Roll No.													

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST 1

Sem & AY: Odd Sem 2019-20
Course Code: MEC 402
Course Name: NANOTECHNOLOGY
Program: B.Tech. & VII (OE)

Date: 12.10.2019
Time: 1.30 PM to 2.30 PM
Max Marks: 40
Weightage: 20%

Instruction:

(i) *Read the question properly and answer accordingly.*
(ii) *Question paper consists of 3 parts.*
(iii) *Scientific and Non-programmable calculators are permitted.*

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries four marks. (4Qx4M=16M)

1. Write a short note on Richard Feynman statement with respect to evolution of nanotechnology. (C.O.NO.2) [Knowledge]

2. Using a suitable sketch write the methods of nanoparticle production.

(C.O.NO.2)[Knowledge]

3. Explain the function of nanostructure in nature by considering the suitable example. (C.O.NO.1) [Knowledge]

4. Classify the Nanomaterials based on the number of dimensions with an example and represent atleast two characteristics of each.

(C.O.NO.2) [Knowledge]

Part B [Thought Provoking Questions]

Answer both the Questions. Each Question carries seven marks. (2Qx7M=14M)

5. Nano scale materials have extremely high surface area to volume ratio as compared to large scale material. Prove the statement and explain the fantastic advantages of this. (C.O.NO.1) [Comprehension]

6. Nanoparticles are produced from the gas phase process by producing the vapor of the product material using chemical or physical means. Explain the two methods of condensing these vapor with neat sketch. (C.O.NO.2) [Comprehension]

Part C [Problem Solving Questions]

Answer the Question. The Question carries ten marks. (1Qx10M=10M)

7. Briefly explain the reaction and processing steps involved in the sol-gel process. Write the advantages and disadvantages of sol-gel process.

(C.O.NO.2) [Comprehension]

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE REACH GREATER HEIGHTS

Semester: 7

Course Code: MEC 402

Course Name: **Nanotechnology**

Date: 27/09/2019

Time: 1PM to 2 PM

Max Marks: 40

Weightage: 20

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels	Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K	C			A			
1	2	1	4	-	-	-	-	-	-	4
2	2	1	4	-	-	-	-	-	-	4
3	1	1	4	-	-	-	-	-	-	4
4	2	2	4	-	-	-	-	-	-	4
5	1	2	-	7			-	-	-	7
6	2	2	-	7			-	-	-	7
7	2	2		10			-	-	-	10
OR										
8	2	2		10			-	-	-	10
	Total Marks		16	24						40

K =Knowledge Level   C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

I hereby certify that All the questions are set as per the above guide lines. Prashanth S P

Annexure- II: Format of Answer Scheme

SCHOOL OF ENGINEERING

SOLUTION

Semester: 7

Course Code: MEC 402

Course Name:

Date: 27/09/2019

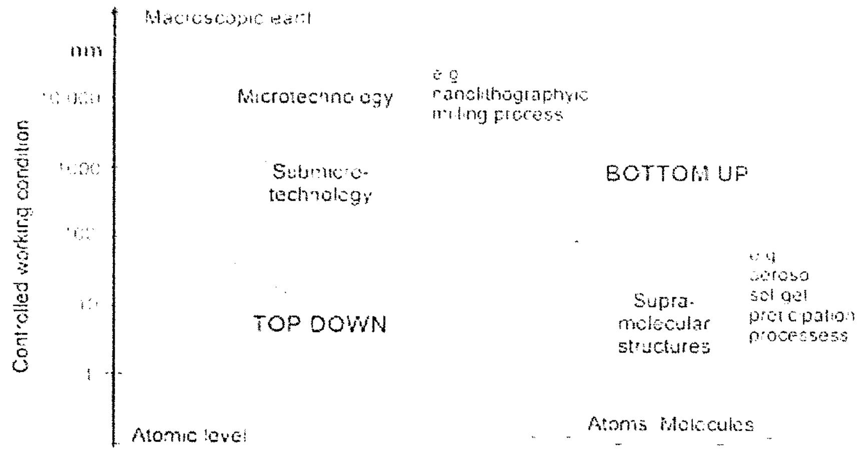
Time: 1PM to 2 PM

Max Marks: 40

Weightage: 20

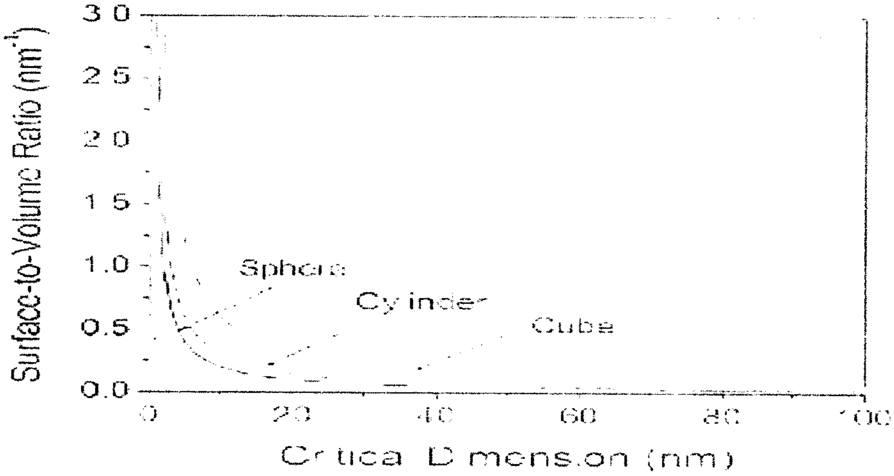
Part A (4Q x 4M = 16Marks)

