never sent to Senate because of objections from State APSCUF

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	06-16g App. 11-28-06

Curriculum Proposal Cover Sheet - University-Wide Undergraduate Curriculum Committee

Contact Person	Email Address
Dr. Devki N. Talwar	talwar@iup.edu
Proposing Department/Unit Physics/NSM	Phone 7-2190

Check all appropriate lines and complete information as requested. Use a separate cover sheet for each course proposal and for each program proposal.

1. Course Proposals (check all that apply)

_____New Course _____Course Prefix Change _____Course Deletion

__X__Course Revision _____Course Number and/or Title Change _____Catalog Description Change

	NMTT 316 *Characterization, Packaging, and Testing of Nanofabrication Structures*
***Current** Course prefix, number and full title*	***Proposed** course prefix, number and full title, if changing*

2. Additional Course Designations: check if appropriate

_____ This course is also proposed as a Liberal Studies Course.

_____ This course is also proposed as an Honors College Course.

_____ Other: (e.g., Women's Studies, Pan-African)

3. Program Proposals

_____Catalog Description Change _____Program Revision

_____New Degree Program _____Program Title Change _____Other

_____New Minor Program _____New Track

***Current** program name*	***Proposed** program name, if changing*

4. Approvals

		Date
Department Curriculum Committee Chair(s)	Kenneth E Hershman	9/13/06
Department Chair(s)	Kenneth E Hershman	9/13/06
College Curriculum Committee Chair	[signature]	09/18/06
College Dean	Gerald M Buriok	10/5/06
Director of Liberal Studies *		
Director of Honors College *		
Provost *		
Additional signatures as appropriate:		
(include title)		
UWUCC Co-Chairs	Gail S Sechrist	11-28-06

* *where applicable*

Received OCT - 6 2006 Liberal Studies

Received NOV 28 2006 Liberal Studies

** where applicable*

6. NMTT 316 Characterization, Packaging, and Testing of Nanofabrication Structures

I. Catalog Description

NMTT 316 Characterization, Packaging, and Testing of Nanofabrication Structures 3c-2l-3cr
Corequisite: Admission to NMT track

Addresses the issues and examines a variety of techniques and measurements essential for testing and controlling the final device fabrication, performance and packaging.

II. Course Objectives

Student will be able to

A. Perform DNA analysis using PCR reaction
B. Perform a variety of techniques and measurements essential for testing, characterizing and controlling the final scaling of biological devices their performances and packaging.
C. Operate the Atomic Force Microscope (AFM), Scanning Electron Microscope (SEM), fluorescence microscopes, and Fourier Transform Infrared Spectroscopy (FTIR).
D. Perform techniques such as deposition/etchback and chemical/mechanical polishing for final assembly.
E. Demonstrate packaging procedures such as die separation, inspection bonding, wire bonding, filp chip bonding, sealing and final test for electronic, biological, and microfluidic devices.

III. Course Outline

Understanding various experimental techniques, performing measurements, testing, characterizing, controlling, scaling of biological devices & learning about their performances and packaging are the most challenging aspects of the Nanofabrication. This course addresses these important issues and provides hands-on treatment of all aspects of probe techniques, measurements, testing and packaging used in the Nanofabrication facility.

Lectures are generally presented for 3 hours for 4 days/week and lab sessions for 3 hours for 3 or 4 days/week in the fall and spring semester. During summers, lectures and labs are held for 5 days/week.

<u>Part A</u>: Lecture (30 hours)

The emphasis of this course is to (i) provide fundamentals of the physics principles and operational methods to operate various device characterization techniques and testing tools in the nanofabrication, (ii) identify equipment, processes and objectives employed for packaging assembly, (iii) describe the importance of nanofabricated biocompatible materials, and (iv) optical applications of nanofabricated materials.

<u>Part B</u>: Lab (18 hours)

The lab component of the course provides hands on experience in the manufacture of a micro-fluidic channel structure for biological applications; observing of fluid flow and mixing in a micro fluidic device. DNA analysis using PCR reaction; scaling of biological devices; self assembly – thiol gold interaction; alkysilanes on silicon dioxide, pen dip lithography, micro contact printing; metallization using sputtering systems; packaging and product testing.

IV. Evaluation method

The final grade will be determined as follows

Mid-term exam (500 points)
Quizzes (usually 3 quizzes each of 100 points = 300 points)
Lab + homework (400 points)
Independent reports and simulation (250 points)
Final presentation (300 points)
Final Exam (500 points optional)

V. Example Grading Scale

The final grade will be determined by the following percent scale.

