FORM B

UNIVERSITY OF MASSACHUSETTS AMHERST
OFFICE OF THE SECRETARY
THE FACULTY SENATE

UNDERGRADUATE COURSE APPROVAL FORM
(Courses Numbered 001-599)

15 Copies Required for Courses Numbered 001-499
20 Copies Required for Courses Numbered 500-599

1. **DEPARTMENT, COURSE NUMBER AND TITLE:** ChE/MIE 571 Physical and Chemical Processing of Materials______

2. **SCHOOL OR COLLEGE:** ________College of Engineering________

3. **Proposer's Name, Telephone and Email:** Prof. Dimitrios Maroudas, 5-3617, maroudas@ecs.umass.edu

4. **Proposed Instructors:** Dr. M. Rauf Gungor, Professor T. J. Mountziaris, and Professor Dimitrios Maroudas

5. **Course Credits:** ________3______________

6. **Are there Prerequisites?** Yes **If yes, please specify** MIE 201

7. **What is the intended clientele?** Lower Division______________________ Upper Division_________X_____________

   Department majors only_______________ **Departmental/related majors**____X______ **Non-Majors** __________________

   If course is intended for majors, what role will it play in the curriculum? Required__________ **Elective**_______X______

8. **Complete Course Catalog Description (30 Words):** Comprehensive introduction to the physical and chemical processes involved in the design and manufacturing of materials used in current materials engineering technologies, including device fabrication technologies.

9. **Please attach the following materials:**

   ________X______ Week-by-week outline of topics covered in course (or syllabus)
   ________X______ List of Required readings
   ________X______ Description of required assignments (papers, exams, projects, reports, presentations, etc.)
   ________X______ Summary of course grade criteria
   ________X______ Selected bibliography of works used by instructor in developing course, especially recent works (as appropriate)

10. **If course has been offered as an experimental or special topics course, please comment (on an attached page) on its evolution.**

Upon approval of the course by the department head, one copy of this form shall be sent from the departmental office to the Faculty Senate Office to allow for the course to be published on the University's Web Site for comment.

<u>For courses numbered 500-599, the "Guidelines for Course Approval Form" from the Graduate Council must accompany the new course proposal</u>.

DEPARTMENT OF CHEMICAL ENGINEERING
DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING
University of Massachusetts, Amherst

ChE/MIE 571 **Spring 2010**

INFORMATION SHEET

Physical and Chemical Processing of Materials

Lecture hours:	2 lectures / week
	75 minutes / lecture (Days and times to be announced)
Classroom:	To be announced

Instructor:	Dr. M. Rauf Gungor, Professor T. J. Mountziaris, and Professor Dimitrios Maroudas
Room:	262C Goessmann Laboratory
Phone:	545-0593
E-mail:	gungor@ecs.umass.edu
Office hours:	Flexible or by appointment

Teaching Assistant:	To be announced
Room:	To be announced
Phone:	To be announced
E-mail:	To be announced
Office hours:	To be announced

1. COURSE OUTLINE

Objective

The course aims at a comprehensive introduction to the physical and chemical processes involved in the design and manufacturing of materials used in current materials engineering technologies, including modern device fabrication technologies. The course will offer a broad review of kinetic processes in engineering materials that control the materials' structural and chemical characteristics in relation to material properties. Emphasis also is placed on specific materials processing methods that are utilized in the production of complex heterogeneous materials microstructures and nanostructures, which are typical of both traditional and modern materials engineering technologies. The course will provide senior undergraduate and first-year graduate students with the necessary background for understanding and addressing materials processing, design, and development problems that are important in materials engineering and for following the relevant science & engineering literature.

Course Syllabus

- **Introduction to physical and chemical processing of materials** (1 lecture)
- **Alloy theory: primary solid solutions** (2 lectures)
    - Intermediate phases, stability of alloys, and ordering
    - Free energy-composition diagrams
- **Interfaces: classification, geometry, and energy of interfaces** (1 lecture)
- **Review of kinetic processes in materials** (16 lectures)
    - Diffusion: phenomenology and atomistic mechanisms
    - Grain boundary segregation
    - Mobility of interfaces
    - Homogeneous and heterogeneous nucleation
    - Continuous and discontinuous grain growth
    - Phase transformations
    - Recovery and recrystallization
    - Precipitation and solid-state nucleation
    - Precipitation kinetics and coarsening
    - Precipitation transformations
    - Eutectic transformation and discontinuous precipitation
    - Martensitic transformations: crystallography, thermodynamics and types of martensites; bainite transformation
- **Crystal growth and wafer fabrication:** silicon purification, Czochralski growth, and other bulk melt growth methods (1 lecture)
- **Epitaxial growth of thin-film materials** (1 lecture)
- **Film deposition and etching methods** (2 lectures)
    - physical vapor deposition (PVD)
    - chemical vapor deposition (CVD); low-pressure CVD (LPCVD)
    - plasma-enhanced CVD (PECVD)
    - electrodeposition
- **Doping and ion implantation** (1 lecture)
- **Plasma etching** (1 lecture)
- **Photolithography** (1 lecture)
- **Chemical, mechanical polishing (CMP)** (1 lecture)