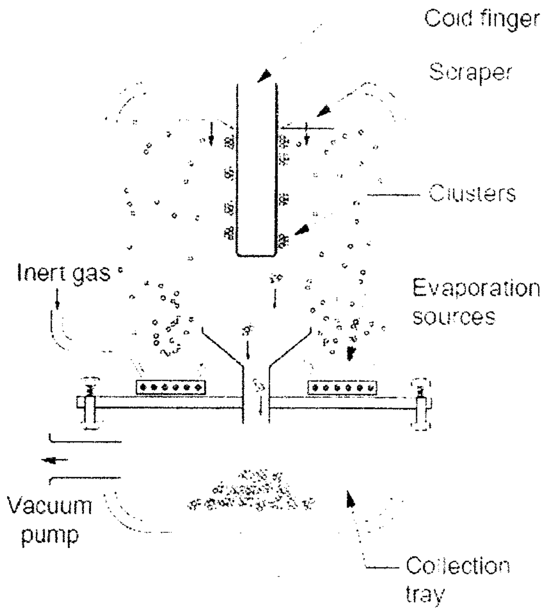
Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	**In 1959, physics Nobel laureate Richard Feynman gave a talk at Caltech on the occasion of the American Physical Society meeting. The talk was entitled, "There's plenty of room at the bottom".** **Richard Feynman said:** *what I want to talk about is the problem of manipulating and controlling things on a small scale., What are the limitations as to how small a thing has to be before you can no longer mold it? How many times when you are working on something frustratingly tiny like your wife's wrist watch have you said to yourself. "If I could only train an ant to do this!" What I would like to suggest is the possibility of training an ant to train a mite to do this…A friend of mine (Albert R Hibbs) suggests a very interesting possibility for relatively small machines. He says that although it is a very wild idea, it would be interesting in surgery if you could swallow the surgeon. You put the mechanical surgeon inside the blood vessel and it goes in to the heart and looks around it. It finds out which valve is the faulty one and takes a little knife and slices it out.*	4	

2	 *Figure 1. Methods of nanoparticle production: top-down and bottom-up*	4	
3	**Any Nano structure in nature**	4	
4		4	

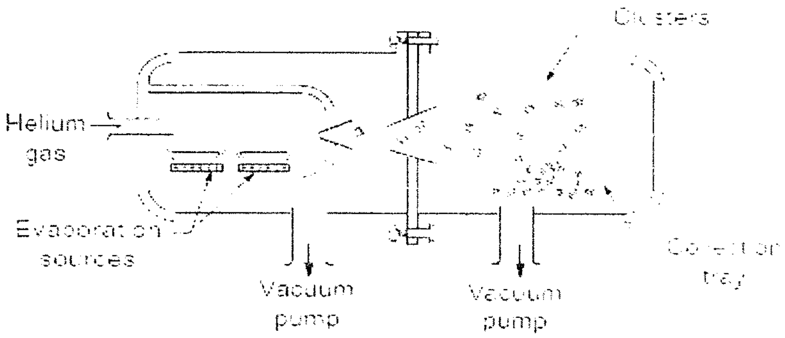
Part B

(7Q x 2M - 14Marks)

<table>
<tr><th>Q No</th><th>Solution</th><th>Scheme of Marking</th><th>Max. Time required for each Question</th></tr>
<tr><td>5</td><td>


Surface-to-volume ratios for a sphere, cube and cylinder as a function of critical dimensions. Nanoscale materials have extremely high surface-to-area ratios as compared to larger-scale materials.
</td><td>7</td><td></td></tr>
<tr><td>6</td><td>


Inert gas condensation. The nanoclusters that form on the cold finger are harvested by the scraper and collector and subsequently consolidated to make products.
</td><td>7</td><td></td></tr>
</table>



Cluster formation by vapor phase expansion from an oven source.

Part C (1Q x 10M = 10Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
7		10	

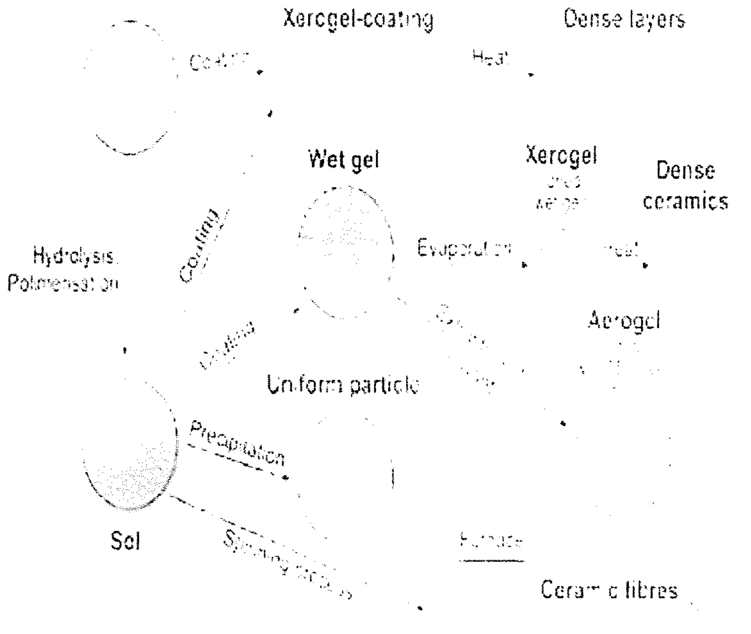
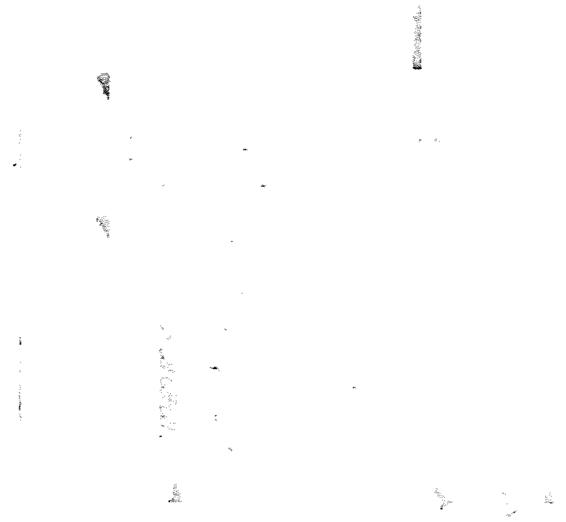