90% - 100% - A
80% - 89% - B
70% - 79% - C
60% - 69% - D
below 60% - F

VI. Attendance Policy

Attendance is mandatory. Make up time is required for any absence that extends beyond two days. The student must give a written explanation for absences. An attendance sheet is attached to the classroom door, and the missed time must be documented before re admittance to the class. Failure to make up lab time results in an F grade.

VII. Required Textbook(s), Supplemental Books and Readings

1. *Semiconductor Manufacturing Technology* by Michael Quirk and Julian Serda (2001) [Prentice-Hall : ISBN 0-13-081520-9]
2. *Nanotechnology A gentle introduction to the next big Idea* by Mark Ratner, Daniel Ratner (2003) [Prentice Hall : ISBN 0-13-101400-5]
3. Nanofab Safety Manual
4. Class notes in printed form
5. Notes issued during class
6. Equipment training notes
7. Lab experiment notes

VIII. Special Resources Requirements

There is no special resource requirements for this course

IX. Bibliography

Books

1. *Nanotechnology: A Gentle Introduction to the Next Big Idea*, by Mark A Ratner *et al.* (Pearson, Education, Inc. 2003).

2. *The Next Big Thing Is Really Small: How Nanotechnology Will Change the Future of Your Business* by Jack Uldrich (Crown Business, 2003).
3. *Our Molecular Future: How Nanotechnology, Robotics, Genetics and Artificial Intelligence Will Transform Our World* by Douglas Mulhall (Prometheus 2002).
4. *Understanding Nanotechnology* by editors at The Scientific American (2002).
5. *Introduction to Nanotechnology*, by Charles P. Poole, Frank J. Owens (Wiley 2003).
6. *Nanotechnology: Basic Science and Emerging Technologies* Edited by Michael Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons (Chapman and Hall 2002)
7. *Engines of Creation : The Coming Era of Nanotechnology*, by Eric Drexler (Anchor 1990).

Popular Articles

It's a Small World After All by Lawrence D. Maloney, Design News Sep 26, 2005
Nanotech could put a new spin on sports by Kevin Maney, USA Today, Nov 17 2004.
Nanomechanical memory demoed by Eric Smalley TRN, Nov 15, 2004

COURSE ANALYSIS QUESTIONNAIRE

Section A: Details of the Course

A1 *How does this course fit into the programs of the department? For what students is the course designed? (majors, students in other majors, liberal studies). Explain why this content cannot be incorporated into an existing course.*

The course will extend knowledge learned in other departmental courses to areas that are currently the subjects of cutting-edge research and technology. The course is designed for the Applied Physics majors who have been admitted to NMT track. This content cannot be incorporated into an existing course because the department currently does not have necessary equipment and facility. Also, the content covers a broad range of topics in physics chemistry and interface areas such as biology, biochemistry, material science, and forensics. There are no physics courses in which all of these topics could be included.

A2 *Does this course require changes in the content of existing courses or requirements for a program? If catalog descriptions of other courses or department programs must be changed as a result of the adoption of this course, please submit as separate proposals all other changes in courses and/or program requirements.*

The course **does not** require changes in the content of existing courses or requirements.

A3 *Has this course ever been offered at IUP on a trial basis (e. g. as a special topic). If so, explain the details of the offering (semester/year and number of students).*

The course has **never been offered** on a trial basis.

A4 *Is this course to be a dual-level course? If so, please note that the graduate approval occurs after the undergraduate.*

No, it is not dual-level.

A5 *If this course may be taken for variable credit, what criteria will be used to relate the credits to the learning experience of each student? Who will make this determination and by what procedures?*

The course is not variable credit.

A6 *Do other higher education institutions currently offer this course? If so, please list examples (institution, course title).*

Yes, similar courses are being taught at several other PASSHE universities including Lock Haven, Shippensburg, California, Millersville, Clarion, etc.

A7 *Is the content, or are the skills, of the proposed course recommended or required by a professional society, accrediting authority, law or other external agency? If so please provide documentation.*

No

Section B: Interdisciplinary Implications

B1 *Will this course be taught by instructors from more than one department? If so, explain the teaching plan, its rationale, and how the team will adhere to the syllabus of record.*

This course will be taught only at the Penn State's NMT facility.

B2 *What is the relationship between the content of this course and the content of courses offered by other departments? Summarize your discussions (with other departments) concerning the proposed changes and indicate how any conflicts have been resolved. Please attach relevant memoranda from these departments that clarify their attitudes toward the proposed change(s).*

The content of this course is not related to courses given in other departments.

B3 *Will this course be cross-listed with other departments? If so, please summarize the department representatives' discussions concerning the course and indicate how consistency will be maintained across departments.*

The course will not be cross-listed with other departments.

