Course Syllabus
JSNN 604
Nanotechniques

COURSE NUMBER: NAN 604

COURSE TITLE: Nanotechniques

CREDITS: 3:3

PREREQUISITES/COREQUISITES: Permission of instructor

FOR WHOM PLANNED: This is an elective course for students enrolled in the Nanoscience Ph.D. or Professional Masters program, and may be taken as an optional course for graduate students from other programs.

INSTRUCTOR INFORMATION:

Instructor: Adam Hall
Office: 208J Joint School of Nanoscience and Nanoengineering
Phone: 336.285.2859
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Office Hours: By appointment

CATALOG DESCRIPTION: This course presents fundamental techniques used in nanotechnology, including methods for nanofabrication, nanocharacterization and nanomanipulation.

STUDENT LEARNING OUTCOMES: Upon successful completion of this course students will be able to

1. Describe the basic fabrication methods used in nanoscience (Test 1, Final exam, pop quizzes)
2. Describe the function of the most important characterization and microscopy techniques as well as interpret results obtained from them (Test 2, Final exam, pop quizzes)
3. Explain the physical principles underlying methods used in nanometer-scale manipulation and force measurement (Final exam, pop quizzes)

TEACHING METHODS AND ASSIGNMENTS FOR ACHIEVING LEARNING OUTCOMES:
The majority of the material in the course will be presented in traditional lecture style format. Copies of the presentations themselves will be available in video format on the class website. The primary source of information for these lectures will be journal articles and supplementary texts (see *e.g.* References section of the syllabus). The class will be divided into three main sections: nanofabrication, nanocharacterization and nanomanipulation/force spectroscopy. In the first section, students will be introduced to

methods commonly used in fabricating nanoscale devices, including thin-film deposition and patterning techniques. In the second section, students will be led through a registry of the most widely used characterization techniques for nanomaterials, and provided with a physical explanation of their workings. In the final section, major techniques used in the application and detection of force on nanoscale objects will be described. At the beginning of each discussion, an overview of the topic will be given, followed by an increasingly detailed description of the subject.

Student learning will be evaluated largely (50%) through **three** exams. These will involve descriptive short-form and long-form answers, diagrammatical explanations, etc. The first exam will only cover topics in section 1 (nanofabrication). The second will only cover topics in section 2 (nanocharacterization). The third (final) will be **cumulative**, but with some emphasis on topics in nanomanipulation. Additionally, written assignments will be given periodically, accounting for another 10% of the final grade. At the end of the semester, students will give a presentation worth an additional 15%.

Throughout the semester, **six** pop quizzes will be given to the students. Of these, the top five grades will be considered toward the total 15% weight given to them. The subject of these quizzes can be content taken directly from lecture, written homework or from pertinent readings from the scientific literature that will be periodically provided to the class.

The final 10% of the grade will be allocated based on the ability of a student to contribute to the class discussion in a meaningful way. In spite of being lecture-based, class discussion will be an integral part of the class.

EVALUATION AND GRADING:

Student learning will be evaluated with three exams (two end-of-unit exams and the final exam), along with writing assignments on primary literature and student contributions to the lecture discussion.

Content		**Grading Scale**:	
Test 1	**15%**	A	94-100
Test 2	**15%**	A-	90-93
Final	**20%**	B+	87-89
Presentation	**15%**	B	84-86
Written Assignments	**10%**	B-	80-83
Pop quizzes	**15%**	C+	75-79
Class participation	**10%**	C	70-74
		F	<70

REQUIRED TEXTS/READINGS/REFERENCES:

Textbook:

There will be no textbook required for this class. However, you may find the following text a useful supplement:

The Physics of Micro/Nano-Fabrication (Microdevices), Ivor Brodie and Julius J. Morey; Springer, paperback, 1st edition (2010), ISBN: 1441932216

Readings will be provided in the form of primary articles, including those listed below.

Primary Articles for Discussion (provided):

1. Krumeich, F., *Properties of Electrons, Their Interactions With Matter and Applications to Electron Microscopy*, ETH Zurich

2. Xia, Y.N. and G.M. Whitesides, *Soft lithography.* Annual Review of Materials Science, 1998. 28: p. 153-184

3. Alessandrini, A. and P. Facci, *AFM: a versatile tool in biophysics.* Measurement Science & Technology, 2005. 16(6): p. R65-R92

4. Butt, H.J., B. Cappella, and M. Kappl, *Force measurements with the atomic force microscope: Technique, interpretation and applications.* Surface Science Reports, 2005. 59(1-6): p. 1-152

5. Grier, D.G., *A revolution in optical manipulation.* Nature, 2003. 424(6950): p. 810-816

6. Neuman, K.C. and S.M. Block, *Optical trapping.* Review of Scientific Instruments, 2004. 75(9): p. 2787-2809

7. Vilfan, I. D., Lipfert, J., Koster, D. A., Lemay, S. G. and Dekker, N. H. , *Magnetic Tweezers for Single-Molecule Experiments*, Springer Handbook of Single-Molecule Biophysics, 2009

CLASS WEBSITE: The website for the class will provide the above articles as well as other reading materials, homework assignments, etc. The website can be found on the instructor's lab site at: **http://jsnn-halllab.uncg.edu/teaching**

TOPICAL OUTLINE/CALENDAR:

Week	Topic
1	welcome/beam source
1	electron beams
2	vacuum technology
2	thin films
3	“hard” lithography
4	“hard”/soft lithography
4	soft lithography
5	etching
5	fabrication strategy
6	emerging methods: DNA origami
6	exam 1
7	crystallography/diffraction
7	TEM
8	SEM
9	scanning probe techniques
10	scanning probe components/operation
10	LAB VISIT
11	emerging methods: superresolution microscopy
11	exam 2
12	STM atomic manipulation
12	scanning probe force mechanics
13	molecular techniques: attachment, etc
14	MEMS manipulation
15	optical tweezers- physics, setup and examples
15	magnetic tweezers- physics, setup and examples
16	emerging methods: micro and nanofluidics

ACADEMIC INTEGRITY POLICY: Each student is required to sign the Academic Integrity Policy on all assignments and tests in this course. A complete description of the Academic Integrity Policy can be found in the UNCG *Undergraduate Bulletin/Graduate Bulletin* or at h*ttp://academicintegrity.uncg.edu/*

ATTENDANCE POLICY: Class attendance is expected. If a student misses a class meeting for any reason, he/she is still responsible for all of the material covered, any announcements made, and any assignments given in his/her absence. Late assignments or other related materials will not be accepted in the absence of a valid excuse. Pop quizzes cannot be made up.

DISABILITY SERVICES: UNCG strives to comply fully with the Americans with Disabilities Act (ADA). If you have any kind of learning of physical disability, please contact the UNCG Office of Disability Services. You must register/petition them first. They will contact the instructor after approval.

FINAL EXAMINATION: A final exam will be given on the date assigned by the University.

ADDITIONAL REQUIREMENTS: None