Materials Science and Engineering 404LD
Low-Dimensional Electronics Laboratory
Spring 2024

Instructor: Prof. Moonsub Shim (mshim@illinois.edu)
Office Hours: email for appointment

Teaching Assistant: Yue Tian (yuet3@illinois.edu)

Course Description/Objectives: Exploration of emerging materials of reduced dimensionality through hands-on experiments. Students will learn to handle/process atomically thin graphene, fabricate field-effect transistors from these materials, and carry out various means of characterization including electrical, Raman, and optical measurements. In addition, effects of external stimuli (e.g., mechanical and chemical) on electrical characteristics will also be examined.

Prerequisite: MSE 307 and MSE 308 or permission of instructor.

Class Schedule: Section LD1: Mon and Wed 2:00 - 4:50 pm
Section LD2: Tues and Thu 2:00 - 4:50 pm
204 Kiln House

Required Reading: Laboratory Manual, Equipment Operating Procedures, Lab Safety document and references therein – available on Canvas. Additional literature survey will also be required. You must read the lab manual and the lab safety document in its entirety prior to starting any experiments. You must read the operating procedures for any equipment you need to use prior to the first use. Because of the limited number of instruments, different people will be carrying out experiments in different order. However, the lab manual is written such that the background information given in each section may require reading and understanding of previous section.

Lectures: First class meeting and one or two additional periods will meet outside the lab for lectures. Please see Canvas for details.

Interim reports will be due one week after completion of each predefined experiment. See "Interim and final report guidelines" for details. Please submit via Canvas Assignment.

Preliminary outline for proposed experiment: The purpose of this assignment is to get you to survey the literature and start thinking about your proposed experiment early on. Your preliminary outline should include:

1. Tentative descriptive title. It is okay to change the topic later but do try to decide on one that you are interested in and will likely pursue.
2. One or two sentences describing why the topic/problem you want to explore is important.
3. One or two sentence description of what "data" you would look for in your proposed experiment – if you have more than one topic at this stage, provide one sentence for each.
4. List of papers you have looked up and read so far (minimum 4).
5. List of specific areas/topics that you will need further literature search on.

Mid-term progress discussion: Approximately at the midpoint of the course, you will sign-up to discuss your progress and potential proposed experiment with Prof. Shim. Prepare about 4 slides (including experiments you have done so far). More information to come.

Final report: The goal of the final report is not only to describe the knowledge you gained and experiments you have carried out but also to come up with your own conclusion(s) and outlook that are supported by experimental evidence. The main part of the report, including figures and tables, should be no more than 10 pages long with a font size of 12. References, which are required, are not included in the 10-page limit. In the main part of the report, you should only include data (analyzed and plotted in the form of figures) that will support a significant conclusion (for *option A*) or demonstrates feasibility/relevant knowledge to carry out proposed experiments to test your hypothesis (for *option B*). Further details are given in "Interim and final report guidelines."

Option A (if you were able to make significant progress in your proposed experiment): Write a paper as if you are writing a manuscript for publication in a scientific journal. We will use *ACS Nano* style for "Articles" (see "Manuscript Preparation/Organization of Paper" section of author guidelines: http://pubs.acs.org/paragonplus/submission/ancac3/ancac3_authguide.pdf). Ideally, your hypothesis (which may be turned into a conclusion) that helps to address or advance a specific aspect of a potential technological use of 2D materials or a new aspect to study should be the focus with the predefined experiments and your own experiments providing evidence/means to validate your idea. Relevant literature should also be included in discussing your hypothesis and results.

Option B (If you were not able to carry out your own proposed experiment): Write a proposal as if you were applying for a grant from a federal funding agency. The proposal should start with a title and your name and affiliation, followed by a summary paragraph that succinctly describes the intellectual merit, including your hypothesis statement, and the broader impact of your proposal. The main section should include background and motivation, preliminary results and experimental plans.

Canvas (https://canvas.illinois.edu/courses/34472): Lab manual, equipment operating procedures, safety document, lecture slides, announcements, assignments, etc. will be posted here.

Grading:

1. Final report including self-proposed experiment (40%)
2. Mid-term progress discussion (not graded but required to receive a passing grade)
3. Preliminary outline for self-proposed experiment (10%)
4. Interim reports (30%)
5. Lab notebook (10%)
6. In-lab attendance/performance (10%)

Experiments (approximate time):

1. Mechanical exfoliation and characterization of number of graphene layers (1.5 weeks)
2. Back-gated graphene field-effect transistors (FETs) (1.5 weeks)
3. Graphene transfer/processing and electrolyte gated FETs (3 weeks)
4. Self-proposed experiment (2 weeks)

Accommodations: To obtain disability-related academic adjustments and/or aids, students should contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, you may visit 1207 S. Oak St., Champaign, e-mail: disability@illinois.edu, or go to the DRES website. If you are concerned you have a disability related condition that is impacting

your academic progress, academic screening appointments are available on campus that can help diagnose a disability. For rare circumstances, such as extended illness and family emergencies that make it difficult for you to keep up with coursework, you should contact Professor Shim as soon as possible to discuss options. In these cases, I encourage you to reach out to the Dean of Students office, which can help you contact and manage accommodations with all of your courses.

Academic Integrity: Honesty and integrity are fundamental to our community. Guidelines for academic integrity are detailed in Article 1, Part 4 of the Illinois Student Code. Any confirmed violations of that code will be taken seriously and may result in failure for the course.