COURSE TITLE	**MICRO AND NANO MACHINING**
COURSE CODE	**01CA1223**
COURSE CREDITS	**3**

Objective:

1 The course intends to introduce technologies used for manufacturing of products at micro and Nano scale.

Course Outcomes: After completion of this course, student will be able to:

1 Analyze various techniques used for manufacturing and inspection in practical applications.

2 Analyze the influence of process parameters in micro-manufacturing techniques for achieving effective outcomes.

3 Analyze the fundamentals of nano-manufacturing and their relevance to practical applications.

4 Analyze advanced technologies used for miniaturization of equipment and their operational significance.

5 Analyze the behavior of materials and equipment at small scales for practical engineering applications.

Pre-requisite of course: Solid Mechanics, Manufacturing Process

Teaching and Examination Scheme

Theory Hours	Tutorial Hours	Practical Hours	ESE	IA	CSE	Viva	Term Work
3	0	0	50	30	20	0	0

Contents : Unit	Topics	Contact Hours
1	**Introduction** Micro fabrication Techniques: Lithography, Thin Film Deposition and Doping, Etching and Substrate Removal, Substrate Bonding, MEMS Fabrication Techniques,, Bulk Micromachining,, Surface Micromachining, High- Aspect- Ratio Micromachining.	5
2	**Micro-Machining** Material removal at micro-scale: size effect, chip thickness, Micro-Structure and Grain Size Effects, Tool geometry, Tool wear, and Tool Deflections,, Tool Stiffness and Deflections under Dynamic Loading, Micro Turing and Micro Milling.	5

Contents : Unit	Topics	Contact Hours
3	**Etching** Characterizing etching processes in bulk micromachining; micro-fabrication of MEMS and semiconductor devices; , basics of micro-fabrication, Integrated circuit fabrication; crystallography and its effects,, silicon as substrate and structural material,, stress and strain, crystal plane effects on etching, wet etching process, reaction phenomena, anisotropic etching, isotropic etch curves, masking for anisotropic etchants, etching control, fusion bonding of silicon on an insulator,, deep reactive ion etching, fabrication of a cantilever probe, manufacture, microprocessors and applications; problems with etching in bulk micromachining.	7
4	**Lithography** Principle of the soft lithography and applications; principle of micro contact printing and applications;, characterizing the surface micromachining process, isolation layer, sacrificial layer, structural material,, selective etching – properties, stress, stress measurement, friction; wafer bonding: anodic and fusion, bonding., Micro and nanotechnology: Applications for space micro propulsion, , subsystems and devices for miniaturized spacecrafts micro propulsion: microbolomete, micro FEEP, integrated cold-gas microthruster, microturbogas, pyrotechnic actuator and micro valve etc - propulsion systems: solid propellant, ADCS	7
5	**Carbon nano-tube production and applications** Basis of nanotechnology, structure and properties of carbon nano tubes, production of carbon nano tube: chemical vapor deposition, arc discharge, , laser ablation, mechanisms of growth, purification of carbon nano tube, applications:, electrical transport of carbon nano tubes for FET, , Computers, nano devices for biomedical,, X-ray equipment, nano mechanic actuator and artificial muscles, Fuel cells, membrane electrode assembly, mechanical and electrical reinforcement of bipolar plates, hydrogen storage	9
6	**Carbon based nanostructures** Structure of carbon nano-tubes Y-shaped, double helical, bamboo, hierarchical morphology, structure of fullerenes, structure of carbon nano balls, structure of carbon nano-fibers, porous carbon, properties of carbon nanostructures, synthesis potential applications of nanostructures - composite materials, nanotechnology for fuel cell applications: nano-particles in heterogeneous catalysis,, O2 electro reduction reaction on carbon-supported Pt catalysts, carbon nano-tubes as catalyst supports	9
Total Hours		**42**

Textbook :

1 Micro-manufacturing: Design and Manufacturing of micro products, Koc M and Ozel T, wiley, 2011

2 Micro-manufacturing and nanotechnology, Mahalik N P, Springer, 2006

References:

1 Micro and nano-manufacturing, Micro and nano-manufacturing, Jackson M J, springer, 2007

2 Micromachining techniques for fabrication of micro, nano structures, Micromachining techniques for fabrication of micro, nano structures, Kahrizi M, intechopen, 2012

3 Introduction to Nano science and Nanotechnology,, Introduction to Nano science and Nanotechnology,, Gabor L H, Tibbals H F, Dutta J and Moore J, CRC., 2008

4 Micro & nano technologies, Micro & nano technologies, Ramsden J,, Elsevier, 2012

5 Emerging nanotechnologies for manufacturing, Emerging nanotechnologies for manufacturing, Ahmed W and Jackson M J, Elsevier, 2015

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation					
Remember / Knowledge	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Higher order Thinking / Creative**
10.00	10.00	20.00	15.00	25.00	20.00

Instructional Method:

1 With the advancement of technology, miniaturization of equipment is increasing. Material and hence equipment behavior at such a small scale is different. New technologies are required to manufacture at such a small scale. The course intends to introduce technologies used for manufacturing of products at micro and Nano scale.

Supplementary Resources:

1 https://archive.nptel.ac.in/courses/112/105/112105231/