

MSE4121: THIN FILMS

Effective Term

Semester B 2023/24

Part I Course Overview

Course Title

Thin Films

Subject Code

MSE - Materials Science and Engineering

Course Number

4121

Academic Unit

Materials Science and Engineering (MSE)

College/School

College of Engineering (EG)

Course Duration

One Semester

Credit Units

3

Level

B1, B2, B3, B4 - Bachelor's Degree

Medium of Instruction

English

Medium of Assessment

English

Prerequisites

Nil

Precursors

AP2102/MSE2102 Introduction to Materials Engineering
AP3171/MSE3171 Materials Characterization Techniques
AP3172/MSE3172 Electronic Properties of Materials
MA2176 Basic Calculus and Linear Algebra or
MA1201 Calculus and Basic Linear Algebra II

Equivalent Courses

AP4121 Thin Film Technology and Nanocrystalline Coatings

Exclusive Courses

Nil

Part II Course Details

Abstract

The course provides fundamental knowledge on modern material syntheses in materials engineering and science. This emerging technology equips the students with knowledge in processing both pure elementary materials and compounds that can be prepared in crystalline, polycrystalline, nanocrystalline or amorphous forms. The course is designed as a practical guide in thin film deposition used in industry and science. It also stimulates ingenuity in experiment and material processing design as well as inventiveness in development of novel materials and nanomaterials. The course represents an important interface between the school and industrial and scientific practice.

Course Intended Learning Outcomes (CILOs)

CILOs		Weighting (if DEC-A1 DEC-A2 DEC-A3 app.)			
1	Recognize the fundamental growth and material parameters of thin films and nanomaterials such as growth rate, arrival rate ratio of particles, surface energy, lattice parameters, density, stress, adhesion, stoichiometry, sticking coefficient, etc.			x	x
2	Recognize the various deposition methods and syntheses of various materials and be able to relate them to the principles of fundamental physics and chemistry.		x	x	x
3	Select modern techniques of deposition and synthesis and apply them to prepare different materials and nanomaterials under proper conditions.		x	x	x
4	Evaluate and design processes of material synthesis to form thin films and nanomaterials.			x	x

A1: Attitude

Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability

Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments

Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Teaching and Learning Activities (TLAs)

TLAs		Brief Description	CILO No.	Hours/week (if applicable)
1	Lecture	Explain the fundamental concepts on the growth and material parameters of thin films and nanomaterials, and discuss the working principles of different thin film techniques and their distinctive features.	1, 2, 3, 4	3 hrs/wk
2	Tutorial	Discuss more examples to substantiate the concepts studied in lecture, and help the students to understand them.	1, 2, 3, 4	1hr/wk
3	Lab work	Demonstrate the designs and working processes of some selected thin film deposition techniques	1, 2, 3, 4	3hrs/wk

Assessment Tasks / Activities (ATs)

ATs		CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Mid-term test	1, 3, 4	10	
2	Lab work (Two Lab Reports)	2, 4	10	
3	Three homework assignments	1, 4	10	

Continuous Assessment (%)

30

Examination (%)

70

Examination Duration (Hours)

2

Additional Information for ATs

For a student to pass the course, at least 30% of the maximum mark for the examination must be obtained

Assessment Rubrics (AR)**Assessment Task**

1. Short quizzes

Criterion

Ability to explain the basic concepts and their applications in thin film deposition techniques

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not even reaching the marginal leave

Assessment Task

2. Lab work

Criterion

Ability to understand the designs and working processes of thin film deposition systems, and to recognise the functions of the system components.

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not even reaching the marginal leave

Assessment Task

3. Midterm test

Criterion

Capability on understanding the fundamentals of the growth and material parameters of thin films and nanomaterials

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not even reaching the marginal leave

Assessment Task

4. Examination

Criterion

Capability on understanding the fundamental concepts and key parameters about the growth of thin films and nanomaterials, explaining the scientific principles, applications and restrictions of deposition methods, and identifying and explaining how the principles of deposition and synthesis are applied, and solving physical and engineering problems in thin film deposition.

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not even reaching the marginal leave

Part III Other Information

Keyword Syllabus

- Definition of thin films.
- Environment and molecular and plasma processes in thin film deposition.
- Cold and thermal plasma.
- Requirement for substrate. Substrate cleaning.
- Formation of thin films
Sticking coefficient. Formation of thermodynamically stable cluster – nucleation. Growth process.
- Properties of thin films: Microstructure. Single crystalline films. Polycrystalline films. Nanocrystalline thin film. Amorphous films. Metastable films. Surface morphology. Film density. Stress in thin films. Adhesion. Stoichiometry.
- Mechanical, electrical, thermal, chemical, and optical properties of thin films.
- Thermal evaporation
Resistance evaporation. Electron beam evaporation. Molecular beam epitaxy.
- Laser ablation. Synthesis of nanomaterials (nanowires, nanoribbons)
- Electrical discharges used in thin film deposition
Mechanism of electrical discharges. I-V characteristic of electrical discharges. Townsend discharge. Glow discharge. Arc.
- Practical electric discharge configuration for deposition of thin films. Direct current electric discharges. Radio-frequency discharges. Microwave discharges. Electron cyclotron resonance plasma. Matching units. Floating potential. Bias potential. Plasma potential. Effective bias. Self-bias.
- Physical deposition techniques
Direct current and radiofrequency sputtering. Magnetron sputtering. Cathodic arc deposition. Filtered cathodic arc deposition. Ion beam sputtering. Ion plating.

- Chemical vapor deposition techniques (CVD)
Thermally activated CVD Plasma enhanced CVD. Oxidizing and nitriding. Photoassisted CVD. Plasma polymerization. Chemical transport in plasma. Hydrogen neutralization in semiconductors.
- Other processing technologies
Pattern transfer. Reactive ion etching. Ion milling. Ion beam dry etching.

Reading List

Compulsory Readings

Title	
1	Nil

Additional Readings

Title	
1	(E-book) H. Lüth, Solid surfaces, interfaces and thin films, Heidelberg, New York, Springer-Verlag, c2010. (5th ed.)
2	(E-book) D. M. Mattox, Handbook of physical vapor deposition (PVD) processing, Oxford, c2010. (2nd ed.)
3	(E-book) by P. M. Martin (Eds), Handbook of deposition technologies for films and coatings, Oxford, 2009. (3rd ed.)
4	D Clocker, S I Shah (Eds), Handbook of Thin Film Process Technology, Institute of Physics Publishing, London 1995.
5	W N G Hitchon, Plasma Processes for semiconductor Fabrication, Cambridge University Press, Cambridge 1999.
6	J L Vossen, W. Kern (Eds), Thin Film Processes II, Academic Press, Boston 1991.
7	Elshabini-Riad, A. R. Aicha, Thin film technology handbook / New York : McGraw-Hill, c1998. (TK7872.T55 E47 1998)
8	F C Maticotta, G. Ottaviani, Science and technology of Thin Films, World Scientific, New Jersey 1995