Figure . Reaction and processing steps in the sol-gel process (Image: Universität Ulm, Anorganische Chemie)

8	[illegible]  [illegible] deposit		10	

Roll No.												

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST – 2

Sem & AY: Odd Sem 2019-20
Course Code: MEC402
Course Name: NANOTECHNOLOGY
Program: B.Tech (Mech) VII DE

Date: 16.11.2019
Time: 1.00 PM to 2.00 PM
Max Marks: 40
Weightage: 20%

Instructions:

(i) *Illustrate with neat sketches wherever deemed necessary.*
(ii) *All questions are compulsory.*

Part A [Memory Recall Questions]

Answer all the Questions. Each question carries four marks. (3Qx4M=12M)

1. Write a brief note on Quantum Dots. (C.O.NO.2)[Knowledge]
2. What are fullerenes? Explain. (C.O.NO.2)[Knowledge]
3. Carbon nanotubes has high tensile strength. Explain in detail. (C.O.NO.2)[Knowledge]

Part B [Thought Provoking Questions]

Answer both the Questions. Each question carries eight marks. (2Qx8M=16M)

4. Carbon atoms arranged in the honeycomb form has variety of applications. Identify the structure and talk briefly on its recent advances. (C.O.NO.3)[Comprehension]
5. Write briefly on scanning probe techniques. (C.O.NO.3)[Comprehension]

Part C [Problem Solving Questions]

Answer the Question. The question carries twelve marks. (1Qx12M=12M)

6. With a neat sketch explain in detail Transmission Electron Microscope. (C.O.NO.3)[Application]

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

Semester: 7th

Course Code: MEC 402

Course Name: Nanotechnology

Date: 16-11-2019

Time: 1 hrs

Max Marks: 40

Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K			C			A			
1	3	Module 2: Nano material structure and synthesis	4									4
2	3	Module 2: Nano material structure and synthesis	4									4
3	3	Module 2: Nano material structure and synthesis	4									4
4	4	Module 2: Nano material structure and synthesis				8						8

5	3	Module 3: Investigation techniques				8						8
6	4	Module 3: Investigation techniques							12			12
	Total Marks		12			16			12			40

K =Knowledge Level   C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

Annexure- II: Format of Answer Scheme

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

SOLUTION

Semester: 7th

Course Code: MEC402

Course Name: Nanotechnology

Branch & Sem: Mechanical & 7th

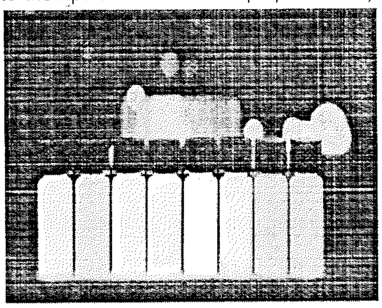
Date:

Time: 1hrs

Max Marks: 40

Weightage: 20%

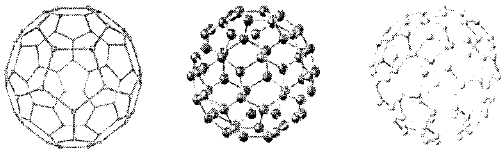
Part A (3Q x4 M = 12Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	What are quantum dots? Nanoparticles of semiconductors – quantum dots – were theorized in the 1970s and initially created in the early 1980s. If semiconductor particles are made small enough, quantum effects come into play, which limit the energies at which electrons and holes (the absence of an electron) can exist in the particles. As energy is related to wavelength (or color), this means that the optical properties of the particle can be finely tuned depending on its size. Thus, particles can be made to emit or absorb specific wavelengths (colors) of light, merely by controlling their size. Quantum dots are artificial nanostructures that can possess many varied properties, depending on their material and shape. For instance, due to their particular electronic properties they can be used as active materials in single-electron transisto  Slide: 77 of 78 The properties of a quantum dot are not only determined by its size but also by its shape, composition, and structure, for instance if it's solid or hollow. A reliable manufacturing technology that makes use of quantum dots' properties – for a wide-ranging number of applications in such areas as catalysis, electronics, photonics, information storage, imaging, medicine, or sensing – needs to be capable of churning out large quantities of nanocrystals where each batch is produced according to the exactly same parameters. Because certain biological molecules are capable of molecular recognition and self-assembly, nanocrystals could also become an important building block for self-assembled functional nanodevices. The atom-like energy states of QDs furthermore contribute to special optical properties, such as a particle-size dependent wavelength of fluorescence; an effect which is used in fabricating optical probes for biological and medical imaging. So far, the use in bioanalytics and biolabeling has found the widest range of applications for colloidal QDs. Though the first generation of quantum dots already pointed out their potential, it took a lot of effort to improve basic properties, in particular colloidal stability in salt-containing solution. Initially, quantum dots have been used in very artificial environments, and these particles would have simply precipitated in 'real' samples, such as blood. These problems have been solved and QDs have found numerous use in real applications. Quantum dots have found applications in composites, solar cells (Grätzel cells) and fluorescent biological labels (for example to trace a biological molecule) which use both the small particle size and tuneabl Slide: 77 of 78 Advances in chemistry have resulted in the preparation of monolayer-protected, high-quality, crystalline quantum dots as small as 2 nm in diameter, which can be conveniently treated and processed as a typical chemical reagent.	1 1 1 1	10MIN

