APPLICATION FOR CHANGE IN EXISTING COURSE: MAJOR & MINOR

1. Submitted by College of Engineering __________________________________________ Date 13 Dec. 2001 ____________________________

Department/Division offering course Materials Engineering

2. Changes proposed:
   (a) Present prefix & number MSE 402G Proposed prefix & number 402G
   (b) Present Title ELECTRONIC MATERIALS AND PROCESSING
       New Title same
   (c) If course title is changed and exceeds 24 characters (including spaces), include a sensible title (not to exceed 24 characters) for use on transcripts:
   (d) Present credits: 3 Proposed credits: 4 (3 + 1)
   (e) Current lecture: laboratory ratio 3:0 Proposed: 3:3
   (f) Effective Date of Change: (Semester & Year) Spring 03

3. To be Cross-listed as: ____________________________________________________________________________
   Prefix and Number __________________________ Signature: Department Chair ____________________________________________________________________________

4. Proposed change in Bulletin description:
   (a) Present description (including prerequisite(s):
       Electrons in metals, alloys, semiconductors and insulators, semiconductor devices, methods to produce and process electronic materials solidification of electronic materials, defect control, diffusion of dopants, oxidation and methods of structural, electronic and chemical characterization. Prereq.MSE 102, MSE 301, Engineering standing or graduate level
       (b) New description:
       Electrons in metals, alloys, semiconductors and insulators, semiconductor devices, methods to produce and process electronic materials solidification of electronic materials, defect control, diffusion of dopants, oxidation and methods of structural, electronic and chemical characterization. Prereq.MSE 102, MSE 301, or related engineering/science senior/graduate level with instructor permission.
       Lecture 3 hours; Laboratory 3 hours per week.
   (c) Prerequisite(s) for course as changed: adding related engineering/science senior/graduate level with instructor permission

5. What has prompted this proposal?
   ABET Concern for lack of laboratory courses

6. If there are to be significant changes in the content or teaching objectives of this course, indicate changes:
   No significant changes to lecture. Lab will be self sufficient lecture and experiment section to emphasize practical experience with electronics processing

7. What other departments could be affected by the proposed change?
   EE students will gain an opportunity for lab course experience in Elect. Mat. Proc.

8. Will changing this course change the degree requirements in one or more programs?* □ Yes ☑ No
   If yes, please attach an explanation of the change.*

9. Is this course currently included in the University Studies Program?
   If yes, please attach correspondence indicating concurrence of the University Studies Committee.
   □ Yes ☑ No

10. If the course is a 100-200 level course, please submit evidence (e.g., correspondence) that the Community College System has been consulted.

*NOTE: Approval of this change will constitute approval of the program change unless other program modifications are proposed.

ORIGINAL
11. Is this a minor change? □ Yes □ No
   (NOTE: See the description on this form of what constitutes a minor change. Minor changes are sent directly from the Dean of
   the College to the Chair of the Senate Council. If the latter deems the change not to be minor, it will be sent to the appropriate
   Council for normal processing.)

12. Within the Department, who should be consulted for further information on the proposed course change?
   Name: Dr. Bruce Hinds  Phone Extension: 7-5507

Signatures of Approval:

Dr. [Signature]
Department Chair

[Signature]
Dean of the College

**Undergraduate Council

**Graduate Council

**Academic Council for the Medical Center

**Senate Council

**If applicable, as provided by the Rules of the University Senate.

ACTION OTHER THAN APPROVAL

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The Minor Change route for courses is provided as a mechanism to make changes in existing courses and is limited to one or more of
the following:

a. change in number within the same hundred series;
b. editorial change in description which does not imply change in content or emphasis;
c. editorial change in title which does not imply change in content or emphasis;
d. change in prerequisite which does not imply change in content or emphasis;
e. cross-listing of courses under conditions set forth in item 3.0;
f. correction of typographical errors. [University Senate Rules, Section III - 3.1]

Rev 11/98
MSE 402G - ELECTRONIC MATERIALS AND PROCESSING

Catalog Description Electrons in metals, alloys, semiconductors and insulators, semiconductor devices, methods to produce and process electronic materials; solidification of electronic materials, defect control, diffusion of dopants, oxidation and methods of structural, electronic and chemical characterization. Prerequ: Engineering standing, MSE 301, PHY 361 or graduate level.

Topics:

1. REVIEW OF THEORIES DESCRIBING THE BEHAVIOR OF ELECTRONS

Basic review of key Materials Principles - Drude/Matthiessen Model - wave and particle nature of electrons - wave equations Schrodinger equation - application of Schrodinger equation to free electrons, electron in a one-dimensional infinite potential energy well and finite potential barrier - electron tunneling.

2. ELECTRONS IN METALS AND ALLOYS

Extension of electron in a one-dimensional potential energy well to three dimensions - degeneracy - free electron theory of metals - Fermi energy - density of states function - Fermi function - photoemission and thermionic emission of electrons Free electron approach - effective mass of electrons valence electrons as charge carriers - drift velocity of electrons - drift mobility of electrons - relaxation time - effect of defects, impurities - Hall effect.

Test I

3. ELECTRONS IN SEMICONDUCTING AND INSULATING MATERIALS


4. ELECTRICAL CONDUCTIVITY IN SEMICONDUCTING AND INSULATING MATERIALS

Density of charge carriers in a semiconductor/insulator - conductivity equation - intrinsic semiconductors - extrinsic semiconductors - n-type and p-type semiconductors Fermi energy in intrinsic and extrinsic semiconductors compensation - work function - effect of temperature on charge carrier density effect of impurities on charge carrier mobility - dielectric materials - organic conductors.