Section C: Implementation

C1 *How will the proposed new track affect students already in the existing program?*

The essence of the Applied Physics/NMT track is to help students in their Junior/Senior year to gain valuable experience (18 cr. Capstone 16 weeks (Fall or Spring) or 12 weeks (Summer)) in nanofabrication manufacturing technology at the Penn State' Nanofabrication Facility while enrolled for the BS degree in Applied Physics at Indiana University of Pennsylvania. Students taking the capstone experience at Penn State will pay tuition for the 18 credits at IUP at the prevailing rate while Penn State will provide, through agreement with the State of Pennsylvania, the necessary boarding and lodging. The 18 credits earned by the students at Penn State will be transferred to IUP in compliance with the agreement between Penn State and PASSHE. Other students in the IUP physics program will not be affected at all.

C2 *Are faculty resources adequate? If you are not requesting or have not been authorized to hire additional faculty, demonstrate how these courses will fit into the schedule(s) of current faculty. What will be taught less frequently or in fewer sections to make this possible?*

Since capstone experience in nanofabrication manufacturing technology will take place at the Penn State' Nanofabrication Facility, no new faculty at IUP will be needed to offer this new track and no change in other courses or programs in the physics department is foreseen.

C3 *Are other resources adequate? (Space, equipment, supplies, travel funds)*

(a) No additional space is necessary to offer this new track
(b) No additional supplies are necessary for this new track
(c) No additional equipment is needed for this new track
(d) Available library materials are adequate for this new track.
(e) No travel funds are needed.

C4 *Do you expect an increase or decrease in the number of students as a result of these revisions? If so, how will the department adjust?*

Although the number of students in this track might not significantly increase the total number of students in the Applied Physics Program, it is expected that the NMT track may help attract highly motivated undergraduates into our program.

C5 *Intended implementation date (semester and year)*

The new track is expected to start as soon as it is approved. Intended implementation date is Fall 2006. Students in the Applied Physics Program with NMT track will be advised in a manner consistent with university procedures for phasing in of the 120 curricula.

Section D: Miscellaneous

D1 Include any additional information valuable to those reviewing this new course proposal.

N/A

Master Syllabus

Nanofabrication Manufacturing Technology (NMT) Capstone Experience

(16 Week Session)

The objective of the NMT program is to develop the knowledge base necessary for the manufacture of ***any micro- and nano-scale product***. The goal is to prepare an individual for a career in industries using nanotechnology, semiconductors based industries, and their supplier industries. You will derive this valuable knowledge base from a program composed of safety training, lectures, software based training, fab experiments, tool training, processing training, product cost evaluation, independent research, and process integration projects. To facilitate the process integration goal, you will be required to work on a micro- or nano-scale structure at the end of the semester as a group project.

The six courses of the NMT capstone experience (NMTT 311-316) are presented sequentially in three phases. The first phase covers 311 and 312, followed by 313/314, and then 315/316. Lab work and training will coincide with the lecture material. Lectures generally will be presented for 3 hours for 4 days/week and lab sessions for 3 hours for 3 or 4 days/week in the fall and spring 16 week semester. Because of equipment availability, labs will occasionally be required on Fridays. During summers, lectures and labs are held 5 days per week due to the shorter 12 week session.

Required Course Materials

Texts:

1 *Semiconductor Manufacturing Technology* by Michael Quirk and Julian Serda (2001) [Prentice-Hall : ISBN 0-13-081520-9]
1. *Nanotechnology A gentle introduction to the next big Idea* by Mark Ratner, Daniel Ratner (2003) [Prentice Hall : ISBN 0-13-101400-5]
3. Nanofab Safety Manual
4. Class notes in printed form
5. Notes issued during class
6. Equipment training notes
7. Lab experiment notes

Course Content:

The NMT Capstone Experience is the sum of four integrated types of exposures:

1. Safety training, equipment training and processing experience.
2. Independent study utilizing the text books, literature and general library references.
3. Group projects.
4. Lectures and presentations.

The tests and quizzes will draw from all three areas.

The *lab portion of the course* will consist of several distinct areas: Nanofab safety, protocol, and processing training, and Lubert training facility use. There will be multiple groups rotating through this process. Lab groups will be staggered to share the availability of processing tools and assure quality training. Lubert training will consist of a software based vacuum simulator, the MKS hardware vacuum trainer. All results from lab research will be formally submitted as a written report. Utilization of the facilities is dependant upon equipment breakdown, staff availability, industrial use, and probably the most unpredictable element - group progress. We will have to work together to maximize efficiency.