2

Fullerence

The first to be discovered was the hollow, cage-like fullerene molecule - also known as the buckyball, or the **C60 fullerene.** There are now thirty or more forms of fullerenes, and also an extended family of linear molecules, carbon nanotubes. **C60** is the first spherical carbon molecule, with carbon atoms arranged in a soccer ball shape. In the structure there are 60 carbon atoms and a number of five-membered rings isolated by six-membered rings. The second, slightly elongated, spherical carbon molecule in the same group resembles a rugby ball, has seventy carbon atoms and is known as C70. **C70's** structure has extra six-membered carbon rings, but there are also a large number of other potential structures containing the same number of carbon atoms. Their particular shapes depend on whether five-membered rings are isolated or not, or whether seven-membered rings are present. Many other forms of fullerenes up to and beyond **C120** have been characterized, and it is possible to make other fullerene structures with five-membered rings in different positions and sometimes adjoining one another.



Slide: 77 of 78

2

2

5MIN

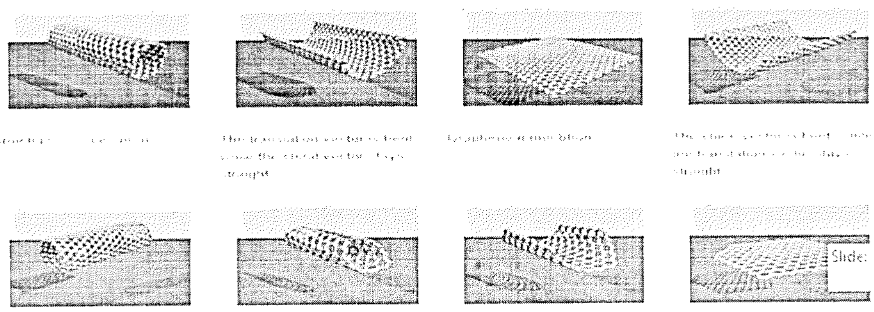
3

Carbon nanotubes

Carbon nanotubes (CNTs) were first observed by Sumio Iijima. CNTs are extended tubes of rolled graphene sheets. There are two types of CNT: single-walled (one tube) or multi-walled (several concentric tubes). Both of these are typically a few nanometres in diameter and several micrometres to centimetres long. CNTs have assumed an important role in the context of nanomaterials, because of their novel chemical and physical properties. They are mechanically very strong as the Young's modulus is over 1 terapascal, making CNTs as stiff as diamond, they are flexible about their axis, and they can conduct electricity extremely well. All of these remarkable properties give CNTs a range of potential applications: for example, in reinforced composites, sensors, nanoelectronics and display devices

Slide: 77 of 78

A nanotube may consist of one tube of graphite, a one-atom thick single-wall nanotube, or a number of concentric tubes called multiwalled nanotubes. When viewed with a transmission electron microscope these tubes appear as planes. Whereas single walled nanotubes appear as two planes, in multi walled nanotubes more than two planes are observed, and can be seen as a series of parallel lines. There are different types of CNTs, because the graphitic sheets can be rolled in different ways. The three types of CNTs are **Zigzag, Armchair, and Chiral.** It is possible to recognize zigzag, armchair, and chiral CNTs just by following the pattern across the diameter of the tubes, and analyzing their cross-sectional structure.



