ANNAMALAI UNIVERSITY
DEPARTMENT OF MANUFACTURING ENGINEERING
TWO-YEAR M.E (FULL TIME) DEGREE PROGRAMME IN
NANO MATERIALS & SURFACE ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS)

REGULATIONS

R1 CONDITION FOR ADMISSION

Candidates for admission to the first year of the four-semester M.E full time degree programme in Nano Materials & Surface Engineering shall be required to have passed **B.E/ B.Tech (Mechanical/ Manufacturing/ Production/ Metallurgy/ Materials Science/Automobile/ Chemical)** They shall satisfy the condition regarding qualifying marks and physical fitness as may be prescribed by the syndicate of the Annamalai University from time to time. The candidates who underwent the degree course under a part time scheme should posses two years of professional experience after passing the B.E degree examinations.

R2 CREDITS

M.E full-time programme will have duration of 4 semesters. The number of credits per semester for the full-time programme shall be as follows:

First and Second semesters: 20 credits per semester
Third Semester: 12 credits
Fourth Semester: 13 credits

The total credits for the programme will be 65. For the award of the degree, a student has to earn a minimum of 65 credits.

R3 DURATION OF THE PROGRAMME

A student of the full-time programme is normally expected to complete in four semesters but in any case not more than four years from the time of admission.

R4 REGISTRATION FOR COURSES

A newly admitted student will automatically be registered for all the courses prescribed for the first semester, without any option. Every other student shall submit a completed registration form indicating the list of courses intended to be credited during the next semester. This registration will be done a week before the last working day of the current semester. Late registration with the approval of the dean on the recommendation of the head of the department along with a late fee will be done up to the last working day. Registration for the Phase I and Phase II shall be done at the appropriate semesters.

R5 ASSESSMENT

The break-up of assessment and examination marks for theory subjects is as follows.

First assessment	: 10 marks
Second assessment (mid-semester test)	: 10 marks
Third assessment	: 05 marks
Examination	: 75 marks

The break-up of assessment and examination marks for practical subjects is as follows.

First assessment (test)	: 15 marks
Second assessment (test)	: 15 marks
Maintenance of record book	: 10 marks
Examination	: 60 marks

The thesis phase (I + II) will be assessed for 40 marks by a committee consisting of the Head of the Department, the guide and a minimum of two members nominated by the Head of the department. The Head of the Department will be the chairman. 60 marks are allotted for the thesis work and viva voce examination at the end of the pre-final semester. The same procedure will be adopted in the final semester also.

R6 COUNSELLOR

To help the students in planning their course of study and for general advice on the academic programmes the head of the department will attach a certain number of students to a member of the faculty who shall function as counselor for those students throughout their period of study. Such counselor shall advise the students, give preliminary approval for the courses to be taken by the students during each semester and obtain the final approval of the head of the department.

R7 CLASS COMMITTEE

For each semester, separate class committees will be constituted by the respective heads of the departments. The composition of the class committees for each semester except the final semester shall be as follows:

Teachers of the individual courses

A project coordinator (in the pre-final and final semester committee only) who shall be appointed by the head of the department from among the project supervisors.

One Professor or Reader, preferably not teaching the concerned class, appointed as Chairman by the head of the department.

The Head of the Department may opt to be a member or the chairman.

All counselors of the class and the head of the department (if not already a member) or any staff member nominated by the head of the department may opt to be special invitees.

The class committee shall meet four times during the semester. The first meeting will be held within two weeks from the date of class commencement in which the types of assessment like test, assignment etc. For the first and three assessments and the dates of completion of the assessments will be decided. The second meeting will be held within a week after the completion of the first assessment to review the performance and for follow-up action.

The second assessment will be the mid-semester test.

The third meeting will be held within a week after the second assessment is completed to review the performance and for follow-up action.

The fourth meeting will be held after all the assessments except the examination are completed for the courses and at least one week before the commencement of the examinations.

During this meeting the assessment on a maximum of 40 marks will be finalized for every student are tabulated and submitted to the need of the department for approval and transmission to the Controller of examinations.

