MATSCEN 7531: Epitaxial Heterostructures

Course Description

Science and techniques behind thin film growth and engineering for combining different materials, altering chemical composition at the nanometer scale, while controlling defects and strain. Epitaxial crystal growth will be explained. Students will gain an understanding of the kinetics, thermodynamics, and technology involved in epitaxial heterostructures and self-assembled nanostructures.

Transcript Abbreviation: Epitax Heterostr
Grading Plan: Letter Grade
Course Deliveries: Classroom
Course Levels: Graduate
Student Ranks: Masters, Doctoral
Course Offerings: Autumn, Spring
Flex Scheduled Course: Never
Course Frequency: Odd Years
Course Length: 14 Week
Credits: 2.0
Repeatable: No
Time Distribution: 2.0 hr Lec
Expected out-of-class hours per week: 4.0
Graded Component: Lecture
Credit by Examination: No
Admission Condition: No
Off Campus: Never
Campus Locations: Columbus
Prerequisites and Co-requisites: Graduate standing
Exclusions:
Cross-Listings: Cross-listed with ECE as ECE 7531

Course Rationale: Course needed to address the growth of thin films, specifically with regard to combination of different materials.

The course is required for this unit's degrees, majors, and/or minors: No
The course is a GEC: No
The course is an elective (for this or other units) or is a service course for other units: Yes

Subject/CIP Code: 14.1801
Subsidy Level: Doctoral Course

Programs

Abbreviation	Description
MATSCEN	Materials Science and Engineering

General Information

This course will be attended by MSE and ECE students, Chemistry, and Physics in the areas of functional materials, solid state electronics, and photonics.

Course Goals

Develop a technical knowledge of vacuum science
Develop a working knowledge of thin film characterization techniques
Students will gain an understanding of kinetics and thermodynamics of thin film / epitaxial growth
Introduce students to advanced impurity doping techniques and limits therein
Students will gain a working knowledge of advanced electronic and optical design tools especially quantum confined and nanostructures.
Students will demonstrate analytical ability in reviewing case studies from scientific literature on the topic of epitaxial heterostructures.

Course Topics

Topic	Lec	Rec	Lab	Cli	IS	Sem	FE	Wor
Intro to Vacuum science: pumps, gauges, mean free path, baking	2.0							
Standard epitaxial characterization: RHEED, HRXRD, AFM	2.0							
Thin film kinetics versus thermodynamics	2.0							
Comparing growth methods (MBE versus MOCVD, sputtering, PLD)	2.0							
Adatom mobility, sticking coefficient, surface diffusion	2.0							
Growth modes: Volmer-Weber, Stranski-Krastinow, Frankvan der Merwe	2.0							
Misfit, threading dislocations, strain relaxation (critical thickness)	2.0							
Impurity doping: techniques, calibration, uniformity, incorporation during growth, diffusion, amphotericity and autocompensation	2.0							
Advanced electronic/optical design tools: quantum wells, modulation doping, polarization doping	2.0							
Digital superlattices, DBRs, multi quantum wells	2.0							
Self-assembled nanostructures: quantum dots, nanowires	2.0							
Case studies: Limited solubility and metastable phases, GaMnAs	2.0							
Case studies: Epitaxy of dissimilar materials, ErAs/GaAs	2.0							
Case studies: nanowire heterostructures, strain accommodation	2.0							

Grades

Aspect	Percent
Weekly quizzes	50%
In-class presentation	25%
Final report	25%

Representative Textbooks and Other Course Materials

Title	Author
Epitaxy of Semiconductors: Introduction to Physical Principles	Udo W. Pohl

ABET-EAC Criterion 3 Outcomes

Course Contribution		College Outcome
	a	An ability to apply knowledge of mathematics, science, and engineering.
	b	An ability to design and conduct experiments, as well as to analyze and interpret data.
	c	An ability to design a system, component, or process to meet desired needs.
	d	An ability to function on multi-disciplinary teams.
	e	An ability to identify, formulate, and solve engineering problems.
	f	An understanding of professional and ethical responsibility.
	g	An ability to communicate effectively.
	h	The broad education necessary to understand the impact of engineering solutions in a global and societal context.
	i	A recognition of the need for, and an ability to engage in life-long learning.
	j	A knowledge of contemporary issues.
	k	An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Prepared by: Mark Cooper