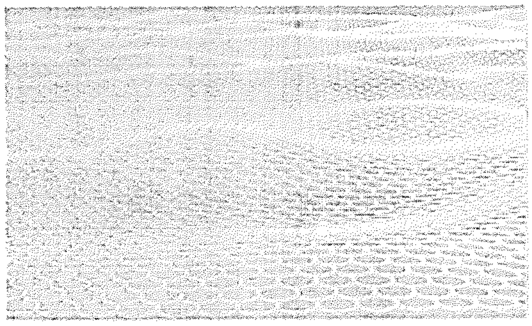
Slide: 77 of 78

2

2

5MIN

Part B (3Q x 6M = 18 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
4	**What is graphene?** Carbon comes in many different forms, from the graphite found in pencils to the world's most expensive diamonds. In 1980, we knew of only three basic forms of carbon, namely diamond, graphite, and amorphous carbon. Then, fullerenes and carbon nanotubes were discovered and, in 2004, graphene joined the club.	1	10MIN
	Graphene is an atomic-scale honeycomb lattice made of carbon atoms. Graphene is undoubtedly emerging as one of the most promising nanomaterials because of its unique combination of superb properties, which opens a way for its exploitation in a wide spectrum of applications ranging from electronics to optics, sensors, and biodevices. Existing forms of carbon basically consist of sheets of graphene, either bonded on top of each other to form a solid material like the graphite in your pencil, or rolled up into carbon nanotubes (think of a single-walled carbon nanotube as a graphene cylinder) or folded into fullerenes.  Slide: 77 of 78 *Mother of all graphitic forms. Graphene is a 2D building material for carbon materials of all other dimensionalities. It can be wrapped up into 0D buckyballs, rolled into 1D nanotubes or stacked into 3D graphite. (Artistic impression of a corrugated graphene sheet: Jannik Meyer)*	2	
	The reason nanotechnology researchers are so excited is that the properties of graphene and other two-dimensional crystals (it's called 2D because it extends in only two dimensions: length and width; as the material is only one atom thick, the third dimension, height, is considered to be zero) open up a whole new class of materials with novel electronic, optical and mechanical properties. Early experiments with graphene have revealed some fascinating phenomena that excite researchers working towards molecular electronics. For instance, it was found that graphene remains capable of conducting electricity even at the limit of nominally zero carrier concentration because the electrons don't seem to slow down or localize. The electrons moving around carbon atoms interact with the periodic potential of graphene's honeycomb lattice, which gives rise to new quasiparticles that have lost their mass, or 'rest mass' (so-called *massless Dirac fermions*). That means that graphene never stops conducting. It was also found that they travel far faster than electrons in other semiconductors. Slide: 77 of 78	1	

Graphene production

The quality of graphene plays a crucial role as the presence of defects, impurities, grain boundaries, multiple domains, structural disorders, wrinkles in the graphene sheet can have an adverse effect on its electronic and optical properties. In electronic applications, the major bottleneck is the requirement of large size samples, which is possible only in the case of CVD process, but it is difficult to produce high quality and single crystalline graphene thin films possessing very high electrical and thermal conductivities along with excellent optical transparency. 1

Another issue of concern in the synthesis of graphene by conventional methods involves the use of toxic chemicals and these methods usually result in the generation hazardous waste and poisonous gases. Therefore, there is a need to develop green methods to produce graphene by following environmentally friendly approaches. The preparation methods for graphene should also allow for in-situ fabrication and integration of graphene-based devices with complex architecture that would enable eliminating the multi step and laborious fabrication methods at a lower production cost .

Currently, the most common techniques available for the production of graphene are shown schematically below, which includes micromechanical cleavage, chemical vapor deposition, epitaxial growth on SiC substrates, chemical reduction of exfoliated graphene oxide, liquid phase exfoliation of graphite and unzipping of carbon nanotubes. However, each of these methods can have its own advantages as well as limitations depending on its target application(s) Slide: 77 of 78 1

Applications: Graphene has received greater attention due to advantages over other materials because of its very high electrical conductivity, optical transparency and flexibility. The flexibility of graphene-based devices goes beyond conventional transistor circuits and includes flexible and transparent electronics, optoelectronics, sensors, electromechanical and energy systems Graphene has numerous applications. below represents few applications.

GRAPHENE AS TRANSPARENT ELECTRODE - Light Emitting Diodes 1

The transparent conductive electrode is an important component of LEDs, through which light couples out of the devices. Recently, organic light-emitting diodes (OLEDs) are a promising electronic display because of their high luminous efficiency, flexibility, cheap and compatibility with a wide variety of substrates. The high transparency, flexibility, large area and strong mechanical properties of graphene make it a suitable candidate for flexible and large area OLEDs electrode.

Touch Screen

An electronic visual display that can detect the presence and location of a touch by a finger or other objects within the display area is known as touch screen. There are a variety of touch screen technologies exist, many such as infrared, resistive, surface acoustic, capacitive, surface capacitance and projected capacitance. The graphene based touch screen first proposed by Bae et al.28 A palm-sized touch screen was made with a CVD grown graphene sheet. The high transparency (~97%), flexibility and no toxicity are very useful for touch screen.

Flexible and Stretchable Electronic

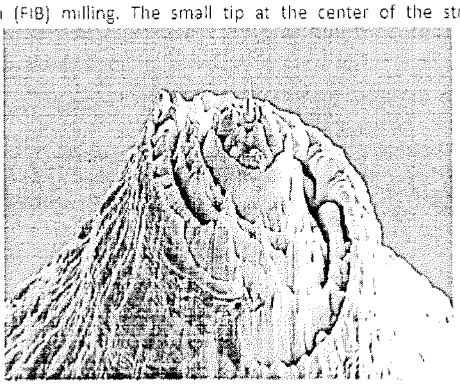
The large area graphene synthesized on metals substrate (Ni or Cu) can be easily transfer to any of the desire suSlide: 77 of 78 approach is attractive because it permits fabrication over large areas and expands the applicability of graphene 1
stretchable devices on thin plastic or elastomeric substrate. The electrical, optical and mechanical properties of graphene allow great applications in the next generation of optoelectronics. Graphene-based flexible and stretchable transistors have been made.

5

The importance of scanning probe techniques 2

It has been 25 years since the scanning tunneling microscope (STM) was invented, followed four years later by the atomic force microscope, and that's when nanoscience and nanotechnology really started to take off. Various forms of scanning probe microscopes based on these discoveries are essential for many areas of today's research. Scanning probe techniques have become the workhorse of nanoscience and nanotechnology research.

