Research Topic #1: Testing of CNT Integrated ISFET Microchip as a pH Sensor
Faculty Mentor: Uche Wejinya (PI), Ph.D., Assistant Professor of Mechanical Engineering
Graduate Student Mentor: Nathan Williems
Problem Statement: The rapid progress in nanotechnology today has drawn more research attention in various fields, especially in biology, chemistry and medicine. Conventional pH sensors need a relatively large amount of target solution in order to realize effective pH measurement at least in milliliter scale. However, there are limitations when nano scale samples are involved in pH testing. Therefore, carbon nanotube (CNT) integrated Ion Sensitive Field Effect Transistor (ISFET) towards pH measurement for nanoliter/sub-microliter solution is proposed.
Objectives and Research Plan: The objective is to fabricate and test an Ion Sensitive Field Effect Transistor (ISFET). The research plan consists of three major tasks: MEMS techniques to fabricate ISFET, packaging and testing of ISFET as a pH sensor, and CNT alignment between electrodes using Dielectrophoresis (DEP).
Training Plan: Weeks 1-4: AutoCAD and microfabrication; Weeks 5-7: testing of ISFET; Weeks 8-9: CNT alignment using DEP and corresponding electrical characterization.
Research Facilities: Micro and Nano Systems Engineering Laboratory and High Density Electronics Center.

Research Topic #2: AFM Based Investigation of Imaging and Tailoring of Graphene
Faculty Mentor: Uche Wejinya, (PI), Ph.D., Assistant Professor of Mechanical Engineering
Graduate Student Mentors: Nathan Williems and Kayla Morrison
Problem Statement: The numerous electrical and mechanical properties for which graphene possesses has paved the way into a new era of research and exploration since Nobel Prize in Physics was awarded to the pioneering graphene researchers Andre Geim and Konstantin Noveselov in 2010. In the midst of heavy research in synthesis and transport techniques, there is an enormous demand for the research in tailoring techniques for the future mass industrial usage of graphene within electronic devices. Therefore, a technique based on Atomic Force Microscopy (AFM) to reveal lattice structure and tailor graphene into a desired shape will be the central focus.
Objectives and Research Plan: The objective is to image and tailor graphene using AFM. The research plan consists of three major tasks: graphene sample preparation, AFM based imaging on graphene lattice structure, and AFM based surface nanomachining to tailor graphene into desired shapes with various combinations of parameters, such as force, speed, and electrical bias.
Training Plan: Weeks 1-2: AFM training; Weeks 3-4: imaging of graphene and offline filtering process; Weeks 5-6: surface nanomachining on graphene with focus on force and speed; Weeks 7-8: surface nanomachining on graphene with electrical bias.
Research Facilities: Micro and Nano Systems Engineering Laboratory

Research Topic #3 : Nanolubricants at Cryogenic Temperatures
Faculty Mentor: Ajay P. Malshe, Ph.D., Distinguished Professor, and 21st Century Endowed Chair Professorship in Materials, Manufacturing and System Integration in MEEG.
Graduate Student Mentor: Parash Kalita
Problem Statement: Lubricants are vital to the energy efficient mechanical devices. Many of these devices are operating at low temperatures including sub-oceanic gas-oil exploration platform, wind turbines in terrains like Alaska, and cryogenic machining. Hence understanding wear and friction at sub-zero temperatures is vital for developing advanced lubrication using nanoscale manufacturing.
Objectives and Research Plan: The objective of this research is to design and selection of materials for sub-zero temperatures. This project will also study mechanics of interfaces under such harsh thermo-mechanical conditions.
Training Plan: Weeks 1-2: Literature review; Weeks 3-5: study mechanics of interfaces and material processing; Week 5-8: testing.
Research Facilities: Materials and Manufacturing Research Laboratories (MMRL)

