



World Skill Development Institute

Nanotechnology

Course Duration – 1 Year.

Nanoscience is an interdisciplinary field that have encompassed physics, biology, engineering chemistry and computer science, among others, the prefix nano appears with increasing frequency in scientific journals and the news. Thus, as we increase our ability to fabricate computer chips with smaller features and improve our ability to cure disease at the molecular level, nanotechnology is at the doorstep. Scientists and engineers believe that the fabrication of nanomachines, nanoelectronics, and other nanodevices will help to solve numerous problems faced by mankind today related to energy, health, and materials development. In nanoelectronics there are two opposing developments: the lithographic scaling down of semiconductor components tending towards the sub10 nanometer region to supramolecular self assembling macroscopic structure with new properties. Currently the trends are mixed and one can build a variety of structures of all scales. For example one can build large scale supramolecular structures serving as templates for building circuits with nanoscale components. On the nanoelectronics architecture side, there have also been many interesting developments trying to cope with the increasing density and smallness of components and the needs of self assembly and fault tolerance. In the emerging field of nanotechnology, the production of nanostructures having special physical and chemical properties with respect to those of bulk materials is an objective due to their limited size and high density of corner or edge surface sites. Metal nanoparticles have received significant scientific and technological interest because of their use in applications such as catalysis, electronics, optics, optoelectronics, biological and chemical sensing and SERS. Nanotechnology is now creating a growing sense of excitement in the life sciences, especially biomedical devices and biotechnology, as there is an immense opportunity to arrange and rearrange molecular structures. The global market for nanotechnology products is worth an estimated compound annual growth rate (CAGR) of 11.1% from 2010 to 2015. The largest segment of the market, made up of nanomaterials, is expected to increase at a 5 year CAGR of 14.7%

The course contains polymeric nanofibres, synthesis of nanostructure, analysis of electron currents through nanojunctions, water soluble carbon nanotubes,

nanoelectronic switching networks, growth of silica nanorods, magnetic nanostructures, nanomachining of microscope tips and carbon nanotubes, nanocrystalline semiconductors and many more.

The present course is a sincere attempt to make the students aware of the evolutionary trends underlying modern engineering practice which are grounded not only on the tried & true principles & techniques of the past, but also on more recent & current advances. This course will be an invaluable resource to technocrats, researchers and new entrepreneurs.

PART - 1

1. Polymeric nanofibres
2. Synthesis of nanostructure
3. Assembly of nanocrystals
4. Electrosynthesis of CeO₂ nanotubes
5. 2D patterned nanocrystal arrays
6. Analysis of electron currents through nanojunctions
7. Multi-walled carbon nanotubes decorated with titanium nanoparticles
8. Synthesis and Self-organisation of Au nanoparticles
9. Water soluble carbon nanotubes
10. Nanospheres for Photoluminescence
11. Nanocables from Poly (dimethyl siloxane)
12. Nanorod arrays and their field emission properties
13. Oxidation of OTS monolayers
14. Three dimensional tungsten nanoscale conductors
15. Tungsten nanogratings by nanojoule energy
16. Macroscopically films by zone casting
17. Uniform arrays of nanoholes and nanopillars
18. Electropolymerization of nano-dimensioned polypyrrole micro ring

19. Resistance switching of an individual nanowire heterostructure
20. Nanoelectronic switching networks
21. Photoluminescence in anodic aluminium oxide membranes
22. Wrapping of carbon nanotubes by DNA
23. Synthesis of poly (3, 4-ethylenedioxy thiophee) nanotubes
24. Functionalization of Lanthadum hydroxide nanowires
25. Switching behaviour in multiferroic nanostructures
26. Growth of super paramagnetic nanospheres
27. Synthesis of magic-sized nanocrystals
28. Rapid synthesis and application of polyhedral gold nanocrystals
29. Nanocrystalline iron-carbon materials
30. Microcantilevers coupled with a nanofibre
31. Calibration of nanomechanochemical sensors
32. Growth of silica nanorods
33. Lithography of nanoscale patterning and manufacturing
34. Nano-machining of microscope tips and carbon nanotubes
35. Structural and optical properties of nanodots
36. Fabrication of a tripod nanorod array
37. Biodiversity: An archive of opportunity for nanodevices
38. Magnetic nanostructures
39. Nanobiotechnology enables new opportunities Bacteriorhodopsin
40. Bioprocessing of Silk Proteins
41. Spider silk production
42. Metalloprotein based electronic nanodevices
43. Scalable fabrication of ZnO nanorod arrays

