CURRICULUM

OF

MS/PhD in Nanoscience and Engineering

School of Chemical and Materials Engineering National University of Sciences and Technology, Islamabad

Courses- MS in Nanoscience and Engineering

Framework
MS in Nanoscience and Engineering

12. List Of Courses

a. Core Courses (Compulsory)

NSE811	Fundamentals of Nanoscience and Engineering	3 CH
MSE 855	Nano Materials and Nano Processing	3 CH
MSE 854	Characterization of Materials	3 CH

b. Nano Elective Courses (Choose any three)

NSE 812	Environmental Nanotechnology	3 CH
NSE 821	Nanofabrication by Self-Assembly	3 CH
NSE 842	Nano Materials for Energy Applications	3 CH
NSE 843	Nano Technology and Photovoltaics	3 CH
NSE 844	Innovation and Entrepreneurship in Nanotechnology	3 CH
NSE 845	Nanolithography and Device Fabrication	3 CH
NSE 846	Introduction to NEMS/MEMS	3 CH
NSE 851	Degradation of Nanomaterials	3 CH

c. University approved MS Courses offered at H-12 campus (Choose any two courses)

XXX	Open Elective 1	3 CH
XXX	Open Elective 2	3 CH

Fundamentals of Nanoscience and Engineering

NSE 811(3 CHs)

Module I: Introduction

1. The course will focus on the core aspects of the physical sciences which are relevant tonanotechnology. The aim of the course is a full understanding of how the dimensions of a nanoscale device impact upon its electronic, optical, magnetic, structural and chemical properties. The course will therefore provide an introduction to key elements of quantum and statistical physics, solid state physics, semiconductor devices, magnetism and superconductivity, basic atomic and molecular physics.

Background

2. SCME is offering MS program in Materials and Surface Engineering since 2006 and now offers the MS in Nanoscience and Engineering.

Rationale

3. Resolve upcoming challenges in the field of Nanoscience &Engineering, with the help of research and its implementation atnanoscale.

Educational Objectives

4. The objective of this course is to give an understanding of the basic concepts of Nanotechnology.

Input Obtained from Industry/Corporate Sector

4. N/A

International Practice

5. a. University of Leeds & Sheffield, UK collaboratively offering following streams in MS Nanotechnology

(1) MSc Nanoscale science and technology

(2) MSc Nanoelectronics and Nanomechanics

(3) MSc Nanomaterials for Nanoengineering

(4) MSc Bionanotechnology

b. Universities offering MS programs in the area of nanotechnology in USA

(1) Arizona State University – Professional Science Master in Nanoscience

(2) Johns Hopkins University – M.S. in Materials Science and Engineering with Nanotechnology

c. North Carolina A&T State Univ. and Univ. of North Carolina Greensboro – M.S. in Nanoscience and M.S. in Nanoengineering

d. Louisiana Tech University – M.S. in Molecular Sciences and Nanotechnology

e. North Dakota State University – M.S. in Materials and Nanotechnology

f. Radiological Technologies University VT (Indiana) – M.S. in Nanomedicine

8. Stevens Institute of Technology – M.Eng. with Nanotechnology Concentration and M.S. with Nanotechnology Concentration

h. University at Albany– M.S. Nanoscale Science and Nanoscale Engineering

j. University of California, San Diego – M.S. Nanoengineering

k. Univeristy of New Mexico – M.S. in Nanoscience and Microsystems

l. University of Pennsylvania – M.S. in Nanotechnology

m. University of Texas at Austin – MSc Engineering Nanomaterials Thrust

n. University of Tulsa,– M.S. with a Specialization in nanotechnology

o. Institute of Nanoscience and Engineering at University of Arkansas, Fayetteville - M.S./PhD. **Proposed Timeframe of Commencement**

6. Specifying semester with year Fall 2013

Course Contents

7. Give details of the course, on the following lines:

a. Course Code: NSE 811 (3CH)

b. Title: Fundamentals of Nanoscience and Engineering

c. Credit Hours: 3CH

d. Objectives: The objective of this course is to give an understanding of the basic concepts in Nanoscience and Engineering.

e. Contents with suggested contact hours: **3 Hours Per Week**

Evolution of Nanotechnology, Sense of Scale: Exponential Vocabulary, Surface Area and Volume Calculations – Nanoscale Implications. Pressure, Density, and Force at Different Scales, The Science behind the Forces at the Nanoscale. Tools of Nanoscience, Phenomena; EM Spectrum; Energy, Waves and Frequency Measurements and Interactions e.g. Optical Microscopes, Surface Tools, Through Tools, Mechanical Measurement Tools. Impacts of a Global Nanotechnology and Public Awareness: Issues and Opportunities. Using Nanoscience to Study the Biological World Nanoparticle Description and Application, Operation of Fluorescing Biological Quantum Dots Biology Meets Chemistry, Physics, and Engineering, A Multidisciplinary Example Applications Using the Tools of Nanoscience to Study the Biological World Micro and Nanofluidic Devices

f. Details of lab work, workshops practice (if applicable). N/A

g. Recommended Reading (including Textbooks and Reference books).

Text Books	1.	Poole Jr., Charles P. and Frank Owens. Introduction to Nanotechnology. Wiley Interscience. 2003. Pages: 386. ISBN: 0-471-07935-9.
	2.	Bhushan, Editor. Handbook of Nanotechnology. Springer. 2004. Edition: First. Pages: 1220. ISBN: 3-540-01218-4.

Faculty

8. List of available faculty with highest qualifications and specialization/ expertise.....

9. Requirement of additional faculty, if applicable (N/A)

Laboratories

10. Requirement of additional/proposed labs, if any, with cost estimates. (N/A)

Approval by DBS/FBS

11. Approval of FBS will be enclosed. (Approved minutes Sheet attached)

Library

12. Number of relevant books held and planned to be inducted, with cost estimates. (Work continue)

Proposed Research Areas/Benefit(s) to the Society

13. Specify with reference to local industry, R&D organizations and private sector demands. (N/A)

Infrastructure

14. Specify requirement of additional infrastructure, if any. (N/A) Extension plan in progress

Miscellaneous

15. Any other aspect which needs to be highlighted in this regard. (N/A)

Environmental Nanotechnology

NSE 812(3 CHs)

Module I: Introduction

1. This course covers the current and potential applications of nanocatalysts, nanodevices, nanosensors in environmental science and engineering; showcasing how nanomaterials can be tailored to address some of the environmental remediation and sensing/detection problems faced today. Areas covered include emission reduction, environmental remediation and monitoring, water and wastewater treatment, energy conversion and storage as well as alternative energy and toxicology. Material will be presented on a level intended for upper-level engineering students.

Background

2. SCME is offering MS program in Materials and Surface Engineering since 2006 and now offers the MS in Nanoscience and Engineering.

Rationale

3. Resolve upcoming challenges in the field of environmental engineering by using nanotechnology and effect of nanotechnology on the environment.

Educational Objectives

4. This course describes the technology, challenges, and applications of nanoscale devices for environmental engineering.