Test II

5. BASIC SEMICONDUCTOR DEVICES

Metal-metal interface - metal-semiconductor interface ohmic contacts - rectifying contacts - p-n junction rectifier tunnel diode - p-n-p junction transistor - field effect transistor - Effects of defects.

6. ADVANCED ELECTRONIC DEVICES

Laser diodes, solar cells, quantum dots, thin-film transistors, organic conductors, displays
7. PROCESSING OF ELECTRONIC MATERIALS


Test III

8. INDEPENDENT STUDY PROJECT

There is a lack of a comprehensive textbook covering the rapidly changing techniques of manufacturing electronic materials. Thus this aspect of the course is ideal for independent research into a particular technique. Each student selects a design topic that relates to electronic materials, processing or packaging and prepares a 15 minute presentation and a 4-8 page paper to be distributed to the class. This material (after being checked for accuracy by the instructor) will be considered part of the course and included as possible exam material.

Possible topics:

- Crystal purification and growth
- Ion implant and diffusion
- Photolithography
- Evaporation and sputtering film deposition
- Chemical vapor deposition
- Gas phase reactive etching processes
- Conducting polymers
- Packaging and thermal stresses
- Interconnect technologies
- Hybrid microelectronics and multichip modules
- Surface mount technology

Grades based on:

- Test 1 (20%)
- Test 11 (25%)
- Test 111 (35%) (Final)

Independent study paper (15%) graded by class peer review process.

Homework (5%)

Grades will be distributed by relative curve (with consideration to performance of past years and level required). Graduate level students will be graded on different scale. For independent project, graduate presentations will be 25 min. and 8-10 page report.

Textbooks: REQUIRED "Principles of Electronic Materials and Devices", S. O. Kasap

The instructor considers this book to be excellent for instruction but is slightly elementary for Junior level work. Thus there will be significant supplements in lecture from the following books (students with strong interests in the field may consider purchasing as reference)

"Solid State Physics" N. W. Ashcroft and N. D. Mermin
"Modern Semiconductor Device Physics" S.M. Sze
"Complete guide to Semiconductor Devices" K. Ng
Homework problems will be assigned during the semester to illustrate the subject matter and indicate the types of questions that will be asked in the tests. The solutions will be reviewed in class.

Make-up tests are strongly discouraged and will only be given in the case of extreme illness. To receive a make-up test, the instructor must be notified in writing prior to the scheduled time of the test.

Goals: This course is designed to introduce materials engineering students at the junior level to solid state physics, electronic device principles and methods for producing, processing and designing electronic materials. Graduate level students from outside departments will gain important fundamental knowledge of electronic device operation and fabrication techniques that could be applied to active research areas.

Outcomes: The students will be able to apply electronic materials science to semiconductor fabrication and semiconductor properties. The students will also be able to identify, analyze and solve a variety of problems that relate to electronic materials properties, fabrication and processing. They will also be able to locate additional information in the literature that pertains to electronic materials and processing and apply the principles from this course to a variety of materials design problems. The extent to which the students achieve these outcomes is evaluated by three in-class tests and a design project that each student works on individually.

Course Relevance: Electronic materials are increasingly being viewed as a distinct class of materials in addition to the traditional materials classifications such as metals, ceramics and polymers. It is important that students obtain exposure to this unique materials type and experience the methods that are used in developing the traditional materials science theme of relating properties to structure. In particular manufacturing techniques and material choices for devices are critical areas for Materials students. Nearly all stumbling blocks in the electronics industry will require a materials/chemical approach to solve the engineering problems.
Electronics Materials Processing Laboratory

1. Description
This is a three (3) hour laboratory course associated with the course 402G - ELECTRONIC MATERIALS AND PROCESSING. The focus of the laboratory is the familiarization of the various fabrication techniques involved with processing electronics materials. Emphasis is placed on understanding the unique requirements and principles of electronics fabrication.

2. Learning Objective
The students will learn the following
- Cleanroom safety and environmental concerns
- Semiconductor cleaning processes and techniques
- Doping and oxidation process
- Photolithography, technique, control and analysis
- Thin film deposition and characterization
- Etching techniques, chemical systems processing variables
- Simple transistor characterization

3. Justification
The skills MSE students are in demand within the semiconductor industry. Formal experience with the fundamentals of the techniques can serve as a basis for finding employment furthering their careers in the field. With the fundamental knowledge of the overall process and the techniques involved, students will be able to apply their general Materials knowledge for successful projects/research. Students from other departments will learn general fabrication techniques that can be applied in innovative ways in either research or industrial positions. Their ability to find suitable employment options will also increase with this experience. The course will take advantage of existing research electronic processing equipment in ASTeCC. Graduate students interested in incorporating electronic materials processing techniques into their thesis research will be encouraged to take this course.

4. Tentative Course Outline
The lab course will be presented as the fabrication of a Si based MOSFET and with students performing every major step of the process. Careful analysis of every major step is included. When possible computer based modeling using MATLAB will be used as laboratory experiments. Major steps include:
- Wafer cleaning and preparation
- Oxidation
- Dopant implant and diffusion
- Photolithography
- Chemical Vapor Deposition
- Thermal and electron beam evaporation
- Ion etching
- Transport measurement and FET fundamentals