As an assigned research project, during the NMTT 313/314 block, groups will analyze special topics, and then teach their peers the detailed subject matter. Typical projects include, analyzing the purchase of a processing system, detailing bonding procedures for microfluidic channels, creating a mask design for an e-beam system, or creating and analyzing unique thin film profiles that are analyzed in the SEM. These reports are very detailed and historically the students have enjoyed building confidence in their craft of nanofabfication. The group research project will be presented to the class and submitted in written form.

Your presentations will be critiqued and partially graded by your classmates. A detailed written report will be graded by the instructor.

During the NMTT 315/316 block, the final project will pull together your lab experience and processing knowledge. The project will also sharpen your communication skills. Successful completion of the specific project assigned to a group will provide valuable experience for tackling *any micro- or nanofabrication project*. Your group's specific project could be a microfluidics structure, a sensor, a diode, or a transistor. As a group, you will develop and undertake the process flow design using your accumulated lab experience, filling any voids with research. The project will be graded in the presentation format and as a written report. Your presentations will be critiqued and partially graded by your classmates. A detailed written report will be graded by the instructor.

Grading Procedures

NO WORK WILL BE ACCEPTED LATE. The capstone experience is based on hands-on work; consequently any tardiness and absence will decrease your grade. More than 2 absences per semester will decline your overall average grade by 3%, with each additional day worth 5%. If a student is late more than 3 times per semester, the individuals semester grade will be decreased by 2% for each additional tardiness. The student must give a written explanation for absences and tardiness. An attendance sheet is attached to the classroom door, and the missed time must be documented before re admittance to the class. Failure to document missed time will result in termination from the program.

Since this course is based on attendance and participation, dismissal from the program will occur when students do not participate in a professional manner. Once a limit of 10% of the class time is missed the students are subject to dismissal from the program. Once a limit of 7 days tardy is reached, the student is subject to failure of the semester. Students that refuse to aid in group activities and the interview process will also be failed for the semester. Once a student fails any semester, they are removed from the program, and they are ineligible to take the capstone again.

Students are required to follow the PSU Code of Student Conduct in addition to their home school conduct rules. The PSU code of Conduct addresses behavior that can warrant suspension or termination from the program. The students are required to review and follow these rules. A non-inclusive brief overview of unacceptable behavior includes; violence, threats, unsafe behavior, drug or alcohol abuse, theft, plagiarism, or sexual harassment. These policies are located in detail on the web at http://www.sa.psu.edu/ja/PoliciesRules.pdf. Students are required to sign a statement that they have read and understand the PSU Code of Student Conduct and the grading policy in this syllabus, and they will abide by these provisions.

The following general format will be used to determine grades. One quiz can be made up within 2 days. The point value will be 60% of the actual score. Semester point values may change due to number of quizzes, and if quizzes are offered in the take home format. The grading scale will follow the Penn State A, A-, B+, format. The point value from the final project and the final exam will be added to all of the grades in all 6 courses. As outlined above, grades will be reduced for absence or tardiness to help employers appraise staff value. Students are required to report attendance matters via email or voice mail, just as you would on the job. Participation is also documented daily in the lab.

Approximate Point Values						
NMTT 311/312, 313/314, and 315/316	Midterm	Quizzes	Lab + Homework	Independent Reports + Simulations	Final Presentation	Final Exam (Optional)
Possible points	500	Usually 100 points each. 300 total	400	250	300	500

Penn State Letter Grade Chart									
Letter Grade	A	A-	B+	B	B-	C+	C	D	F
Percentage	94	90	87	84	80	76	70	60	0

The general Penn State calendar is available at www.psu.edu/ur/calender.html. The actual NMT class schedule for a given session (spring, summer, or fall) will be available during that session and, at any time, should accurately anticipate the week of events. However, it is subject to change at short notice, and should be checked regularly. Evening exam review sessions will be held a few days before the exam.

