VIRGINIA MICROELECTRONICS CONSORTIUM

VMEC Scholar Program

Summer 2022 Job Descriptions

September 3, 2021

This document contains brief job descriptions for VMEC Scholars that would be placed at our university or industry members. You are encouraged to contact the designated contacts to learn more about these opportunities.

BAE Systems, Inc (Manassas, Virginia)

Company Overview:

BAE Systems plc., a global defense company, is engaged in the development, delivery, and support of advanced defense, security, and aerospace systems. BAE Systems employs 88,200 people with operations in six home countries - Australia, Saudi Arabia, South Africa, Sweden, UK, US, and customers in over 100 countries.

BAE Systems, Inc., with greater than 40,000 employees, is the US subsidiary of BAE Systems plc. The US focus is:

- Support and service solutions for current and future defense, intelligence, and civilian systems.
- Design, develop and manufacture a wide range of electronic systems and subsystems for both military and commercial applications;
- Design, develop, produce, and provide service support of armored combat vehicles, artillery systems and intelligent munitions.

Site Overview:

BAE Systems in Manassas, VA is the headquarters of the Space Systems division. We offer advanced systems and components for many types of space missions, including command and control; intelligence, surveillance, and reconnaissance; environmental and space science; communications; and navigation. These missions include notable programs like the computers for the Mars rovers, and computers for command and control of GPS satellites. We also build and test high reliability airborne RF microelectronics, for use in several airborne platforms. The Manassas site is a complete design, packaging, and test facility for development and production of CMOS devices, and production of RF microelectronic units.

Intern Responsibilities:

BAE Systems Manassas is looking for summer interns to work in various phases of integrated circuit modeling, design, and test. Job responsibilities may include simulation, data collection and analysis, hands on circuit test and debug, and process or flow development. Interns develop skills in the use of design and modeling software, and work to develop and test a host of devices such as advanced microprocessors, memories, FPGAs, ASICs and other high function devices.

Requirements:

We are interested in students completing their sophomore or junior year in electrical engineering with a desire to grow and learn about microelectronics. Students attending Virginia Tech, University of Virginia, Old Dominion University, Virginia Commonwealth University, The College of William and Mary, and George Mason University may apply.

BAE Systems is committed to a high-performance culture and provides an environment that challenges our employees to be remarkable and obtain their full potential. We are an EEO/Affirmative Action Employer that understands the value of diversity and its impact on a high performance culture.

Micron Technology, Inc. (Manassas, VA)

Company Overview:

Micron is a world leader in innovating memory and storage solutions. We deliver the world's broadest portfolio of technologies at the core of today's most significant disruptive breakthroughs such as artificial intelligence and autonomous vehicles. Micron's memory and storage solutions define what the world can do with data. Our more than 40,000 team members, in 17 different countries, work with countless customers to innovate every day and pursue the products that will shape how we live and work tomorrow.

Site Overview:

Micron Technology Virginia (MTV), located in Manassas, is Micron's Automotive Center of Excellence and the primary manufacturing location for long lifecycle memory products including DRAM, NAND and NOR. MTV employs more than 1,600 team members, is Micron's most diverse site and is one of the largest exporters in Virginia. The site is currently undergoing an expansion. As a leading high-tech manufacturing company in Virginia, we realize a strong and healthy community is critical to the success of individuals, companies and society. MTV works closely with government and community organizations to improve the region's quality of life, connects our team members to the community and support initiatives that positively impact our community and the rest of Virginia.

Intern Responsibilities:

Challenge yourself intellectually by working side-by-side, gaining real-world experience from leading industry professionals. You will directly play a pivotal role in continuing the growth of one of the world's leading providers of advanced semiconductor solutions. During your internship you will work on projects in the areas of product characterization and yield analysis, new tool implementation and process enhancement or new product implementation.

