

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 579 Advanced Materials Engineering
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 synthesis, processing, and physical properties of nonmetallic engineering materials (ceramics, composites, semiconductors, and dielectrics) for advanced applications in materials engineering and device/component fabrication.
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.

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

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

ChE/MIE 579

Spring 2010

INFORMATION SHEET

Advanced Materials Engineering

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 synthesis, processing, and physical properties of nonmetallic engineering materials (ceramics, composites, semiconductors, and dielectrics) for advanced applications in materials engineering and device/component fabrication. A broad review of the applications, structural characteristics, processing methods, and physical properties will be given of ceramic, composite, and electronic materials. Emphasis also is placed on understanding the design and properties of nonconventional material structures that are utilized in advanced engineering applications. The course will provide senior undergraduate and first-year graduate students with the necessary background for understanding and addressing synthesis, processing, design, and development problems that are important in engineering ceramic, composite, and electronic materials and for following the relevant science & engineering literature.

Course Syllabus

- **Ceramics and Glasses** (10 lectures)
 - Ceramic powders: synthesis, densification, and sintering
 - Classification of ceramic materials: triaxial whitewares, electrical ceramics, magnetic ceramics, refractories, cements and mortars, abrasives, glasses, and glass ceramics
 - Effects of processing on the development of microstructures and properties of ceramics
 - Glasses: structure, formation, and applications
 - Principles of glass working: viscosity, melting, and forming processes
 - Mechanical properties of glass, annealing, and tempering
 - Optical and elastic properties of glasses; Glass defects
- **Composite materials** (8 lectures)
 - Brief review of composite materials
 - The interfaces, bonding, and controlling the bond strength
 - Fabrication of polymer, metal, and ceramic composites
 - Calculation of thermoelastic properties and strength
 - Tensile and compressive testing and fracture
 - Corrosion and degradation of composites
 - Applications of composite materials
- **Electronic Materials** (10 lectures)
 - Semiconductors: energy band diagrams and charge carriers
 - Conduction in semiconductors: n-type and p-type doping
 - Carrier concentration and mobility
 - Temperature dependence of conductivity
 - pn junction and pn junction band diagram
 - Field effect transistor and metal-oxide-semiconductor field effect transistor (MOSFET)
 - Light emitting diodes (LEDs): principles and characteristics
 - Dielectric materials: permittivity and electronic polarization
 - Dielectric constant and dielectric loss
 - Dielectric strength and breakdown
 - Dielectric applications in capacitors and semiconductor devices

Course Goals

1. To comprehend the synthesis, processing, and physical properties of nonmetallic engineering materials (ceramics, composites, semiconductors, and dielectrics) for advanced applications in materials engineering and device/component fabrication.
2. Knowledge of the applications, structural characteristics, processing methods, and physical properties of ceramic, composite, and electronic materials.
3. To understand the design and properties of nonconventional material structures that are utilized in advanced engineering applications.
4. Acquiring the necessary background for understanding and addressing synthesis, processing, design, and development problems that are important in engineering ceramic, composite, and electronic materials and for following the relevant science & engineering literature.

Course Outcomes

- Understanding the synthesis, densification, and sintering of ceramic powders and the effects of processing on the development of microstructures and on the properties of ceramics
- Understanding the classification of ceramic materials and their applications
- Comprehension of glasses, production methods, and applications
- Knowledge of annealing and tempering of glass and their effects on the mechanical properties
- Understanding the optical and elastic properties of glasses
- Comprehension of the fabrication processes of different composite materials
- Understanding the importance of interfacial properties and bonding in controlling the strength of composite materials
- Understanding the mechanical properties of composite materials and their use in the design of composite materials for engineering applications
- Knowledge of corrosion and degradation processes in composite materials
- Understanding of the origin of the electrical/electronic properties of semiconductors and dielectric materials
- Understanding of transport processes and their role in the fabrication of semiconductor materials: n-type and p-type doping, carrier concentration and mobility, temperature dependence of conductivity
- Comprehension of semiconductor devices: field effect transistors and metal-oxide-semiconductor field effect transistors (MOSFETs)
- Knowledge of principles and characteristics of light emitting diodes (LEDs).
- Understanding of dielectric material properties, such as permittivity, electronic polarization, dielectric constant, and dielectric loss, and of the role of dielectric materials in microelectronic devices
- Knowledge of reliability issues associated with dielectric materials in microelectronic devices

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

Homeworks (20%)

Midterm Exam (30%)

Final Exam (50%)

2. REFERENCES

Required Textbooks

1. R. Abbaschian, L. Abbaschian, and R. E. Reed-Hill, *Physical Metallurgy Principles*, CL-Engineering (2008).
2. D. Hull and T. W. Clyne, *An Introduction to Composite Materials*, Cambridge University Press, Oxford (1996).

Additional References

1. P. Haasen, *Physical Metallurgy*, Cambridge University Press, Cambridge (1986).
2. J. D. Veerhoven, *Fundamentals of Physical Metallurgy*, Wiley, New York (1975).
3. K. K. Chawla, *Composite Materials: Science and Engineering*, Springer, New York (1998).
4. E. J. Barbero, *Introduction to Composite Materials Design*, Taylor & Francis, Philadelphia (1998).
5. M. Ohring, *Reliability & Failure of Electronic Materials & Devices*, Academic Press (1998).
6. S. O. Kasap, *Principles of Electronic Materials and Devices*, McGraw-Hill, New York (2002).
7. L. H. Van Vlack, *Elements of Materials Science and Engineering*, Addison-Wesley, New York (1989).
8. W. D. Callister, *Materials Science and Engineering: An Introduction*, Wiley, New York (2007).
9. D. W. Richerson, *Modern Ceramic Engineering*, Marcel Dekker, New York (1992).
10. W. D. Kingery, *Introduction to Ceramics*, Wiley, New York (1976).
11. C. Harper, *Electronic Materials and Processes Handbook*, McGraw-Hill, New York (2009).
12. R. E. Hummel, *Electronic Properties of Materials*, Springer, New York (2001).

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.

3. COURSE REQUIREMENTS

Background

Materials Science: Prerequisite: Introduction to Materials Science and Engineering (MIE 2xx/201) or equivalent course or instructor's permission.

Engineering: 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.

Mathematics: 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. Within course submission, include the Syllabus, along with the following:
 - 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.