

ECE 592-Special Topics
Emerging Frontiers in Nano/Micro-sensors
Course section: ECE 592-093

Instructor:

Amay J. Bandodkar (Email: ajbandod@ncsu.edu)

Course meetings:

Tues and Thurs 11:45 AM – 1:00 PM.

Course Website:

Moodle and Panopto

Mode of teaching:

In-person

Questions on Course Material:

I strongly encourage you to use the Moodle message boards to ask questions on the course material. I will respond most quickly to these questions and other students may find the discussion helpful. If you need to send me an email related to the class, please put “ECE 592” in the subject line.

Description: Sensors possess broad applications in healthcare, industry, agriculture, consumer electronics, automobiles, defense, and pollution monitoring. With the advent of emerging fields, such as, wearables, implants, Internet of Things, and deep space exploration there is ever-growing need for innovative sensing technologies explicitly designed for such applications. Developing novel types of highly sensitive and precise nano/micro-sensors is key to fully exploit the potential of these unique fields. In this interactive course we will learn how advances in electronics, materials science, and biology can be synergistically leveraged to develop high performance nano/micro-sensing systems. The course will focus on the building blocks for developing nano/micro-sensors and teach us various routes to synthesize and functionalize nano/micro-materials, fabrication techniques, and working principles specifically designed for advanced sensing

applications. We will also briefly cover topics focused on sensor data acquisition, processing, and display and the advances in electronics and optics that enable such capabilities. Through examples we will illustrate the practical nature and real-life use of the knowledge acquired in this course.

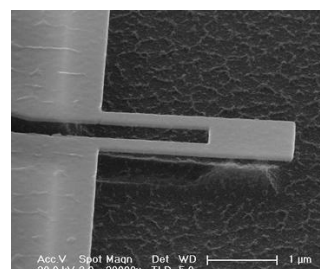
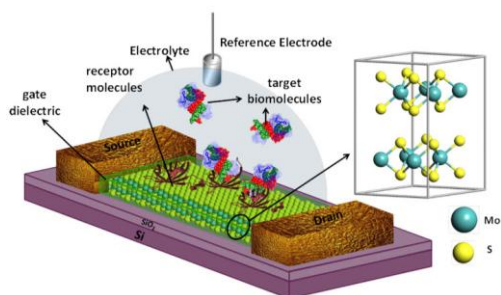
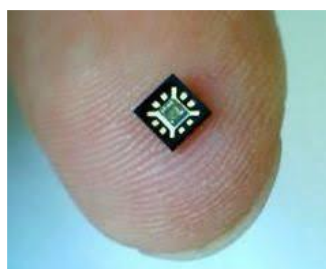
Outcome: The students will acquire knowledge about the key components (materials, sensing techniques, transducers, fabrication processes, assembly, data acquisition, and analytics) of nano/micro-sensors. This course will provide the students with opportunities to synergistically bring electronics, materials science, and biology together to develop advanced sensors. Upon completion of the course a student should be able to:

1. Build upon the knowledge acquired during the course to develop potential strategies for realizing nano/micro-sensors for specific applications.
2. Understand the attributes and limitations imposed by electronics, materials, and biology and learn how to navigate these while developing a practical approach to fabricate sensors.
3. Identify optimal sensing mechanism, transducer, sensing materials, and fabrication techniques suitable for developing sensors for a particular application.

Prerequisites: Graduate or Senior Undergraduate Standing. Familiarity with basic materials science, biology, and chemistry.

Textbook: No textbook required.

Topics: Nano/micro-materials for electrical, optical, and magnetic sensors. Materials functionalization strategies. Fabrication techniques (nano/micro-fabrication, 2D and 3D printing, hybrid processes). Sensing mechanisms (physical/chemical). Transducers (electrical, optical, piezoelectric, thermal). Data transmission, acquisition, and processing.



Grading:

Quizzes and reading assignment summaries	30%
Final project	35%
Final exam/project presentation	35%

Active participation in class 10% (Additional points)

This course uses Standard NCSU Letter Grading, as percentage of total points earned:

$97 \leq \mathbf{A+} \leq 100$

$93 \leq \mathbf{A} < 97$

$90 \leq \mathbf{A-} < 93$

$87 \leq \mathbf{B+} < 90$

$83 \leq \mathbf{B} < 87$

$80 \leq \mathbf{B-} < 83$

$77 \leq \mathbf{C+} < 80$

$73 \leq \mathbf{C} < 77$

$70 \leq \mathbf{C-} < 73$

$67 \leq \mathbf{D+} < 70$

$63 \leq \mathbf{D} < 67$

$60 \leq \mathbf{D-} < 63$

$0 \leq \mathbf{F} < 60$

Topics to be covered in the class:

The topics mentioned below may change depending on the students background

1. Introduction. Focus of the course will be on temperature, haptic, enzymatic, affinity and their various applications
2. Components of sensors