Benefits:

Intern team members are eligible for Medical Health Insurance, Paid Holidays, 401(k) Retirement Plan as well as 8 hours of paid time off to volunteer. You are immediately eligible to participate in Retirement Plan as part of Micron Technology, Inc. team. Micron will match your Pre-Tax or Roth Contributions up to 5% of your eligible annual earnings. In addition to the above benefits, Micron provides corporate housing for interns who reside outside of a 50-mile radius, as well as free Gym & Indoor swimming pool membership at nearby GMU Freedom Center.

Requirements:

During their summer internship, students must be enrolled as sophomores, juniors or seniors at one of the following Institutions: Virginia Tech, UVA, ODU, NSU, VSU, VCU, GMU, or College of William and Mary, pursuing a B.S. in any of the following disciplines: EE, ChE, ME, CE, CS, Electronics, EET, Materials Science, or Data Analytics.

George Mason University

VMEC Summer Scholar Project

The Microelectronics research group at George Mason University is led by Prof. Qiliang Li and Prof. Dimitris Ioannou. The major focus of the group is on chemical and optical sensors and intelligent sensing systems.

The VMEC Summer Scholar will be working with the faculty and graduate students on one of the following **three projects**:

(1) gas sensors and systems based on semiconductors and nanomaterials;

(2) optoelectronic chemical sensors and smart systems;

(3) intelligent recognition and interaction based on vision and Lidar fusion.

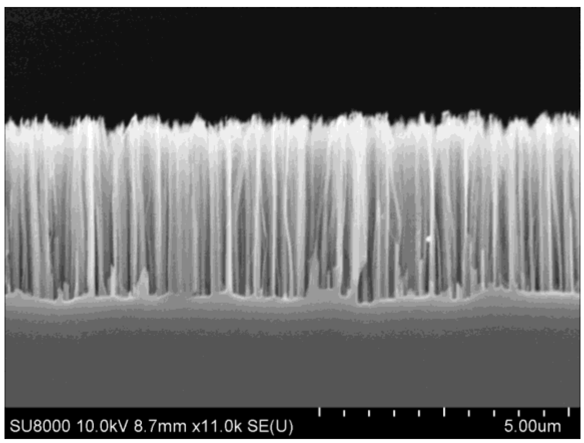
The student will learn both hardware integration and software development in a friendly George Mason campus.

Contact: Prof. Qiliang Li, Dept. of Electrical and Computer Engineering, 4400 University Dr, Fairfax, VA 22030, e-mail: qli6@gmu.edu

Norfolk State University

1. Fabrication of silicon nanowire arrays for reducing surface reflection

Silicon nanowire (SiNW) arrays are useful to reduce surface reflection of silicon substrates significantly below its 35% reflectivity. The reduction in reflectivity should lead to enhanced performance of silicon detectors, solar cells and other optoelectronic devices. This project will investigate the antireflection properties of SiNW and any resultant enhancement in quantum efficiency of such devices.



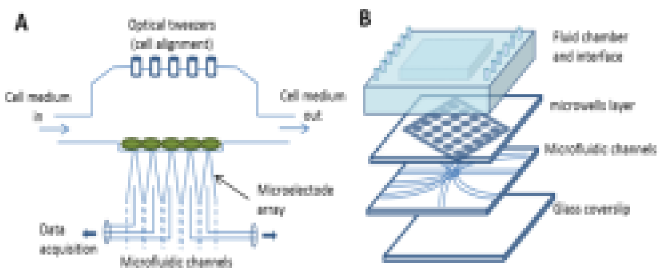
The student will fabricate SiNW using Ag assisted catalytic etching method that is simple and does not require expensive equipment to fabricate large area samples. A high degree of control on the diameter, length, and density of SiNW can be achieved using the AgNO3/HF solution that provides the Ag nanoparticles for catalytic etching. The VMEC summer project will focus on the following topics:

1. Metal assisted etching of Si surface to produce SiNW.
2. Surface reflectivity of the nanostructured silicon surface.
3. Effect of low reflectivity of nanostructured silicon surface of a Si p-n junction.

NSU has excellent cleanroom facilities to conduct the chemical fabrication. The surface structures will be studied using high resolution scanning electron microscopes and atomic force microscopes. Reflectivity will be measured using integrating sphere and spectrometer. Si p-n junctions will be fabricated using diffusion and/or ion implantation and annealing. Quantum efficiency will be measured using our solar cell research facility.

