=77K
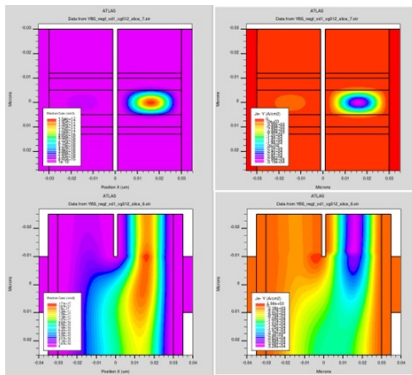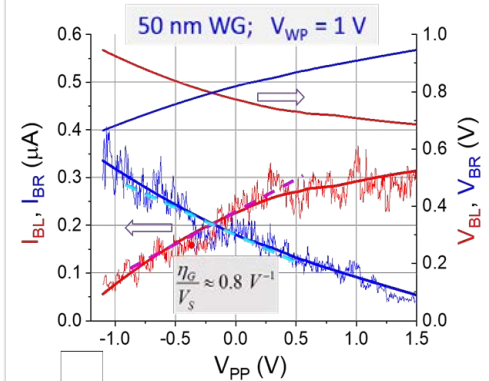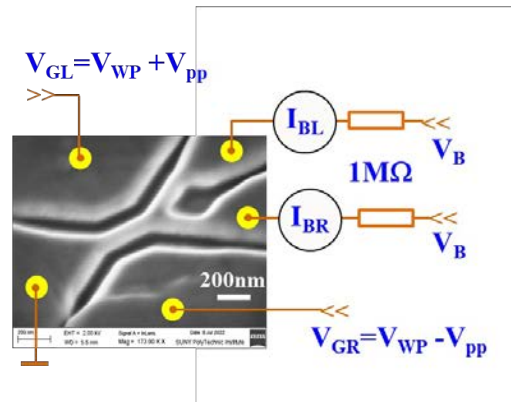

Highlights

Schematic diagram of a Y-branch switch with MOS gates in operation
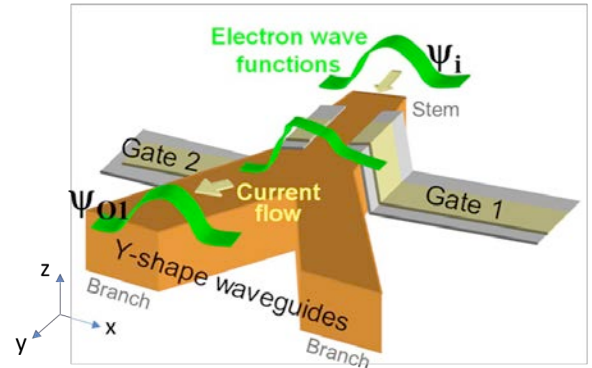
SEM image, schematics and 77K YBS characteristics of the ballistic YBS characteristic

$V_{GL}=V_{WP} +V_{pp}$

I_{BL} V_B

$1M\Omega$

I_{BR} V_B

$200nm$

$V_{GR}=V_{WP} -V_{pp}$

50 nm WG; V_{WP} = 1 V

$\frac{\eta_G}{V_S} \approx 0.8\ V^{-1}$

Publications

1. T. McDonough, V. Mitin, V. Tokranov, M. Yakimov, and Serge Oktyabrsky, "Quantum switching modeling and optimization of a metal-oxide-semiconductor gated Y-shaped structure," NanoWorld Journal, 2021. DOI: 10.17756/nwj.2021-089.

2. V. Mitin, T. McDonough, M. Yakimov, V. Tokranov, and S. Oktyabrsky, "Switching based on a one-dimensional electron gas in a Y-shaped device," in Workshop on Innovative Nanoscale Devices and Systems, Book of Abstracts, ed. J.Fabian et al., 2022, p. 23-24.

Acknowledgements

Serge Oktyabrsky

soktyabrsky@sunypoly.edu

Neural Nets and AI in Biomedical Neuroscience

## Project Summary

- Multiscale models of neurons at the level of synapses, dendrite or axon functions, and spatial neuronal networks are being developed as custom *integrated software-custom hardware* platforms (collaboration Dr. Mukherjee, Amrita Univ).

- **SyNC**- neural net for synaptic plasticity modeling of complex synaptopathies (Autisms) and patient-specific drug treatment interactions (patented).

- **DyNAMO**- theoretical axon for axonopathies arising from Traumatic Brain Injury.

- **NEMo**- dendrite to axon nanocommunication network for modeling amyloid beta perturbation of receptors, membranes, calcium signaling, and axonal transport in Alzheimer's disease.

- **SCENIC derivations**- CNN Deep Learning diagnostics for brain tumor detection and typing (glioblastoma vs metastasized tumors)of MRI clinical modalities (collaborator Dr. Julie Pilitsis, M.D. Ph.D.).

- **Other**: spatial multi-synaptic, multi-neuron type signaling; dendritic trees; brain vascular mapping.

Highlights
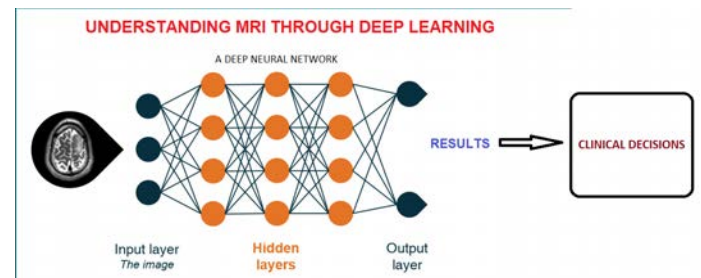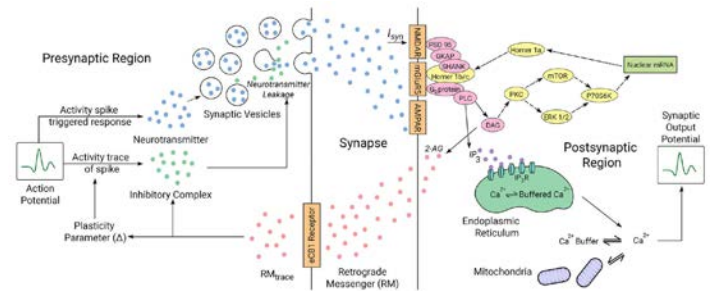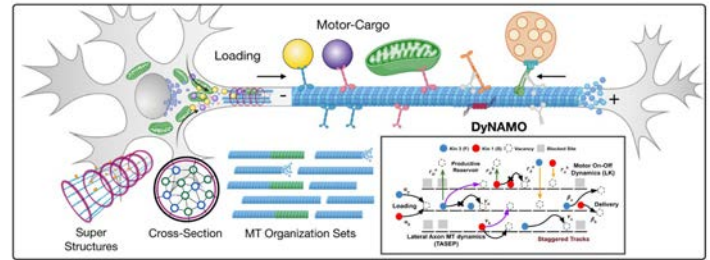
Publications

- Z.T. S.F. Bush, **J.L. Paluh**, G. Piro, V. Rao, V. Prasad, A. Eckford, et al. (2015) P1906.1^{TM}-2015 *Recommended Practice for Nanoscale and Molecular Communication Framework*. IEEE Standard 1906.1^{TM}-2015. ISBN: 978-1-5044-01-1-2
- S.F. Bush, G. Mantelet, **J.L. Paluh**, et al. (2020) IEEE Standard Data Model for Nanoscale Communication Systems. IEEE Standard 1906.1.1^{TM}-2020. ISBN: 978-1-5044-6994-4
- A. Banerjee, **J.L. Paluh**, A. Mukherjee, K.Gaurav Kumar, A. Ghosh, M.K. Naskar (2018) Modeling the neuron as a nanocommunication system to identify spatiotemporal molecular events in neurodegenerative disease. Intern. J. Nanomed. 13: 3105-3128. dx.doi.org/10.2147/IJN.S152664
- R. Chatterjee, **J.L. Paluh**, S. Chowdhury, S. Mondal, A. Raha, A. Mukherjee (2021) SyNC, a computationally extensive and realistic neural net to identify relative impacts of synaptopathy mechanisms on glutamatergic neurons and their networks in Autism and complex neurological disorders. Frontiers in Cellular Neuroscience. 15:674030. doi: 10.3389/fncel.2021.674030
- B. Sai T. Naidu, S. Biswas, R. Chatterjee, S. Mandal, S. Pratihar, A. Chatterjee, A. Raha, A. Mukherjee and **J.L. Paluh** (2022) SCENIC: An area and energy-efficient CNN-based hardware accelerator for discernable classification of brain pathologies using MRI. VLSI Design Conference.
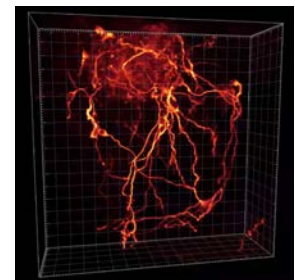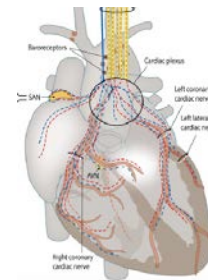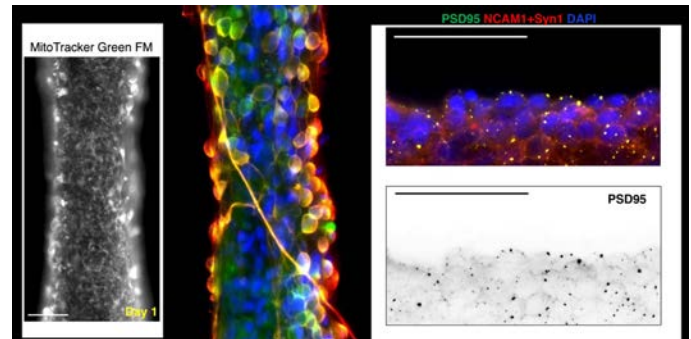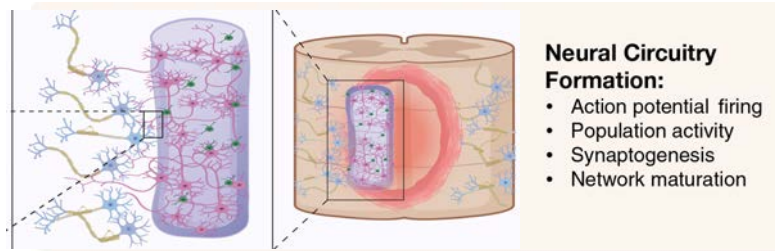
Acknowledgements

Janet L. Paluh, Ph.D.

paluhj@sunypoly.edu

https://www.sunypoly.edu/research/paluh-research-group.html

https://sunypoly.edu/faculty-and-staff/janet-paluh.html

Transplantable Neuronal Circuitry for Spinal Cord Injury

Project Summary

- Spinal Cord Injury (SCI) that results in loss of neurons in patients remains untreatable. Human stem cell neurotechnologies now allow regional matching of neurons that is coupled with single cell RNA-Seq for molecular and spatial diagnostics to accelerate bench to clinic therapeutics. In a first of its kind series of studies, research from the Paluh lab that preforms and transplants neuronal circuits in animal models is being done to replace lost spinal neuron connectivity.