Input Obtained from Industry/Corporate Sector

5. N/A

International Practice

6. a. University of Leeds & Sheffield , UK collaboratively offering following streams in MS Nanotechnology

   (1) MSc Nanoscale science and technology

   (2) MSc Nanoelectronics and Nanomechanics

   (3) MSc Nanomaterials for Nanoengineering

   (4) MSc Bionanotechnology

b. Universities offering MS programs in the area of nanotechnology in USA

(1) Arizona State University – Professional Science Master in Nanoscience

(2) Johns Hopkins University – M.S. in Materials Science and Engineering with Nanotechnology

(3) North Carolina A&T State Univ. and Univ. of North Carolina Greensboro – M.S. in Nanoscience and M.S. in Nanoengineering

(4) Louisiana Tech University – M.S. in Molecular Sciences and Nanotechnology

(5) North Dakota State University – M.S. in Materials and Nanotechnology

(6) Radiological Technologies University VT (Indiana) – M.S. in Nanomedicine

(7) Stevens Institute of Technology – M.Eng. with Nanotechnology Concentration and M.S. with Nanotechnology Concentration

(8) University at Albany– M.S. Nanoscale Science and Nanoscale Engineering

(9) University of California, San Diego – M.S. Nanoengineering

(10) Univeristy of New Mexico – M.S. in Nanoscience and Microsystems

(11) University of Pennsylvania – M.S. in Nanotechnology

(12) University of Texas at Austin – MSc Engineering Nanomaterials Thrust

(13) University of Tulsa,– M.S. with a Specialization in nanotechnology

(14) Institute of Nanoscience and Engineering at University of Arkansas, Fayetteville - M.S./PhD. **Proposed Timeframe of Commencement**

6. Specifying semester with year Fall 2013

Course Contents

7. Give details of the course, on the following lines:

a. Course Code: NSE 811 (3CH)

b. Title: Fundamentals of Nanoscience and Engineering

c. Credit Hours: 3CH

d. Objectives: The objective of this course is to give an understanding of the basic concepts in Nanoscience and Engineering.

f. Contents with suggested contact hours: **3 Hours Per Week**

The course covers the following topics: Review of the molecular basis that determines the properties and applications of nanostructured materials. Overview of the most common tools used to characterize nanostructures. Description of selected functional nanostructured materials, their structure and properties. Presentation of a global perspective on how nanotechnology can address current environmental issues Overview of selected areas in which nanotechnology is already used to target specific environmental problems. Identification of target areas in which nanostructured materials can offer an adequate solution to existing environmental challenges. Analysis of the impact of nanotechnology-based solutions in a global and societal context, as related to environmental issues. Recognition of the consequences of indiscriminate release of nanomaterials in the environment.

g. Details of lab work, workshops practice (if applicable). N/A

h. Recommended Reading (including Textbooks and Reference books).

Text Books	1. Huber, J. "New Technologies and Environmental Innovation" Edward Elgar Pub. 2004. 2. Hee. S. J.; Cheng, I. F."Nanotechnology for Environmental Remediation" Springer 2006. 3. Theodore, L.; Kunz, R. "Nanotechnology: Environmental Implications and solutions" Wiley, 2005
	4. Hornyak, G. et al "Introduction to Nanoscience and Nanotechnology" CRC Press 2009.

Faculty

8. List of available faculty with highest qualifications and specialization/ expertise…….

9. Requirement of additional faculty, if applicable (N/A)

Laboratories

10. Requirement of additional/proposed labs, if any, with cost estimates. (N/A)

Approval by DBS/FBS

11. Approval of FBS will be enclosed. (Approved minutes Sheet attached)

Library

12. Number of relevant books held and planned to be inducted, with cost estimates. (Work continue)

Proposed Research Areas/Benefit(s) to the Society

13. Specify with reference to local industry, R&D organizations and private sector demands. (N/A)

Infrastructure

14. Specify requirement of additional infrastructure, if any. (N/A) Extension plan in progress

Miscellaneous

15. Any other aspect which needs to be highlighted in this regard. (N/A)

Nano Fabrication by Self Assembly

NSE 821(3 CHs)

Module I: Introduction

1. Molecular self-assembly is a strategy for nanofabrication that involves designing molecules and supramolecular entities so that shape-complementarity causes them to aggregate into desired structures. Self-assembly has a number of advantages as a strategy, This course will describe these advantages and techniques used in self-assembly for nano fabrication.

Background

2. SCME is offering MS program in Materials and Surface Engineering since 2006 and now offers the MS in Nanoscience and Engineering.

Rationale

3. Resolve upcoming challenges in the field of Nanoscience &Engineering, with the help of research and its implementation atnanoscale.

Educational Objectives

4. The objective of this course is to give an understanding of the principles and techniques of self-assembly.

Input Obtained from Industry/Corporate Sector

5. N/A

International Practice

6. a. University of Leeds & Sheffield, UK collaboratively offering following streams in MS Nanotechnology

   (1) MSc Nanoscale science and technology

   (2) MSc Nanoelectronics and Nanomechanics

   (3) MSc Nanomaterials for Nanoengineering

   (4) MSc Bionanotechnology

   b. Universities offering MS programs in the area of nanotechnology in USA

(1) Arizona State University – Professional Science Master in Nanoscience

(2) Johns Hopkins University – M.S. in Materials Science and Engineering with Nanotechnology

(3) North Carolina A&T State Univ. and Univ. of North Carolina Greensboro – M.S. in Nanoscience and M.S. in Nanoengineering

(4) Louisiana Tech University – M.S. in Molecular Sciences and Nanotechnology

(5) North Dakota State University – M.S. in Materials and Nanotechnology

(6) Radiological Technologies University VT (Indiana) – M.S. in Nanomedicine

(7) Stevens Institute of Technology – M.Eng. with Nanotechnology Concentration and M.S. with Nanotechnology Concentration

(8) University at Albany– M.S. Nanoscale Science and Nanoscale Engineering

(9) University of California, San Diego – M.S. Nanoengineering

(10) Univeristy of New Mexico – M.S. in Nanoscience and Microsystems

(11) University of Pennsylvania – M.S. in Nanotechnology

(12) University of Texas at Austin – MSc Engineering Nanomaterials Thrust

(13) University of Tulsa,– M.S. with a Specialization in nanotechnology

(14) Institute of Nanoscience and Engineering at University of Arkansas, Fayetteville - M.S./PhD. **Proposed Timeframe of Commencement**

6. Specifying semester with year Fall 2013

Course Contents

7. Give details of the course, on the following lines:

   a. Course Code: NSE 821 (3CH)

   b. Title: Nano Fabrication by Self Assembly

   c. Credit Hours: 3CH

   d. Objectives: The objective of this course is to give an understanding of the principles and techniques of Self Assembly.

   e. Contents with suggested contact hours: **3 Hours Per Week**

      Molecular self-assembly, Nanofabrication by designing molecules and supramolecular entities, Advantages of Self-assembly, atomic-level modification of structure by synthetic chemistry. Examples in biology for self-assembly for the development of complex, functional structures, Incorporation of biological structures as final systems, thermodynamically most stable defect-free and self-healing structures. Function in self-assembled aggregates based on organic compounds such electrical insulators, Self-assembled monolayers (SAMs) with tailorable functions e.g., interfacial free energies. Microcontact printing (uCP).Principles and techniques for self-assembly of films and structures on the nanometer scale. Macromolecules, biological membranes, protein multilayers, Langmuir-Blodgett, thiol, silane and layer-by-layer self-assembly techniques, nanocapsules, bio/nanoreactors, fullerenes and nanotubules, fluorescent nanosensors, electrochemical polymerizations deposition.

   f. Details of lab work, workshops practice (if applicable). N/A

   g. Recommended Reading (including Textbooks and Reference books).