2. Design & fabrication of optofluidic chip for biological electrophysiology measurements

Excitable biological cells exhibit mechano-electric sensitivity by which their electrical behavior is modulated by mechanical stimuli or stretch. Specialized stretch-activated ion channels in cells are thought to be responsible for this mechano-electric modulation. The goal of this project is to design a microfluidic-based platform to record electrophysiological currents from biological cells in their stretched conditions. A microfluidic chamber consisting of an array of micro-wells will be designed as depicted in the schematic below. Each microwell will be equipped with a microelectrode recording assembly underneath the substrate. The cells will be trapped and guided to the microwells using computer controlled optical tweezers. A novel optical non-contact cell stretching method using counter-propagating laser beams, carried to the microwells via optical waveguides, will be designed to produce a controlled stretch in the trapped cells. The proposed optofluidic chip will be used to systematically characterize the stretch-activated ion channels in biological cells. The proposed research has potential to provide mechanistic breakthroughs in our understanding of several chronic diseases such as heart failure and hypertension.



Contact: Dr. Sacharia Albin
Department of Engineering
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Email: salbin@nsu.edu

3. Optofluidic Non-Contact Cell-Characterization Platform to Identify Breast Cancer

Breast cancer is the second leading cause of cancer deaths among women in the United States. Majority of the deaths is due to disease spreading to other parts of the body (metastasis) and impairment of vital body functions. Early detection and accurate diagnosis of metastatic breast cancer remains a challenge despite the widespread use of mammography, due to limited sensitivity and specificity. We plan to develop a microfluidic platform integrated with two novel screening technologies, optical tweezers and Surface Enhanced Raman Spectrometry (SERS), to identify cancer cells among a cell population at very early stages of the disease. By performing two independent but complementary cell characterizations, it is possible to identify the presence of breast cancer in cells even before the structural disease manifestation begins to show up. The project has three major components: a) Development of on-chip dual-laser-beam optical trap (OT)/stretching assembly, 2) Design and fabrication of novel plasmonic SERS substrates to amplify Raman signal, and 3) Experimentation using the OT/SERS profiling platform to characterize breast cancer cells in a microfluidic platform.

The student will work in a team with other graduate students and faculty involved in the project. The student will get an opportunity to use the modern cleanroom facility in the Department of Engineering, and learn experimental techniques and algorithm development in MATLAB and C++.

Contact: Dr. Sacharia Albin, Professor, Department of Engineering, Norfolk State University. Email: salbin@nsu.edu, Web: http://www.nsu.edu/engineering

Old Dominion University

The VMEC Summer Interns will work at the Off-Campus ODU-Applied Research Center located within the campus of Thomas Jefferson National Accelerator Facility in Newport News, Virginia 23606

Project 1: Fabrication of nanoscaled Thermoelectric thin Films with Atomic Layer Deposition (ALD) Technology and Seebeck Measurements

Thermoelectrics is a green renewable energy technology which can significantly contribute to power generation due to its potential in generating electricity out of waste heat. The main challenge for the development of thermoelectrics is its low conversion efficiency. One key strategy to improve conversion efficiency is reducing the thermal conductivity of thermoelectric materials. In this project Nanostructuring of Thermoelectric films is used trying to beat the alloy limit. In principle all low dimensional nano-structures, including two-dimensional quantum wells or superlattices, one-dimensional nano-wires or nano-tubes, and zero-dimensional quantum dots, confine the motion of electrons in one or more dimensions, which decouples the dependence between the Seebeck coefficient *S*, the electrical conductivity σ and thermal conductivity κ, and make it possible to enhance the power factor product of S^2��.