44. Mechanism of anodic alumina
45. Thickness and density of nanowire hybrid film
46. Chitosan nanoparticles as a smart drug delivery system
47. Synthesis of composites using capsicum annum extract
48. The stability and electronic structure of single walled ZnO nanotubes
49. SWNT reinforced composites
50. Super paramagnetic core and rhodamine B doped silica shell
51. Synthesis and characterization of nanoordinating solvent
52. Platinum coated prodes
53. Multiscale failure for carbon nanotube systems
54. Dynamical model for restricted diffusion in nano channels
55. Synthesis of quantum dots
56. Measurement of photonic crystal holes
57. Growth control of nanowires
58. Synthesis of CdSe clusters
59. Nanocrystalline semiconductors
60. Nanotechnology in Bioengineering

1. DESIGN OF PROTEIN BASED NANOMACHINES

Introduction

Renowned Nanomachines of the Biological Cell Confirm Engineering Principles and Inspire Nanomachine Design

De Novo Design of Diverse Elastic-Contractile Protein Machines

Hydrophobic and Elastic Consilient Mechanisms: Definitions

Hydrophobic Consilient Mechanism and the Inverse Temperature Transition

The Elastic Consilient Mechanism and the Nature of Near Ideal Elasticity

Coupled Hydrophobic and Elastic Consilient Mechanisms

Principal Thermodynamic Quantities Controlling Diverse Energy Conversions in Model Proteins

The Change in Gibbs Free Energy for Solubility, $\Delta G(\text{solubility}) = \Delta H - T\Delta S$

The Change in Gibbs Free Energy for a Phase Transition

The Change in Gibbs Free Energy for an Inverse Temperature Transition

Apolar-Polar Repulsive Gibbs Free Energy of Hydration, ΔG_{ap}

Calculations of the Entropic Elastic Force and Energy

Biology Protein-based Nanomachines Confirm the Hydrophobic and Elastic Consilient Mechanisms

The Three Classes of Energy Conversion Within the Cell

Complex III of the Electron Transport Chain Within the Inner Mitochondrial Membrane

ATP Synthase of the Inner Mitochondrial Membrane

The Myosin II Motor of Muscle Contraction

Confirmation of the Hydrophobic and Elastic Consilient Mechanisms

Designing Protein-based Nanomachines Using the Hydrophobic and Elastic Consilient Mechanisms

Design of an AFM-Based Stress-Strain Nanomachine for the Detection of a Single Molecular Event

Use of the 3 kHz Mechanical Resonances in the Design of an AFM-Based Nanomachine for Detection of Interactions at Fixed Length

An Additional Opportunity in the Deciphering of Engineering Principles for the Design of Protein-Based Nanomachines