- Recent discoveries in mammalian development identify bifurcating pathways for neurodevelopment of the brain and spine, with the latter requiring neuromesodermal progenitors (NMPs). The ability to match neuron identities regionally via stem cell neurotechnologies now allows direct in vivo therapeutics with neurons, for brain Parkinson's or rapidly integrating circuits for spinal trauma.

- Central and peripheral nervous systems (CNS, PNS) interconnect in networks from the spine. The Paluh lab use of NMPs has enabled the first CNS-PNS integrated models of the primitive gut and heart (patented), also benefiting organ biomanufacturing

Highlights

Neural Circuitry Formation:
- Action potential firing
- Population activity
- Synaptogenesis
- Network maturation

Publications

- Z.T. Olmsted and **J.L. Paluh** (2021b) Stem cell neurodevelopmental solutions for restorative treatments of the human trunk and spine. *Frontiers Cell Neurosci.* 15:667590. doi: 10.3389/fncel.2021.667590
- M. B. Paredes-Espinosa and **J.L. Paluh** (2022) Human stem cell derived neurons and neural circuitry therapeutics: Nest frontier in spinal cord injury repair. *Experimental Biology and Medicine.* doi: 10.1177/15353702221114099
- Z.T. Olmsted, C. Stigliano, A. Scimemi, T. Wolfe, J. Cibelli, P.J. Horner, and **J.L. Paluh** (2021c) *Transplantable human motor networks as a neuron-directed strategy for spinal cord injury*. iScience. 24:102827. doi: 10.1016/j.isci.2021.102827.
- Z.T. Olmsted and **J.L. Paluh** (2021a) *Co-development of central and peripheral neurons with trunk mesendoderm in human elongating multi-lineage organized gastruloids*. Nature Communications 12:3020. doi: 10.1038/s41467-021-23294-7
- Z.T. Olmsted and **J.L. Paluh** (2022) *A combined human gastruloid model of cardiogenesis and neurogenesis*. iScience. 25:104486. doi: 10.1016/j.isci.2022.104486

Acknowledgements

Janet L. Paluh, Ph.D.

paluhj@sunypoly.edu

https://www.sunypoly.edu/research/paluh-research-group.html

https://sunypoly.edu/faculty-and-staff/janet-paluh.html

Project Summary

1. Automation, Productivity and Innovation in Information Technology

This research develops a theoretical model to study the impact of innovations in Information Technology (IT) on automation, productivity growth and employment, and how increasing automation of production in turn affects the rate of innovation in IT.

2. Market Structure in Technology Industries

This research re-examines an old question in industrial organization – what determines whether a firm decides to make a component or tool in-house or buy it from an external supplier? The project studies this in the context of a technologically intensive input that has a wide variety of use, like semiconductor chips.

3. Diffusion of Information Technology

This project uses data from U.S Input-Out Tables to understand the pattern of diffusion of semiconductor chips, computer hardware and software across different sectors in the economy.

Highlights

- Even if innovations in IT leads to increasing automation in every firm, it is possible to have total employment in the economy increase over time, as innovations lead to reduction in production costs, and entry of new products which require labor in production.

- The model developed in the research can explain why different parts of the semiconductor chip supply chain show different evolutions in the make or buy decision.

Publications

1. Automation, Productivity and Innovation in Information Technology, Unni Pillai, *Macroeconomic Dynamics*, 2022.

2. Diversity of Input Use and R&D Outsourcing, Unni Pillai, In Review (Journal of Economic Management and Strategy)

Acknowledgements

Unni Pillai

https://sunypoly.edu/faculty-and-staff/unni-pillai.html

upillai@sunypoly.edu

A Search for Novel Efficient *p*-type Nitride Materials

Project Summary

Low *p*-type doping efficiency is a perennial issue in III-nitride material and device development. This is largely because the only currently viable *p*-type dopant in the material system, Mg, is a deep acceptor, ~160 meV above the GaN valence band maximum (VBM). Be has a shallower acceptor level, ~113 meV above the GaN VBM, but to date, no reliable or reproducible *p*-GaN:Be has been shown. However, metal-organic chemical vapor deposition (MOCVD) has been largely under-utilized in GaN:Be research until our recent work.

As part of our development of *in situ* Be doping during MOCVD growth of GaN, we explored a large parametric space of growth variables. Through these studies, we are able to control Be concentration up to technologically-relevant values of ~10^{19} cm^{-3} with smooth 2D surface morphology, which is essential for device fabrication.

We also developed a novel "pulsed growth" method, wherein Be precursor is pulsed into the growth chamber separately from nitrogen and gallium precursors to reduce gas-phase parasitic reactions. This results in both elevated Be concentration and highly controllable growth rate.

Highlights

Promising the possibility of obtaining p-type GaN from Be doping, we find the presence of a UVLBe band, which confirms the presence of the predicted shallow acceptor state in MOCVD GaN:Be. Unknown acceptor compensation is suggested by the YL$_{Be}$ band, however. An atomic force microscope image is shown right, showing high-quality smooth 2D growth mode.

Publications

B. McEwen, M. A. Reshchikov, E. Rocco, V. Meyers, K. Hogan, O. Andrieiev, M. Vorobiov, D. O. Demchenko, and F. Shahedipour-Sandvik, *ACS Applied Electronic Materials 4* (8), 3780-3785 (2022). DOI: 10.1021/acsaelm.1c01276
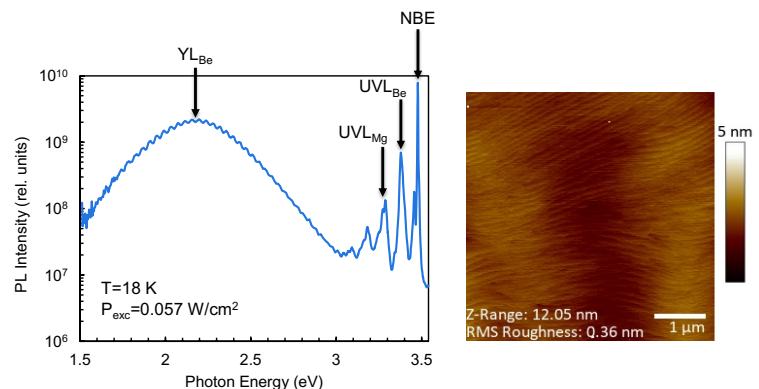
B. McEwen, M. Reshchikov, E. Rocco, V. Meyers, K. Hogan, O. Andrieiev, M. Vorobiov, D. Demchenko, and S. Shahedipour-Sandvik "Toward highly efficient p-doping in III-nitride optoelectronics: MOCVD growth of Be-doped GaN", SPIE Photonics West (2022). https://doi.org/10.1117/12.2626491

M. A. Reshchikov, O. Andrieiev, M. Vorobiov, D. Ye, D. O. Demchenko, K. Sierakowski, M. Bockowski, B. McEwen, V. Meyers, and F. Shahedipour-Sandvik, Thermal annealing of GaN implanted with Be, *Journal of Applied Physics* **131**, 125704 (2022). https://doi.org/10.1063/5.0080060

M. A. Reshchikov, M. Vorobiov, O. Andrieiev, B. McEwen, E. Rocco, V. Meyers, D. O. Demchenko, and F. S. Shahedipour-Sandvik, Photoluminescence from Be-Doped GaN Grown by Metal-Organic Chemical Vapor Deposition, *Phys. Status Solidi B* 2200487 (2023). https://doi.org/10.1002/pssb.202200487

Acknowledgements

Shadi Shahedipour-Sandvik

sshahedipour-sandvik@sunypoly.edu

Team | SUNY Polytechnic Institute

Google Scholar

Microwave activation-annealing of Mg-implanted GaN

Project Summary

P-type doping of GaN presents distinct challenges for power electronics, LEDs, and sensors. The prevailing p-type dopant, Mg, can be introduced by implantation cheaply and controllably. However, implantation creates defects that must be removed at very high temperatures before a p-type film is possible.

By the novel employment of a gyrotron microwave source (in collaboration with Gyrotron Technology Inc.), a wafer of GaN can be annealed in short (<2 s) 'pulses' at temperatures of 1450 °C (2640 °F) to achieve p-type activation of Mg-implanted GaN without significant surface degradation.

We study the creation, evolution, and redistribution of defect and dopant states to understand how they respond to this ultra-hot annealing. In turn, this gives us insight into how better power electronics can be engineered. Extensive use of CNSE metrology facilities and clean room enables material characterization and device fabrication.

Highlights

Distortion of an implanted dopant profile due to diffusion during annealing can be reduced 10-fold through a 2-stage anneal.

This works by removing some crystalline damage at a moderate temperature (1000 °C) before activating dopants at a high temperature (1450 °C).

Legend: Gyrotron+thermal; Gyrotron only; Fit: gyrotron+thermal $D_B = 1.33 \cdot 10^{-12}$ cm^2/s; Fit: gyrotron only $D_B = 7.58 \cdot 10^{-12}$ cm^2/s

Shahedipour-Sandvik, Shadi, et al. "Defect Microstructural Evolution of Co-Implanted and Gyrotron Microwave-Annealed GaN." Meeting of the Electrochemical Society. Delivered virtually, 2021.

Publications

Meyers, V., *et al.* "P-type conductivity and suppression of green luminescence in Mg/N co-implanted GaN by gyrotron microwave annealing." *J. of Appl. Phys.* 130.8 (2021)

Meyers, V., et al. "Defect-mediated diffusion of implanted Mg in GaN: suppressing dopant redistribution by sequential thermal and microwave annealing *J. of Appl. Phys. (in review)*
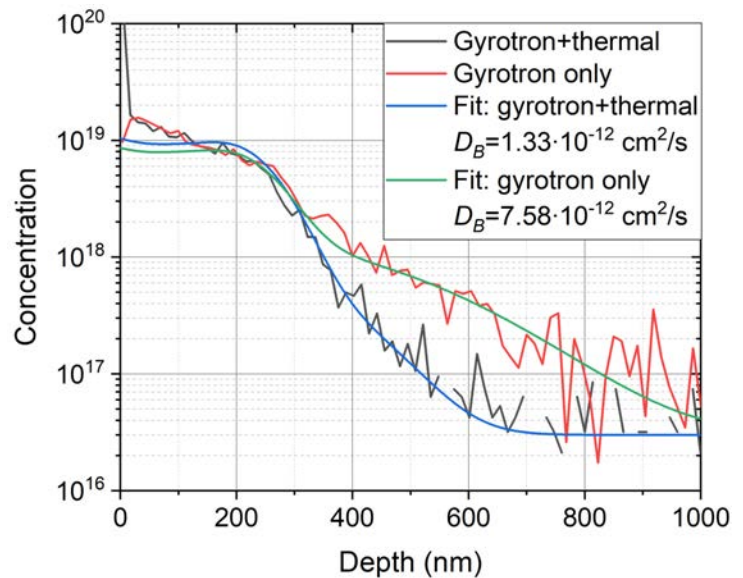
Acknowledgements

Shadi Shahedipour-Sandvik

sshahedipour-sandvik@sunypoly.edu

Lab Webpage

Google Scholar

# GaN/AlGaN Superlattices for Infrared Detection

Project Summary

We are developing optical detectors that work in the infrared based on GaN/AlGaN superlattice structures called QWIPs (quantum well infrared photodetectors). This is possible by taking advantage of shallow quantum wells created by the superlattice, causing long-wavelength light to absorb in material that has a band gap so large that it normally absorbs only ultraviolet light.