Research Topic #4: Nano-channel Based Two-Phase Separation
Faculty Mentor: Adam Huang, Ph.D., Associate Professor
Graduate Student Mentors: John Bishop Lee and Abdoul Kader Maiga
Problem Statement: To date there have not been any nano-satellites, or smaller, with the mobility to change its orbit, perform coordinate formation flight, or proximity maneuvers. Although the reason for this is from multiple fronts (scientific, technological, safety, budgetary, and inter-agency politics), the key criteria tends to be safety and asset risk assessment related. Questions regarding mobility relates to the propulsive technology available, hence the propellant safety (explosion), toxicity (ground crew exposure), corrosive effects (damage to other satellites and launch vehicle in case of leak), orbital performance (orbital collisions), and clean-up (space debris) are the leading inhibitors. The goal of the mentor's current propulsion research is to demonstrate a non-toxic, non-flammable, and non-pressurized propellant micro-propulsion technology for nano-satellites using nano-channel based phase separation of liquid propellants.
Objectives and Research Plan: Training Plan: Weeks 1-2: Review of fluid mechanics, leading into nano-fluidics; Week 3-4: Introduction of relevant micro/nano-fabrication techniques (photolithography and nanolithography), Week 5-6: nano-channel fabrication, Week 7-8: test sample measurements. Training equipment includes basic micro/nano fabrication techniques and atomic force microscopy.
Research Facilities: Engineered Micro/Nano-Systems Laboratory (ENRC-3915) and UA High Density Electronics (HiDEC) Facility.

Research Topic #5: Developing Graphene-based new Supercapacitors
Faculty Mentor: Z. Ryan Tian, Ph.D., Associate Professor of Chemistry and Biochemistry
Graduate Student Mentor: Hulusi Turgut
Problem Statement: It's well known that the membrane is among the most expensive components in rechargeable lithium-ion batteries and sodium-sulfur batteries as well as supercapacitor. Carbon-based materials such as multilayered graphene possess unique band-gaps that can be reversibly tuned by the surface chemical adsorptions/desorptions. The membrane type all-carbon devices can drastically reduce the cost to the manufacturing and disposal or recycling of these products, and help boost the development of technologies/products/economy in a highly sustainable manner. This type of work has been seldom reported in literature.
Objectives and Research Plan: We will use the carbon materials to develop new membranes using little or no polymeric binders, for widely tuning the membrane's apparent conductance, capacitance, mechanical strength/flexibility, thermal behavior, permeability/diffusivity/sorption. Since the carbon materials will readily self-assembled into paper-like freestanding membrane, to possess a negligible resistivity. The reduced resistivity will reduce the energy loss into heat, making the suprcpacitor less likely to accumulate heat hence being safer._Then, we will assemble and test supercapacitors using the carbon-nanopowder and graphene sheets, we will use our nanostructured carbon-materials to make the supercapacitors at low-cost.
Training Plan: Weeks 1-2: On graphene synthesis and characterization; Weeks 3-4: on graphene membrane's fab and testing; Weeks 5-6: On supercapacitor assembly;Weeks 7-8: on supercapacitor's testing and optimization; Weeks 9-10: writing research report and presentation of results.
Research Facilities: Nanostructures and Manufacturing Lab and UA High Density Electronics (HiDEC).

Research Topic #6: Atomistic Simulations of Nanostructured Materials
Faculty Mentor: Douglas Spearot, Ph.D., Associate Professor of Mechanical Engineering
Graduate Student Mentors: Shawn Coleman and Khanh Dang
Problem Statement: Atomistic simulation plays a key role in materials research as a means to study the fundamental atomic scale processes that occur when a material is subjected to thermo-mechanical boundary conditions (applied stresses, high temperatures, etc.). Materials with nanostructure are often found to have unique properties relative to materials with the same composition but with coarse microstructural features; however, the specific role of material nanostructure on macroscale observable properties is not well understood in many cases.
Objectives and Research Plan: The objective of this research is to perform atomistic simulations to study linkages between material nanostructure and macroscale material properties. Materials of interest include

nanocrystalline metallic materials, polymer-based nanocomposites and finite size systems such as nanoparticles and nanowires.
Training Plan: Weeks 1-2: familiarize student with high-performance computing, Linux and LAMMPS; Weeks 3-4: building nanostructure simulation models; Weeks 5-8: perform research using nanostructured simulation models. Weeks 9-10: report writing and presentations.
Research Facilities: Arkansas High Performance Computing Center

