EMA 4125: Transport Phenomena in Materials Processing

Instructor: Rajiv Singh, 217 Materials Engineering Bldg

Schedule: Monday-Wednesday-Friday AM – 5th Period 11.45 am -12.35 pm. The classes will be held in FLG Room 220. The time/location for extra classes/missed classes will be decided later.

Office Hrs: Wednesday-Friday 9 AM – 10 AM

TA To be Announced (no TA currently assigned)

Class text D. R. Poirier and G. H. Geiger, " Transport Phenomena in Materials Processing', TMS Publications, Warrendale PA , 1994

Optional Texts

James Welty, Charles Wicks, Robert Wilson and Gregory Rorrer: "Fundamentals of Momentum, Heat and Mass Transfer", 4th edition NY, John Wiley and Sons. 2001

Please check MIT web-site: http://ocw.mit.edu/OcwWeb/Materials-Science-and-Engineering/3-185Fall-2003/CourseHome/index.htm

Grades: The grades will be based on homework assignments, and 2 take home exam and 3 quizzes. The final grades are as follows

Homework –	10 %
Take home -Project-1	20%
Take Home -Project -2	15%
Exam	50%
Class Attendance	5%

Exam 1 – Diffusion
Exam 2 – Heat Conduction and Radiation
Exam 3: Fluid Dynamics and Combined Transport Systems
Before each exam there will be a extra revision (tutorial) class conducted during the extra period.

Grading Scale:

Percentage	**≥90**	**≥88**	**≥84**	**≥80**	**≥76**	**≥72**	**≥68**	**≥65**	**≥62**	**≥59**	**≥56**	**<56**
Letter Grade	**A**	**A-**	**B+**	**B**	**B-**	**C+**	**C**	**C-**	**D+**	**D**	**D-**	**E**

The instructor reserves the discretion to grade on the curve depending on the average grade of the class.

General Comments:

This course will cover general areas of solid state diffusion, heat conduction and radiation, fluid dynamics and heat and mass transfer.

The focus of the course will be to understand the fundamentals related to processing of materials.

Similar courses have been a fundamental staple in other engineering departments (e.g chemical engineering). The primary difference between this course and similar course taught elsewhere is the application of *transport phenomena to materials processing problems*. Examples of materials problems include (i) film growth in chemical vapor deposition, (ii) doping in semiconductors, (iii) heat treatment of metals, (iv) casting and solidification, (v) sustained drug release in biomaterials, (vi) injection molding, etc.

A strong background in mathematics/calculus (including differential equations) is necessary for this course. We will have some extra lectures in this area as needed. The take-home exam may require the help of a computer to solve the transport problem. The test dates for the exams will be decided in class.

Course Content

I: Introduction to Transport Phenomena in Materials Processing

II. Diffusion: Introduction; Steady State Diffusion ; Unsteady State Diffusion and Homogenous Chemical Reaction; Diffusion in metals, ceramics and semiconductors and porous media; dimensional analysis; examples;

III. Heat Conduction and Radiation: Introduction; Energy Conservation; finite difference equation; phase change; multilayers; radiation heat transfer; illustrative examples

IV. Fluid Dynamics: Introduction: 1-D Laminar Momentum Diffusion; Navier Stokes Equation; Drag Coefficient; Boundary Layer; Turbulent Phenomena; Illustrative Examples

V. Fluid Heat and Mass Transfer: Heat/Mass Flat Plate Boundary Layer; Natural Convection, Illustrative Examples

Illustrative Examples:

1) Ion Implantation and Diffusion in Silicon
2) Ultra Rapid Thermal Annealing of Semiconductors
3) Gas Phase Transfer Chemical Vapor Deposition of Silicon Films
4) Sintering of Ceramic Powders
5) Carburization of Steel
6) Formation of Electric Double Layer in Particles and Surfaces

7) Oxide/Scale formation in Metals and Semiconductors
8) Microspheres Based Sustained Drug Release Systems
9) Convective Effects During Crystal Growth
10) Systemic/Targeted Absorption of Drugs

COURSE CALENDAR

PART I

WK 1 (Lec. 1 - 2):	**Introduction and Mathematical Fundamentals**
WK 2 (Lec. 3-5):	**Conservation and Constitutive Equation Diffusion Coefficient; Solid State Diffusion; Materials Aspects of Diffusion**
Wk 3 -4 (6-11):	**Steady and Unsteady State Diffusion; Boundary Conditions**
Wk 5 (14-14):	**Diffusion continued wrap –up ; Make-up Examples Quiz 1:**

PART II

W 6(15-17)	**Numerical Solutions of Transport Problems; Take home 1; Introduction to Heat Conduction, Convection and Radiation; Materials Issues Related to Conservative Properties; Biot Number**
W 7 (18-20)	**Heat Conduction (Continued) Energy Conservation; Steady and Unsteady Heat Conduction; Phase Change ; Conduction versus Convection**
W 8 (21-23)	**Conduction (complete); Radiation Heat Transfer; Examples**
W 9 (24-26):	**Heat Transfer; Wrap Up, Finite difference wrap-up ; Make-up Quiz 2**

PART III

W 10&11 (27-32)	**Fluid Dynamics: Introduction to Viscosity, Materials Issues; Momentum diffusion; Navier Stokes Equation; Drag Coefficient; Boundary Layer; Turbulent Flow**
Wk 12-13: (33-38)	**Heat and Mass Transfer: Importance of Non-dimensional quantities; Convection (natural and forced), CVD : examples in Materials Processing;**
Wk 14 (39-41)	**Wrap-Up; Make-up Quiz 3 Relation to Program Outcomes:**

Outcome	Coverage*
1. Apply knowledge.	
2. Conduct experiments.	
3. Statistical design of experiments.	
4. Design.	
5. Function on teams.	
6. Solve problems.	
7. Professional and ethical responsibility.	
8a. Communicate (written)	
8b. Communicate (oral)	
9. Economic impact.	
10. Global, societal, and environmental impact.	High
11. Lifelong learning.	
12. Contemporary issues.	High
13. Techniques, skills, and tools for MSE.	

* Coverage is given as high, medium, or low. An empty box indicates that this outcome is not a part of the course.

Honesty Policy – All students admitted to the University of Florida have signed a statement of academic honesty committing themselves to be honest in all academic work and understanding that failure to comply with this commitment will result in disciplinary action. This statement is a reminder to uphold your obligation as a UF student and to be honest in all work submitted and exams taken in this course and all others.

Accommodation for Students with Disabilities – Students Requesting classroom accommodation must first register with the Dean of Students Office. That office will provide the student with documentation that he/she must provide to the course instructor when requesting accommodation.

UF Counseling Services – Resources are available on-campus for students having personal problems or lacking clear career and academic goals. The resources include:
-University Counseling Center, 301 Peabody Hall, 392-1575, Personal and Career Counseling
- SHCC mental Health, Student Health Care Center, 392-1171, Personal and Counseling.
Center for Sexual Assault/Abuse Recovery and Education (CARE), Student Health Care Center, 392-1161, sexual assault counseling.
Career Resource Center, Reitz Union, 392-1601, career development assistance and counseling

Software Use – All faculty, staff and student of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.