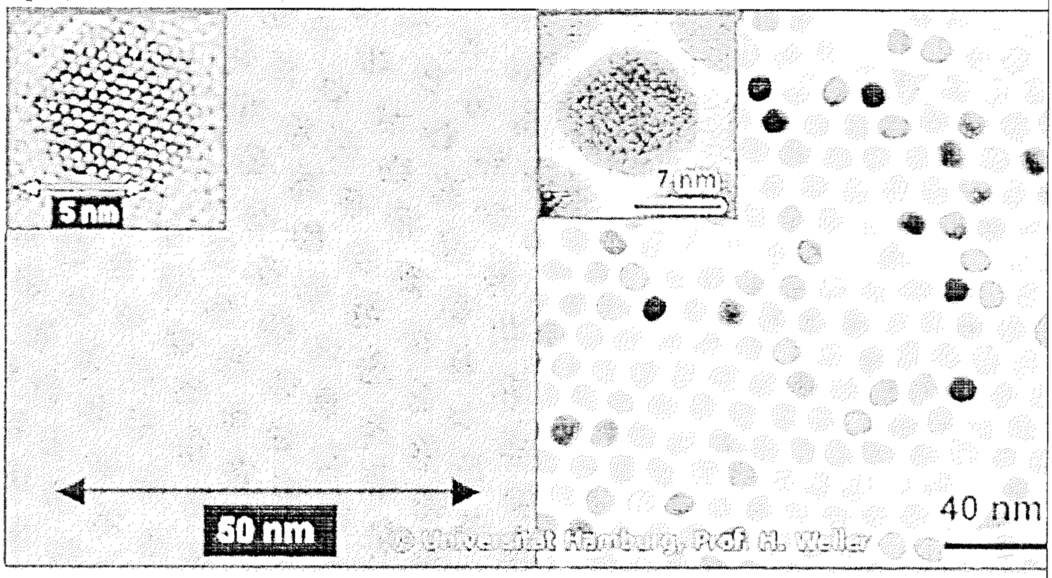
Here is a Scanning Electron Microscope (SEM) image of a gold tip for Near-field Scanning Optical Microscopy (SNOM) obtained by Focussed Ion Beam (FIB) milling. The small tip at the center of the structure measures some tens of nanometers. 2



Gold Tip for SNOM, imaged by IFM, 2006, Gian Carlo Gazzadi and Pietro Gucciardi ... viewed ... from Blow Up: Images from the nanoworld, edited by S3 Research Center ... National Research Center ... Modena, Italy

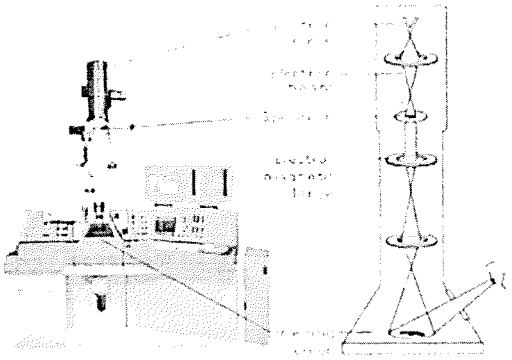
2

10MIN

	 *Electron microscopical images of various nanoparticles*	2	

Part C (2Q x 5M = 10Marks)

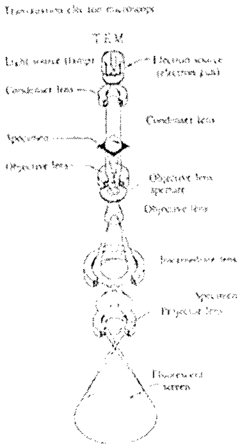
Q No	Solution	Scheme of Marking	Max. Time required for each Question
6	A TEM specimen must be thin enough to transmit sufficient electrons to form an image with minimum energy loss. Therefore, specimen preparation is an important aspect of the TEM analysis. For most electronic materials, a common sequence of preparation techniques is ultrasonic disk cutting, dimpling, and ion-milling. *Dimpling* is a preparation technique that produces a specimen with a thinned central area and an outer rim of sufficient thickness to permit ease of handling. *Ion milling* is traditionally the final form of specimen preparation. In this process, charged argon ions are accelerated to the specimen surface by the application of high voltage. The ion impingement upon the specimen surface removes material as a result of momentum transfer. The three component systems: the illumination system, the objective lens/stage, and the imaging system. The illumination system comprises the gun and the condenser lens and its role is to take the electrons from the source and transfer them to your specimen. illumination system can be operated in two principal modes: parallel beam and convergent beam. The first mode is used for TEM imaging and diffraction, while the second is used for scanning (STEM) imaging microanalysis and micro-diffraction. The objective lens/stage system is the heart of the TEM. The critical region usually extended over less than 1 cm along the length of the column. the beam specimen interactions take place in the column and here the bright-field, dark-field images, and selected-area diffraction patterns (SAD) are generated.	2 2 2 3	20MIN



1

2

The imaging system uses several lenses to magnify the image or the diffraction pattern produced by the objective lens and to focus these on the viewing screen. the magnifying lenses are known as intermediate and diffraction lenses and the final lens as the projector lens (it projects an image on the viewing screen). Alternatively, an electron detector coupled to a TV/CRT is used to display the STEM images.



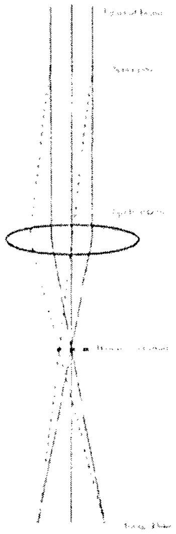


Fig 1 - General layout of a TEM describing the path of electron beam in a TEM

Fig 2 - A ray diagram for the diffraction mechanism in TEM

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BENGALURU

SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

Semester: Odd Semester: 2019 - 20

Course Code: MEC 402

Course Name: NANOTECHNOLOGY

Program & Sem: B.Tech,(All Programs) & VII (OE-II)

Date: 23 December 2019

Time: 9:30 AM to 12:30 PM

Max Marks: 80

Weightage: 40%

Instructions:

(i) Read the all questions carefully and answer accordingly.
(ii) Question paper consists of three parts.
(iii) Scientific and Non-programmable calculators are permitted

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Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries 1 mark. **(10Qx1M=10M)**

1.