Project 2: Synthesis of novel 12CaO7Al$_2$O$_3$ Electride Material for Electron Emission

In this project the 12CaO·7Al2O$_3$ electride, a sub-nanoporous compound having a work function of 2.4 eV, will be synthesized as a candidate cathode material in fluorescent lamps among other applications. The 12CaO·7Al2O3 (C12A7) electride is a new electronic oxide compound with a work function as low as 2.4 eV, which is close to those of alkaline metals. Its crystal structure can be regarded as a stack of cage-like subunits that share their faces, and this arrangement differs from that of zeolite-based compounds. For thisproject we shall try to synthesize this electride from ALD CaII amidinate precursor: Bis(N,N-di-i propylformamidinato) Calcium(II) - Ca(pr-fmd)$_2$ and react it with either oxygen or DI H_2O. This project requires successful synthesis of a multicomponent thin film nanolaminate composed of alternating layers of Al_2O_3 and CaO which need to be alloyed by subsequent high temperature annealing to attain the required Cage structure of the C12A7 electride.

Project 3: Novel Design of multiple Nested Coaxial ZnO Nanotube Solid-State MOS Gas Sensors Synthesized in Porous Templates

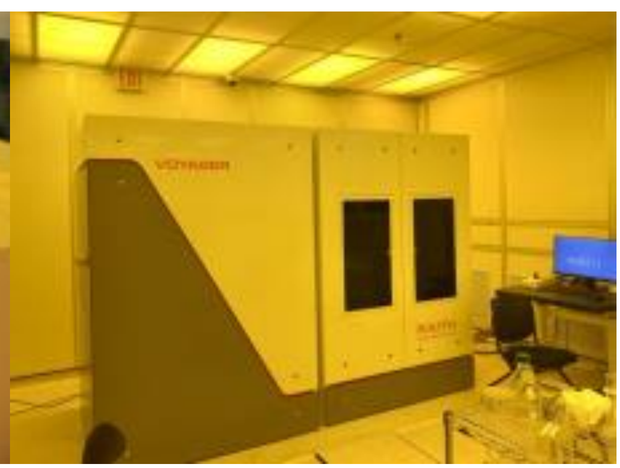
In these projects ZnO nanotubes are to be grown and synthesized by hydrothermal solution methods on porous templates. ZnO nanotube nanostructures will be employed for gas sensing of ethanol vapor concentrations, which is aided by their high electrochemical stability, nontoxicity, and, especially, high surface-to-volume ratio. The sensing performance of ZnO nanotube gas sensors to ethanol vapor will be investigated with a gas sensor testing system equipped with a sealed reaction chamber and control system with stable temperature control and accurate concentration control.

Mentor: Dr. Helmut Baumgart, VMEC Professor, Department of Electrical and Computer Engineering, Old Dominion University, Norfolk, VA and ODU-Applied Research Center at Jefferson Labs, Newport News, Virginia 23606, e-mail: hbaumgar@odu.edu

Virginia Commonwealth University

Wright-Virginia Microelectronics Center at VCU

Virginia Commonwealth University (Richmond, VA) hosts 8000 ft^2 of state-of-the-art, class-100 cleanroom laboratories in its Wright-Virginia Microelectronics Center. We have a whole micro/nanofabrication "suit" that includes photo- and e-beam lithography with a resolution as fine as 600 and 10 nm, respectively, e-beam evaporation and RF sputtering, reactive-ion etching, atomic-layer deposition, and diffusion/oxidation furnaces. The available equipment makes it possible to create and test various micro/optoelectronic, photonic, and biomedical devices
The VCU VMEC Internship offers the unique opportunity to work independently in this high-tech facility and really "do it yourself". You will have the opportunity to work hands-on, from initial concept to final testing and obtain a complete micro/nanofabrication experience, including:
(1) CAD layout and design of a microelectronic, photonic, or biomedical device;
(2) Photomask fabrication using our own custom mask making facilities;
(3) 3-D print shadow masks, molds, holders, if deemed needed;
(3) Device fabrication in the W-VMC clean room;
(4) Device testing in our characterization labs.
Training will also include standard clean room protocol and safety training. The technology for this fabrication project will vary. In the past, the projects have included MOSFETS, polymer based micromachines, surface acoustic wave (SAW) devices, solar cells, and ultra-narrow band-pass filters for short-wave infrared optical range. Our current interests encompass but not limited to micro/nano-electromechanical devices for power applications, innovative nanophotonic devices, Wearable Biomedical sensor systems, infrared imaging.

