



## **VMEC Scholar Program**

### **Summer Scholar Job Descriptions**

This document contains brief job descriptions for VMEC Scholars that would be placed at our university or industry members.



WILLIAM & MARY

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## nano & biomaterials lab

### Bio-Templated Multi-Scale Manufacturing: from Nano to Meter

Nature produces materials with highly complex and rich structures and geometries. The structural sophistication of common biogenic materials, such as bone, exhibits hierarchical features spanning many length scales, from a few nanometers to meters, bearing similarities to the multi-scale architectures found in microelectronic components and devices.

This project will explore how biologically made structures can be exploited to manufacture nanostructures from synthetic materials via bio-templation. Therefore, processes will be developed that start with naturally grown structures and translate them into structures in silicon wafers. The structures we work with are frustules, the glassy skeletons of diatoms, algae-like micro-organisms (Figure 1). Since they are, essentially, made of glass, processing techniques compatible with semiconductor engineering can be employed.

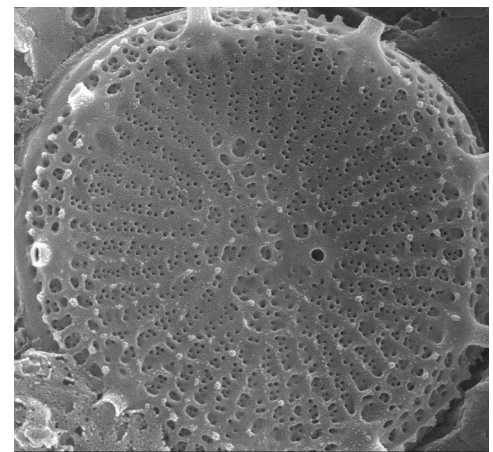


Figure 1: Electron micrograph featuring a 3  $\mu\text{m}$ -diameter diatom frustule. The smallest features are pores with a diameter of  $\approx 5$  nm.

The smallest feature sizes of frustules are  $\approx 5$  nm, comparable to the smallest feature sizes in cutting-edge microelectronics. To achieve larger structures, and ultimately span all length scales between nanometers and meters, we will explore techniques such as self-assembly and 3D-printing.

***The vision of this project is that future structures from nano to macro could emerge from biological processes. They would simply be grown in parallel and on a large scale, in an environmentally benign way.***

Participation in this project will provide exposure to many cutting-edge processing and characterization techniques, including optical microscopy, electron microscopy, self-assembly, and 3D-printing. 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 several PhD and undergraduate students in the group.

#### Contact:

Prof. Hannes Schniepp, Department of Applied Science, [schniepp@wm.edu](mailto:schniepp@wm.edu), <http://nanomat.as.wm.edu>



## Virginia Commonwealth University

Wright-Virginia Microelectronics Center at Virginia Commonwealth University (Richmond, VA) has a whole micro/nanofabrication “suit” that includes photo- and e-beam lithography with a resolution as fine as 600 and 10 nm, respectively, metal and dielectric deposition reactive-ion etching, etc. The available equipment makes it possible to create and test various micro/optoelectronic, photonic, and biomedical devices

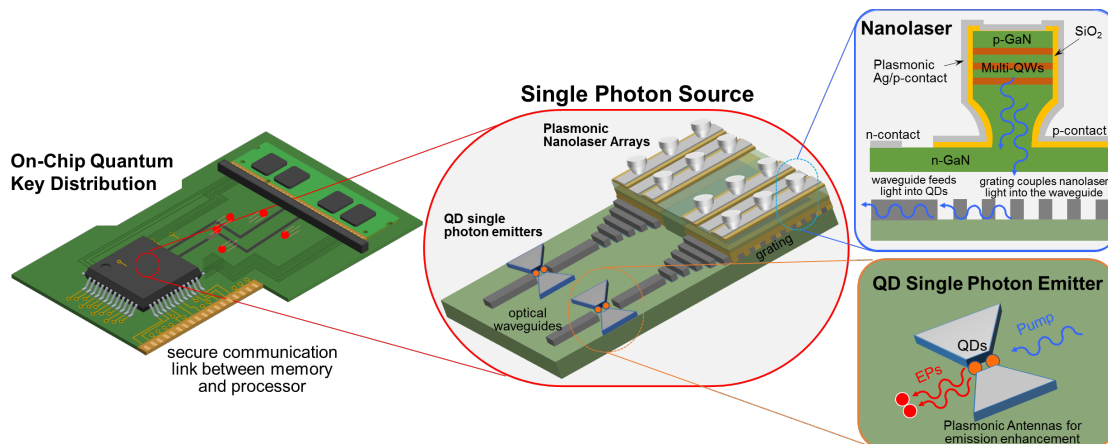


***The VCU VMEC Internship offers the unique opportunity to work independently in this high-tech facility and really “do it yourself”.*** You will have the opportunity to work hands-on, from initial concept to final testing and obtain a complete micro/nanofabrication experience, including:

- (1) CAD layout and design of a microelectronic, photonic, or biomedical device;
- (2) Photomask fabrication using our own custom mask making facilities or using Maskless photolithography;
- (3) Device fabrication in the W-VMC clean room;
- (4) Device testing in our characterization labs.