(a). Nanotechnology deals with structures sized between .... nanometer in at-least ....dimension. (C.O.No.1) [Knowledge]

(b). In 1959, physics Nobel laureate .... gave a talk at Caltech on the occasion of the American Physical Society meeting. The talk was entitled,................ (C.O.No.1) [Knowledge]

(c). Nanomaterials are typically categorized as 0-D, 1-D, 2-D, and 3-D. Give examples of dimensions. (C.O.No.2) [Comprehension]

(d). ....and ......methods are used in Nanomaterial synthesis. (C.O.No.2) [Comprehension]

(e). For investigating and manipulating the materials under nanoscale the microscopes are broadly grouped into which categories? (C.O.No.3) [Comprehension]

(f). Electron microscopes have much greater .... power than light microscopes that uses .... radiation. (C.O.No. 3) [Comprehension]

(g). From a general point of view, the combined effects of ...... and .... are the main reasons for the increased lubricating behaviour of nanoparticles. (C.O.No.4) [Comprehension]

(h). The .... temperature and the ......temperature are fundamental temperature of nanomaterials as they are directly related to the strength of the bonds in the solid. (C.O.No.4) [Comprehension]

(i). Write two significant drawbacks which were observed when suspensions of solid particles in liquid with sizes in the order of millimeters or micrometers was previously investigated by several researchers. (C.O.No.5) [Comprehension]

(j). What is Brownian motion in Nano-fluid? (C.O.No.5) [Comprehension]

Part B [Thought Provoking Questions]

Answer all Questions. Each Question carries 10 marks. (4Qx10M=40M)

2. Identify and write a short note on revolutionary Nanomaterial whose invention in the year 2004 opened up the door for the characterization and functionalization of many Nano products.
   (C.O.No.2) [Comprehension]
3. One of the most fascinating and useful aspects of the nanomaterials is their optical property. Explain briefly the parameters which affect the optical property of Nanomaterials.
   (C.O.No.4) [Comprehension]
4. "Nano scale materials have extremely high surface to air ratios as compared to large scale materials". Explain and Prove it. (C.O.No.2) [Comprehension]
5. Explain working principle of SEM and its applications. (C.O.No.3) [Comprehension]

Part C [Problem Solving Questions]

Answer all the Questions. Each Question carries 15 marks. (3Qx10M=30M)

6. What is electron tunneling? Explain in detail about Atomic force microscopy with the aid of a schematic diagram.
   (C.O.No.3) [Comprehension]
7. What is Nano-fluid? Explain the application of Nano-fluid in Nuclear power plant and the microprocessor with a neat sketch. (C.O.No.4) [Comprehension]
8. Elucidate Top-down and Bottom-up methods of Nanomaterial synthesis. Explain Sol-gel process with advantages and disadvantages. (C.O.No.2) [Comprehension]

SCHOOL OF ENGINEERING

SOLUTION

Semester : Odd Semester: 2019 - 20
Course Code: MEC 402
Course Name: Nanotechnology
Program & Sem: B.Tech, 7th sem

Date: 23 Dec 2019
Time: 9.30 to 12.30 hrs
Max Marks: 80
Weightage: 40 %

Part A (1Q x 10M = 10Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
a.	1 to 100 Nm and 1dimension	1	**2 minute each**
b.	Richard Fenyman, There's plenty of room at the bottom	1	
c.	Nanoclusters, Nanofibres, Nanofilms, Bulk	1	
d.	Top down and Bottom up	1	
e.	Scanning probe, Electron and optical	1	
f.	Resolving power and electromagnetic radiation	1	
g.	Sliding and rotating	1	
h.	Melting and glass temperature	1	
i.	1. The particles settle rapidly, forming a layer on the surface and reducing the heat transfer capacity of the fluid. 2. If the circulation rate of the fluid is increased, sedimentation is reduced, but the erosion of the heat transfer devices, pipelines, etc., increases rapidly.	1	
j.	Brownian motion is the irregular juggling sort of movements which is studied under microscope	1	

Part B (4Q x 10M = 40 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
2	The quality of graphene plays a crucial role as the presence of defects, impurities, grain boundaries, multiple domains, structural disorders, wrinkles in the graphene sheet can have an adverse effect on its electronic and optical properties. In electronic applications, the major bottleneck is the requirement of large size samples, which is possible only in the case of CVD process, but it is difficult to produce high quality and single crystalline graphene thin films	10M	15 MIN EACH