2.METASTABILITIES IN NANOCRYSTALLINE

SILICON

Experimental Procedure

Results

Discussion

Conclusion

3.INTERACTION OF SULPHURIC ACID WITH

GRAPHENE

Sulphuric Acid in Gas and Solid Phases

Sulphuric Acid on Graphene

Conclusions

4.NANOSCALE CHARACTERIZATION OF

NANOWIRES

Experimental Methods

Nanowire Morphology, Periodicity and Diameter

Chemical Analysis of the CoPt/Pt Nanowires

Structural Analysis of the CoPt/Pt Nanowires

Discussion

Conclusions

5.THERMOPOWER MEASUREMENTS ON NICKEL NANOWIRES

Experimental Details

Results and Discussion

Structural Characterization of the NWs

Initial Characterization of the Measurement Device

6.MULTI-WALLED CARBON NANOTUBE EMITTERS EXPERIMENT

Fabrication of CNT Cathode

Experimental Structures

Current-Voltage Characteristics

Simulations

Simulated Structures

Predicted I - V Characteristics

Cathode Support Structure Geometry

Conclusion

7.VIBRATION OF A CARBON NANOTUBE

The Model for a CNT filled with a C-chain

Vibration of a CNT filled with a C-chain

Axisymmetric Radial Breathing Vibration ($n = 0$)

Coupled Vibration with $n = 1$

Vibration of Higher-order Modes ($n > 2$)