3. Role of Nano/micro materials in sensing
4. Synthesis of nano/micro materials for sensing
5. Clean room fabrication of sensors
6. Additive manufacturing of sensors
7. Nano/micro electronics and optics for temperature sensors
8. Nano/micro electronics and optics for haptic sensors
9. Nano/micro electronics and optics for enzymatic sensors
10. Nano/micro electronics and optics for affinity sensors
11. Unique piezo and magnetic properties of nanomaterials for sensors
12. Nano/Microfluidics for sensing applications
13. Wireless electronics for sensors
14. Soft nano/micro electronics and optics for wearable applications
15. Soft nano/micro electronics and optics for implantable applications
16. Sensors for cells, tissues, and organoids
17. Grand challenges and unexplored territories in sensors

Students will also receive hands-on lab experience on developing nano/micro sensors (exact details subject to change):

1. AutoCAD to design 3D structures.
2. Carbon nanotubes or silver microparticles-based strain sensors using printing.
3. Wearable soft microfluidics for sweat rate monitoring using 3D printing and soft lithography.
4. Carbon nanotubes-based 3D sensors for organoid monitoring using picosecond laser.

Reading/homework assignments:

Students will be responsible to critically analyze the reading/homework assignments (journal papers and references therein). Each student will be independently expected to write a short summary of the paper that describes the goals, achievements, key experiments of the paper and also include their conclusions on the attributes and limitations of the work with a short note of how they would overcome the limitations and build upon the knowledge acquired from the reading material to develop a better sensing system. The assignments will be announced in class and posted on the class website. Students are responsible for lecture materials and reading assignments for active class discussions, presentation, and the final project.

Final project:

A list of final project topics, project guidelines, minimum requirements, and format will be provided to the students. The students will be expected to form a team of 2-3 individuals and select the topic of their choice. The instructor must be informed immediately upon selecting the topic for approval. The teams can also select a topic outside of the list as long as it is first discussed with the instructor. Each team will be expected to submit a NIH-style 5-page project proposal.

Final exam/ project presentation:

Each team will be required to present their project proposal in the form of a 15 min oral presentation followed by a 5 min Q&A session.

Policies on incomplete grades:

If an extended deadline is not authorized by the instructor or department, an unfinished incomplete grade will automatically change to an F after either (a) the end of the next regular semester in which the student is enrolled (not including summer sessions), or (b) the end of 12 months if the student is not enrolled, whichever is shorter. Incompletes that change to F will count as an attempted course on transcripts. The burden of fulfilling an incomplete grade is the responsibility of the student. The university policy on incomplete grades is located at <http://policies.ncsu.edu/regulation/reg-02-50-3>.

Late assignments:

Unexcused late exam, homework, and article assignments will not be accepted. A grade of 0 points will be recorded.

Attendance policy:

Attendance will be taken. Lectures will start promptly. Your punctuality is expected and will be greatly appreciated. Getting involved in discussion and asking questions about the points that are not clear is important for learning the material. Participants are expected to be engaged in meetings, to learn from the execution of the coursework, and to share their own unique insights into the course material.

Absences policy:

Please see the university attendance regulation at <http://policies.ncsu.edu/regulation/reg-02-20-03> for further information and definition of excused absences.

Makeup work policy:

Each student is responsible for all assignments, announcements, and material covered in each class. If excused absences fall a day that an assignment is due, the assignment may be turned in prior to the due date in class, or via electronic mail or upload to the course website on the due date.

Additional excuses policy:

None.

Academic integrity:

Students are required to comply with the university policy on academic integrity found in the Code of Student Conduct found at <http://policies.ncsu.edu/policy/pol-11-35-01>

Academic honesty:

See <http://policies.ncsu.edu/policy/pol-11-35-01> for a detailed explanation of academic honesty.

Honor pledge:

Your signature on any test or assignment indicates, "I have neither given nor received unauthorized aid on this test or assignment."

Electronically-hosted course components:

Students may be required to disclose personally identifiable information to other students in the course, via electronic tools like email or web-postings, where relevant to the course. Examples include online discussions of class topics, and posting of student coursework. All students are expected to respect the privacy of each other by not sharing or using such information outside the course.

Accommodations for disabilities:

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with the Disability Resource Office at Holmes Hall, Suite 304, 2751 Cates Avenue, Campus Box 7509, 919-515-7653. For more information on NC State's policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities Regulation (REG02.20.01).

Non-discrimination policy:

NC State University provides equality of opportunity in education and employment for all students and employees. Accordingly, NC State affirms its commitment to maintain a work environment for all employees and an academic environment for all students that is free from all forms of discrimination. Discrimination based on race, color, religion, creed, sex, national origin, age, disability, veteran status, or sexual orientation is a violation of state and federal law and/or NC State University policy and will not be tolerated. Harassment of any person (either in the form of quid pro quo or creation of a hostile environment) based on race, color, religion, creed, sex, national origin, age, disability, veteran status, or sexual orientation also is a violation of state and federal law and/or NC State University policy and will not be tolerated. Retaliation against any person who complains about discrimination is also prohibited. NC State's policies and regulations covering discrimination, harassment, and retaliation may be accessed at <http://policies.ncsu.edu/policy/pol-04-25-05> or http://www.ncsu.edu/equal_op/. Any person who feels that he or she has been the subject of prohibited discrimination, harassment, or retaliation should contact the Office for Equal Opportunity (OEO) at 919-515-3148.