	possessing very high electrical and thermal conductivities along with excellent optical transparency. Another issue of concern in the synthesis of graphene by conventional methods involves the use of toxic chemicals and these methods usually result in the generation hazardous waste and poisonous gases. Therefore, there is a need to develop green methods to produce graphene by following environmentally friendly approaches. The preparation methods for graphene should also allow for in-situ fabrication and integration of graphene-based devices with complex architecture that would enable eliminating the multi step and laborious fabrication methods at a lower production cost . Currently, the most common techniques available for the production of graphene are shown schematically below, which includes micromechanical cleavage, chemical vapor deposition, epitaxial growth on SiC substrates, chemical reduction of exfoliated graphene oxide, liquid phase exfoliation of graphite and unzipping of carbon nanotubes. However, each of these methods can have its own advantages as well as limitations depending on its target application(s)		
3	One of the most fascinating and useful aspects of nano materials is their optical properties. Applications based on optical properties of nano materials include optical detector, laser, sensor, imaging, phosphor, display, solar cell, photo catalysis, photo electrochemistry and biomedicine. The optical properties of nano materials depend on parameters such as feature size, shape, surface characteristics, and other variables including doping and interaction with the surrounding environment or other nanostructures. Likewise, shape can have dramatic influence on optical properties of metal nano structures. Emplifies the difference in the optical properties of metal and semiconductor nano particles. With the Cd Se semiconductor nano particles, a simple change in size alters the optical properties of the nano particles. When metal nano particles are enlarged, their optical properties change only slightly as observed for the different samples of gold nano spheres in. However, when an anisotropy is added to the nano particle, such as growth of nano rods, the optical properties of the nano particles change dramatically.	10M	
4	difference in tunneling current, with the tip being fixed on the back of the cantilever. This allows the detection of normal and lateral displacements of the cantilever. Optical detection is far superior to other forms of detection, though there are problems associated with the laser such as the heating of the cantilever and the sample. The image is generated from the interaction force. In the scan, the interaction force is kept constant by a feedback control. The increase in the interaction force when the tip approaches an elevated part is related to the vertical displacement of the scanner needed to eliminate this increase in signal. This is converted to height. Thus the basic components of the microscope are the cantilever, the detection system, scanners and the electronics. These components are schematically represented in Fig. 2.18. This also suggests that depending on the kind of interactions between the cantilever and the surface, various kinds of microscopies are possible. The probe can be made magnetic to investigate the magnetic interactions with materials. This results in magnetic force microscopy. The tip can have specific temperature probes or the tip itself can be made of a thermocouple. This facilitates scanning thermal microscopy (SThM). The tip may be attached with molecules which are designed to have specific molecular interactions with the surface. This results in chemical force microscopy.	10M	

5	SERS is a surface sensitive technique that results in the enhancement of Raman scattering by molecules adsorbed on rough metal surfaces. The enhancement factor can be as much as $10^{14} – 10^{15}$, which allows the technique to be sensitive enough to detect single molecules. Metal surfaces with nanometre scale roughness have the property of amplifying the Raman scattering signals of absorbed molecules. In simple words, Raman scattering is the inelastic scattering of photons. Normally, when light is scattered from an atom or molecule, it has the same energy (frequency) and wavelength as the incident light (Rayleigh scattering). This is an elastic scattering. However, a small fraction of the scattered light (approximately 1 in 10 million photons) is scattered by an excitation, with the scattered photons having energy (frequency) different from the frequency of the incident photons. Metal surfaces with nanoscale roughness increase the Raman scattering of molecules absorbed on them. This effect is due to chemical and electromagnetic factors, as well as increased surface area. We will not go into the details of this effect: what is important is that the SERS effect can induce a signal enhancement of up to 108 times. In one specific case, it has been possible to achieve a Raman enhancement effect of 1015 times! This means that the SERS effect makes it possible to push the detection limit of surface detection techniques. The SERS signal depends on the characteristics of the nano-substrate: the size, shape, orientation and composition of the surface nano-roughness. Advancement in SERS technology will allow detection at the attomole (10-18 mol) level, and single molecule detection.	10M	

Part C (3Q x 10M = 10Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
6	**Surface-to-Volume Ratio Versus Shape** One of the most fundamental differences between nanomaterials and larger-scale materials is that nanoscale materials have an extraordinary ratio of surface area to volume. Though the properties of traditional large-scale materials are often determined entirely by the properties of their bulk, due to the relatively small contribution of a small surface area, for nanomaterials this surface-to-volume ratio is inverted. For these reasons, a nanomaterial's shape is of great interest because various shapes will produce distinct surface-to-volume ratios and therefore different properties. The expressions that follow can be used to calculate the surface-to-volume ratios in nanomaterials with different shapes and to illustrate the effects of their diversity.	10M	20MIN EACH
7	Nanofluid is a new kind of heat transfer medium, containing nanoparticles (1–100 nm) which are uniformly and stably distributed in a base fluid. These distributed nanoparticles, generally a metal or metal oxide greatly enhance the thermal conductivity of the nanofluid, increases conduction and convection coefficients, allowing for more heat transfer. Nanofluids have been considered for applications as advanced heat transfer fluids for almost two decades. However, due to the wide variety and the complexity of the nanofluid systems, no agreement has been achieved on the magnitude of potential benefits of using nanofluids for heat transfer applications. Compared to conventional solid–liquid suspensions for heat transfer	10M	

	intensifications, nanofluids having properly dispersed nanoparticles possess the following advantages: 1. High specific surface area and therefore more heat transfer surface between particles and fluids. 2. High dispersion stability with predominant Brownian motion of particles. 3. Reduced pumping power as compared to pure liquid to achieve equivalent heat transfer intensification. 4. Reduced particle clogging as compared to conventional slurries, thus promoting system miniaturization. 5. Adjustable properties, including thermal conductivity and surface wettability, by varying particle concentrations to suit different applications.		
8	Sol-gel syntheses (production of a gel from powder-shaped materials) are wet-chemical processes for producing porous nanomaterials, ceramic nanostructured polymers as well as oxide nanoparticles. The synthesis takes place under relatively mild conditions and low temperatures. The term sol refers to dispersions of solid particles in the 1-100 nm size range, which are finely distributed in water or organic solvents. In sol-gel processes, material production or deposition takes place from a liquid sol state, which is converted into a solid gel state via a sol-gel transformation. The sol-gel transformation involves a three-dimensional cross-linking of the nanoparticles in the solvent, whereby the gel takes on bulk properties. A controlled heat treatment in air can transform gels into a ceramic oxide material.	10M	