University of Kerala

Discipline	**PHYSICS**				
Course Code	**UK4DSEPHY202**				
Course Title	**SYNTHESIS OF NANOMATERIALS**				
Type of Course	**DSE**				
Semester	**IV**				
Academic Level	**200 - 299**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 Hrs	-	2 Hrs	5 Hrs
Pre-requisites	-				
Course Summary	The course has the following major objectives: Introductory Quantum Mechanics, Fabrication of Nanostructured Materials Physical Methods, Fabrication of Nanostructured Materials Chemical Methods, Self-assembly and Lithography, Elementary ideas of structural and optical characterization of nanostructures.				

BOOKS FOR STUDY:

1. Advances in the Liquid-phase synthesis of inorganic nanoparticles, Brain L. Cushing, Vladimir L. Kolesnichenko, Charles J. O'Connor, Chem Rev. 104 (2004) 3893-3946.
2. Nanocrystals: Synthesis, Properties and Applications, C. N. R. Rao, P. J. Thomas and G. U. Kulkarni, Springer, (2007).
3. Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Guozhong Gao, Imperial College Press, (2004).
4. Introduction To Nanoscience And Nanotechnology By Chattopadhyay, PHI ,India
5. Nanochemistry: A Chemical Approach to Nanomaterials-Royal Society of Chemistry, Cambridge, UK, (2005).
6. DIY NANO, Published by the NISE Network

BOOKS FOR REFERENCE:

1. Fundamentals of Nanotechnology, CRC press, by G.L. Hornyak, J.J. Moone, H.F. Tihhale, J. Dutta
2. Nanotechnology by Mark Ratner and Daniel Ratner, Pearson Education.
3. Nano Essentials- T.Pradeep/TMH
4. Nanostructures and Nanomaterials- Synthesis, Properties & applications by Guozhong Cao, Imperial College Press, (2006).

WEB REFERENCE

1. https://mmrc.caltech.edu/Cary%20UV-Vis%20Int.Sphere/Literature/Spectroscopy%20Jaramillo.pdf
2. https://sci-hub.se/https://doi.org/10.1021/acs.jpclett.8b02892
3. https://mmrc.caltech.edu/FTIR/Literature/Diff%20Refectance/Kubelka-Munk.pdf
4. https://nptel.ac.in/courses/118/102/118102003/
5. https://nptel.ac.in/courses/118/107/118107015/
6. https://nptel.ac.in/content/syllabus_pdf/118102003.pdf

DETAILED SYLLABUS: THEORY

Module	Unit	Content	Hrs	CO No
I		**Introductory Quantum Mechanics**	**9**	
	1	Band Structure and Density of State at nanoscale: Energy Bands, Density of States at low dimensional structures	2	1,2
	2	Size effects in small systems, Quantum behaviours of nanometric world	1	1,2
	3	Trapped particle in 3D (nanodot), electron trapped in 2D plane (nanosheet),	3	1,2
	4	Electrons moving in 1D (nanowire, nanorod, nanobelt), Excitons, Quantum confinement effect in nanomaterials	2	1,2
	5	Classification of Nanomaterials, OD, 1D, 2D and 3D types of nanomaterials, (Quantum dots, Quantum wires etc.)	1	1,2
II		**Fabrication of Nanostructured Materials Physical Methods**	**9**	
	6	Top-down and bottom-up approaches of nanomaterial synthesis, Mechanical Methods, High Energy Ball Milling	2	3
	7	Physical Vapour Deposition - thermal Evaporation method	3	3
	8	Laser Vaporization (Ablation),		

	9	Sputter Deposition; DC Sputtering, RF Sputtering, Magnetron Sputtering	3	3
III	**Fabrication of Nanostructured Materials Chemical Methods**		**9**	
	10	Colloids and Colloids in Solutions, Colloids in a Medium, Effect of Charges on Colloids,	3	3
	11	Synthesis of Metal Nanoparticles by Colloidal Route, Co-precipitation Method,	2	3
	12	Sol-Gel Method, Combustion Method	2	3
	13	Hydrothermal Synthesis, Green Synthesis Using Plant Extracts,	2	3
IV	**Self-assembly and Lithography**		**9**	
	14	Self-assembly, Process of self-assembly,	4	4
	15	Introduction to Lithography, E-beam Lithography.	5	4
V*	**Elementary ideas of structural and optical characterization of nanostructures**		**9**	
	16	Basic ideas of X-ray diffraction (XRD) technique, Braggs Law, Quantitative determination of phase and grain/crystallite size calculation	4	5
	17	UV visible spectroscopy, Determination of optical band gap, Tauc's plot, KM function (Web resources-1,2,3)	5	5

