City University of Hong Kong
Course Syllabus

offered by Department of Materials Science and Engineering
with effect from Semester A 2022/23

Part I Course Overview

Course Title:	**Thin Film Technology and Nanocrystalline Coatings**
Course Code:	**MSE6121**
Course Duration:	**One semester**
Credit Units:	**3**
Level:	**P6**
Medium of Instruction:	**English**
Medium of Assessment:	**English**
Prerequisites: *(Course Code and Title)*	**Nil**
Precursors: *(Course Code and Title)*	**Nil**
Equivalent Courses: *(Course Code and Title)*	**AP6121 Thin Film Technology and Nanocrystalline Coatings (From the old curriculum)**
Exclusive Courses: *(Course Code and Title)*	**AP8121 Thin Film Technology and Nanocrystalline Coatings (From the old curriculum)**

Part II Course Details

1. Abstract

The course provides fundamental knowledge on modern technologies for thin films and nanomaterials synthesis, and it equips the students with knowledge in processing both pure elementary materials and compounds that can be prepared in crystalline, polycrystalline, nanocrystalline or amorphous forms. Various growth techniques, their working principles and characteristics are discussed in details. The practical applications of these techniques are demonstrated.

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.

2. Course Intended Learning Outcomes (CILOs)

(CILOs state what the student is expected to be able to do at the end of the course according to a given standard of performance.)

No.	CILOs	Weighting (if applicable)	Discovery-enriched curriculum related learning outcomes (please tick where appropriate)		
			A1	*A2*	*A3*
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.			√	√
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 and to provide innovative solutions.		√	√	√
3.	Select modern techniques of deposition and synthesis and apply them to prepare different materials and nanomaterials under proper conditions.		√	√	√
4.	Evaluate and design processes of material synthesis to form thin films and nanomaterials.			√	√
5.	Identify state-of-the-art developments in the relevant area and to form opinions on specific issues.			√	√
		100%			

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 self-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.

3. Teaching and Learning Activities (TLAs)

(TLAs designed to facilitate students' achievement of the CILOs.)

TLA	Brief Description	CILO No.						Hours/week (if applicable)
		1	2	3	4	5		
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, their distinctive features, and practical applications.	√			√			2 hrs/wk
Tutorial	Discuss more examples to substantiate the concepts studied in lecture, and help the students to understand them.	√		√	√	√		0.5 hrs/wk
On-site discussion	Demonstrate the designs and working processes of different thin film deposition techniques in labs, and discuss their characteristics and limitations.		√			√		2 hrs/semester

4. Assessment Tasks/Activities (ATs)

(ATs are designed to assess how well the students achieve the CILOs.)

Assessment Tasks/Activities	CILO No.						Weighting	Remarks
	1	2	3	4				
Continuous Assessment: 30%								
Short quizzes	√			√			15%	
Mid-term test	√		√	√			15%	
Examination: 70% (duration: 2 hours)								
							100%	

5. Assessment Rubrics

(Grading of student achievements is based on student performance in assessment tasks/activities with the following rubrics.)

Applicable to students admitted in Semester A 2022/23 and thereafter

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B)	Marginal (B-, C+, C)	Failure (F)
1. Short quizzes	Ability to explain the basic concepts and their applications in thin film deposition techniques	High	Moderate	Basic	Not even reaching the marginal leave
2. Midterm test	Capability on understanding the fundamentals of the growth and material parameters of thin films and nanomaterials	High	Moderate	Basic	Not even reaching the marginal leave
3. Examination	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.	High	Moderate	Basic	Not even reaching the marginal leave

Applicable to students admitted before Semester A 2022/23

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
1. Short quizzes	Ability to explain the basic concepts and their applications in thin film deposition techniques	High	Significant	Moderate	Basic	Not even reaching the marginal leave
2. Midterm test	Capability on understanding the fundamentals of the growth and material parameters of thin films and nanomaterials	High	Significant	Moderate	Basic	Not even reaching the marginal leave
3. Examination	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.	High	Significant	Moderate	Basic	Not even reaching the marginal leave

Part III Other Information (more details can be provided separately in the teaching plan)

1. 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 is semiconductors.
- Other processing technologies
  Pattern transfer. Reactive ion etching. Ion milling. Ion beam dry etching.

2. Reading List

2.1 Compulsory Readings

(Compulsory readings can include books, book chapters, or journal/magazine articles. There are also collections of e-books, e-journals available from the CityU Library.)

Nil

2.2 Additional Readings

(Additional references for students to learn to expand their knowledge about the subject.)

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 Matacotta, G. Ottaviani, Science and technology of Thin Films, World Scientific, New Jersey 1995