Contact: Prof. Vitaliy Avrutin, Dept. of Electrical & Computer Engineering, vavrutin@vcu.edu

University of Virginia

VMEC Projects

The University is an iconic public institution of higher education, boasting nationally ranked schools and programs, diverse and distinguished faculty, a major academic medical center and proud history as a renowned research university. The community and culture of the University are enriched by active student self-governance: https://www.virginia.edu/aboutuva

The High-Performance Low-Power (HPLP) lab: the VMEC Scholar activities will be conducted in the HPLP lab which provides all the necessary infrastructure for IC and system design and testing, space, equipment, and computing for all IC design and verification activities, including custom and semicustom design flows. This servers running CAD software packages from all major EDA vendors including Cadence, Synopsys and Mentor Graphics: https://engineering.virginia.edu/high-performance-low-power

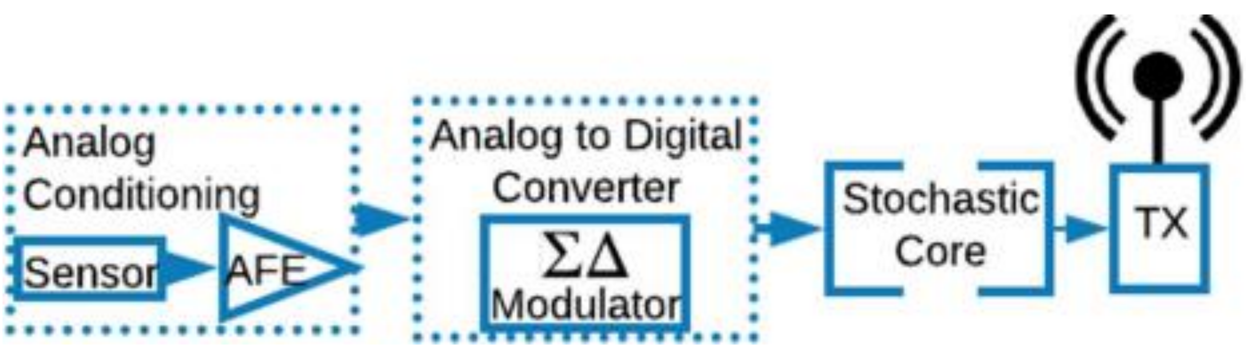
Additionally, the UVA ECE Department has facilities that include 3500 square feet of clean room space equipped with all of the processing equipment necessary to fabricate state-of the-art semiconductor devices, from epitaxial growth through die separation. Additional facilities are available for the electrical, optical and RF characterization of solid-state materials, devices and circuits. Significant laboratory space is also available for use in microwave and electro-optic device characterization.

Responsibilities: the VMEC scholar will be challenged intellectually by working side-by-side with PhD graduate students in the HPLP lab. During the internship the VMEC scholar will work on projects in theareas of AI/ML hardware, low-power VLSI design, IoT at the edge hardware and printable electronics.

Requirements: Currently attending one of the following Institutions: George Mason University, William & Mary, Virginia Commonwealth University, Old Dominion University, Virginia Tech, Norfolk State University, Virginia State University, Virginia Military Institute.

https://engineering.virginia.edu/high-performance-low-power/hplp-research-areas

VMEC mentor: Mircea R. Stan, ECE dept., Rice Hall 512, Charlottesville, VA 22904, mircea@virginia.edu
https://engineering.virginia.edu/faculty/mircea-r-stan