Course Goals

1. Comprehension of the physical and chemical processes involved in the design and manufacturing of materials used in current materials engineering technologies, including modern device fabrication technologies.
2. Advanced level understanding of the kinetic processes in engineering materials that control the materials' structural and chemical characteristics in relation to material properties.
3. Knowledge of the processing methods that are utilized in the production of complex heterogeneous materials microstructures and nanostructures, which are typical of both traditional and modern materials engineering technologies.
4. Acquiring the necessary background for understanding and addressing materials processing, design, and development problems that are important in materials engineering and for following the relevant science and engineering literature.

Course Outcomes

- Understanding the theory of alloys and primary solid solutions, including intermediate phases, alloy stability and ordering, and free energy-composition diagrams
- Understanding the classification, geometry, and energy of interfaces in engineering materials
- Comprehension of kinetic processes in materials that control the evolution of microstructure, structural and physical properties. These kinetic processes include diffusion, grain boundary segregation, interface mobility, homogeneous and heterogeneous nucleation, continuous and discontinuous grain growth, phase transformations, recovery and recrystallization, precipitation and coarsening, eutectic transformation and discontinuous precipitation, and martensitic transformations.
- Understanding of crystal growth of bulk materials and silicon wafer fabrication, including silicon purification, Czochralski growth, and other bulk melt growth methods
- Understanding of growth processes of thin-film materials, including epitaxial growth, physical vapor deposition (PVD), chemical vapor deposition (CVD), low-pressure CVD (LPCVD), plasma-enhanced CVD (PECVD), and electrodeposition
- Understanding of thin-film and wafer processing methods, including doping and ion implantation, plasma etching, photolithography, and chemical-mechanical polishing (CMP).

Outcome Measurement and Assessment

- 6-7 homework assignments on the topics covered in the classroom and reading assignments;
- 1 two-hour in-class (midterm) exam; and
- 1 three-hour comprehensive final exam.

Grading

Grades will be determined on the following basis
Homework Assignments (20%)
Midterm Exam (30%)
Final Exam (50%)

2. REFERENCES

Required Textbooks

1. D. A. Porter and K. E. Easterling, ***Phase Transformation in Metals and Alloys***, CRC Press (1992).
2. S. A. Campbell, ***The Science and Engineering of Microelectronic Fabrication***, Oxford University Press, Oxford (2001).

Additional References

1. R. Abbaschian, L. Abbaschian, and R. E. Reed-Hill, ***Physical Metallurgy Principles***, CL-Engineering (2008).
2. P. Haasen, ***Physical Metallurgy***, Cambridge University Press, Cambridge (1986).
3. J. D. Veerhoven, ***Fundamentals of Physical Metallurgy***, Wiley, New York (1975).
4. R. F. Yanda, M. Heynes, and A. K. Miller, ***Demistifying Chipmaking***, Elsevier, Oxford (2005).
5. L. H. Van Vlack, ***Elements of Materials Science and Engineering***, Addison-Wesley, New York (1989).
6. W. D. Callister, ***Materials Science and Engineering: An Introduction***, Wiley, New York (2007).
7. C. Harper, ***Electronic Materials and Processes Handbook***, McGraw-Hill, New York (2009).
8. A. P. Sutton and R. W. Baluffi, ***Interfaces in Crystalline Materials***, Oxford University Press, New York (1996).

Note: Additional references for further reading will be recommended throughout the semester for each topic that will be covered in the course. Several handouts and papers from the literature also will be distributed in class.

