ME/MSE 556 3(3,0,0) NANO CRYSTALLINE MATERIALS Muhammad Farzik Ijaz, PhD Second Semester 1443[2021-2022] Instructor Contact Information:



Dr. Muhammad Farzik Ijaz Mechanical Engineering Department, Bldg. 3, Rm 2C 46 King Saud University Tel: +966 11 467 6650, Fax: +966 11 467 6652 Email: <u>mijaz@ksu.edu.sa</u> (preferred contact) Class schedule: 5:00-7:30 pm (**TUESDAY**)

This course aims to present a number of topics in nanotechnology and science, with emphasis on the role of size on mechanical, optical, thermal and electrical properties of materials. The course also introduces various modern techniques developed to produce Nanostructures and Nano devices and to characterize them.

Materials		
Nanomaterials	Bulk materials	
 Nanomaterials (NMs) are chemical substances or materials that are of size, at least in one dimension, in nanoscale 1-100 nm Cannot be seen by simple microscope, or naked eye. Advanced microscopic techniques are used. Large surface to volume ratio leads to better performance such as in catalysis, solar veils, gas sensors High percentage of atoms or molecules on the surface which leads to unique properties Surface forces are very important Metal nanoparticles have unique scattering properties Semiconductor nanoparticles may exhibit confined energy states in the electronic band structure Their chemical and physical properties are unique and change by size and shape NMs properties can be 'tuned' by varying the size of the particle (e.g. changing the fluorescence colour so a particle can be identified) NMs complexity offers a variety of functions to products Adsorption and absorption of molecules (gas or liquid phases) are high and fast Examples are nanosilica, nanotitania, nanoalumina, etc. 	 Bulk materials are particles that have their size above 100 nm in all dimensions Can be seen by simple microscope, or naked eye. Low surface to volume ratio leads to better performance such as in catalysis, solar veils, gas sensors Low percentage of atoms or molecules on the surface which leads to their properties Bulk forces are not as important as surface forces Metal bulk have normal scattering properties Semiconductor bulk may not exhibit confined energy states in the electronic band structure Their chemical and physical properties (gas or liquid phases) are low and slow Examples includes sand, cement, alumina, ore, salts, etc. 	

2. Learning outcome

After completion of this course, you should be able to:

1.To have an updated knowledge of the state-of-the-art in nanomaterials and their applications

2.To understand why nanoscaled materials have different properties from their bulk counterparts and how

Course Topics (Preliminary Schedule):

- 1. Introduction to Nanotechnology: The future of Moore's law, what is nanotechnology, why nanotechnology, existing applications of nanotechnology, nanocrystals, different dimensions of nanocrystals and properties of nanocrystals.
- 2. Nanofabrication: "top-down" and bottom-up" nanofabrication, optical lithography techniques, electron beam lithography (EBL), focused ion beam (FIB), limitations of "top-down" lithography", nanoimprint, self-assembly, Nano-manipulation, charge writing, dip-pen nanolithography, physical vapor deposition (PVD) and chemical vapor deposition (CVD). Printing and coating. Electrospinning.
- 3. Characterization at the nanoscale: Different nanomaterials characterization techniques such as Scanning electron microscope (SEM), Transmission electron microscope (TEM), Scanning tunneling microscope (STM) X-ray diffraction (XRD), Energy dispersive X-ray (EDX), Thermogravimetric analysis (TGA), Fourier Transform infrared analysis (FTIR), X-ray photo-electron spectroscopy (XPS), Atomic force microscopy (AFM), and Photoluminescence (PL).
- 4. Carbon Nanostructures: Diamond, Graphene, Carbon Nanotubes and Fullerenes.
- 5. Metal oxide Nanostructures: ZnO nanomaterials, Advantages, Properties, Fabrication, Dimensions, Limitations and Applications.Functionalization and modification of nanocrystals: Self-assembly, Self-assembled Monolayer (SAMs), Thiols, Siloxanes, Electrostatic attraction.Recent advances in nanotechnology research: A focus on uses of nanotechnology in Bio-applications, Electronics, Mechanical applications and Water Treatment Technologies.



Grading Policy

Homework (2×5)	10
Two Major Exams (15×2)	30
Project and presentation	20
Final Exam	40

Exam Schedule

Midterm1	.26 th October,2021[5:00-6:30 PM]
Midterm 2	7 th December,2021[5:00-6:30 PM]

Reference Texts:

- Introduction to Nanoscale Science and Technology", M. Di Ventra et al. (Ed.), Springer
- "Nanoscale Science and Technology", R. Kelsall et al. (Ed.), Wiley

Articles

- (1) H. Gleiter, -Nanocrystalline Materials, Progress in Materials Science Vol. 33, pp. 223315, 1989
- (2) C. C. Koch, -Nanostructured Materials: Processing, Properties and Applications^{II}, 2nd Edition, Ed.:2007
- (3) Nanomaterials, Nanotechnologies and Design: an Introduction to Engineers and Architects, D. Michael Ashby , Paulo Ferreira, Daniel L. Schodek, Butterworth-Heinemann, 2009
- (4) J. R. Weertman, in Nanostructured Materials: Processing, Properties and Applications, edited by C. C. Koch (Andrews, Norwich, 2002), p. 397