Text Books	3.	*Fabrication of Submicron Features on Curved Surfaces by Microcontact Printing* Jackman, R.; Wilbur, J.; Whitesides, G.M., Science, 1995, 269, 664-666.
	4.	*Patterned SAMs and Meso-Scale Phenomena* Kumar, A.; Abbott, N.A.; Kim.E.; Biebuyck, H.A.; Whitesides, G.M., Acc. Chem. Res. 1995, 28, 219-226.
	5.	*The Use of Minimal Free Energy and Self-Assembly to Form Shapes*, Kim, E.; Whitesides, G.M., Chem. Mat. 1995, 7, 1257-126
	6.	*Making Polymeric Microstuctures: Capillary Micromolding* Kim, E.; Xia, Y.; Whitesides, G.M., Nature, 1995, 376, 581-

Faculty

8. List of available faculty with highest qualifications and specialization/ expertise……..

9. Requirement of additional faculty, if applicable (N/A)

Laboratories

10. Requirement of additional/proposed labs, if any, with cost estimates. (N/A)

Approval by DBS/FBS

11. Approval of FBS will be enclosed. (Approved minutes Sheet attached)

Library

12. Number of relevant books held and planned to be inducted, with cost estimates. (Work continue)

Proposed Research Areas/Benefit(s) to the Society

13. Specify with reference to local industry, R&D organizations and private sector demands. (N/A)

Infrastructure

14. Specify requirement of additional infrastructure, if any. (N/A) Extension plan in progress

Miscellaneous

15. Any other aspect which needs to be highlighted in this regard. (N/A)

Nano Materials for Energy Applications

NSE 842(3CH)

Module I: Introduction

1. The development of sustainable energy systems is among the most pivotal challenges of the 21st century. Nanotechnology potentially provides paradigm-changing solutions to problems related to energy technology, because energy conversion processes of practical relevance occur at interfaces and surfaces, which are abundant in nanostructured materials. These materials properties can be specifically adapted and combined to produce highly potent, customized, multi-functional materials for intelligent conversion, storage, and 'consumption' of energy.

Background

2. SCME is offering MS program in Materials and Surface Engineering since 2006 and now offers the MS in Nanoscience and Engineering.

Rationale

3. The development of sustainable energy sources using nanostructured materials is an important area of research. Use of nanotechnology for producing materials with efficient conversion, storage and consumption of energy is excessively sought currently.

Educational Objectives

4. The objective of this course is to give an understanding about the broad scope of nanomaterials for energy production, via fuel cells and nanostructured materials for fuel production, supercapacitors and for climate change.

Input Obtained from Industry/Corporate Sector

5. N/A

International Practice

6. a University of Leeds &Sheffield , UK collaboratively offering following streams in MS Nanotechnology

(1) MSc Nanoscale science and technology

(2) MSc Nanoelectronics and Nanomechanics

(3) MSc Nanomaterials for Nanoengineering

(4) MSc Bionanotechnology

b. Universities offering MS programs in the area of nanotechnology in USA

(1) Arizona State University – Professional Science Master in Nanoscience

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(3) North Carolina A&T State Univ. and Univ. of North Carolina Greensboro – M.S. in Nanoscience and M.S. in Nanoengineering

(4) Louisiana Tech University – M.S. in Molecular Sciences and Nanotechnology

(5) North Dakota State University – M.S. in Materials and Nanotechnology

(6) Radiological Technologies University VT (Indiana) – M.S. in Nanomedicine

(7) Stevens Institute of Technology – M.Eng. with Nanotechnology Concentration and M.S. with Nanotechnology Concentration

(8) University at Albany– M.S. Nanoscale Science and Nanoscale Engineering

(9) University of California, San Diego – M.S. Nanoengineering

(10) Univeristy of New Mexico – M.S. in Nanoscience and Microsystems

(11) University of Pennsylvania – M.S. in Nanotechnology

(12) University of Texas at Austin – MSc Engineering Nanomaterials Thrust

(13) University of Tulsa,– M.S. with a Specialization in nanotechnology

(14) Institute of Nanoscience and Engineering at University of Arkansas, Fayetteville - M.S./PhD. **Proposed Timeframe of Commencement**

6. Specifying semester with year Fall 2013

Course Contents

7. Give details of the course, on the following lines:

a. Course Code: NSE 842 (3CH)

b. Title: Nano Materials for Energy Applications

c. Credit Hours: 3CH

d. Objectives: Nanomaterials for energy production, via fuel cells and nanostructured materials for fuel production,supercapacitors and for climate change are introduced.

e. Contents with suggested contact hours: **3 Hours Per Week**

Nanomaterials for Energy Conversion: Light and Electricity, Light Emitting Diodes and Carrier Multiplication: Giant Nanocrystal Quantum Dots for Light-Emission Applications, Multiple Exciton GenerationNanomaterials for Energy-Conversion: Electrochemical Energy Conversion and StorageElectrical Transport in Nanostructured Materials; Mesoscopic Transport, Nanoionics: Size Effects on Ion Conduction and Storage, Electronic Properties of Semiconductor Nanostructures Nanomaterials for Conversion of Chemical Energy; Nanostructured Catalysts for Conversion of Chemical Energy, Artificial Photosynthesis Nanomaterials for Photovoltaics and Solar Cells; Photoelectrochemistry, Nanostructures for Photovoltaics and Solar Energy Conversion, Nanostructured Solar CellsCharge Carriers in Doped Nanomaterials; Material design of p-type oxide semiconductors,

Theoretical aspects of doping nanocrystals, A bottom-up approach for nanostructured thermoelectrics: From nanopowder to devices, Nanocomposites for Thermoelectrics, Nanostructured Thermoelectrics

f. Details of lab work, workshops practice (if applicable). N/A

g. Recommended Reading (including Textbooks and Reference books).

Text Books	7.	Nanomaterials for Energy Storage Applications Edited by Hari Singh Nalwa by American Scientific Publishers 2009 ISBN: 1-58883-120-5
	8.	Nanotechnology for the Energy Challenge, edited by Javier Garcia-Martinez, John Wiley & Sons2010 440 pages
	9.	Nanotechnology for Electronics, Photonics, and Renewable Energy, AnatoliKorkin, Springer2010, 272 pages
	10.	Chen, Gang. Nanoscale Energy Transport and Conversion: A Parallel Treatment of Electrons, Molecules, Phonons, and Photons. Oxford University Press, 2005. ISBN: 9780195159424.