Research Topic #7: Microfluidic Biosensors
Faculty Mentor: Steve Tung, Ph.D., Professor of Mechanical Engineering
Graduate Student Mentor: Bo Ma
Problem Statement: Miniature biosensors are becoming increasingly important as a biological and biomedical diagnostic tool for homeland security and public healthcare. Microfluidic systems, being small in size and fast in response time, provide an ideal platform for achieving miniature biosensors with high performance. Research in microfluidic biosensors primarily focus on the design, fabrication, and testing of novel sensor designs.
Objectives and Research Plan: The main objective is to design and fabricate a microfluidic biosensor for fast diagnostic of biomolecules such as DNA and virus particles. The research plan is composed of three main tasks: biosensor system design, microfabrication of biosensor, and biosensor testing.
Training Plan: Weeks 1-2: review of fabrication procedure; Weeks 3-4: design; Weeks 5-6: microfabrication; Weeks 7-9: testing and report writing. Week 10: Research Presentation.
Research Facilities: Micro and Nano Systems Laboratory and UA High Density Electronics (HiDEC).

Research Topic #8: Exploring the Heat Transfer Enhancement of Adhered MWCNT on Copper and Aluminum Tubing Surfaces Used in Heating and Cooling Equipment
Faculty Mentor: Darin Nutter, Ph.D., P.E., Professor of Mechanical Engineering
Graduate Student Mentor: Salem Algarni
Problem Statement: The heating, ventilating, and air-conditioning (HVAC) system plays a vital role in maintaining comfort, health, and security within residential or commercial buildings. Surprisingly, the basic HVAC system has not significantly changed over the last 20-30 years, including the use of the vapor compression refrigeration cycle and the use of common and more recently alternative refrigerants. The use of nanoparticles in heat transfer media is in its infancy and their potential impact toward efficiency gains in HVAC equipment. A recent study [21] showed the circulation characteristics and distribution of MWCNT within an operable packaged air-conditioner. From this, further research was identified and the REU student will participate in extending this work, with particular focus on the heat transfer characteristics of adhered multi-walled carbon nanotubes (MWCNT) on inner tube surfaces.
Objectives and Research Plan: The objective is to continue the applicability study of nanoparticles to increase heat transfer in the field of heating, ventilating, and air-conditioning (HVAC) systems.
Training Plan: Weeks 1-2: nanoparticle fundamentals; Weeks 3-6: experiments; Weeks 7-10: analysis, report writing, and research presentation.
Research Facilities: Laboratory for Energy Systems Studies (LESS)

Research Topic #9: Mechanical and Tribological Properties of Nano-engineered Surfaces
Faculty Mentor: Min Zou, Ph.D., Professor of Mechanical Engineering
Graduate Student Mentor: Robert Fleming
Problem Statement: Tribological issues affect the production yield and product reliability in micro-electro-mechanical/nano-electro-mechanical systems (MEMS/NEMS) due to the large surface-area-to-volume ratios. Our research effort focuses on surface nano-engineering to improve Tribological performances in miniaturized systems [22-27].
Objectives and Research Plan: The objective is to study the mechanical and tribological properties of the nano-engineered surfaces produced by various fabrication techniques [1-5]. The REU student will learn the sample fabrication process and study the mechanical and tribological properties of nano-engineered surfaces using nanomechanical and tribological characterization equipment.
Training Plan: Week 1: Sample fabrication process, Week 2: Tribometer; Week 3-4: TriboIndenter.
Research Facilities: Nanomechanics and Tribology Laboratory