Combining quantum-mechanical and classical simulations of GaN/AlGaN band structures in collaboration with SRI International enables us to tune the absorption spectrum of these structures. Metalorganic chemical vapor deposition (MOCVD) is used to grow the superlattice structures monolayer-by-monolayer to achieve nm-scale controllability of film thickness.

Highlights

By utilizing pulsed introduction of GaN precursors in an MOCVD reactor, highly controllable growth rate (similar to atomic layer deposition) can be achieved from a typically rapid (>2 µm/hr) growth method.
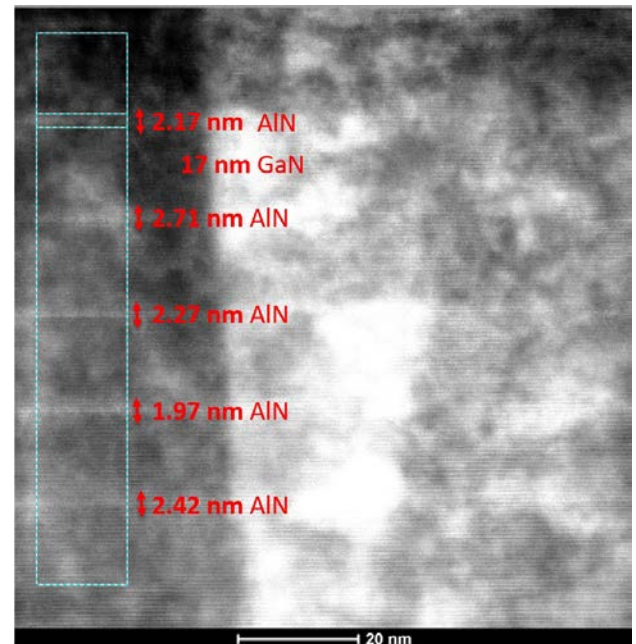
Acknowledgements

- DARPA (funding agency)
- David Hill and Winston Chan (SRI International)
- Dr. Thomas Murray (SUNY Poly metrology)

Shadi Shahedipour-Sandvik

sshahedipour-sandvik@sunypoly.edu

Lab Webpage

Google Scholar

Project Summary

The WBG-Optronix Laboratory continues an ongoing research program on the development of high-efficiency, air-stable III-nitride photocathodes. Photocathodes have applications in photon detection for astronomy, communications, and image intensifiers. Additionally, photocathodes are used in high-energy physics applications as high-brightness electron sources.

Recent studies have focused on improving device efficiency by optimizing the electrostatic profile. The role of planes on Mg p-type dopant incorporation has been investigated through MOCVD selective area growth (SAG) of microstructures with polar, semi-polar and non-polar facets along Ga- and N-polar directions. Mg-incorporation in the various planes and the impact on photocathode device efficiency have been studied via optical and electrical measurements. Control of unintentional impurity profiles has also been studied by secondary ion mass spectrometry (SIMS). Oxygen impurities are found to incorporate at interfaces and diffuse through bulk and defect mediated pathways based on process parameters.

Surface stabilization of photocathodes has also been investigated. Wet chemical treatments have been used to remove surface contaminants and increase device efficiency. We have also investigated 2-D materials including graphene and hexagonal boron nitride (h-BN) to fully stabilize the III-nitride surface.

Highlights

Shown below, SEM micrographs of Ga-polar microstructure grown SAG in MOCVD with polar and semi-polar facets, and subsequent overgrowth of GaN:Mg layers. The resulting structure was characterized by micro-photoluminescence mapping. We observe increased intensity of the UVL_{Mg} band - associated with high p-type conductivity - on the semi-polar facets.

Publications

E. Rocco, J. Marini, K. Hogan, V. Meyers, B. McEwen, L.D. Bell, and F. Shahedipour-Sandvik, Overview and Progress Toward High-Efficiency, Air-Stable Photocathode Detectors. (2022) IEEE Photonics Journal, vol. 14, no. 2, pp. 1-12. https://doi.org/10.1109/JPHOT.2022.3155383
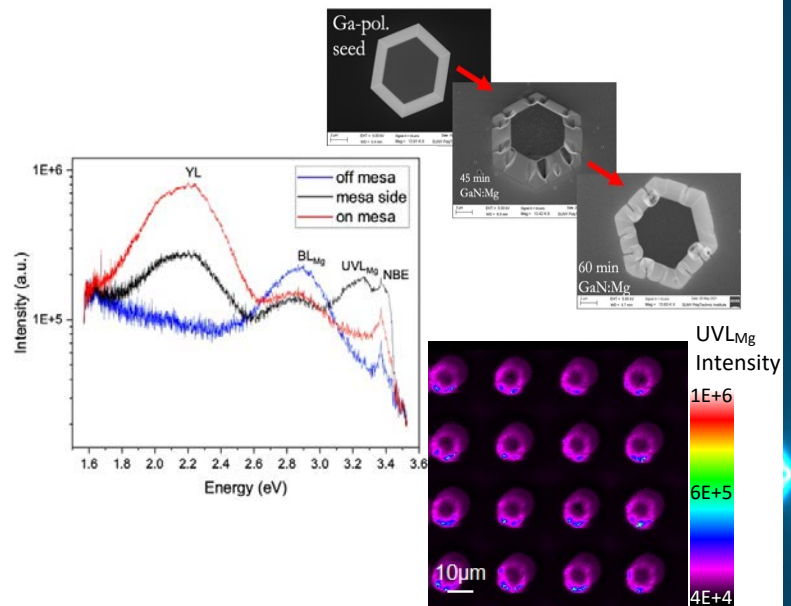
L. Cultrera, E. Rocco, F. Shahedipour-Sandvik, L.D. Bell, J.K. Bae, I.V. Bazarov, P.Saha, S. Karkare, and A. Arjunan, Photoemission characterization of N-polar III-nitride photocathodes as candidate bright electron beam sources for accelerator applications. (2022) Journal of Applied Physics, vol. 131, 124902. https://doi.org/10.1063/5.0076488

E. Rocco, I. Mahaboob, K. Hogan, V. Meyers, B. McEwen, L.D. Bell, and F. Shahedipour-Sandvik. Impurity incorporation and diffusion from regrowth interfaces in N-polar GaN photocathodes and the impact on quantum efficiency. (2021) Journal of Applied Physics, vol. 129, 195701. https://doi.org/10.1063/5.0049344

Acknowledgements

Shadi Shahedipour-Sandvik

sshahedipour-sandvik@sunypoly.edu

https://sunypoly.edu/research/wbgoptronixlab

Google Scholar

Future Manufacturing: Development of Bio-hybrid Electronic and Photonic Devices

Project Summary

The objective of this Future Manufacturing project is to develop novel manufacturing technologies for production of hybrid bioelectronic and biophotonic devices.

The specific questions to be addressed are: 1) How do we design and manufacture electronic and photonic devices that are biocompatible (i.e., facilitate growth and function of healthy biological tissues) and are bio-resilient (i.e., able to withstand the wet, salty, proteinaceous chemical environment of biological systems) while permitting information transfer either electronically or using integrated photonics? 2) How will we interface different tissues with devices in a manner that provides overlap to facilitate scalable manufacturing?

Research in this seed grant focuses on design and manufacturing of silicon-wafer electronic and photonic devices applied to the following testbeds: 1) Implementation of a pressure sensing device that can measure outflow from ocular tissues to address development of glaucoma therapeutics; 2) Creation of multielectrode arrays interfaced with three-dimensional cell cultures (e.g., neuronal organoids) for electrical stimulation and observation.

In addition, we will develop an extensive workforce training program stretching from community college to doctoral students.
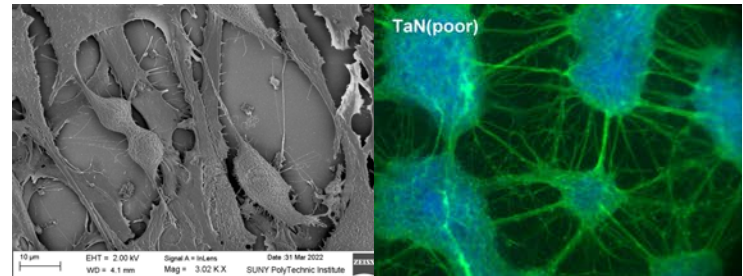
Highlights

- NIH 3T3 fibroblasts and neural stem cells have been cultured on silicon wafers coated with a variety of different metals routinely used in semiconductor technologies.

Left panel: SEM of NIH3T3 cells on aluminum-coated wafers; right panel: fluorescent micrograph of neural stem cells grown on tantalum nitride-coated wafers.

- Photonic chips have been designed to investigate the effects of cell growth on light propagation in waveguides, Mach-Zehnder interferometers, ring resonators, and Bragg gratings

- Outreach activities were held with students from Questar New Visions and SUNY Poly Utica campus

Publications

Acknowledgements

Susan Sharfstein

sharfss@sunypoly.edu

Novel Low-shear Bioreactor for Hematopoietic and Stem Cell Expansion

Project Summary

- This project focuses on development of a novel, low-shear, high mass-transfer bioreactor for automated expansion and recovery of hematopoietic cells and stem cells for therapeutic applications, including immuno-oncology. Proof of principle experiments will employ Jurkat cells as a model T cell line and induced pluripotent stem cells (iPSCs) differentiated down the pancreatic lineage. Novel cell removal strategies include thermo-responsive polymers to reduce cell damage upon removal from the matrix.

- Matrix materials under consideration include cellulose and 3D printed poly-lactic acid (PLA)

- In parallel with academic studies optimizing culture conditions for cell growth and recovery, our industrial partner, Sepragen (owner of the bioreactor technology), is focused on development of a closed, automated system to translate the technology into a commercial product for deployment in the cell therapy market.

Highlights

- Studies with iPSCs differentiated down the pancreatic lineage, demonstrated our ability to obtain insulin producing cells in the novel bioreactor with a cellulose matrix.

- In contrast, Jurkat cells grew poorly on the cellulose matrix, but performed much better on the PLA matrix (shown in the black box below).