Our current interests encompass but not limited innovative nanophotonic devices, infrared imaging, single-photon sources for quantum communication.

The 2024 VMEC Summer projects is expected to be a part of the research program: **Secure Quantum Communication Optical Interface (SQCOI) with Controllable Aperture Plasmonic Nanolasers**



This project aims to develop an essential requirement for on-chip QKD systems: monolithically integrated single-photon sources based on quantum dot emitters resonantly excited by nanoscale plasmonic lasers (Figure). The generation of non-classical light has so far been generally accomplished via bulk approaches, e.g. the generation of weak coherent states. On-chip sources are highly desirable to enable miniaturized quantum cryptography for secure intra-chip communications, and will be the building blocks of on-chip photonic quantum technologies. The major thrust will be on the development of compact on-chip single photon sources based on QD emitters optically excited by nanolasers.

**Contacts:** Prof. Vitaliy Avrutin, Dept. of Electrical & Computer Engineering, [vavrutin@vcu.edu](mailto:vavrutin@vcu.edu); Prof. Nibir Dhar, Dept. of Electrical & Computer Engineering, [dharnk@vcu.edu](mailto:dharnk@vcu.edu)



## **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, Virginia State University, or Virginia Military Institute, Norfolk State University, 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 that accelerate the transformation of information into intelligence, inspiring the world to learn, communicate and advance faster than ever. 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 37,000 team members, in 18 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 and is one of the largest exporters in Virginia. The site is currently undergoing an expansion with a \$3B investment and 1,100 new jobs. As a leading high-tech manufacturing company in Northern 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 and support initiatives that positively impact the Manassas and Prince William region and the Commonwealth 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 aggressive 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 and new product implementation.

## Benefits:

Intern team members are eligible for Medical, Clinic, Business Travel Accident Insurance, Holiday, and Retirement at Micron (RAM) 401(k) Plan is a way for you to save for your retirement. You are immediately eligible to participate in this 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, University of Virginia, Old Dominion University, Norfolk State University, George Mason University, William and Mary, Virginia Commonwealth University, Virginia State University, or Virginia Military Institute, pursuing a B.S. in any of the following disciplines:

Electrical Engineering, Mechanical Engineering, Chemical Engineering, Microelectronic Engineering, Materials Science, Data Analytics, Computer Engineering, or Computer Science.



## 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](mailto:qli6@gmu.edu)







## Norfolk State University

### VMEC Projects

#### 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.

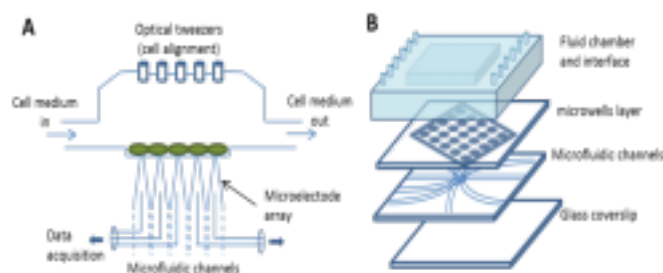
The student will fabricate SiNW using Ag assisted catalytic etching method that is simple and does not require expensive equipment to fabricate large area samples. A high degree of control on the diameter, length, and density of SiNW can be achieved using the  $\text{AgNO}_3/\text{HF}$  solution that 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.



### 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. Kevin Santiago, Professor, Department of Engineering, Norfolk State University. Email: [kcsantiago@nsu.edu](mailto:kcsantiago@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  $\sigma$  and thermal conductivity  $\kappa$ , and make it possible to enhance the power factor product of  $S^2\sigma$ .

### **Project 2: Synthesis of novel $12\text{CaO} \cdot 7\text{Al}_2\text{O}_3$ Electride Material for Electron Emission**

In this project the  $12\text{CaO} \cdot 7\text{Al}_2\text{O}_3$  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  $12\text{CaO} \cdot 7\text{Al}_2\text{O}_3$  (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 this project we shall try to synthesize this electride from ALD Call amidinate precursor: Bis( N,N-di-i propylformamidinato) Calcium(II) -  $\text{Ca}(\text{pr-fmd})_2$  and react it with either oxygen or DI  $\text{H}_2\text{O}$ . This project requires successful synthesis of a multicomponent thin film nanolaminate composed of alternating layers of  $\text{Al}_2\text{O}_3$  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](mailto:hbaumgar@odu.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 the areas of AI/ML hardware, low-power VLSI design, IoT at the edge hardware and printable electronics.