Conclusions

8.A NANOPOROUS TiO₂ ELECTRODE

Experimental Details

Preparation of the ILSE Films

Characterization of the ILSE Films

Electrode and DSSC Fabrication Containing the ILSE

Electrode Characterization

Results and Discussion

Conclusions

9.FREEZING BEHAVIOUR OF AN NANOMETER-SIZED Au DROPLET

Numerical Simulations

Results and Discussion

Conclusions

10.NANOSCALE IN INVESTIGATION OF ULTRATHIN SILICONE OXIDE THERMAL DECOMPOSITION

Experimental Details

Results and Discussion

High Temperature STM in situ Observation of the Thermal Decomposition Process

Individual Void Growth Kinetics at the Initial Decomposition Stage

Decomposition Rate Variation and Rate Limiting Steps

Morphology Effects on the Decomposition Process

Conclusions

11.CARBON NANOTUBE FIELD-EFFECT TRANSISTOR

Methodology

Results and Discussion

Conclusions

12.CYLINDRICAL NANODOT ARRAYS

System and Units

Theoretical Model

Vortex-core Magnetization

Total Energy Calculation

Results and Discussion

Conclusions

13.SUPERELASTICITY OF ENGINEERING CERAMICS BY NANOTUBES

Experimental Details

Results and Discussion

Conclusion

14.POROUS ANODIC ALUMINA

Experimental Details

Results

Initial Specimens and Anodizing

Film Morphology

Film Composition

Discussion

Conclusions

15.METAL NANOCLUSTERS IN GLASS

Experimental Procedure

Results and Discussion

Ion-Beam Mixed Ag in Silica

Ion-Exchanged Ag in Soda Lime Glass

Conclusion

16.LIGHT EMISSION FROM NANOCOMPOSITES

Experiments

Results and Discussion

Conclusion

17.NANOCRYSTALLINE SILICON FILMS

Experimental Details

Results

Optical Absorption Study

X-ray Diffraction Study

Infrared Absorption Study

Raman Study

Electron Microscopy

Discussion

Conclusion

18. CARBON NANOTUBES IN CHEMICAL VAPOUR DEPOSITION

19. NANOSCALE DEEP INDENTATION

Simulation Methodology

Results and Discussion

Conclusion

20. REDUCTION OF NANOWIRES

Experimental Details

Results and Discussions

Summary and Conclusion

21. DISPERSION OF CARBON NANOTUBES

Experimental Details

Purification and Dispersion of MWCNTs

Preparation of Nanocomposite Films

Carbon Nanotube Dispersion Study in Solution and in Nanocomposite Films

Electrical Conductivity Measurement

Results and Discussion

MWCNT Dispersion in Solution

Nanocomposite Preparation and Carbon Nanotube Distribution in Composite Films

Electrical Conductivity Study of Nanocomposite Films

Conclusion

22.CREATION OF CARBON ONIONS AND COILS

Experimental Details

Result and Discussion

Conclusions

23.MAGNETIC PROPERTIES OF NANOSPHERES

Experimental Details

Results and Discussion

Conclusion

24.LUMINESCENCE OF CRYSTALS NANORODS

Experimental Section

Results and Discussion

Conclusions

25.NANONECKLACE MORPHOLOGY

Experimental Details

Growth of Cu-Pt Nanoparticles

Growth of Cu-Pt Nanonecklace Nanowires

Conclusions

26.OPTICAL PROPERTIES OF NANODOT ARRAYS

Experimental Details

Results and Discussion

Conclusions

27.GENERATION SPECTROSCOPY OF NANOPARTICLE MONOLAYER

Experimental Section

Materials

Synthesis of AuNPs

Synthesis of Dense AuNPs Monolayer

Dodecanethiol SAM Formation

Characterization

SFG Set-up

Results and Discussion

Conclusions

28.CHEMICAL DOPING WITH CARBON NANOTUBES

Experimental Details

Results and Discussion

Summary

29.DIRECT-WRITE PROGRAMMING OF NANOSCALE DEMULTIPLEXER ARRAYS

30.POLY(N-ISOPROPYLACRYLAMIDE)

NANOPARTICLES

Introduction

Experimental Details

PNIPAM-coated Fe₃O₄@SiO₄@CdTe Nanoparticles and ZnPcS Loading

Biological Systems

PL and Fluorescence Measurements

ZnPcS Released from the Nanoparticles in PBS Solution

ZnPcS Released from the Nanoparticles in the CHO Cells

Results and Discussion

ZnPcS Embedded in the PNIPAM of Nanoparticles

Release of ZnPcS from the ZnPcS loaded Nanoparticles in PBS Solution

Release of ZnPcS from the ZnPcS-loaded Nanoparticles in CHO Cells

Release of ZnPcS from the ZnPcS-loaded Nanoparticles in Zebra Fish

Movement of the Nanoparticles in Zebra Fish by the Magnetic Field Gradient

Phthalocyanines and PDT

Conclusion

31. COBALT FERRITE NANOPARTICLES

Experimental Details

Synthesis

Characterization Methods

Results and Discussion

Fundamental Characteristics, Crystallite size Versus Coercivity and Remanence

Mossbauer Spectra and Distribution of Cations

Heating Efficiency from Calorimetric Measurements and ac

Hysteresis Loops

Conclusions

32. Au NANOPARTICLES ON LIGHT-EMITTING POLYMERS

Experimental Section

Measurements

Device Fabrication and Characterization

Materials

Synthesis of PDOFT-bis-4-thiol

End-capping at AuNP onto PDOFT-bis-4-thiol (PDOFT-Au 10, PDOFT-Au15, PDOFT-Au 20 and PDOFT-Au 30)

Results and Discussion

Synthesis and Characterization

Photophysical Properties

Electroluminescent Properties and Current Density-Voltage-Luminescence (J-V-L) Characteristics of the PLED Devices

Conclusions

33. CARBON NANOSTRUCTURE BASED NANOCOMPOSITES

Experimental Details

Results and Discussion

Conclusions

34. Au NANOPARTICLE CHAINS

Experimental Results and Discussion

Sample Preparation and Measuring System

General Considerations on Dielectrophoresis

Dielectrophoresis on Flat Substrates

Dielectrophoresis on V-groove-etched Substrates

Discussion of Results on Patterned Substrates, Electric Field Numerical Calculation