- Current studies are focused on improving adhesion to the matrix by coupling thermo-responsive polymers to the PLA.
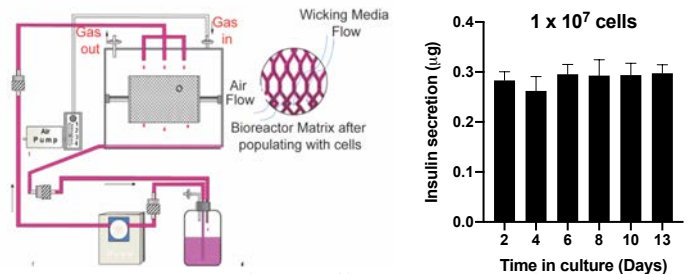
Publications

- N. Amini, J.L. Paluh, Y. Xie, V. Saxena, and S.T. Sharfstein, Insulin production from hiPSC-derived pancreatic cells in a novel wicking matrix bioreactor, Biotechnology and Bioengineering, 117: 2247-2261 (2020) doi: 10.1002/bit.27359

- Novel Bioreactors for Therapeutic Cell Expansion: Regenerative Medicine and Immuno-oncology Applications, Keynotion Global Bioprocessing Summit, San Francisco, CA, November 2022
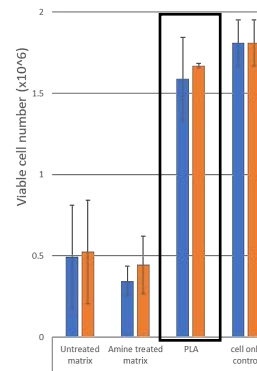
Susan Sharfstein

sharfss@sunypoly.edu

# Production of a Bioengineered Heparin in Murine Mastocytoma Cells

Project Summary

- The objective of this project is to create a competitively priced bioengineered heparin produced by murine mastocytoma cells cultured in bioreactors as an alternative to the currently available animal-derived heparin, which is primarily sourced from pig intestines harvested in China.

- Metabolic engineering was performed by our collaborators at TEGA Therapeutics to optimize the composition and anticoagulant activity of the mastocytoma derived heparin. The focus of activities at SUNY Poly is to improve productivity by increasing the maximum cell density for cells grown in stirred tank bioreactors and to determine whether the specific productivity can be improved by optimizing medium formulation and bioprocess conditions.

  - Bioreactor experiments demonstrated significant shear sensitivity, which was alleviated by increasing the Pluronic F68 concentration. Aeration required optimization to provided adequate oxygen without increased shear.

Highlights

- Media formulation significantly affects viable and integrated viable cell density (IVCD)
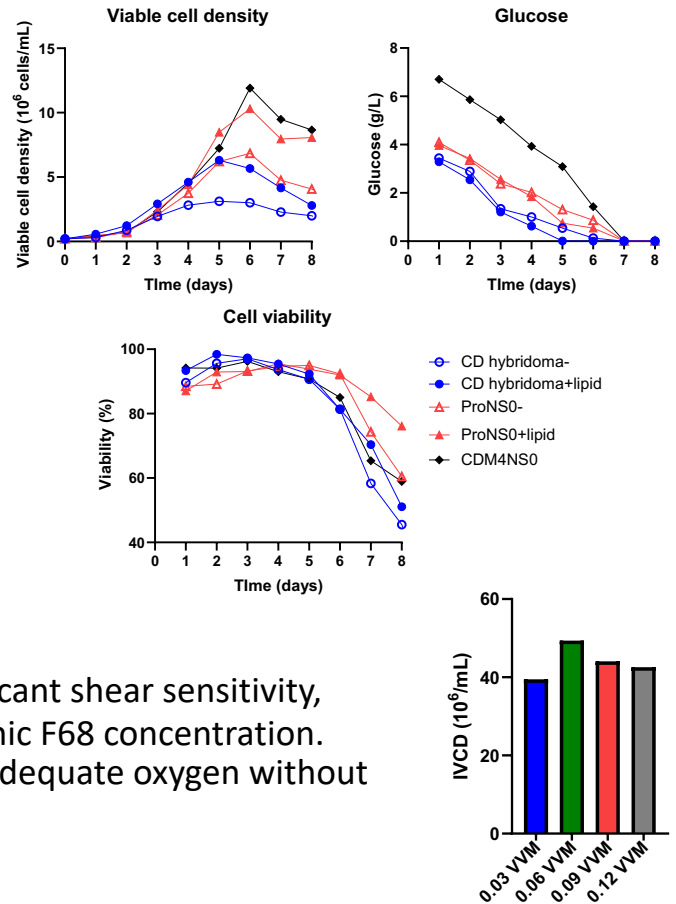
Publications

- B.E. Thacker, K. J. Thorne, C. Cartwright, J.Park, K. Glass, A. Chea, B. P. Kellman, N. E. Lewis, Z. Wang, A. Di Nardo, S.T. Sharfstein, W. Jeske, J. Walenga, J. Hogwood, E. Gray, B. Mulloy, J. D. Esko, C.A. Glass, Multiplex genome editing of mammalian cells for producing recombinant heparin, Metabolic Engineering, 70: 155-165 (2022) doi: 10.1016/j.ymben.2022.01.002

- B.E. Thacker and S.T. Sharfstein, Metabolic Engineering of Mammalian Cells to Produce Heparan Sulfates, Emerging Topics in Life Sciences, 2 (3) 443-452 (2018) DOI: 10.1042/ETLS20180007

Acknowledgements

- Center for Biopharmaceutical Education and Training, Albany College of Pharmacy and Health Sciences

- TEGA Therapeutics

- NIH 1R01GM090127; NSF IIP-1321432, IIP-1622959, IIP-1842736, IIP-2026188

Susan Sharfstein

sharfss@sunypoly.edu

Improving SiC Wafers and Processing for Lower Costs and Higher Reliability

OFFICE OF RESEARCH
SUNY POLYTECHNIC INSTITUTE

Project Summary

- Currently, SiC MOSFETs are fabricated using elevated temperature (≥ 500° C) aluminum implantation for the formation p-doped regions to prevent the introduction Basal Plane Dislocations (BPDs) during the activation anneal. Switching to room temperature (RT) implantation of aluminum would decrease the overall processing complexity and cost. However, when RT implantation is performed, it is common for BPDs to be introduced from implantation damage and activation anneal processes. These BPDs degrade the performance and reliability of MOSFETs and other SiC devices.
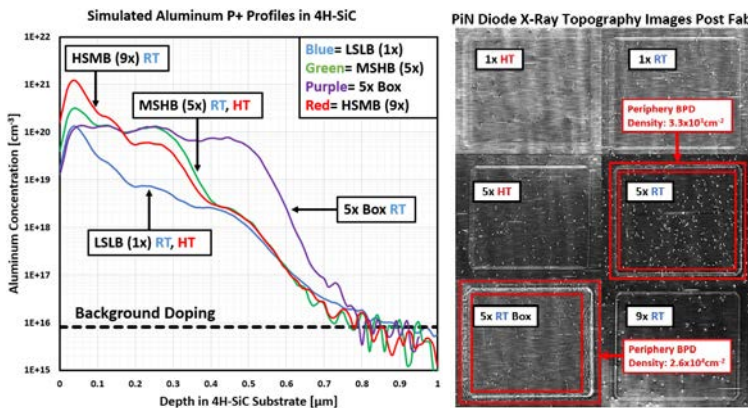
Highlights

- Previously, a critical aluminum dose of $1 \times 10^{15} \text{cm}^{-2}$ was reported to prevent significant BPD generation while utilizing room temperature ion implantation however, with proper control over the implantation energy and dose altogether (i.e., the profile) devices with an implant dose nearly 10x greater than the previous critical dose can be fabricated while simultaneously suppressing BPD generation and thus improving device performance and longevity.
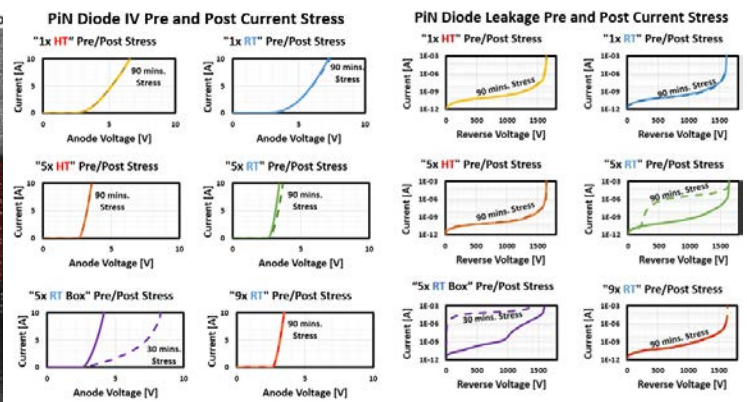
Publications

- S. A. Mancini, S. Y. Jang, D. Kim and W. Sung, "Increased 3rd Quadrant Current Handling Capability of 1.2kV 4H-SiC JBS Diode-Integrated MOSFETs (JBSFETs) with Minimal Impact on the Forward Conduction and Blocking Performances," *2021 IEEE 8th Workshop on Wide Bandgap Power Devices and Applications (WiPDA)*, 2021, pp. 101-106, doi: 10.1109/WiPDA49284.2021.9645152.

- S. A. Mancini *et al*., "Static Performance and Reliability of 4H-SiC Diodes with P+ Regions Formed by Various Profiles and Temperatures," *2022 IEEE International Reliability Physics Symposium (IRPS)*, 2022, pp. P62-1-P62-6, doi: 10.1109/IRPS48227.2022.9764538.

- S. A. Mancini, S. Yup Jang, D. Kim and W. Sung, "Exploring Optimum Designs for 1.2kV 4H-SiC JBS Diode Integrated MOSFETs (JBSFETs)," 2022 IEEE 9th Workshop on Wide Bandgap Power Devices & Applications (WiPDA), 2022, pp. 11-16, doi: 10.1109/WiPDA56483.2022.9955290.

- S. A. Mancini *et al*. "Investigation of 1.2kV 4H-SiC MOSFET Static Performances Fabricated Utilizing All Room Temperature Ion Implantation," to be submitted to IEEE Transaction on Electron Devices.

- S. A. Mancini *et al*., "Design and Cell Layout in 4H-SiC MOSFETs to Provide Long Term Reliability Even in the Presence of Basal Plane Dislocations," to be submitted to IEEE Transaction on Electron Devices.

Acknowledgements

Woongje Sung

sungw1@sunypoly.edu

https://sunypoly.edu/research/centers-programs/suny-casper.html

https://sunypoly.edu/faculty-and-staff/woongje-sung.html

Manufacturing of Ultra-high-voltage SiC devices (MUSiC)

Project Summary

- There is an urgent need to create a source of domestic high voltage devices and modules to encourage lower prices and help the adoption of high voltage devices for steady state and pulse power applications.

- Many commercial applications such as variable speed drives for MW class electric motors, 13.8 kV distribution grid equipment, incorporation of renewables on the distribution grid and High Voltage DC (HVDC) transmission will benefit from these devices.

- The MUSiC team proposes to develop a baseline process to fabricate state-of-the-art 20+ kV SiC PiN diodes, MOSFETs, IGBTs.