NMT WEEKLY LECTURE AGENDA NMTT 311/312		
Week	**Major Tasks**	**Events**
1	Safety, vacuum technology, dangers in the NMT manufacturing environment Methodology Top down processing verses bottom up processing.	Ch1 (intro) pages 1-20 no Questions Ch5 (chemical in mfg) pages 91-111 Q 8,10,14,15,19,20,24,28 NNBI read 1-36 no Questions
2	Nano materials properties. Vacuum pump types and technology. Mean free path for vacuum. Evaporator block diagram. MOS as a fabricated structure;	Ch2 (char of SC) pages 21-42 Q 3,4,5,6,11,14. Ch8 (Vacuum) pages 181-197 Q 3,4,6,7,15,19,20,23. quiz1
3	Role of temperature /chemistry/ bombardment in processing. Oxidation. Growing wet/dry oxide charts. Litho overview. Intro to plasmas, and processing tool sets - COO (cost of ownership).	Ch10 (oxidation) pages 225-255 Q 1,2,5,8,13,1423,47,50.
4	Block diagrams of ion implanter, RGA,. DI water. Microcontamination. Preventing and cleaning microcontamination. Importance of load locks for throughput and contamination. Resume' review. MKS vacuum trainer.	Ch17 (ion implant) pages 475-513 Ch6 (contam. control) pages 113-146 Q 3,5,9,10,31,33,44,54,57 quiz2
5	Block diagram of the RIE, magnetron sputtering system and PECVD. All system block diagrams with TCB. Isolating the chemical and physical "knobs" on systems to control the process. BPSG / CMP. COO.	quiz3
6		Exam 1 - Week 1-5

NMT WEEKLY LECTURE AGENDA NMTT 313/314		
Week	**Major Tasks**	**Events**
6	Continue block diagrams of RIE, MERIE, PECVD, LPCVD, SPUTTER, ION IMPLANT, EVAPORATOR. Link concepts concerning thin films to hardware on process tools. Critical thinking - analyzing processing tool parameters and their effect of thin films. Night review of Midterm 1 Issue first formal group project - . Due – week 11.	Exam 1 Week 1-5 Ch16(etch) pages 435-474 Q 2,5,8,9,11,31,32,41,63 Ion implant homework issued in class.
7	Advanced Plasma technology for processing, Dry etch/DC bias/ polymers for sidewalls. Common plasma chemistry for etch. Algorithms for dry etch analysis. PT 720 – P5000 block diagrams – contrasts. High density plasma systems. Carbon/fluorine ratio effects of sidewalls and sidewall polymer formation for SiO2 etch. Silicon nitride applications and traits. Wet etch chemistry.	Quiz 4 Ch11 (deposition) pages 257-296 Q 1,2,6,7,15,17,22,23,27,40
8	Group project interim peer review. PECVD overview. Start advanced litho. Importance of graph	Ch13 (chemistry for litho fundamentals) pages 335-366

	and data presentation. In depth look at contact printing with emphasis on chemistry. Novel lithography techniques including embossing litho, stamp litho, probe litho, and self assembly lithography.	Q2,3,4,5,13,14,19,30,31,32,40,43,44,48 Quiz 5 NNBI read 37-61
9	Advanced lithography systems and techniques. Start lab group rotation for statistics review.	Ch14 (photo systems) pages 367 - 412 Q2,7,12,19,24,25,27,31,34,35,36,37,38, 45, 57
10	Continue advanced litho with chemistry. Ebeam + steppers. Production yield and economics. Finish Statistics review for manufacturing. Group project presentation #1.	Quiz 6
11	Exam 2	Exam 2 - Week 6-10

NMT WEEKLY LECTURE AGENDA NMTT 315/316		
Week	**Major Tasks**	**Events**
11	First group presentation. Issue Final Project. Central Dogma of biology. DNA analysis using the PCR reaction. Scaling of biological devices, and the relationship to nanomanufacturing systems and materials. Nanoscale products for biological applications. Microfluidic channel as a fabricated structure.	Issued bio questions, plus lab questions NNBI read 63-81, 107-120
12	Exam 2 review Self assembly, thiol gold interaction, alkysilanes on silicon dioxide, pen dip lithography, micro-contact printing, molecular ruler nanolithography. Nanotubes. Metalization – traits of metal and alloys for nanofabrication, Critique systems for usefulness for metal deposition. Specialized sputtering systems. CMP + BPSG revisited, Dielectric K engineering.	Quiz 7 bio and dielectrics Ch12 (metalization) pages 299-333 Q1,2,5,6,7,8,9,12,16,18,19,20,21, 27,28,34 Ch18 (CMP) pages 515-543 Q.1,2,6,13,20
13	Final Project interim peer review. Optical applications of nanofabricated materials Thanksgiving break	Quiz 8 metal Ch20 (packaging) pages 571-592 Q 2,3,8,10-13,16,18,21,22,24-26 NNBI read 121-140
14	December 1, comp day for night exam review Metrology. Packaging and product testing. Testing materials and devices. Atomic force microscope. FTIR. C/V. *Interconnects and copper technology*	Quiz # 9 opto / packaging Ch19 (wafer test) pages 545-569 Q 1,5,8,11,25,39
15	Exam #3 Final presentation on project processing. Issue final grades.	Exam 3 Week 11-15
16	Optional Final Exam	Comprehensive

Office hours and contact info

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