City University of Hong Kong
Course Syllabus

offered by
Department of Mechanical Engineering
with effect from Semester A 2024 / 25

Part I Course Overview

Course Title:	Kinetics in Nanoscale Materials
Course Code:	MNE8102
Course Duration:	One Semester
Credit Units:	3
Level:	R8
Medium of Instruction:	English
Medium of Assessment:	English
Prerequisites: *(Course Code and Title)*	Background knowledge in related disciplines is required and course registration will be subject to the approval of the Course Examiner
Precursors: *(Course Code and Title)*	Nil
Equivalent Courses: *(Course Code and Title)*	Nil
Exclusive Courses: *(Course Code and Title)*	Nil

Part II Course Details

1. Abstract

The aim of this course is to explain why the subject of kinetics in nanoscale materials is of wide interest today; because of its link to nanotechnology. In recent years, a major development in science and engineering is nanoscience and nanotechnology. At the moment, the research and development on nanoscale materials science for nanotechnology is ubiquitous, for example, the study of silicon, metal, and oxide nanowires. To build the nanowire device hetero-structure of silicide/Si/silicide requires the study of line contact reaction between Si and metal nanowires to form the silicide electrodes. To use Ag nanowire mesh as the transparent conducting electrodes on flexible solar cells requires the study of point contact reaction between two Ag nanowires. What is unique in kinetics in nanoscale materials is the dominant effect of Gibbs-Thomson potential energy, high concentration gradient, large quantity of non-equilibrium vacancies, very few dislocations, yet very high density of nanotwins and grain boundaries.

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	**Learn** the unique microstructure and kinetic behaviors of nanoscale materials such as nanospheres, nanowires, nanothickness thin films, and nanostructure in bulk-type materials.		√	√	
2	**Understand** linear and non-linear diffusion equations and solutions for nano materials.			√	
3	**Analyse** Kirkendal effect and inverse Kirkendall effect andtheir interaction in core-shell nanoscale materials.			√	
4	**Learn** spinodal decomposition and chemical potential in inhomogenous solid solution and interdiffusion in man-made superlattices.			√	
5	**Identify and apply** ripening kinetics among nano-precipitate and the mean-field assumption in LSW theory of ripening			√	
6	**Analyse and design** thermodynamics and kinetics of homogeneous nucleation. Homogenous nucleation is rare in bulk materials and that is why F. C. Frank's model of spiral growth around a screw dislocation was invented to overcome homogeneous nucleation. The link between Zeldowitch's steady state nucleation theory and experimental study of repeating homogeneous nucleation of epitaxial silicide in Si nanowires will be derived and applied to both functional materials.			√	
	** If weighting is assigned to CILOs, they should add up to 100%.*	N.A.			

Attitude

A1: *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.

3. Learning and Teaching Activities (LTAs)

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

LTA	Brief Description	CILO No.						Hours/week (if applicable)
		1	2	3	4	5	6	
Lecture	The emphasis will be on learning the decomposition, growth, thermodynamics, microstructure and diffusion kinetics associated with the synthesis of nanostructured materials in different geometrical forms.	√	√	√	√	√	√	39 hours

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	5	6		
Continuous Assessment: 100%								
Quiz	√	√	√	√	√	√	80%	
Assessment of Term Report						√	20%	
Examination: 0%								
							100%	

5. Assessment Rubrics

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

<u>Applicable to students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter</u>

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
Quiz	Ability to describe the types of nanomaterials and their microstructural evolution, perform thermodynamic and kinetic calculations associated with their synthesis (dissociation or growth) towards developing them in various geometrical forms.	High	Significant	Moderate	Basic	Not even reaching marginal levels
Assessment of Term Report	Ability to systematically design a scheme to synthesise a typical nanomaterial and perform associated analysis with one or two more students as a small group. In addition, the methodologies adopted and the results obtained should be documented in the form of a scientific report.	High	Significant	Moderate	Basic	Not even reaching marginal levels

<u>Applicable to students admitted from Semester A 2022/23 to Summer Term 2024</u>

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B)	Marginal (B-, C+, C)	Failure (F)
Quiz	Ability to describe the types of nanomaterials and their microstructural evolution, perform thermodynamic and kinetic calculations associated with their synthesis (dissociation or growth) towards developing them in various geometrical forms.	High	Significant	Moderate	Not even reaching marginal levels
Assessment of Term Report	Ability to systematically design a scheme to synthesise a typical nanomaterial and perform associated analysis with one or two more students as a small group. In addition, the methodologies adopted and the results obtained should be documented in the form of a scientific report.	High	Significant	Moderate	Not even reaching marginal levels

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

1. Keyword Syllabus

(An indication of the key topics of the course.)

Past, present, and future microelectronic technology, Overview of kinetic processes in nanoscale materials, Linear and non-linear diffusion, Kirkendall effect and inverse Kirkendall effect, Ripening, Spinodal decomposition, Nucleation events in bulk, thin film, and nanoscale materials, and Growth events in contact reactions on Si; plane, line, and point contacts.

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.)

There is no textbook on this subject, but lecture notes of all the lectures are available and will distributed to all the students in the class.

The following books on kinetics in phase transformations are helpful.

2.2 Additional Readings

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

(1) D. A. Porter and K. E. Easterling "Phase transformation in metals and alloys," Chapman & Hall, London (1992).

(2) Paul Shewmon, 2nd edition on "Diffusion in solids," TMS, Warrendale, Pa. (1989).

(3) King-Ning Tu and Audriy M. Gusak, "Kinetics in Nanoscale Materials," John Wiley and Sons, (2014).