Highlights

- Development of state-of-the-art High Voltage (HV), >15kV rated 4H-SiC MOSFETs

- Established a baseline process for fabrication of Ultra-HV (20kV) rated devices at a leading foundry company located in the U.S

- Developed and demonstration of custom Ultra-HV packages for use in high voltage applications
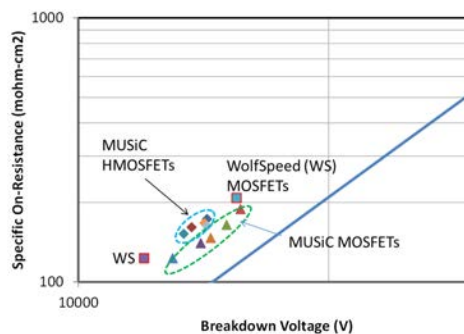

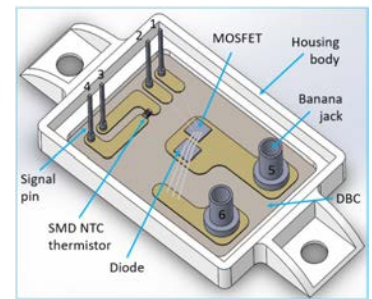Fig. 1. Ron,sp – BV trade-off achieved in Phase I, SiC MOSFET development.

Fig. 2. Internal view of HV custom package used to evaluate and verify device performance

Publications

- J. Lynch, N. Yun, and W. Sung, "Design Considerations for High Voltage SiC Power Devices: An Experimental Investigation into Channel Pinching of 10kV SiC Junction Barrier Schottky (JBS) Diodes," International Symposium on Power Semiconductor Devices and ICs (ISPSD), May 2019, doi: 10.1109/ISPSD.2019.8757593.
- N. Yun, D. Kim, J. Lynch, A. Morgan, W. Sung, M. Kang, A. Agarwal, R. Green, and A. Lelis, "Developing 13-kV 4H-SiC MOSFETs: Significance of Implant Straggle, Channel Design, and MOS Process on Static Performance," in IEEE Transactions on Electron Devices, vol. 67, no. 10, pp. 4346-4353, Oct. 2020, doi: 10.1109/TED.2020.3017150.
- J. Lynch, N. Yun, W. Sung, I. Deckman, D. Rossman, S. Kim, D. Nguyen, J. Seo, D. Haberstat, M. Hinojosa, R. Green, and A. Lelis, "Demonstration of High Voltage (15kV) Split-Gate 4H-SiC MOSFETs," Wide Bandgap Power Devices & Applications (WiPDA), November 2021, doi: 10.1109/WiPDA49284.2021.9645153
- N. Yun, J. Lynch, A. J. Morgan, S. deBoer, D. Xing, M. Jin, M. Kang, A. Agarwal, R. Stahlbush, R. Green, A. Lelis, and W. Sung,, "14 kV-Rated Monolithic Integration of 4H-SiC MOSFET and JBS Diode (JBSFET) for High-Power Applications," IEEE Transactions on Electron Devices, under review.
- N. Yun, J. Lynch, S. deBoer, A. J. Morgan, D. Xing, M. Jin, M. Kang, A. Agarwal, R. Green, A. Lelis, and W. Sung,, "Comprehensive Evaluations of High Voltage,14 kV 4H-SiC Power MOSFETs with Various Channel and Cell Designs" IEEE Transactions on Electron Devices, under review.
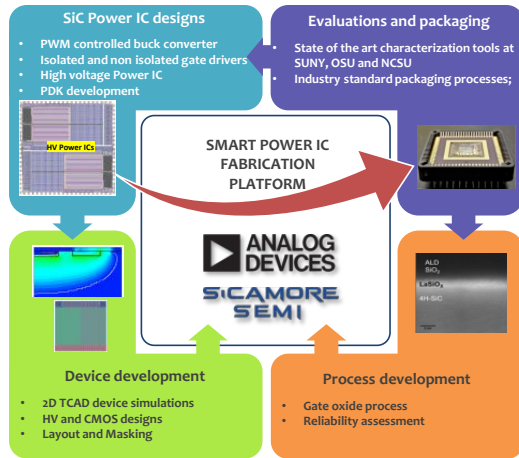
Acknowledgements

Woongje Sung

sungw1@sunypoly.edu

https://sunypoly.edu/research/centers-programs/suny-casper.html

https://sunypoly.edu/faculty-and-staff/woongje-sung.html

OFFICE OF RESEARCH
SUNY POLYTECHNIC INSTITUTE

Scalable, Manufacturable, And Robust Technology for SiC power integrated circuits (SMART SiC Power ICs)

Project Summary

- This project aims to develop Scalable, Manufacturable, And Robust Technology for SiC power integrated circuits (SMART SiC Power ICs). Disruptive designs and processes were being developed to achieve high-voltage (HV) integrated circuits of large scale (>1 cm2) by monolithically integrating the SiC Complementary Metal-Oxide-Semiconductor (CMOS) and HV (400 – 600 V) lateral power nMOSFETs on 100-150 mm 4H-SiC substrates

- **Approach**

Highlights

- SMART IC technology cross-section

- HV NMOS electrical characteristics

- CMOS IC (ring oscillator) demonstration
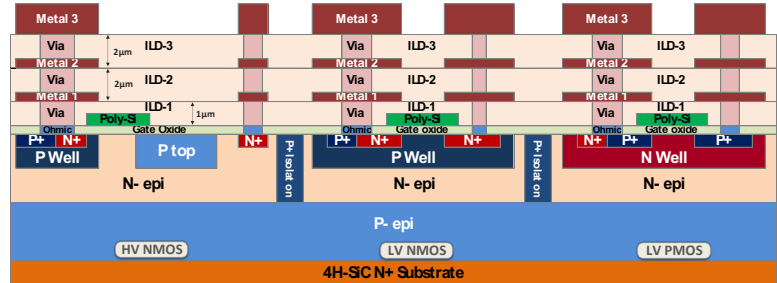

Publications

- Sundar Babu Isukapati, H. Zhang, T. Liu, E. Ashik, B. Lee, A. Morgan, W. Sung, A. Fayed, and A. Agarwal, "Monolithic Integration of Lateral HV Power MOSFET with LV CMOS for SiC power IC technology," in 2021 33rd International Symposium on Power Semiconductor Devices and ICs (ISPSD). IEEE, 2021.

- Sundar Babu Isukapati, H. Zhang, T. Liu, E. Ashik, B. Lee, A. Morgan, W. Sung, A. Fayed, and A. Agarwal, "Development of Isolated CMOS and HV MOSFET on an N-epi/P-epi/4H-SiC N+ Substrate for Power IC Applications," in 8th IEEE Workshop on Wide Bandgap Power Devices and Applications (WiPDA 2021). IEEE, 2021.
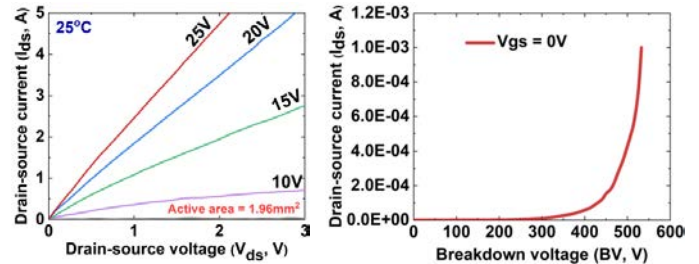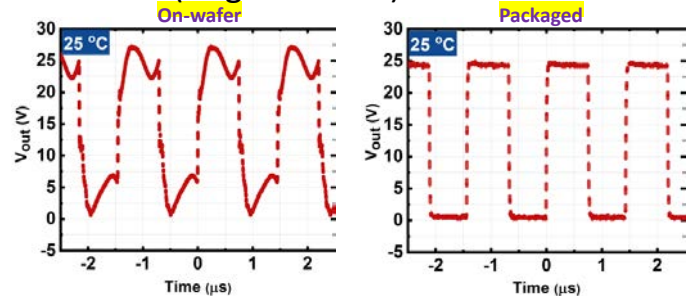
Acknowledgements

Woongje Sung

sungw1@sunypoly.edu

https://sunypoly.edu/research/centers-programs/suny-casper.html

https://sunypoly.edu/faculty-and-staff/woongje-sung.html

# Development of Trench 1.2kV 4H-SiC MOSFETs

Project Summary

- This project aims to 1) design and optimize 1.2kV SiC Trench MOSFET cell structure to achieve a low on-resistance, a highly efficient edge termination structure, a reasonable threshold voltage, circuit-oriented switching behaviors, and the avalanche ruggedness, and 2) establish a process baseline to fabricate the proposed MOSFETs. Designs, fabrications, and characterizations of three lots for MOSFETs devices are planned.

Highlights

- 1.2 kV SiC trench MOSFET cell structures were optimized in terms of $R_{on,sp}$, BV, and E_{ox}.
- Extensive 2-D device simulations have been conducted under a support of a private company.
- 56 different devices were designed for Lot1.
- The process baseline for 4H-SiC trench MOSFET is being developed at a 6-inch foundry partner company.
- The outcome of this project will allow next generation power devices on SiC, further reducing power loss for many different applications such as EV power inverters, fast chargers, and consumer electronics.
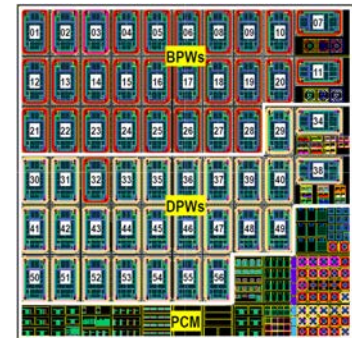

BPW1 **BPW2** **Deep P1** **Deep P2**

Deep P with BPW
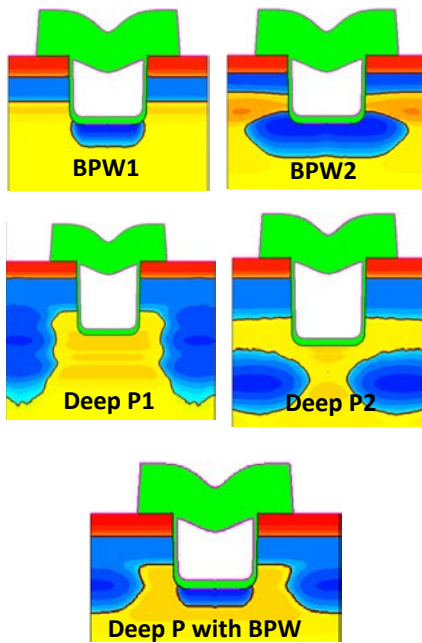
Simulated cross-sectional view of 4H-SiC trench MOSFETs
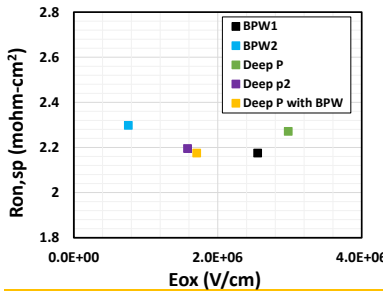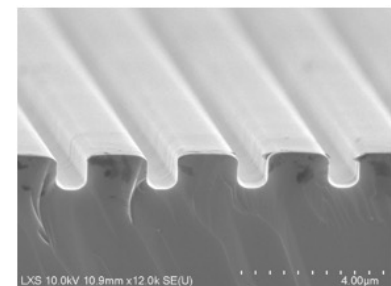