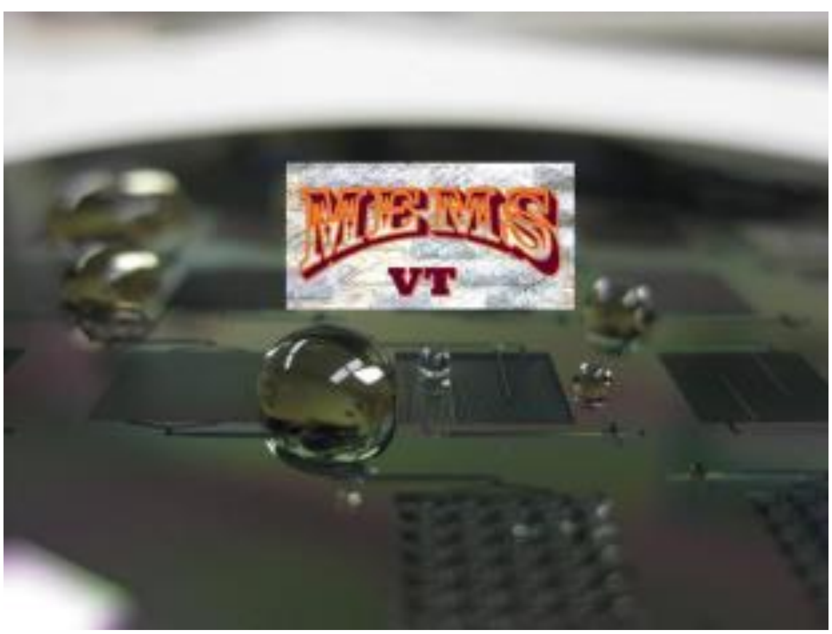
Virginia Tech

VT MEMS Lab has been pursuing research in MEMS, nanotechnology, and Microfluidics (MnM) to develop highly innovative miniaturized analyzers for chemical and biomedical applications. Two major research thrusts in the lab are Micro Analytical Chemistry (MAC) and BioMEMS/NEMS (Bio).

In the MAC thrust, graduate and undergraduate students work to design and fabricate micro instruments that can be used for real-time analysis of gaseous samples. Examples of applications include environmental monitoring, assessment of personal exposure to hazardous chemicals, breath analysis for possible disease diagnosis.

In the Bio thrust, graduate and undergraduate students work to design and fabricate microfluidic chips by which they can assess the physical properties of living cells. These properties which include electrical and mechanical properties at single cell level can potentially be used to distinguish cancerous cells and to assess the efficacy of therapeutics.

Undergraduate students involved in various aspects of VT MEMS lab will be trained on layout design, chip manufacturing, and testing the performance of the chips and the instruments using the chips. Interested students can contact Professor Masoud Agah, agah@vt.edu and can take a closer look at the projects by visiting www.agah-lab.org.



Virginia State University

1. Smart Multifunctional Textiles for Wearable and Flexible Sensing Systems

This smart systems will enable sensing, data processing, and machine learning through multifunctional textile composite electrodes which are coated/3D printed or grown on conductive textile fibers. Kinetic/thermal energy is converted into high sensitive electrical signals to monitor the performance of the smart textile structures. Such sensing systems can be used for damage detection, real-time monitoring, and energy harvesting. For example, the energy from human body motion will be collected and stored *in situ* in the textile to self-power the smart textile sensing systems while monitoring the performance in real-time. Stretch fabric, PVDF, Twisted microfiber-TiO2 nanowire hybrid yarn, MoS2, or Smart materials such as carbon nanofiber and/or graphene will be incorporated into the textiles to enable multifunctionalities, improve the conductivity of textile collectors, enhance the energy density, mechanically strengthen yarn-like electrodes. Students will help to design, fabricate and test the sensing system using micro/nano technology in summer. First to design recyclable smart fabrics and interactive textiles in which fibers and yarns will be integrated with spacer piezoelectric such as PVDF yarns by 3D printing, knitting, and weaving to achieve stretchability, flexibility, and durability of the textile structures. Then need to test the textiles' mechanical properties to satisfy the robustness of such textiles. Finally, to assemble multifunctional textiles into sensing systems to perform sensing and energy harvesting from the textile deflection, temperature fluctuation, and environmental change.

Mentor: Peng Cheng, Associate professor, Department of Applied Engineering Technology, Virginia State University. pcheng@vsu.edu.