Faculty

8. List of available faculty with highest qualifications and specialization/expertise……...

9. Requirement of additional faculty, if applicable (N/A)

Laboratories

10. Requirement of additional/proposed labs, if any, with cost estimates. (N/A)

Approval by DBS/FBS

11. Approval of FBS will be enclosed. (Approved minutes Sheet attached)

Library

12. Number of relevant books held and planned to be inducted, with cost estimates. (Work continue)

Proposed Research Areas/Benefit(s) to the Society

13. Specify with reference to local industry, R&D organizations and private sector demands. (N/A)

Infrastructure

14. Specify requirement of additional infrastructure, if any. (N/A) Extension plan in progress

Miscellaneous

15. Any other aspect which needs to be highlighted in this regard. (N/A)

NanoTechnology and Photovoltaics

NSE 843(3 CHs)

Module I: Introduction

1. There's only one source of renewable energy that can provide all of the world's needs and that's the Sun. In fact, enough sunlight falls on the Earth's surface in just a couple of hours each day to meet the whole world's energy needs for one year. The question is: how can we effectively and economically harness this solar energy, without mass-producing very expensive conventional solar cells, which would ultimately require vast tracts of land in order to do their job? Nanotechnology could provide the answer in the form of a new kind of solar cells, one which would be relatively inexpensive to manufacture and highly flexible in design.

Background

1. SCME is offering MS program in Materials and Surface Engineering since 2006 and now offers the MS in Nanoscience and Engineering.

Rationale

2. Use of Nanotechnology promises to solve energy problem by inventing new technologies using nanostructures.

Educational Objectives

3. The objective of this course is to give idea about the new and current techniques based on nanoscience for harnessing the solar energy by converting it to electrical energy.

Input Obtained from Industry/Corporate Sector

4. N/A

International Practice

5. a. University of Leeds &Sheffield , UK collaboratively offering following streams in MS Nanotechnology

(1) MSc Nanoscale science and technology

(2) MSc Nanoelectronics and Nanomechanics

(3) MSc Nanomaterials for Nanoengineering

(4) MSc Bionanotechnology

b. Universities offering MS programs in the area of nanotechnology in USA

(1) Arizona State University – Professional Science Master in Nanoscience

(2) Johns Hopkins University – M.S. in Materials Science and Engineering with Nanotechnology

(3) North Carolina A&T State Univ. and Univ. of North Carolina Greensboro – M.S. in Nanoscience and M.S. in Nanoengineering

(4) Louisiana Tech University – M.S. in Molecular Sciences and Nanotechnology

(5) North Dakota State University – M.S. in Materials and Nanotechnology

(6) Radiological Technologies University VT (Indiana) – M.S. in Nanomedicine

(7) Stevens Institute of Technology – M.Eng. with Nanotechnology Concentration and M.S. with Nanotechnology Concentration

(8) University at Albany– M.S. Nanoscale Science and Nanoscale Engineering

(9) University of California, San Diego – M.S. Nanoengineering

(10) Univeristy of New Mexico – M.S. in Nanoscience and Microsystems

(11) University of Pennsylvania – M.S. in Nanotechnology

(12) University of Texas at Austin – MSc Engineering Nanomaterials Thrust

(13) University of Tulsa,– M.S. with a Specialization in nanotechnology

(14) Institute of Nanoscience and Engineering at University of Arkansas, Fayetteville - M.S./PhD. **Proposed Timeframe of Commencement**

6. Specifying semester with year Fall 2013

Course Contents

7. Give details of the course, on the following lines:

a. Course Code: NSE 843 (3CH)

b. Title: Nanotechnology and Photovoltaics

c. Credit Hours: 3CH

d. Objectives: The objective of this course is to give idea about the new and current techniques based on nanoscience for harnessing the solar energy by converting it to electrical energy

f. Contents with suggested contact hours: **3 Hours Per Week**

Introduction to Photovoltaic Physics, Applications, and Technologies. Optical

Properties of Nanostructures, Photovoltaic Device Physics on the Nanoscale, Nanostructured Organic Solar Cells Recent Progress in Quantum Well Solar Cells, Nanowire- and Nanotube-Based Solar Cells, Semiconductor Nanowires: Contacts and Electronic Properties. Quantum Dot Solar Cells, Luminescent Solar Concentrators, Nanoparticles for Solar Spectrum Conversion, Nanoplasmonics for Photovoltaic Applications. Future Manufacturing Methods for Nanostructured Photovoltaic Devices.

g. Details of lab work, workshops practice (if applicable). N/A

h. Recommended Reading (including Textbooks and Reference books).

Text Books	11.	Nanotechnology for Photovoltaics: A State-of-the-Art Overview 430 pages. By LuocasTsakalakos CRC Press 2010
	12.	Nanomaterials for Energy Storage ApplicationsEdited by Hari Singh Nalwa, American Scientific Publishers 2009 ISBN: 1-58883-120-5

Faculty

8. List of available faculty with highest qualifications and specialization/ expertise……..

9. Requirement of additional faculty, if applicable (N/A)

Laboratories

10. Requirement of additional/proposed labs, if any, with cost estimates. (N/A)

Approval by DBS/FBS

11. Approval of FBS will be enclosed. (Approved minutes Sheet attached)

Library

12. Number of relevant books held and planned to be inducted, with cost estimates. (Work continue)

Proposed Research Areas/Benefit(s) to the Society

13. Specify with reference to local industry, R&D organizations and private sector demands. (N/A)

Infrastructure

14. Specify requirement of additional infrastructure, if any. (N/A) Extension plan in progress

Miscellaneous

15. Any other aspect which needs to be highlighted in this regard. (N/A)

Innovation and Entrepreneurship in Nanotechnology

NSE 844(3 CHs)

Module I: Introduction

1. This course will cover the key issues related to the effective identification, acquisition, development and exploitation of nanotechnology in a commercial environment. Nanotechnology potentially affects very large parts of the product delivery supply-chain and therefore requires a greater degree of understanding and integration of the supply and customer base to extract maximum benefit.

Background

2. SCME is offering MS program in Materials and Surface Engineering since 2006 and now offers the MS in Nanoscience and Engineering.

Rationale

3. An effective identification, acquisition, development and exploitation of nanotechnology in a commercial environment.

Educational Objectives

4. Students will be made to comprehend that nanotechnology potentially affects very large parts of the product delivery supply-chain and therefore requires a greater degree of understanding and integration of the supply and customer base to extract maximum benefit.