Simulated trade off relationship between $R_{on,sp}$ and E_{ox}
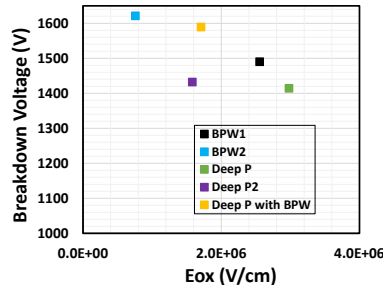
Simulated trade off relationship between BV and E_{ox}

Mask design of trench MOSFETs

SEM image of trench structure

Woongje Sung

sungw1@sunypoly.edu

https://sunypoly.edu/research/centers-programs/suny-casper.html

https://sunypoly.edu/faculty-and-staff/woongje-sung.html

Project Summary

- The main objective of this project is to develop 1.2 KV SiC MOSFETs that are superior to their Silicon counterparts (IGBTs) in all aspects, such as cost, performance, and reliability. To accomplish the goal, many different variations in device and process design have been pursue

Highlights

- SiC MOSFETs with deep P-wells (1.8 µm), formed by using an additional channeling implantation, and short channels (0.3 µm) were proposed that significantly improved the conventional trade-off relationship between Ron,sp and the BV or SCWT
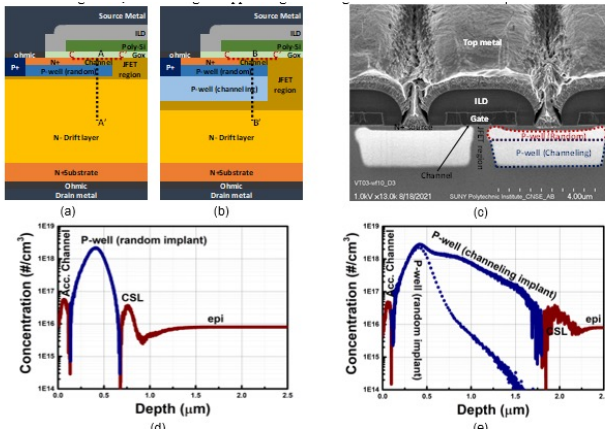

Figure 1. Cross-sectional view of (a) conventional 1.2kV 4H-SiC MOSFETs and (b) proposed 1.2kV 4H-SiC MOSFETs. (c) The SEM cross-sectional view of the proposed 1.2 kV MOSFETs. (d) Net doping profile (A-A' shown in Fig. 1 (a)) for the conventional MOSFETs using SPROCESS. (e) Net doping profile (B-B' shown in Fig. 1 (b)) for the proposed MOSFETs using SPROCESS.
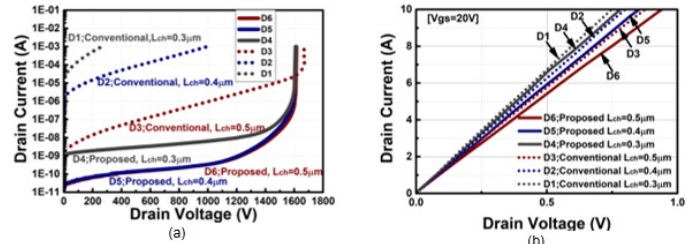

Figure 2. (a) Measured forward blocking characteristics and (b) output characteristics at V_{gs} of 20 V of the fabricated 1.2 kV MOSFETs with different channel lengths.
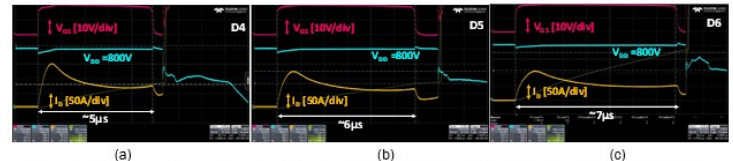

Figure 3. (a) Image of the packaged devices from Lot2. (b) PBTI, and (c) NBTI of the fabricated MOSFETs.

Publications

•D. Kim, N. yun, S. Y. Jang, A. J. Morgan, and W. Sung, "An Inclusive Structural Analysis on the Design of 1.2kV 4H-SiC Planar MOSFETs," IEEE Journal of the Electron Devices Society, vol. 9, pp. 804–812, 2021, doi: 10.1109/JEDS.2021.3109605.

•D. Kim and W. Sung, "Improved Short-Circuit Ruggedness for 1.2kV 4H-SiC MOSFET Using a Deep P-Well Implemented by Channeling Implantation," IEEE Electron Device Letters, vol. 42, no. 12, pp. 1822–1825, Dec. 2021, doi: 10.1109/LED.2021.3123289.

•D. Kim, S. Y. Jang, S. De Boer, A. J. Morgan, and W. Sung, "An Optimal Design for 1.2kV 4H-SiC JBSFET (Junction Barrier Schottky diode integrated MOSFET) with Deep P-well," IEEE Electron Device Letters, pp. 1–1, 2022, doi: 10.1109/LED.2022.3162156.

•D. Kim, N. Yun, S. Y. Jang, A. J. Morgan, and W. Sung, "Channel Design Optimization for 1.2-kV 4H-SiC MOSFET Achieving Inherent Unipolar Diode 3rd Quadrant Operation," IEEE Journal of the Electron Devices Society, vol. 10, pp. 495–503, 2022, doi: 10.1109/JEDS.2022.3185526.

•D. Kim, N. Yun, A. J. Morgan, and W. Sung, "The Effect of Deep JFET and P-Well Implant of 1.2kV 4H-SiC MOSFETs," IEEE Journal of the Electron Devices Society, vol. 10, pp. 989–995, 2022, doi: 10.1109/JEDS.2022.3218689.

•D. Kim, A. J. Morgan, N. Yun, W. Sung, A. Agarwal, and R. Kaplar, "Non-Isothermal Simulations to Optimize SiC MOSFETs for Enhanced Short-Circuit Ruggedness," in 2020 IEEE International Reliability Physics Symposium (IRPS), Apr. 2020, pp. 1–6. doi: 10.1109/IRPS45951.2020.9128324.

•D. Kim, N. Yun, S. DeBoer, A. J. Morgan, S. Y. Jang, W. Sung, J. Fan, S. Yu, M. Kang, and A. K. Agarwal, "A Static, Switching, Short-circuit Characteristics of 1.2 kV 4H-SiC MOSFETs: Comparison between Linear and (Bridged) Hexagonal Topology," in 2021 IEEE 8th Workshop on Wide Bandgap Power Devices and Applications (WiPDA), Nov. 2021, pp. 9–13. doi: 10.1109/WiPDA49284.2021.9645098.

•D. Kim, S. Y. Jang, A. J. Morgan, and W. Sung, "Implementation of a short channel (0.3 µm) for 4H-SiC MOSFETs with deep P-well using 'channeling' implantation," in 2022 IEEE 34th International Symposium on Power Semiconductor Devices and ICs (ISPSD), May 2022, pp. 217–220. doi: 10.1109/ISPSD49238.2022.9813633.

•D. Kim, S. DeBoer, S. Y. Jang, A. J. Morgan, and W. Sung, "A Comparison of Short-Circuit Failure Mechanisms of 1.2 kV 4H-SiC MOSFETs and JBSFETs," in 2022 IEEE 9th Workshop on Wide Bandgap Power Devices & Applications (WiPDA), Jan. 2022, pp. 54–57. doi: 10.1109/WiPDA56483.2022.9955302.

•D. Kim, S. DeBoer, S. A Mancini, S. B. Isukapati, J. Lynch, N. Yun, A. J. Morgan, S. Y. Jang, and W. Sung, "A Static, Dynamic, Short-circuit Characteristics of Split-Gate 1.2 kV 4H-SiC MOSFETs," In 2023 IEEE International Reliability Physics Symposium (IRPS), accepted.

Acknowledgements

Woongje Sung

sungw1@sunypoly.edu

https://sunypoly.edu/research/centers-programs/suny-casper.html

https://sunypoly.edu/faculty-and-staff/woongje-sung.html

Project Summary

- The sxRNA approach is based on the binding of one RNA molecule to a second RNA molecule in a designed manner. This allows us to target the presence of a cellular or disease specific RNA to act as a "Trigger" to change the structure of a "Bait" RNA that has been engineered to turn ON when the two RNAs interact.

- This mechanism provides a unique 'ON/OFF' switch for the controlled expression of target protein. Unlike other technologies that only turn off gene expression, the switchable gene expression control system offered by the sxRNA platform provides a means to turn ON the gene expression.

- By coupling the protein expression with the unique RNA signature of a cell, our sxRNA technology enables the tissue-specific expression of a selected gene product and the ability to control this expression at the level of mRNA rather than DNA.

- sxRNA creates many new possibilities for RNA-based gene therapies, diagnostics, and biomanufacturing as well as other medical applications. For example, sxRNA could be used to express a suicide protein specifically in pancreatic cancer tissue or integrated into a point-of-care test used to screen for exposure to the SARS-COV2 or incorporated into the biomanufacturing pipeline to speed up the process and increase yield.
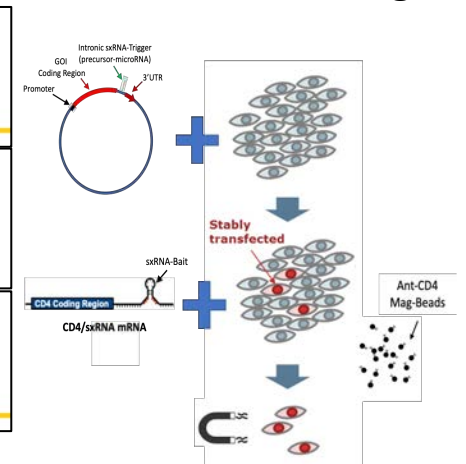
Highlights

sxRNA Therapeutics
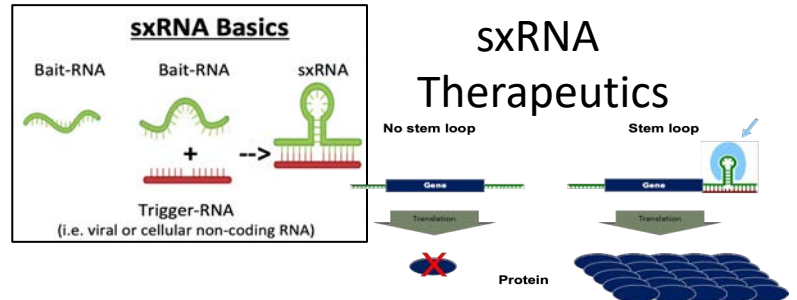
sxRNA Diagnostics
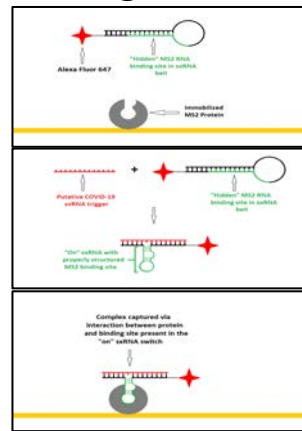
sxRNA Biomanufacturing

Publications

- PTSelect™: A post-transcriptional technology that enables rapid establishment of stable CHO cell lines and surveillance of clonal variation. Muralidharan-Chari V, Wurz Z, Doyle F, Henry M, Diendorfer A, Tenenbaum SA, Borth N, Eveleth E, Sharfstein ST. J Biotechnol. 2021 Jan 10;325:360-371.
- Redox and mTOR-dependent regulation of plasma lamellar calcium influx controls the senescence-associated secretory phenotype. Chandrasekaran A, Lee MY, Zhang X, Hasan S, Desta H, Tenenbaum SA, Melendez. JA.Exp Biol Med (Maywood). 2020 Nov;245(17):1560-1570.
- Surface Enhanced Raman Spectroscopy for Single Molecule Protein Detection. Almehmadi LM, Curley SM, Tokranova NA, Tenenbaum SA, Lednev IK. Sci Rep. 2019 Aug 26;9(1):12356.
- FASTmiR: an RNA-based sensor for in vitro quantification and live-cell localization of small RNAs. Huang K, Doyle F, Wurz ZE, Tenenbaum SA, Hammond RK, Caplan JL, Meyers BC. Nucleic Acids Res. 2017 Aug 21;45(14
- Engineering Structurally Interacting RNA (sxRNA). Doyle F, Lapsia S, Spadaro S, Wurz ZE, Bhaduri-McIntosh S, Tenenbaum SA. Sci Rep. 2017 Mar 28;7:45393. doi: 10.1038/srep45393.