2. Development of chemical sensing for Monitoring Environmental Pollutants, Water and Food Safety

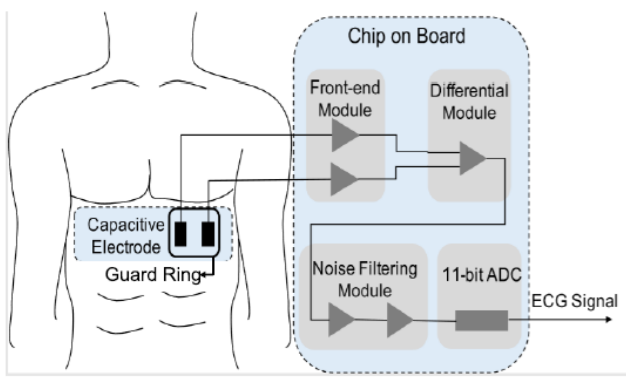
Environmental pollution is extremely important for human health. Small molecular particles, toxic chemicals, pesticides, or biodegradable substances are often suspended in soil and water and could be harmful to human and aquatic life. Detection of some of these potentially cancer-causing agent is a major challenge. These pollutants can be monitored and detected by using proper sensors or devices. In this project, a design, fabrication and testing method of a microfluidic sensor is proposed to detect pollutants (such as TNT) intensity in water. A microfluidic sensor with a microchannel, some transducers, and a pair of reservoirs is designed and fabricated. A combination of metal-oxide-poly-siloxanes thin film is spin-coated on a substrate. Once explosive materials exist in microfluidic channel, the transducers of the microfluidic sensor detect the resistance changes which are caused by the reaction of the TNT with the thin film nanocomposite. The resistance changes of the transducer then can be recorded and analyzed. This sensing system has the potential of detecting explosive materials and other types of environment contaminants in wet or dry condition. It also has potential applications in food industry, biomedical, chemistry, transportation, aerospace and military fields.

Students will help to fabricate and test this novel sensor to monitor and detects the environmental contaminants.

Mentor: Peng Cheng, Associate professor, Department of Applied Engineering Technology, Virginia State University. pcheng@vsu.edu.

3. Flexible Capacitive ECG Electrodes for Heart Rate Monitoring

Noninvasive sensors capable of measuring weak biopotential signals, such as electrocardiogram (ECG) and EEG, and communicating results wirelessly to a host computer are developing rapidly. Some of them utilize capacitively coupled electrodes in an attempt to place the sensor at a distance from the skin. Our research project demonstrates the fabrication and development of a capacitively coupled ECG electrode prototype using custom high specific capacitance electrodes and custom high-performance electronics. Two ultrathin capacitive electrodes are fabricated on a flexible polyimide substrate (2 × 2 in) protected by a guard ring to reduce noise. The detection and amplification circuitry consisted of operational amplifiers (OpAmps) that filter and condition the ECG signal. R-peaks in the ECG are readily detected and quantified using both simulated signals from ECG databases and real signals from human subjects. Heart rates and heart rate variability calculated from our monitor measurements are comparable with commercial rigid wearable sensors, including a smartwatch and an ECG monitor that uses standard clinical ionic electrodes. The prototype monitor is tested on human subjects during rest and moderate exercise and shows appropriate responses. The challenge of high-gain low-noise amplification is met by the development of highly thinned OpAmps whose operation is shown to be equivalent to commercially available rigidly packaged OpAmps, demonstrating that high-performance Si-electronics can be used to produce high-fidelity signals from weak biopotentials.



Block Diagram of the ECG Monitor

The student in the summer could perform further investigation about the project:

1. Improve the sensor circuit design to reduce the influence from noise, generated from movement of sensor from the skin.
2. Test of the sensor towards different types of ECG signals to obtain its accuracy result.
3. Establish the connection between the ECG sensors with smartphone to provide pervasive monitoring towards users.