Requirements: Currently attending one of the following Institutions: Virginia Polytechnic Institute, Old Dominion University, George Mason University, William and Mary, Virginia State University, Norfolk State University, Virginia Commonwealth University, Virginia Military Institute. Current Junior or Senior pursuing a BS in Electrical Engineering or Computer Engineering.

<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](mailto:mircea@virginia.edu)  
<https://engineering.virginia.edu/faculty/mircea-r-stan>





# Virginia Tech

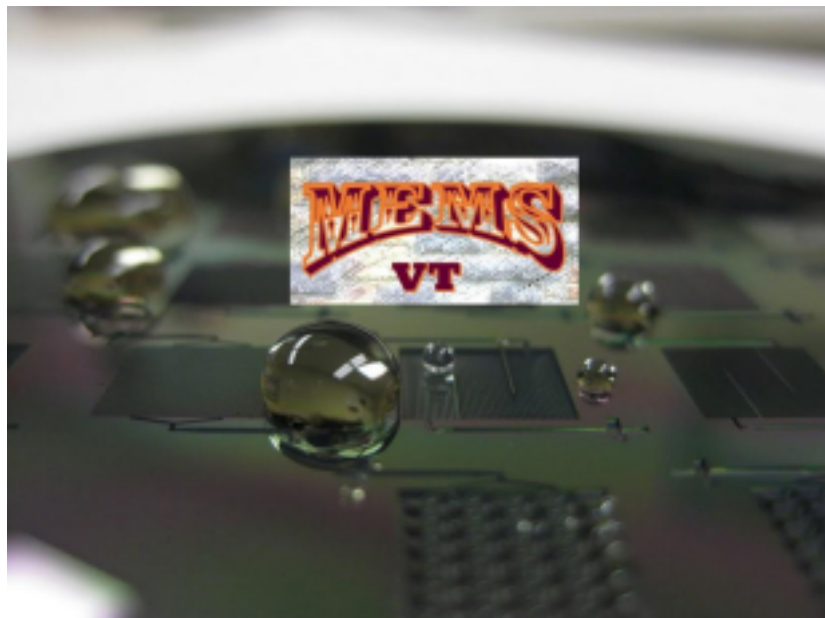
## VMEC Projects

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](mailto:agah@vt.edu) and can take a closer look at the projects by visiting [www.agah-lab.org](http://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 highly 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-TiO<sub>2</sub> nanowire hybrid yarn, MoS<sub>2</sub>, 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.



Figure 1 Functions of smart multifunctional textile

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

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

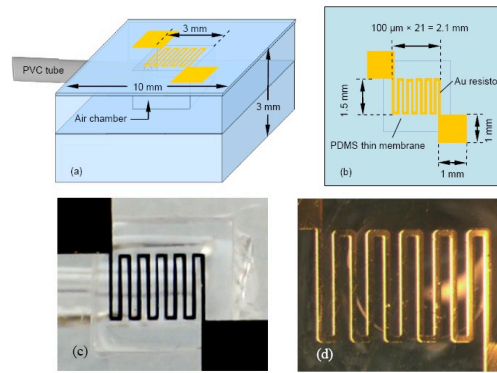
Environmental pollution is extremely important for human health. Small molecular particles, toxic chemicals, pesticides, or biodegradable substances are often suspended in soil and water and could be harmful to human and aquatic life. Detection of some of these potentially cancer-causing agent is a major 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. Miniature, light weight and wearable pressure sensor array**

In this project, we plan to design a prototype of a miniature, light weight and wearable pressure sensor array. This sensor array will be fabricated on flexible polymer (PDMS or polyurethane) base, which will provide the large deformation under pressure. The electric circuit will be fabricated on the flexible polymeric membrane using micro-manufacturing methods. This pressure sensing will have these key performance: 1) negligible hysteresis, 2) excellent linearity, 3) high creep and fatigue resistance and high repeatability, 4) wide pressure range, 5) large sensing area, 6) high operating frequency. This sensor array has wide application fields, such as medical instrument, artificial skin and robot.



Xinchuan Liu *et al* 2013 *J. Micromech. Microeng.* **23** 025022

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

1. Design the pattern of the sensor array.
2. Design the photomask of the sensor array
3. Fabricate the sensor array
4. Characterize the sensor array

Mentor: Xinchuan Liu, Assistant professor, Department of Applied Engineering Technology, Virginia State University. xliu@vsu.edu.