Input Obtained from Industry/Corporate Sector

5. N/A

International Practice

6. a. University of Leeds & Sheffield, UK collaboratively offering following streams in MS Nanotechnology

(5) MSc Nanoscale science and technology

(6) MSc Nanoelectronics and Nanomechanics

(7) MSc Nanomaterials for Nanoengineering

(8) MSc Bionanotechnology

b. Universities offering MS programs in the area of nanotechnology in USA

(1) Arizona State University – Professional Science Master in Nanoscience

(2) Johns Hopkins University – M.S. in Materials Science and Engineering with Nanotechnology

(3) North Carolina A&T State Univ. and Univ. of North Carolina Greensboro – M.S. in Nanoscience and M.S. in Nanoengineering

(4) Louisiana Tech University – M.S. in Molecular Sciences and Nanotechnology

(5) North Dakota State University – M.S. in Materials and Nanotechnology

(6) Radiological Technologies University VT (Indiana) – M.S. in Nanomedicine

(7) Stevens Institute of Technology – M.Eng. with Nanotechnology Concentration and M.S. with Nanotechnology Concentration

(8) University at Albany– M.S. Nanoscale Science and Nanoscale Engineering

(9) University of California, San Diego – M.S. Nanoengineering

(10) Univeristy of New Mexico – M.S. in Nanoscience and Microsystems

(11) University of Pennsylvania – M.S. in Nanotechnology

(12) University of Texas at Austin – MSc Engineering Nanomaterials Thrust

(13) University of Tulsa,– M.S. with a Specialization in nanotechnology

(14) Institute of Nanoscience and Engineering at University of Arkansas, Fayetteville - M.S./PhD.

Proposed Timeframe of Commencement

6. Specifying semester with year Fall 2013

Course Contents

7. Give details of the course, on the following lines:

a. Course Code: NSE 844 (3CH)

b. Title: Innovation and Entrepreneurship in Nanotechnology

c. Credit Hours: 3CH

d. Objectives: The objective of this course is to give an understanding nanotechnology potentially affects very large parts of the product delivery supply-chain and therefore requires a greater degree of understanding and integration of the supply and customer base to extract maximum benefit.

f. Contents with suggested contact hours: **3 Hours Per Week**

Innovation for sustainability, social entrepreneurship, innovation for development, and creating and capturing value from innovation and entrepreneurship. Process model of entrepreneurship with clearer links between innovation and entrepreneurship. Training in the commercial aspects of high-technology management is found lacking in a number of areas, when applied to such a new technology. Nanotechnology is differentiated from the major technological booms of the past in IT and biotechnology by its far more interdisciplinary nature and its broader sphere of impact.

g. Details of lab work, workshops practice (if applicable). N/A

h. Recommended Reading (including Textbooks and Reference books).

Text Books	13. The Impacts of Nanotechnology on Companies Policy Insights from Case Studies OECD Publishing 2010
	14. Nanotechnology: Importance and Applications by M.H. Fulekar, I. K. International Pvt Ltd, 2010,282 pages

Faculty

8. List of available faculty with highest qualifications and specialization/ expertise……..

9. Requirement of additional faculty, if applicable (N/A)

Laboratories

10. Requirement of additional/proposed labs, if any, with cost estimates. (N/A)

Approval by DBS/FBS

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Library

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Proposed Research Areas/Benefit(s) to the Society

13. Specify with reference to local industry, R&D organizations and private sector demands. (N/A)

Infrastructure

14. Specify requirement of additional infrastructure, if any. (N/A) Extension plan in progress

Miscellaneous

15. Any other aspect which needs to be highlighted in this regard. (N/A)

Nanofabrication: Principles, Capabilities and Limits

NSE 845 (3CH)

Module I: Introduction

1. Nanofabrication: Principles, Capabilities and Limits presents a one-stop description at the introductory level on most technologies that have been developed which are capable of making structures below 100nm. Principles of each technology are introduced and illustrated with minimum mathematics involved. The capabilities of each technology in making sub-100nm structures are described. The limits of preventing a technology from further going down the dimensional scale are analyzed.

Background

1. SCME is offering MS program in Materials and Surface Engineering since 2006 and now offers the MS in Nanoscience and Engineering.

Rationale

2. Resolve upcoming challenges in the field of Nanoscience &Engineering, with the help of research and its implementation at nanoscale.

Educational Objectives

3. The objective of this course is to give an understanding of the basic concepts of Nanotechnology.

Input Obtained from Industry/Corporate Sector

4. N/A

International Practice

5. a. University of Leeds & Sheffield, UK collaboratively offering following streams in MS Nanotechnology

(1) MSc Nanoscale science and technology

(2) MSc Nanoelectronics and Nanomechanics

(3) MSc Nanomaterials for Nanoengineering

(4) MSc Bionanotechnology

b. Universities offering MS programs in the area of nanotechnology in USA

(1) Arizona State University – Professional Science Master in Nanoscience

(2) Johns Hopkins University – M.S. in Materials Science and Engineering with Nanotechnology

(3) North Carolina A&T State Univ. and Univ. of North Carolina Greensboro – M.S. in Nanoscience and M.S. in Nanoengineering

(4) Louisiana Tech University – M.S. in Molecular Sciences and Nanotechnology

(5) North Dakota State University – M.S. in Materials and Nanotechnology

(6) Radiological Technologies University VT (Indiana) – M.S. in Nanomedicine

(7) Stevens Institute of Technology – M.Eng. with Nanotechnology Concentration and M.S. with Nanotechnology Concentration

(8) University at Albany– M.S. Nanoscale Science and Nanoscale Engineering

(9) University of California, San Diego – M.S. Nanoengineering

(10) University of New Mexico – M.S. in Nanoscience and Microsystems

(11) University of Pennsylvania – M.S. in Nanotechnology

(12) University of Texas at Austin – MSc Engineering Nanomaterials Thrust

(13) University of Tulsa,– M.S. with a Specialization in nanotechnology

(14) Institute of Nanoscience and Engineering at University of Arkansas, Fayetteville - M.S./PhD. **Proposed Timeframe of Commencement**

6. Specifying semester with year Fall 2013

Course Contents

7. Give details of the course, on the following lines:

a. Course Code: NSE 811 (3CH)

b. Title: Fundamentals of Nanoscience and Engineering

c. Credit Hours: 3CH

d. Objectives: The objective of this course is to give an understanding of the basic concepts in Nanoscience and Engineering.

f. Contents with suggested contact hours: **3 Hours Per Week**

Evolution of Nanotechnology, Sense of Scale: Exponential Vocabulary, Surface Area and Volume Calculations – Nanoscale Implications. Pressure, Density, and Force at Different Scales, The Science behind the Forces at the Nanoscale. Tools of Nanoscience, Phenomena; EM Spectrum; Energy, Waves and Frequency Measurements and Interactions e.g. Optical Microscopes, Surface Tools, Through Tools, Mechanical Measurement Tools. Impacts of a Global Nanotechnology and Public Awareness: Issues and Opportunities. Using Nanoscience to Study the Biological World Nanoparticle Description and Application, Operation of Fluorescing Biological Quantum Dots Biology Meets Chemistry, Physics, and Engineering, A Multidisciplinary Example Applications Using the Tools of Nanoscience to Study the Biological World Micro and Nanofluidic Devices.

g. Details of lab work, workshops practice (if applicable). N/A

h. Recommended Reading (including Textbooks and Reference books).

Text Books	15.	Nanofabrication: Principles, Capabilities and Limits, Zheng Cui, Springer 2008, 343 pages
	16.	Bhushan, Editor. Handbook of Nanotechnology. Springer. 2004. Edition: First. Pages: 1220. ISBN: 3-540-01218-4.

