MATSE 450: SYNTHESIS AND PROCESSING OF ELECTRONIC AND PHOTONIC MATERIALS

Course Designation: This is a required course in the Electronic and Photonic Materials Option, and an elective course for other options.

Catalog Description: The materials science of applying thin film coatings, etching and bulk crystal growth; includes materials transport, accumulation, epitaxy and defects.

Course Description: This course covers the basic techniques and fundamental processes of thin film deposition. The kinetic theory of gases and the basics of vacuum science and technology are introduced to provide students with an understanding of gas transport under high vacuum conditions and at atmospheric pressure. The fundamental processes occurring during thin film deposition, such as adsorption, surface diffusion, nucleation and microstructure development are addressed using relevant theory and models. Methods of bulk crystal growth and wafer fabrication are discussed. Major thin film deposition processes such as evaporation, sputtering and chemical vapor deposition are presented with an emphasis on the fundamentals and applications of each technique.
Individual case study projects are used to select and evaluate appropriate thin film deposition methods for specific materials. Students interested in disciplines such as electronic and photonic materials, metallurgy, engineering science and mechanics, electrical engineering and chemical engineering will benefit significantly from this course.

The course is offered annually, in the fall semester, in the Department of Materials Science and Engineering.

Prerequisites: CHEM 013, PHYS 214, MATSE 400, MATSE 401, MATSE 402

Textbook: The Materials Science of Thin Films by M. Ohring

Course Objectives:

1. To gain an understanding of the fundamental physical and chemical processes which are involved in crystal growth and thin film fabrication.
2. To become familiar with the important synthesis and processing techniques which are used for the fabrication of electronic and photonic devices.
3. To gain an understanding of how material characteristics are influenced by processing and deposition conditions.
4. To apply this knowledge to a case study/design project.

Course Topics:

1. Kinetic theory of gases and vacuum science and technology.
2. Material transfer mechanisms at low and high pressure.
3. Adsorption, desorption and surface diffusion processes.
4. Nucleation: homogeneous and heterogeneous.
5. Microstructure development: ripening, coalescence, zone model of grain structure.
6. Epitaxy: homoepitaxy and heteroepitaxy
7. Defects and mechanisms of defect introduction during growth.
8. Bulk crystal growth techniques.
9. Physical vapor deposition: evaporation, sputtering, molecular beam epitaxy

10. Chemical vapor deposition: reaction types, thermodynamics, kinetics, transport processes, reactor design, low pressure CVD, metalorganic CVD

Class Schedule: 3 credit course offered annually meeting 3 times per week for 50 minutes.

Course Outcomes:

Upon completion of the course, the student shall be able to:

1. Utilize the kinetic theory of gases and basic rules of vacuum science in the design of gas transport and vacuum deposition equipment and processes.
2. Understand the fundamental surface processes that occur during thin film deposition and their impact on film morphology.
3. Describe the primary methods used for bulk crystal growth of semiconductors.
4. Select appropriate conditions for the evaporation of metal films of a desired composition and predict film uniformity given a specific geometry.
5. Determine sputtering yield for a material and understand the differences between various sputtering methods.
6. Apply the concepts of thermodynamics, kinetics and mass transport to the predication and rationalization of chemical vapor deposition processes.
7. Select the most appropriate film deposition process to achieve a desired outcome, given a specific application.

Assessment Tools:

1. Five homework assignments.
2. Three in-class presentations on individual case study projects.
3. Final technical report on individual case study project.
4. Closed book final exam.

Professional Component: The course topics address the scientific and engineering principles regarding the interrelationships between structure, properties and performance of materials (with an emphasis on electronic and photonic materials).

Prepared by: Joan M. Redwing, February 2002

MAP TO DEPARTMENTAL OUTCOMES (For further detail, see coursebook)											
a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**
1	3	1	3	1	3	1	2	3	2	2	1

MAP TO DEPARTMENTAL OBJECTIVES (For further detail, see coursebook)						
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
1,2,3,4	1,2,3,4	1,3	4	2,4	2	