R8 WITHDRAWAL FROM A COURSE

A student can withdraw from a course at any time before a date fixed by the head of the department prior to the second assessment, with the approval of the dean of the faculty on the recommendation of the head of the department.

R9 TEMPORATY BREAK OF STUDY

A student can take a one-time temporary break of study covering the current semester and / or the next semester with the approval of the dean on the recommendation of the head of the department, not later than seven days after the completion of the mid-semester test. However, the student must complete the entire programme within the maximum period of four years for full-time.

R10 SUBSTITUTE ASSESSMENTS

A student who has missed, for genuine reasons accepted by the head of the department, one or more of the assessments of a course other than the end of semester examination may take a substitute assessment for any one of the missed assessments. The substitute assessment must be completed before the date of the fourth meeting of the respective class committees.

A student who wishes to have a substitute assessment for a missed assessment must apply to the head of the department within a week from the date of the missed assessment.

R11 ATTENDANCE REQUIREMENTS

To be eligible to appear for the examination in a particular semester, a student must put in a minimum of 80% of attendance in that programme. However, if the attendance is 75% or above but less than 80% in any course, the authorities can permit the student to appear for the examination in that course on payment of the prescribed

condemnation fee. A student who withdraws from or does not meet the minimum attendance requirement in a course must re-register for and repeat the course.

R12 PASSING AND DECLARATION OF EXAMINATION RESULTS

All assessments of all the courses on an absolute marks basis will be considered and passed by the respective results passing boards in accordance with the rules of the University. Thereafter, the controller of examinations shall convert the marks for each course to the corresponding letter grade as follows, compute the grade point average and overall grade point average and prepared the grade cards.

MARKS AND THEIR RESPECTIVE GRADES

90 to 100 marks: **S**

80 to 89 marks: **A**

70 to 79 marks: **B**

60 to 69 marks: **C**

55 to 59 marks: **D**

50 to 54 marks: **E**

Less than 50 marks: **F**

A student who obtains less than 24 marks out of 60 in the examination or is absent for the examination will be awarded grade 'F'. A student who earns a grade of S, A, B, C, D or E for a course is declared to have successfully completed that course and earned the credits for that course. Such a course cannot be repeated by the student. A student who obtains letter grades I or W in a course must re-register for and repeat the course.

The following grade points are associated with each letter grade for calculating the grade point average and overall grade point average.

S – 10; A – 9; B – 8; C – 7; D – 6; E – 5; F – 6

F grade will be considered for computing GPA (Grade Point Average) and OGPA (Overall Grade Point Average). A student can apply for retotaling of one or more of his / her examination answer papers within a week from the date of issue of grade sheet to the student on payment of the prescribed fee per paper. The application must be made to the controller of examinations with the recommendation of the head of the department.

After results are declared, grade cards will be issued to the students. The grade card will contain the list of courses registered during semester, the grades scored and the grade point average for the semester. GPA is the sum of the products of the number of credits of a course with the grade point scored in that course, taken over all the courses for the semester, divided by the sum of the number of credits for all courses taken in that semester. OGPA is similarly calculated considering all the courses taken from the time of admission. The results of the final semester will be withheld until the student obtains passing grades in all the subjects of all the earlier semesters.

After successful completion of the programme, the degree will be awarded with the following classifications based on OGPA. For First Class with Distinction the student

must earn a minimum of 65 credits within four semesters for full-time from the time of admission, pass all the courses in the first attempt and obtain a OGPA of 8.25 or above. For First Class, the student must earn a minimum of 65 credits within two years and six months for full-time from the time of admission and obtain a OGPA of 6.75 or above. For Second class, the student must earn a minimum of 65 credits within four years for full-time from the time of admission.

R13 RANKING OF CANDIDATES

The candidates who are eligible to get the M.E degree in First Class with Distinction will be ranked on the basis of OGPA for all the courses of study from I to IV semester for M.E full-time. The candidates passing with First Class and without failing in any subject from the time of admission will be ranked next to those with distinction on the basis of OGPA for all the courses of study from I to IV semester.

R14 ELECTIVES

Apart from the various elective courses offered in the curriculum of the branch of specialization, a student can choose a maximum of two electives from any specialization under the faculty during the entire period of study, with the approval of the head of the department and the head of the department offering the course.