DETAILED SYLLABUS: PRACTICALS

Part A – At least 5 Experiments to be performed		**CO No**
Sl No	**Name of Experiment**	
1	Synthesis of noble nanoparticles by using biological method	6
2	To study the Absorption spectrum of Noble metal nanoparticles	6
3	Find the average grain/crystallite size and phase of the materials using X-ray diffraction pattern of the given sample	6
4	Interpretation of UV- visible spectra of materials – direct band gap OR indirect band gap materials	6
5	To find the optical band gap of the given semiconducting materials by measuring UV Visible transmission spectrum.	6

6	X-ray diffraction-structure evaluation and identification of material.	6
7	Deposition of any sulphide thin film by chemical bath deposition	6
8	Synthesis of noble metal nanoparticles by using biological method	6
9	Deposition of various sulphide thin film by chemical bath deposition.	6
10	Synthesis of noble metal nanoparticles by Chemical Route.	6
11	Synthesis of Au/Ag nanoparticles using co-precipitation method	6
12	Synthesis of Metal sulphide nanoparticle using hydrothermal process.	6
13	Synthesis of Transition Metal Oxides nanoparticles by any one of these methods Green synthesis/Hydrothermal method/Co-precipitation	6
14	Using the given XRD data find the phase and crystalline size of the materials	6
Part B* – At least One Experiment to be performed		
15	Analysis of powder XRD data and phase analysis	6
16	Determination of band gap of a semiconductor nanomaterial using UV-visible absorption spectra	6
17	Synthesis of Metal Oxide/Sulphide/ nanoparticles using sol-gel process.	6
18	Synthesis of Metal Oxide nanofibers using electrospinning	6
19	Preparation of Transition metal oxide nanostructures using microwave synthesis	6
20	Synthesis of Transition Metal Oxides OR Sulphide nanoparticles by any one of these methods Green synthesis/Hydrothermal method/Co-precipitation	6
21	Determination of Fermi energy of copper	6
22	Find the optical band gap of the given semiconducting materials from the data of given transmission spectra	6
23	Find the optical band gap of the given semiconducting materials from given transmission spectra	6
24	To optimize the concentration of nanoparticles dispersed solution using UV-vis spectroscopy.	6
25	Synthesis of Metal Oxide thin films using sputtering process.	6

26	Find the thickness of a thin film from the given UV-Visible spectra	6
27	Find the band gap of a bulk material and corresponding nanomaterials using UV-Visible spectra and	6

COURSE OUTCOMES

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Describe the role of density of states on its physical, chemical, and electrical properties	U	PSO-1,2
CO-2	Classify and interpret quantum structures and their confinement phenomena with low dimensional structures.	U, Ap	PSO-2,3
CO-3	Describe the synthesis of Nanomaterials and their merits	R, U	PSO-1,2,3
CO-4	List and discuss various characterization techniques available for studying the structural and optical properties of nanostructured materials.	R, U	PSO-4,5
CO-5	Analyse the obtained characterization data and categorise applications of nanomaterials and to develop devices for sustainable future.	Ap, An	PSO-5,6
CO-6	Practice experiments related to nanomaterial synthesis	Ap	PSO-6,7

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: SYNTHESIS OF NANOMATERIALS

Credits: 3:0:1 (Lecture: Tutorial: Practical)

CO No.	CO	PO / PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
CO-1	Describe the role of density of states on its physical,	PO1,3,4,5 ,6,8/ PSO-1,2	U	F, C	L	-

	chemical, and electrical properties					
CO-2	Classify and interpret quantum structures and their confinement phenomena with low dimensional structures.	PO1,2,3,4,5,8/ PSO-2,3	U, Ap	F, C	L	-
CO-3	Describe the synthesis of Nanomaterials and their merits	1.2.3.4.5.6.8/ PSO-1,2,3	R, U	F, C	L	-
CO-4	List and discuss various characterization techniques available for studying the structural and optical properties of nanostructured materials.	PO1,2,3,4,6,7/ PSO-4,5	R, U	F, C	L	-
CO-5	Analyse the obtained characterization data and categorise applications of nanomaterials and to develop devices for sustainable future.	1,2,3,4,7/ PSO-5,6	Ap, An	F, C	L	-
CO-6	Practice experiments related to nanomaterial synthesis	1,2,3,4,5,7,8/ PSO-6,7	Ap	F, C	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO-1	2	2	-	-	-	-	-	2	2	1	1	1	1	-	1
CO-2	-	2	1	-	-	-	-	2	2	1	1	1	-	-	1
CO-3	2	2	3	-	-	-	-	2	2	1	1	1	1	-	1
CO-4	-	-	-	2	2	-	-	2	2	2	1	-	1	2	-
CO-5	-	-	-	-	2	1	-	2	2	2	1	-	1	2	-
CO-6	-	-	-	-	-	2	3	2	2	2	2	-	2	2	-

Correlation Levels:

Level	-	1	2	3
Correlation	Nil	Slightly / Low	Moderate / Medium	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

CO No	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO-1	✓	-	-	✓
CO-2	-	✓	-	✓
CO-3	-	✓	-	✓
CO-4	-	✓	-	✓
CO-5	✓	-	-	-
CO-6	✓	-	-	-