Faculty

8. List of available faculty with highest qualifications and specialization/ expertise……..

9. Requirement of additional faculty, if applicable (N/A)

Laboratories

10. Requirement of additional/proposed labs, if any, with cost estimates. (N/A)

Approval by DBS/FBS

11. Approval of FBS will be enclosed. (Approved minutes Sheet attached)

Library

12. Number of relevant books held and planned to be inducted, with cost estimates. (Work continue)

Proposed Research Areas/Benefit(s) to the Society

13. Specify with reference to local industry, R&D organizations and private sector demands. (N/A)

Infrastructure

14. Specify requirement of additional infrastructure, if any. (N/A) Extension plan in progress

Miscellaneous

15. Any other aspect which needs to be highlighted in this regard. (N/A)

Introduction to NEMS/MEMS

NSE 846(3 CHs)

Module I: Introduction

1. The course will focus on the core aspects of miniaturization, batch fabrication, and integrated electronics. The techniques rapidly enable the development of a broad range of smart products, MEMs (Micro Electro Mechanical Systems)and NEMS(Nano Electro Mechanical Systems) are creating enormous opportunities for commerce and functionality.

Background

2. SCME is offering MS program in Materials and Surface Engineering since 2006 and now offers the MS in Nanoscience and Engineering.

Rationale

3. The many applications of MEMS/NEMS technology include computer devices, electronics, instrumentation, industrial process control, biotechnology, medicine, chemical systems, office equipment, and communications.

Educational Objectives

4. The objective of this course is to give an understanding of the basic concepts of MEMs and NEMS.

Input Obtained from Industry/Corporate Sector

5. N/A

International Practice

6. a. University of Leeds & Sheffield, UK collaboratively offering following streams in MS Nanotechnology:

(1) MSc Nanoscale science and technology

(2) MSc Nanoelectronics and Nanomechanics

(3) MSc Nanomaterials for Nanoengineering

(4) MSc Bionanotechnology

b. Universities offering MS programs in the area of nanotechnology in USA

(1) Arizona State University – Professional Science Master in Nanoscience

(2) Johns Hopkins University – M.S. in Materials Science and Engineering with Nanotechnology

(3) North Carolina A&T State Univ. and Univ. of North Carolina Greensboro – M.S. in Nanoscience and M.S. in Nanoengineering

(4) Louisiana Tech University – M.S. in Molecular Sciences and Nanotechnology

(5) North Dakota State University – M.S. in Materials and Nanotechnology

(6) Radiological Technologies University VT (Indiana) – M.S. in Nanomedicine

(7) Stevens Institute of Technology – M.Eng. with Nanotechnology Concentration and M.S. with Nanotechnology Concentration

(8) University at Albany– M.S. Nanoscale Science and Nanoscale Engineering

(9) University of California, San Diego – M.S. Nanoengineering

(10) University of New Mexico – M.S. in Nanoscience and Microsystems

(11) University of Pennsylvania – M.S. in Nanotechnology

(12) University of Texas at Austin – MSc Engineering Nanomaterials Thrust

(13) University of Tulsa,– M.S. with a Specialization in nanotechnology

(14) Institute of Nanoscience and Engineering at University of Arkansas, Fayetteville - M.S./PhD. **Proposed Timeframe of Commencement**

7. Specifying semester with year Fall 2013

Course Contents

8. Give details of the course, on the following lines:

a. Course Code: NSE 846 (3CH)

b. Title: Fundamentals of Nanoscience and Engineering

c. Credit Hours: 3CH

d. Objectives: The objective of this course is to give an understanding of the basic concepts of MEMs and NEMS.

f. Contents with suggested contact hours: **3 Hours Per Week**

Introduction to MEMS and NEMS technologies: MEMS/NEMS applications and key commercial success stories (accelerometers, gyroscopes, digital light projectors, resonators). Review of micromachining techniques and MEMS/NEMS fabrication approaches. Actuation methods in MEMS and NEMS, MEMS/NEMS design and modeling.Examples of MEMS/NEMS components from industry and academia. Case studies: MEMS inertial sensors, microscale mirrors, micro and nano resonators, micro and nano switches, MEMS/NEMS chem/bio sensors, MEMS gyroscopes, MEMS microphones.

g. Details of lab work, workshops practice (if applicable). N/A

h. Recommended Reading (including Textbooks and Reference books).

Text Books	17.	MEMS and NEMS: Systems, Devices, and Structures, Sergey Edward Lyshevski– 2002
	18.	MEMS/NEMS: Handbook Techniques and Applications, Cornelius T. Leondes, Springer 2006, 2141 pages
	19.	Fundamentals of Microfabrication and Nanotechnology: From MEMS to Bio-MEMS and Bio-Nems : manufacturing techniques and applications.Marc J. Madou, CRC Press, 2011

	650 pages

Faculty

9. List of available faculty with highest qualifications and specialization/ expertise……..

10. Requirement of additional faculty, if applicable (N/A)

Laboratories

11. Requirement of additional/proposed labs, if any, with cost estimates. (N/A)

Approval by DBS/FBS

12. Approval of FBS will be enclosed. (Approved minutes Sheet attached)

Library

13. Number of relevant books held and planned to be inducted, with cost estimates. (Work continue)

Proposed Research Areas/Benefit(s) to the Society

14. Specify with reference to local industry, R&D organizations and private sector demands. (N/A)

Infrastructure

15. Specify requirement of additional infrastructure, if any. (N/A) Extension plan in progress

Miscellaneous

16. Any other aspect which needs to be highlighted in this regard. (N/A)

Degradation of Nanomaterials

NSE 851

Module I: Introduction

1. Corrosion and degradation of nano engineering materials is an essential area of Nanoscience & technology as the degradation starts at nano-level originating from the development of nano-scale electrochemical cells. The study at nano-level helps to understand the mechanisms behind the phenomena as well as facilitates in estimating their lives.

Background

1. SCME is offering MS program in Materials and Surface Engineering since 2006 and now offers the MS in Nanoscience and Engineering.

Rationale

2. Resolve upcoming challenges in the field of Nanoscience &Engineering, with the help of research and its implementation atnanoscale.

Educational Objectives

3. The objective of this course is to give an understanding of the basic concepts of Degradation of nanomaterials.

Input Obtained from Industry/Corporate Sector

4. N/A

International Practice

5. a. University of Leeds & Sheffield, UK collaboratively offering following streams in MS Nanotechnology

   (1) MSc Nanoscale science and technology

   (2) MSc Nanoelectronics and Nanomechanics

   (3) MSc Nanomaterials for Nanoengineering

   (4) MSc Bionanotechnology

   b. Universities offering MS programs in the area of nanotechnology in USA

(1) Arizona State University – Professional Science Master in Nanoscience

(2) Johns Hopkins University – M.S. in Materials Science and Engineering with Nanotechnology

(3) North Carolina A&T State Univ. and Univ. of North Carolina Greensboro – M.S. in Nanoscience and M.S. in Nanoengineering

(4) Louisiana Tech University – M.S. in Molecular Sciences and Nanotechnology

(5) North Dakota State University – M.S. in Materials and Nanotechnology

(6) Radiological Technologies University VT (Indiana) – M.S. in Nanomedicine

(7) Stevens Institute of Technology – M.Eng. with Nanotechnology Concentration and M.S. with Nanotechnology Concentration