Mentor: Dr. Xiaoliang Wang
Department of Applied Engineering Technology
Virginia State University.
Email: xwang@vsu.edu
Phone: 8045241211

4. Neural Network Based Machine Learning Architecture Implementation over FPGA

We study an OpenCL-based FPGA Accelerator for Large-Scale Convolutional Neural Networks (CNNs). There is a growing trend among the FPGA community to utilize High Level Synthesis (HLS) tools to design and implement customized circuits on FPGAs. Compared with RTL-based design methodology, the HLS tools provide faster hardware development cycle by automatically synthesizing an algorithm in high-level languages (e.g., C/C++) to RTL/hardware. OpenCL is an open, emerging cross-platform parallel programming language that can be used in both GPU and FPGA developments. The main goal of this project is to provide a generic, yet efficient OpenCL-based design of CNN accelerator on FPGAs. It utilizes pipelined CNN functional kernels to achieved improved throughput in inference computation. Our design is scalable both in performance and hardware resource, and thus can be deployed on a variety of FPGA platforms. It supports both Intel OpenCL SDK and Xilinx based FPGA design flow.

Xilinx FPGA Evaluation System

The student in the summer could perform further investigation about the project:

1. Implement various types of Neural Network architectures over FPGA, based on HLS techniques.
2. Using RTL based design techniques to optimize matrix calculation in neural networks.
3. Integrate the FPGA board with other types of sensors, such as Radar, Lidar, etc. to realize the sensor fusion technique for potential applications, such as Autonomous Driving, Smart Surveillance, etc.
4. Test of the FPGA based system in Advanced Electronics Lab to verify its robustness in different environment situations.

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WILLIAM & MARY

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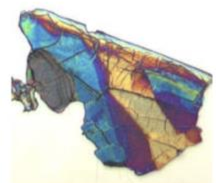
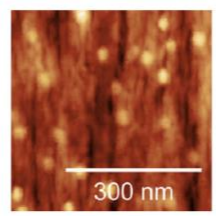
nano & biomaterials lab

The nano & biomaterials lab strives to make and explore synthetic and natural materials featuring enhanced thermal, mechanical, or adhesive properties and novel functionalities through structures at different length scales, especially at the nanoscale. The lab has developed several unique techniques for characterization of thermal, mechanical and adhesive properties directly at the nanoscale, especially using scanning probe techniques. The group has two labs providing 1,600 sq ft. of space to prepare and characterize materials, plus access to the William & Mary core characterization facilities. Materials preparation techniques include a mix of non-traditional and traditional methods, such as graphene exfoliation, particle dispersion, soft lithography, contact transfer, bio-templation, spin-casting, high-shear mixing, 3D-printing and solution/melt casting.



• PROJECT 1: High-Thermal Conductivity Materials
Low-dimensional nanoparticles, such as graphene and boron nitride nanotubes will be embedded in polymer matrices to create materials with high thermal conductivity, for applications in electronics and other areas. Thermal conductivity will be measured at the nanoscale and at the macroscale. This allows the systematic and hypothesis-driven optimization of materials performance.

• PROJECT 2: Diatom-Based Materials with Switchable Mechanical & Optical Properties and a Negative Carbon Footprint
Diatoms, micro-algae featuring glass skeletons with unique nanostructures, have interesting mechanical and optical properties. We grow diatoms and use their glass skeletons to make a novel type of lightweight composites with high strength and a negative CO_2 footprint. In this project we will work toward making such materials with switchable properties.



• PROJECT 3: Spider Silk-Based Super Adhesives
Spiders not only make super strong silks to build their webs, but they also use unique strategies to adhere these webs to other structures. In this project we explore the design of novel, nanostructured adhesive films inspired by spider silk. Synthesis of these adhesives is part of the project, as is characterization of the adhesive strength using tensile testing.

STEM students with an interest in experimental materials science are welcome to join the lab, located in the middle of the beautiful historic William & Mary campus, to work alongside of the other ≈6 PhD students and several undergraduates in the group. In addition to all other needed characterization and processing techniques for each project, students will get training in atomic force microscopy (AFM), a highly powerful and versatile characterization and manipulation technique.

Contact:
Prof. Hannes Schniepp, Department of Applied Science, schniepp@wm.edu, http://nanomat.as.wm.edu