Acknowledgements

Scott Tenenbaum

http://sxrna.sunycnse.com/nanobio/tenenbaum/

stenenbaum@albany.edu / tenenbs@sunypoly.edu

Project Summary

- Certain trace elemental impurities can cause embrittlement of copper interconnects in semiconductor devices, degrading their performance. Some elements, such as bismuth, segregate to the grain boundaries, so even small amounts are problematic.

- Many other elements have little impact on the fracture toughness. There appears to be little correlation with valence or atom size.

- Density Functional Theory is a tool for understanding the distribution of valence electrons in material systems, and can give insight into physical behaviors as well as help interpret other experimental data.

- In this case, it was found that when impurity atoms have a valence number very difference from the host Cu, an ionic character develops. However, transition metal impurities provide a high density of states at the Fermi level (i.e., empty d-orbitals) allowing for screening of the ionic charges and enabling ductility.

- We conclude that simple metal impurities with low solubility in Cu may give rise to brittleness, with the extent correlating with increased valence.
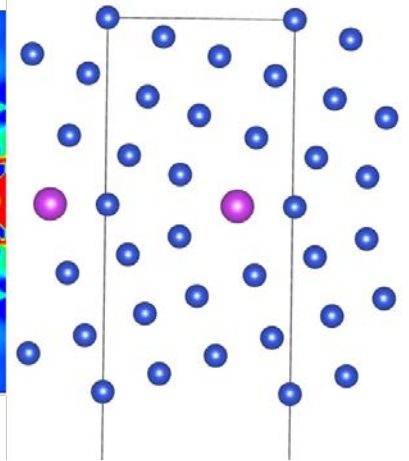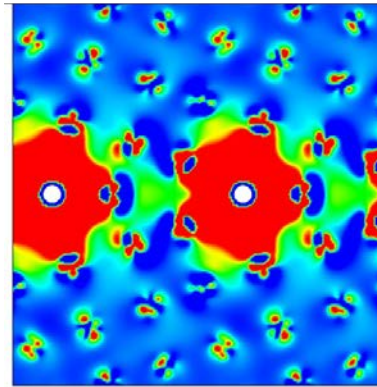
Publications

- In preparation

Acknowledgements

Highlights

- Redistribution of valence electrons caused by impurity atoms substituting for copper in the grain boundary. Bismuth, with five valence electrons develops a positive charge of 1.3 (indicated in red) while the adjacent GB copper has a slight negative charge (indicated in blue).
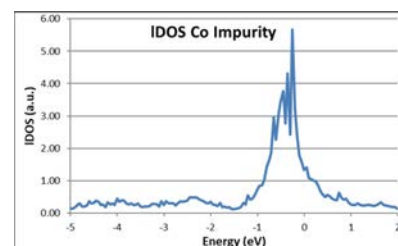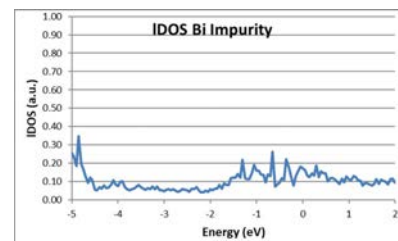
- Local Density of States at the impurity site in the grain boundary. Bi results in a low DOS, correlating with brittleness, whereas the high DOS from Co retains toughness.

Brad Thiel

bthiel@sunypoly.edu

https://sunypoly.edu/research/thiel.html

Project Summary

- The miniaturization of microelectronic devices is typically done by a top-down approach using lithography and plasma etching steps. The current nanometric dimensions make this miniaturization more and more expensive and complex (use of EUV lithography, double and quadruple patterning steps). This can result in edge placement error of a few nm on a 300mm wafer. A promising solution is to reduce the lithography and etching steps by developing a bottom-up process, where a material is directly and selectively deposited on a surface, which is called area selective deposition (ASD).

- Three different ASD projects are currently being developed at CNSE thanks to the support of the TEL innovation scientist grant and a grant from the Semiconductor Research Collaboration (SRC).

    - Study of small inhibitors for ASD by inhibition (TEL grant, Ph.D. work of Anthony Valenti)

    - ASD by PECVD on metal organic resist (TEL grant, Ph.D. work of Rosanna Robert)

    - ASD by physisorption on EUV resist (SRC grant, Ph.D. work of Paul Ph.D. of Nicolas Paul Maldonado)
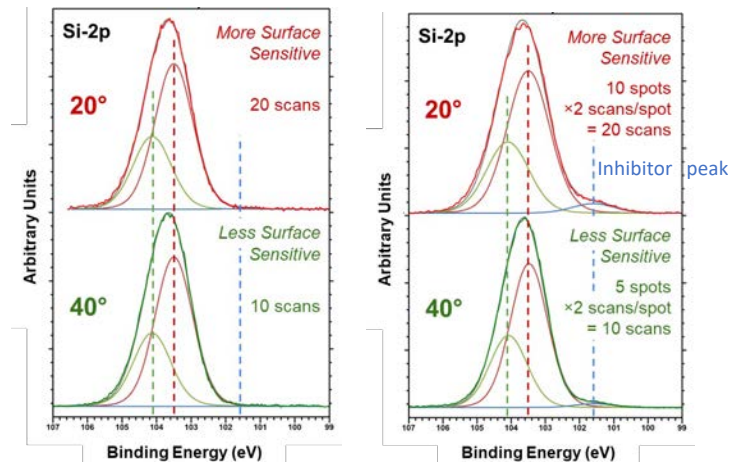
Publications

- M. Bonvalot, C. Vallée, et al. , Area Selective Deposition using alternate deposition and etch super-cycle strategies, <u>Dalton Trans</u>. **51** (2022) 442-450

Highlights

- A. Valenti has developed a specific XPS methodology which permits to characterize the presence of nanoscale inhibitors on the surface of oxides

Without (left) and with new XPS methodology (right)

- R. Robert has developed a PECVD process allowing to obtain 6 nm of selectivity between two surfaces. The mechanisms implemented are based on deposition/etching competitions on one surface and radical diffusion/saturation on another.

- N.P. Maldonado has built a vacuum chamber for its selective deposition test by physisorption which can be assisted by plasma and/or electron gun. An in-situ ellipsometer has also been mounted on the reactor. With this equipment, it has ben demonstrated that some gases used in plasma etching processes can be selectively physisorbed on an EUV resist leading to an ASD process.

Acknowledgements

Christophe Vallée, Carl A. Ventrice, Jr, and Greg Denbeaux

valleec@sunypoly.edu , ventric@sunypoly.edu , denbeag@sunypoly.edu

Project Summary

- Plasma, the 4th state of matter, is essential for the fabrication of microelectronic devices. It is used either for deposition (PVD, PECVD, PEALD) or for etching (RIE, Plasma ALE...). When it is used for etching, it must be optimized, and the success of the associated process is described by i) profile control (isotropic vs anisotropic etching), ii) etching rate, iii) selectivity (ability to etch faster a selected material), III) control of induced defects (chemical modification of materials in contact with the plasma, roughness, etch residues).

- In order to produce smaller and smaller 3D patterns with a high aspect ratio, this etching process is constantly being made more complex: plasma pulsing, plasma ALE (Atomic Layer Etching), cryogenic etching...

- This research activity is mainly done in collaboration with the company TEL and the goal is to optimize some plasma etching processes essential to the miniaturization efforts. Optimizing the external parameters (RF power, pulse, pressure, gas selection...) of the reactor requires an excellent understanding of the plasma/surface interactions and the dissociation mechanisms of the precursors in the gas phase. This requires the implementation of in situ diagnostics of the gas phase and/or the thin film being processed on the reactors (OES and ellipsometry for example).

Highlights

- During his first year of research on advanced metal etching, I. Otto (Ph.D. student) clearly showed that the chemistry of the walls of a 300 mm etching reactor could strongly modify the etching rates of different materials exposed to the plasma. Thus, with an adapted reactor cleaning strategy, an etch selectivity could be achieved between a metal layer and an oxide, which is not possible without this optimization. These results were presented at the AVS conference in 2022 and a paper is currently being submitted.

- D. Santos (Ph.D. student) studied the impact of temperature and gas selection for etching low dielectric constant materials in a 300 mm plasma reactor. He showed that by reducing the temperature, for some gases the plasma etching is stopped, and we go into a deposition regime, while for other gases it is accelerated. This result can allow to optimize the etching profile of materials with low dielectric constant and limit their modification by the plasma (increase of the dielectric constant). These results have been presented at the AVS 2022 conference and a paper is currently being written for publication.

Publications

- In Progress

Acknowledgements

Christophe Vallee

valleec@sunypoly.edu

Project Summary

This research project is a collaborative effort between Menlo Microsystems and my Surface Science research group. Menlo Micro has developed novel RF switches made from microelectromechanical systems (MEMS). These MEMS devices use electrostatically controlled cantilevers to control the propagation of the RF signals. The contact material for the cantilevers is ruthenium. It is used as an electrical contact material due to its resistance to oxidation at elevated temperatures. In addition, the most stable stoichiometry of ruthenium oxide under ambient conditions is RuO_2, which is an electrically conductive oxide. The goal of this study is to determine the stoichiometry and measured thickness of the surface oxide on Ru formed by typical MEMS fabrication processing techniques. The primary analysis methods used in this study are angle-resolved X-ray photoelectron spectroscopy (AR-XPS) and atomic force microscopy (AFM).