(8) University at Albany– M.S. Nanoscale Science and Nanoscale Engineering

(9) University of California, San Diego – M.S. Nanoengineering

(10) Univeristy of New Mexico – M.S. in Nanoscience and Microsystems

(11) University of Pennsylvania – M.S. in Nanotechnology

(12) University of Texas at Austin – MSc Engineering Nanomaterials Thrust

(13) University of Tulsa,– M.S. with a Specialization in nanotechnology

(14) Institute of Nanoscience and Engineering at University of Arkansas, Fayetteville - M.S./PhD. **Proposed Timeframe of Commencement**

6. Specifying semester with year Fall 2013

Course Contents

7. Give details of the course, on the following lines:

a. Course Code: NSE 851 (3CH)

b. Title: Degradation of Nanomaterials

c. Credit Hours: 3CH

d. Objectives: The objective of this course is to give an understanding of the basic concepts of Degradation of nanomaterials.

f. Contents with suggested contact hours: **3 Hours Per Week**

Degradation & Corrosion, Definition & mechanisms, Types of corrosion, Corrosion fundamentals and electrochemical aspects, Enabling theory of corrosion, Polarization and double layer phenomenon, Passivity and its breakdown, Electrochemical DC corrosion testing, E-log i diagrams, 3-electrode system and Linear polarization method, Corrosion at nano scale, Effect of microstructure in metals and alloys, Degradation in polymers, Humidity and UV protection, nano changes in structure of polymers, Effect of temperature on degradation of polymers, Degradation in ceramics & glasses, Amorphousness and crystallinity in glasses, Protection methods, Protection by Nano-inhibitors, Types of inhibitors, Use of eco-friendly nano-inhibitors, Cathodic protection in alloys, Degradation in biomaterials and their protection.

g. Details of lab work, workshops practice (if applicable). N/A

h. Recommended Reading (including Textbooks and Reference books).

Text Books	20.	Corrosion of Glass, Ceramics and Ceramic Superconductors, Principles, Testing, Characterization and Applications, David E. Clark and Bruce K. Zoitos, 1992.
	21.	Handbook of corrosion engineering, P R Roberge, 2000.
	22.	Electrochemical techniques in corrosion, Kelly et al, 2002.
	23.	Corrosion prevention and protection practical solutions, Sastrai et

	al, 2007.Bhushan, Editor. Handbook of Nanotechnology. Springer. 2004. Edition: First. Pages: 1220. ISBN: 3-540-01218-4.

Faculty

8. List of available faculty with highest qualifications and specialization/ expertise……..

9. Requirement of additional faculty, if applicable (N/A)

Laboratories

10. Requirement of additional/proposed labs, if any, with cost estimates. (N/A)

Approval by DBS/FBS

11. Approval of FBS will be enclosed. (Approved minutes Sheet attached)

Library

12. Number of relevant books held and planned to be inducted, with cost estimates. (Work continue)

Proposed Research Areas/Benefit(s) to the Society

13. Specify with reference to local industry, R&D organizations and private sector demands. (N/A)

Infrastructure

14. Specify requirement of additional infrastructure, if any. (N/A) Extension plan in progress

Miscellaneous

15. Any other aspect which needs to be highlighted in this regard. (N/A)

Courses- PhD in Nanoscience and Engineering

Detail Curriculum

NSE-901
Advanced Concepts in Nanoscience and Engineering
Credit Hours: 3

Prerequisites: Nil

Course Objectives:

- The course will focus on advanced aspects of nanotechnology.

Course Contents:

- Impact of dimensions at nanoscale on electronic, optical, magnetic, structural and chemical properties of a particular material.
- Introduction to key elements of quantum and statistical physics for nanomaterials.
- Chemical routes for obtaining 0, 1 and 2 D nanomaterials.
- Physical techniques employed to obtain various type of nanomaterials.
- Introduction of characterization techniques for studying properties of materials at nanoscale.
- Highlights exciting developments, challenges and opportunities in nanotechnology.

Course Outcomes:

The objective of this course is to give an understanding of the advanced concepts of Nanotechnology. The course will therefore provide an introduction to key elements of quantum and statistical physics for nanomaterials and brief overview of the synthesis/fabrication and characterization tools used in nanotechnology.

Recommended Books:

- Nanoscience and Nanotechnology in Engineering, Vijay K. Varadan, A. Sivathanu Pillai and Debashish Mukherji, World Scientific Publishing Company 2010
- Selected Topics in Nanoscience and Nanotechnology, Andrew T. S. Wee, World Scientific Publishing Company, 2009.
- Molecular Chemistry of Sol-Gel Derived Nanomaterials, Robert Corriu and Nguyeˆn Trong Anh, John Wiley & Sons, Ltd. 2009.
- Aligned Carbon Nanotubes: Physics, Concepts, Fabrication and Devices, Zhifeng Ren, Yucheng Lan, Yang Wang (auth.), Springer Berlin Heidelberg, 2013.
- Textbook of Nanoscience and Nanotechnology, Murty, B.S., Shankar, P., Raj, B., Rath, B.B., Murday, J.Co-publication with Universities Press (India) Pvt. Ltd. 2013
- Characterization of Materials 2nd Edition by Elton N. Kaufmann of Argonne National Laboratory, Argonne, Illinois, John Wiley and Sons, Inc. 1999-2014.

NSE-921
Selected Topics in Nanotechnology
Credit Hours: 3

Prerequisites: Nil

Course Objectives:

- To provide and understanding on selected state of the art concepts/techniques/processes/tools/applications related to nanoscience and engineering

Course Contents:

- Nano drug delivery and bio nanoimaging
- Synthesis, functionalization and bio-medical applications of Gold, Titania, Zinc Oxide and related nanomaterials
- Materials Chemistry and chemistry leading to interactive nanomaterials
- Scanning probe techniques
- Advances in aligned carbon materials
- Advances in bionanoelectronics
- Use of 2 D Nanomaterials

Course Outcomes:

The students will get an in depth understanding on the selected and state of the art areas/topics related to nanoscience and engineering. The student will be able to use this knowledge in practical applications/research in nanoscience and engineering.

Recommended Books:

- Bio nanotechnology, Elisabeth S. Papazoglou, Aravind Parthasarathy, Morgan & Claypool, 2007.
- Molecular Chemistry of Sol-Gel Derived Nanomaterials, Robert Corriu and Nguyeˆn Trong Anh, John Wiley & Sons, Ltd. 2009.
- Selected Topics in Nanoscience and Nanotechnology, Andrew T. S. Wee, World Scientific Publishing Company, 2009.
- Aligned Carbon Nanotubes: Physics, Concepts, Fabrication and Devices, Zhifeng Ren, Yucheng Lan, Yang Wang (auth.), Springer Berlin Heidelberg, 2013.
- Bionanoelectronics: Bioinquiring and Bioinspired Devices, Daniela Dragoman, Mircea Dragoman, Springer, 2012.