CONCLUSION

35.GOLD-SILICA NANOCOMPOSITES

36.NANOPINS BY CHEMICAL VAPOUR DEPOSITION

Experimental Section

Preparation

Characterization

Results and Discussion

Conclusions

37.OXIDATION RESISTANT METAL NANOPARTICLES

Experimental Details

Thermo-Gravimetric Studies

Particle Size Reduction

Synthesis and Coating of Metal Nanoparticles

Results and Discussion

Thermo-Gravimetric Analysis

Fluidized Bed Processing

Particle Size Reduction

Passivation of Metal Nanoparticles by in situ ALD

Conclusions

38. MOLECULAR CARBON-IONIONS

Experimental Details

Discussion of Results

Conclusion

39. ATOMIC SCALE MANIPULATION

Tip-Surface Interaction

Experimental Response

Discussion and Conclusion

40. SILICONE NANOWIRES

Experimental Session

Results and Discussion

Conclusion

41. CARBON NANOFIBERS

Experimental Details

Results

Discussion and Conclusion

42. SINGLE-CRYSTALLINE NANOWIRES

Experiments

Results and Discussion

Conclusion

43.SILICONE OXIDE NANOSTRUCTURES

Experimental Details

Results and Discussion

Conclusion

44.A SQUARE TITANIUM NANOMESH

Experimental Details

Results and Discussion

Conclusions

45.NANO-POROUS ANODIC ALUMINIUM OXIDE MEMBRANES

Experimental Details

Results and Discussion

Conclusions

46.Co NANOPARTICLES

Experimental Section

Materials

Synthesis and Assembly of Cobalt Nanoparticles

Characterization

Results and Discussion

Conclusions

47.ZERO-BIAS CONDUCTANCE OF GOLD MOLECULAR JUNCTION

Methodology

Results and Discussion

Conclusion

48.ALL-INKJET-PRINTED ELECTRONICS OF METAL NANOPARTICLES

Fabrication and Experimental Details

Nanoparticle Solution Preparation

Semi-conducting Polymer Preparation

Organic Field Effect Transistor Fabrication Process and Characterization (Inkjet Printing of Nanoparticle Solution, Polymer Dielectric Layer and Semi-conducting Polymer)

Results and Discussion

Nanoparticle Sintering Characterization

OFET Characterization

Summary

49.TRIODE TYPE CARBON NANOTUBE FIELD EMITTER

Experimental Details

Results and Discussion

Conclusions

50.PROTEIN AND POLYMER IMMOBILIZED NANOPARTICLES FOR BIOMEDICAL APPLICATIONS

Methodology

Chemicals and Materials

Experimental Set-up
Analyses
Results and Discussion
Protein Estimation
Conjugation Studies
Magnetic Studies
Microscopy Studies
Cytotoxicity Studies
Leaching Studies
Hyperthermia Studies
Conclusion

51.3D STRUCTURES OF NANOWIRES

Methods
Nanowire Growth
TEM Characterization
Image Simulations
Result
Crystal Structure
Image Simulations
Discussion
Summary

52.SUPERIOR CONDUCTIVITY OF NANOPARTICLES

Experimental Details

Synthesis of Nanocomposites

Characterization

Results and Discussion

Conclusions

53.STRUCTURAL AND ELECTRONIC PROPERTIES OF ZnO NANOTUBES

Computational Method

Results and Discussion

Conclusions

54.SYNTHESIS OF NANOCRYSTALLINE CERAMIC POWDERS

Experimental Procedure

Results and Discussion

Nanocrystalline CeO₂ Powders Through Glycine-Nitrate and Citrate-Nitrate Combustion

Auto-Ignition Synthesis of Monophasic BaTi₄O₉ and Ba₂Ti₉O₁₂ Powders

Combustion Synthesis of TbO₂, and MTbO₃ (M = Ba and Sr)

Conclusions

55.NANOCLUSTERS ON POLYMER SURFACES

Organization of Nanoparticles on the Polymer Matrices: Why?

Nanoclusters Organization on Polymers: How?

Electrostatic Organization

Covalent Organization

Vander-Waals Organization

Different Preparation Strategies

Nanocomposites Versus Surface Functionalisation

Selection of Polymers

Selection of Clusters

Metallic Nanoclusters

Semi-conducting Nanoclusters

Characterisation Techniques

Selected Applications

Catalytic Applications

Photovoltaic Applications

Biological Applications

Limitations of Cluster Organization on Polymers.

Conclusions.