COURSE REQUIREMENTS

Background

<u>Materials Science:</u>	Prerequisite: Introduction to Materials Science and Engineering (MIE 2xx/201) or equivalent course or instructor's permission.
<u>Engineering</u>:	Fundamental knowledge of thermodynamics, transport phenomena (fluid mechanics and heat & mass transfer), and kinetics – as typically offered by a standard undergraduate chemical or mechanical engineering curriculum – will be particularly helpful. The necessary engineering science fundamentals will always be reviewed prior to the in-depth presentation of the relevant materials science topics and implementation of methods of analysis, thus making the course accessible also to senior undergraduate and graduate students with backgrounds outside of chemical or mechanical engineering.
<u>Mathematics</u>:	A standard background in advanced engineering mathematics – equivalent to that provided by a standard mathematics curriculum for a science or engineering program – is assumed.

Coursework

1. 6-7 homework assignments (20 %)
2. 1 two-hour in-class (midterm) exam (30 %); the exact date of the exam will be announced in class well ahead of time
3. 1 three-hour final exam (50 %)

Guidelines for Course Approval Forms (Forms B & C)
For Courses Numbered 500-999

The following is a detailed checklist of requirements that must be submitted in support of any course to be approved by the Graduate Council. This checklist is an addendum to Forms B (courses numbered 500-599) and C (courses numbered 600-999).

1. Is this course part of a program revision or a new program? If yes, please indicate how this course fits into this program, including whether it is a core or elective course.

    Yes. We have developed a 15-credit curriculum for a Materials Engineering Certificate. This certificate program involves specialized study in Materials Engineering with most of the requirements extending beyond the requirements of any individual major within COE and within the University in general. The Certificate students will acquire skills and knowledge specific to the discipline (or, as it is usually regarded, the interdisciplinary field) of Materials Science and Engineering.

2. Has this course been taught in another department before? If yes, please indicate the reasons why the course has been moved, including information on changes between this and the previous course. If the course is cross-listed, what is the department and course number?

    No. The courses will be cross-listed with the Mechanical and Industrial Engineering Department with the same course numbers as listed in the Chemical Engineering Department.

3. Is there a possibility that a course similar to this one is available and taught in another school/college/department or campus? If yes, please indicate the reasons why this new course is necessary. Also, include documentation of consultation with other schools/colleges/departments on this matter.

    No.

4. Would this course substitute for another course currently in the curriculum? If yes, please indicate whether the original course will be discontinued.

    No.

5. Would this course count for your own major? If no, please indicate its function such as service to a particular population, etc.

    Yes. It will provide a technical elective for students in the College of Engineering in addition to those who will be pursuing the Materials Engineering Certificate.

6. Is the proposed instructor a member of the graduate faculty? If no, please explain why non-graduate faculty would teach this course.

    All of the proposed instructors will be members of the graduate faculty.

7. <u>Within course submission, include the Syllabus, along with the following</u>:

    - New course number
    - Course description specific to the new course
    - Clearly specified course objectives
    - Week-by-week outline of topics covered in the course with a brief description of each of these topics & assignments for the week
    - Readings associated with each of the topics in the outline
    - Description of required assignments -- guidelines for papers or projects
    - Grading policy and specific grading criteria associated with each of the required assignments (with % or points converted to letter grades)
    - Anticipated enrollment
    - Selected bibliography of works used in developing the course
    - Accommodation policy (stated below)

- Academic honesty statement

If the course has been offered as an experimental (seminar) course, also include:

- Experimental (seminar) course syllabus
- Teaching evaluations (Note: Teaching evaluations are confidential and if included must be accompanied by a signed release from the instructor.)

Accommodation Policy Statement

Include this or a similar accommodation policy:

The University of Massachusetts Amherst is committed to providing an equal educational opportunity for all students. If you have a documented physical, psychological, or learning disability on file with Disability Services (DS), Learning Disabilities Support Services (LDSS), or Psychological Disabilities Services (PDS), you may be eligible for reasonable academic accommodations to help you succeed in this course. If you have a documented disability that requires an accommodation, please notify me within the first two weeks of the semester so that we may make appropriate arrangements.

Graduate School Interim Statement on Academic Honesty

It is expected that all graduate students will abide by the Graduate Student Honor Code and the Academic Honesty Policy (available at the Graduate Dean's Office, the Academic Honesty Office (Ombud's Office) or online at http://www.umass.edu/gradschool/handbook/univ_policies_regulations_a.htm). Sanctions for acts of dishonesty range from receiving a grade of F on the paper/exam/assignment or in the course, loss of funding, being placed on probation or suspension for a period of time, or being dismissed from the University. All students have the right of appeal through the Academic Honesty Board.