NSE-931
Advanced Synthesis and Fabrication Techniques
Credit Hours: 3

Prerequisites: Nil

Course Objectives:

- Introduction to key concepts/techniques for the synthesis and fabrication of nanomaterials
- Detailed understanding on various synthesis/fabrication procedures currently employed in the domain of nanomaterials

Course Contents:

- Key concepts/techniques on the synthesis and fabrication of nanomaterials
- Directed assembly of nanostructures
- Bio-mediated assembly of ordered nanoparticles superstructures
- Wet Chemical methods for the synthesis of nanomaterials
- Synthesis of nanomaterials through ex-foliation procedures
- Fabrication of thin films for solar cells and devices
- Synthesis and fabrication of nano composite materials
- Chemical modification of nanomaterials for solar cells/sensors/biomedical and related applications

Course Outcomes:

The student will get an in depth understanding on the fundamental concepts as well as detailed understanding on various synthesis and fabrication techniques used these days in the domain of nanomaterials. The student will be able to use this knowledge in practical applications.

Recommended Books:

- Inorganic materials synthesis and fabrication, John N. Lalena, David A. Cleary, Wiley Interscience, 2008.
- Nanostructures and nanomaterials, Synthesis, properties and applications, Imperial College Press, 2004.
- Molecular Chemistry of Sol-Gel Derived Nanomaterials, Robert Corriu and Nguyeˆn Trong Anh, John Wiley & Sons, Ltd. 2009.

NSE-941
Nanocomposite Materials
Credit Hours: 3

Prerequisites: Nil

Course Objectives:

- To provide and understanding on properties of metal, metal oxide, polymeric/organic nanomaterials as fillers
- To provide fundamental concepts related to different matrix materials for composites.
- To provide understanding on various synthetic techniques used in the preparation of nanocomposites
- To provide understanding on state of the art applications of nanocomposites

Course Contents:

- Physical, chemical, mechanical and electrical properties of nanofillers (ceramic and metallic nanofillers) specifically graphene, CNTs, nanoclays, nanoferrites, nanowires, nanofibers etc.
- Physical Characteristics and mechanical properties of polymeric matrices: thermoplastic matrices, thermosetting matrices, elastomeric matrices
- Synthesis techniques for the preparation of synthetic polymers: Addition polymerization, condensation polymerization, emulsion polymerization etc.
- Preparation techniques of nanocomposites: In-situ polymerization method, solution casting method, melt method using twin screw extruder etc.
- Characterization of nanocomposites: Thermal, mechanical, electrical and barrier properties of nanocomposites
- Structure and morphology of nanocomposites: intercalated and exfoliated morphologies
- Size effects and its interfacial effect on the properties of nanocomposites
- Natural polymers-their blends and nanocomposites

Course Outcomes:

The students will get an in depth understanding on nan-sized metal and ceramic particles together with synthetic and natural polymers. This knowledge will help students to prepare themselves for upcoming challenges in the area of nanocomposites.

Recommended Books:

- Polymer nanocomposites and their applications, Suprakas Sinha Ray and Mosto Bousmina, American Scientific Publishers, 2006, ISBN: 158883-099-3
- Polymer Nanocomposites: Processing, Characterization and Applications, Joseph H. Koo, McGraw-Hill, 2006, ISBN: 9780071458214
- Metal-polymer nanocomposites, Luigi Nicolais and Gianfranco Carotenuto, John Wiley & Sons, Inc. 2005.

- Advances in Natural Polymers: Composites and Nanocomposites, P. M Visakh, Aji P. Mathew, Sabu Thomas (auth.), Sabu Thomas, P. M. Visakh, Aji. P. Mathew (eds.), Springer Berlin Heidelberg, 2013.

NSE-951
Nanostructured Materials
Credit Hours: 3

Prerequisites: Nil

Course Objectives:

- Introduction to key concepts related to nanostructured materials and materials processing
- Detailed understanding on light alloys, crystals growth and analysis, properties of nano bainite
- Understanding on the applications of nanostructured materials

Course Contents:

- Nano Crystalline materials: introduction, classification, synthesis (inert gas condensation, mechanical alloying, spray conversion processing, electro-deposition, devitrification of amorphous phases, consolidation of powders to bulk shapes)
- Nanostructured hybrid materials, lamellar materials
- Rapid solidification of light alloys, structure (Microstructure, atomic structure of grains and grain boundaries, grain growth and grain growth inhibition),
- Nano-bainite, thermal stability, properties (diffusion and sinterability, physical properties, optical properties, mechanical properties, electric and magnetic properties, chemical properties)
- Quasi and nano-quasi crystals
- Applications of nanostructured materials.

Course Outcomes:
The student will get an in depth understanding on the fundamental concepts related to nanostructured materials and various processes involved in the synthesis and fabrication of such materials. The student will be able to use this knowledge in practical applications.
Recommended Books:

- Nanocrystals: Synthesis, Properties and Applications, Series: Springer Series in Materials Science, Vol. 95Rao, C.N.R., Thomas, P. John, Kulkarni, G.U. 2007, VIII
- Glassy, amorphous and nano-crystalline materials by prof. Jaroslavšesták, meng., dr. Jiri j. Mares, dr. Pavelhubik
- Nanocrystalline materials their synthesis-structure-property relationships and applications by sie-chin tjong
- Molecular Chemistry of Sol-Gel Derived Nanomaterials, Robert Corriu and Nguyeˆn Trong Anh, John Wiley & Sons, Ltd. 2009.

NSE-961
Surface coating and thin films
Credit Hours: 3

Prerequisites: Nil

Course Objectives:

- This course introduces nano science and engineering students to the concepts that are central to the study of thin films, surfaces energy, interfaces and vacuum concept.
- Understand physical phenomena that can be exploited for the deposition of thin films.
- Demonstrate knowledge of different thin film deposition strategies
- Develop proficiency for experimental techniques used to deposit and characterize thin films

Course Contents:

- Elementary thermodynamic ideas of surfaces, Surface energies and the Wulff theorem
- Introduction to surface and adsorbate reconstructions
- Introduction to surface electronics
- Kinetic theory concepts, Vacuum concepts
- Surface preparation and cleaning procedures : *in situ* experiments
- Role of Thin films in Technology and Device
- Nucleation and Growth: Adsorption, Surface coalescence and depletion, grain structure and microstructure and its dependence on deposition parameters.
- Role of energy enhancement in nucleation; Self-assembly: mechanisms and controls for nanostructures of 0 and 1 D
- Thin film deposition procedures

Course Outcomes:

The student will obtain the deep understanding the concept of surfaces thermodynamic, electronics, kinetic, vacuum and how these concepts are important for thin films fabrication processes. The student will be able to use this knowledge in practical applications.

Recommended Books:

- Introduction to Surface and Thin Film Processes, JOHN A. VENABLES *Arizona State*
  University and University of Sussex, John A. Venables 2000
- Chemical Solution Deposition of Functional Oxide Thin Films, Theodor Schneller (auth.), Theodor Schneller, Rainer Waser, Marija Kosec, David Payne (eds.), Springer, 2013.
- Characterization of Polymer Surfaces and Thin Films, K. Grundke, M. Stamm, H.-J. Adler, Springer, 2006.
- Adhesion Aspects of Thin Films, Mittal K. L., VSP, 2007