Air Exposed Ru/SiO$_2$/Si(100)

Ru-3d
$\theta = 45°$
$\Delta\theta = 40°$

Ru/SiO$_2$/Si(100) Post Anneal

Ru-3d
$\theta = 45°$
$\Delta\theta = 40°$

Publications

- *Angle-resolved XPS Analysis of the Oxidation of Ru Thin Films*, S. Antar, R. Wheeler, A. Valenti, C.A. Ventrice, Jr., M. Strohmayer, J. Brewer, C. Nassar, and C. Keimel, **68th International Symposium of the American Vacuum Society**, Pittsburgh, Pennsylvania, November 7, 2022.

Group Members

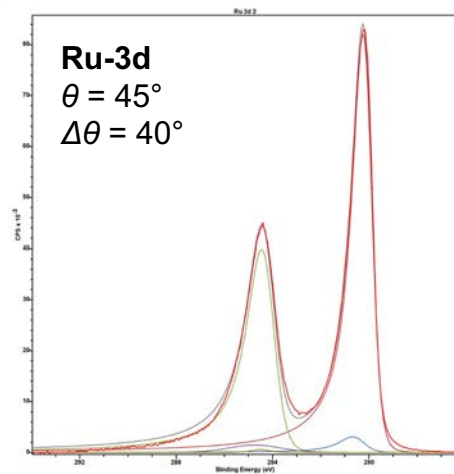- Shivan Antar (UG), Anthony Valenti (Grad), and Randall Wheeler (Grad)

Menlo Micro Group

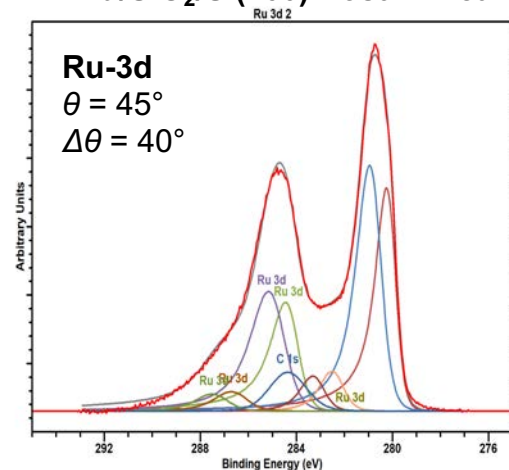- Matthew Strohmayer, Joleyn Brewer , Christopher Nasser, and Christopher Keimel

Acknowledgements

Carl A. Ventrice, Jr.

ventric@sunypoly.edu

Micro-/Nanofiber Scaffolds for Salivary Gland Regeneration

Project Summary

- Salivary gland dysfunction is associated with aging, radiation therapy for head and neck cancers, and the autoimmune disorder, Sjögren's syndrome. Fibrosis occurs in salivary glands of afflicted individuals, inhibiting tissue regeneration.

- Salivary gland stroma contains tissue-resident mesenchymal stromal cells (MSCs), which have anti-fibrotic potential. To test the hypothesis that exogenous MSCs can revert endogenous fibrotic MSCs to a homeostatic state, reducing fibrosis, we developed fabrication methods to reproducibly produce cryogenic hydrogel nanofiber sponge scaffolds that mimic the ECM topography and biomechanical properties of the salivary gland tissue as well as alginate microfibers. These scaffolds support maintenance of salivary gland tissue-resident MSC phenotype and self-organization of stromal and epithelial cells in vitro.

- This project lays a foundation for bioengineering healthy and fibrotic salivary gland tissues in vitro and delivery of MSCs in vivo to reduce salivary gland fibrosis, leading to salivary gland tissue regeneration.

Highlights

- Hydrogel nanofiber scaffolds could mimic topographical and viscoelastic properties of soft-tissue ECM, maintain homeostatic phenotype of MSCs, and suppress disease-associated fibrotic phenotype.

Mesenchymal stromal cells → in vivo cell delivery

Decellularized salivary gland matrix

Salivary gland epithelial cells

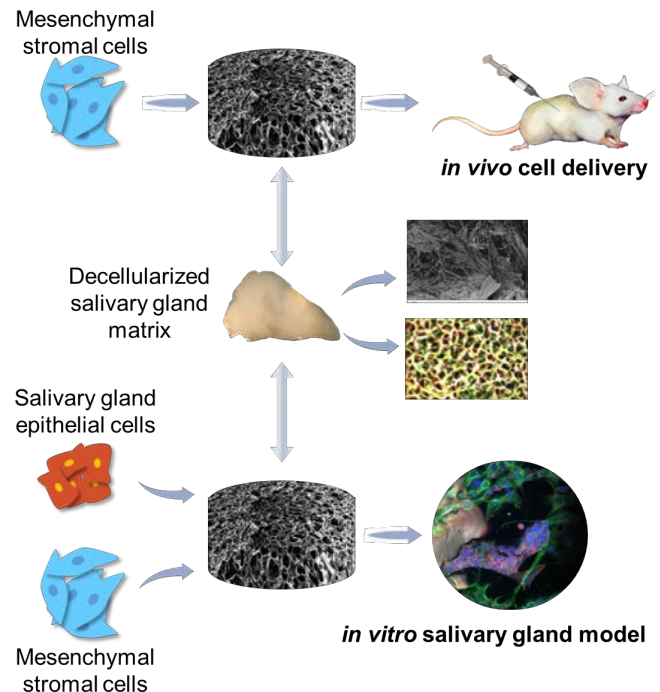Mesenchymal stromal cells → in vitro salivary gland model

Publications

- Xie Y, Kollampally SCR, Jorgensen M, Zhang X. Alginate microfibers as therapeutic delivery scaffolds and tissue mimics. Exp Biol Med. in press. doi: 10.1177/15353702221112905.

- Ramesh P, Moskwa N, Hanchon Z, Koplas A, Nelson DA, Mills KL, Castracane J, Larsen M, Sharfstein ST, Xie Y. Engineering cryoelectrospun elastin-alginate scaffolds to serve as stromal extracellular matrices. Biofabrication. 2022 May 17;14(3). doi: 10.1088/1758-5090/ac6b34.

- Jorgensen M, Ramesh P, Toro M, Evans E, Moskwa N, Zhang X, Sharfstein ST, Larsen M, Xie Y. Alginate Hydrogel Microtubes for Salivary Gland Cell Organization and Cavitation. Bioengineering. 2022 Jan 15;9(1):38. doi: 10.3390/bioengineering9010038.

Acknowledgements

Yubing Xie

xiey@sunypoly.edu

https://sunypoly.edu/faculty-and-staff/yubing-xie.html

https://sunypoly.edu/research/centers-programs/fitgc.html

Project Summary

Functional and Integrative Tissue Generation Center (FITGC) aims to promote convergent research, education and workforce training, and technology innovation and translation for widely-accepted adoption of next generation tissue engineering.

- Research on functional cell-biomaterial interactions and multicellular interactions for directed cell regulation based on biomaterial science and cell biology/physiology;
- Development of enabling technologies for engineering cell organization and tissue function employing real-time biosensing to promote longevity and functional outcomes while enabling biomanufacturing in a scalable and reproducible manner;
- Translation of innovation in integration to generate reproducible, scalable, functional cell/tissue/organoid products for biological studies, drug testing, cell therapy and regenerative medicine.

Highlights
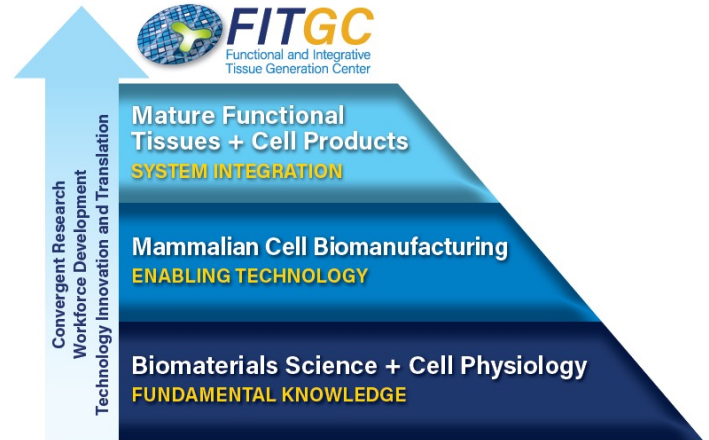
- Bioengineering Ocular Outflow Physiology for High-throughput Drug and Gene Screening
- Nanofiber Scaffolds for Salivary Gland Regeneration
- Hydrogel Microtubes for Organoid Cultures
- Controlled-Release Sutures for Wound Healing and Regenerative Medicine
- T Cell Manufacturing and Novel Bioreactors

Publications

- Xie Y, Kollampally SCR, Jorgensen M, Zhang X. Alginate microfibers as therapeutic delivery scaffolds and tissue mimics. Exp Biol Med. in press. doi: 10.1177/15353702221112905.
- Ramesh P, Moskwa N, Hanchon Z, Koplas A, Nelson DA, Mills KL, Castracane J, Larsen M, Sharfstein ST, Xie Y. Engineering cryoelectrospun elastin-alginate scaffolds to serve as stromal extracellular matrices. Biofabrication. 2022;14(3). doi: 10.1088/1758-5090/ac6b34.
- Jorgensen M, Ramesh P, Toro M, Evans E, Moskwa N, Zhang X, Sharfstein ST, Larsen M, Xie Y. Alginate Hydrogel Microtubes for Salivary Gland Cell Organization and Cavitation. Bioengineering. 2022;9(1):38. doi: 10.3390/bioengineering9010038.
- Jorgensen M, Gibbons A, Sui K, Carpenter R, Zhang X, Xie Y. Predictable fabrication of pre-made alginate hydrogel microtubes for stem cell aggregation using needle-in-needle devices. Biofabrication. 2021;13(3). doi: 10.1088/1758-5090/abfd7b.

Acknowledgements

Yubing Xie

xiey@sunypoly.edu

https://sunypoly.edu/faculty-and-staff/yubing-xie.html

https://sunypoly.edu/research/centers-programs/fitgc.html

Project Summary

- As artificial intelligence and big data become ever more present and influential in our lives, there is a need for researchers to confront challenges of digital technology from all walks of life by combining knowledge from both physical and social sciences. In this highly interdisciplinary project, we seek to integrate statistical, computational, and human perspectives of digitization and understand and shape digital transformation of society from its scientific and technological basis to its impact on social and economic inequality.

Highlights

- How can artificial intelligence and data science learn from physics, transform economic reasoning, financial engineering, and quantitative social research?

- How do current trends of datafication and financialization of digital economy lead to new models of business and new ways of value creation, while reshaping the power imbalance between labor and capital?

- How do advancement of artificial intelligence and automation lead to new ways of working and organizing, impact higher education, and reshape long-term trends of employment precarity and polarization?

Publications

- J. Mao and Y. Xue, **Salvaging adulthood at youth work: Dignity, social disrespect, and the micro-politics of recognition in a polarized world,** Organization 2022, Vol. 29(6), 1056–1080.

Acknowledgements

Yongqiang (Alex) Xue

yxue@sunypoly.edu

https://sunypoly.edu/faculty-and-staff/yongqiang-alex-xue.html

OFFICE OF RESEARCH
SUNY POLYTECHNIC INSTITUTE

sunypoly.edu/research/office-research