MNE8102: KINETICS IN NANOSCALE MATERIALS

Effective Term

Semester A 2026/27

Part I Course Overview

Course Title

Kinetics in Nanoscale Materials

Subject Code

MNE - Mechanical Engineering

Course Number

8102

Academic Unit

Mechanical Engineering (MNE)

College/School

College of Engineering (EG)

Course Duration

One Semester

Credit Units

3

Level

R8 - Research Degree

Medium of Instruction

English

Medium of Assessment

English

Prerequisites

Background knowledge in related disciplines is required and course registration will be subject to the approval of the Course Examiner

Precursors

Nil

Equivalent Courses

MNE6107 Kinetics in Nanoscale Materials

Exclusive Courses

Nil

Part II Course Details

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.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-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.		x	x	
2	Understand linear and non-linear diffusion equations and solutions for nano materials.			x	
3	Analyse Kirkendal effect and inverse Kirkendall effect and their interaction in core-shell nanoscale materials.			x	
4	Learn spinodal decomposition and chemical potential in inhomogenous solid solution and interdiffusion in man-made superlattices.			x	
5	Identify and apply ripening kinetics among nano-precipitate and the mean-field assumption in LSW theory of ripening			x	
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.			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.

Learning and Teaching Activities (LTAs)

	LTAs	Brief Description	CILO No.	Hours/week (if applicable)
1	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.	1, 2, 3, 4, 5, 6	39 hours

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Quiz	1, 2, 3, 4, 5, 6	80	-	No
2	Assessment of Term Report	6	20	-	Yes

Continuous Assessment (%)

100

Examination (%)

0

Assessment Rubrics (AR)

Assessment Task

Quiz (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

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.

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Not even reaching marginal levels

Assessment Task

Assessment of Term Report (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

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.

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Not even reaching marginal levels

Assessment Task

Quiz (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

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.

Excellent

(A+, A, A-) High

Good

(B+, B) Significant

Marginal

(B-, C+, C) Moderate

Failure

(F) Not even reaching marginal levels

Assessment Task

Assessment of Term Report (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

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.

Excellent
(A+, A, A-) High

Good
(B+, B) Significant

Marginal
(B-, C+, C) Moderate

Failure
(F) Not even reaching marginal levels

Part III Other Information

Keyword Syllabus

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.

Reading List

Compulsory Readings

	Title
1	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.

Additional Readings

	Title
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).