R15 TRANSITORY REGULATIONS

If a candidate studying under the old regulations M.E could not attend any of the subjects in his / her courses, shall be permitted to attend equal number of subjects, under the new regulation and will be examined in those subjects. The choice of subjects will be decided by the Head of the Department concerned. However, he / she will be permitted to submit the thesis as per the old regulations. The results of such candidates will be passed as per old regulations.

First Semester:

Code	Subject	Ins. Hrs./Week		Exam Duration in hours	Internal assessment marks	End exam marks	Total Marks	Credit Points
		T	P					
NMSC 101	Materials Science	4	-	3	25	75	100	3
NMSC 102	Nano Structures	4	-	3	25	75	100	3
NMSC 103	Nano Materials	4	-	3	25	75	100	3
NMSC 104	Nano Characterization	4	-	3	25	75	100	3
NMSC 105	Micro Manufacturing	4	-	3	25	75	100	3
NMSE 106	Elective – I	4	-	3	25	75	100	3
NMSP 107	Nano Materials Laboratory	-	6	3	40	60	100	2
Total		18	6		190	510	700	20
Cumulative Total								20

(T: Theory; P: Practical)

Second Semester:

Code	Subject	Ins. Hrs./Week		Exam Duration in hours	Internal assessment marks	End exam marks	Total Marks	Credit Points
		T	P					
NMSC 201	Surface Modification Techniques	4	-	3	25	75	100	3
NMSC 202	Thermal Spray Techniques	4	-	3	25	75	100	3
NMSC 203	Engineering Tribology	4	-	3	25	75	100	3
NMSC 204	Corrosion Engineering	4	-	3	25	75	100	3
NMSE 205	Elective – II	4	-	3	25	75	100	3
NMSE 206	Elective – III	4	-	3	25	75	100	3
NMSP 207	Surface Engineering Laboratory	-	6	3	40	60	100	2
Total		18	6		190	510	700	20
Cumulative Total								40

Third Semester:

Code	Subject	Ins. Hrs./Week		Exam Duration in hours	Internal assessment marks	End exam marks	Total Marks	Credit Points
		T	P					
NMSE 301	Elective IV	3	-	3	25	75	100	3
NMSE 302	Elective V	3	-	3	25	75	100	3
NMST 303	Thesis Phase I and Viva Voce	-	15	-	40	60	100	6
Total		6	15		90	210	300	12
Cumulative Total								52

Fourth Semester:

Code	Subject	Ins. Hrs./Week	Exam Duration in hours	Internal assessment marks	End exam marks	Total Marks	Credit Points
NMST 401	Thesis Phase II and Viva Voce	24	-	40	60	100	13
Total				40	60	100	13
Cumulative Total							65

LIST OF ELECTIVES (NMSE 106/ 205/ 206/ 301/ 302)

1. NANO MECHANICS
2. NANO TRIBOLOGY
3. THIN FILM COATINGS
4. ADVANCED POWDER TECHNOLOGY
5. ADVANCED MATERIALS & APPLICATIONS
6. SURFACE ENGINEERING MATERIALS
7. SURFACE CHARACTERISATION TECHNIQUES
8. ENGINEERING CERAMICS
9. LASER AND LASER PROCESSING OF MATERIALS
10. PLASMA PROCESSING OF MATERIALS
11. APPLIED PROBABILITY AND STATISTICAL INFERENCES
12. MECHANICAL BEHAVIOUR OF MATERIALS
13. HEAT TREATMENT AND MATERILAS PROCESSING
14. PRECISION ENGINEERING
15. FINITE ELEMENT ANALYSIS

I – SEMESTER

NMSC 101: MATERIALS SCIENCE

UNIT I: INTRODUCTION TO MATERIALS SCIENCE

Classification of Engineering Materials – Levels of Structure – Structure – Property Relationships in Materials; Equilibrium and kinetics: Stability and Metastability - Basic Thermodynamics Functions - The Statistical Nature Entropy – The Kinetics of Thermally Activated Processes; The Space Lattices – Space Lattices and Crystal Structures

UNIT II: ATOMIC STRUCTURE & CHEMICAL BONDING

The Quantum States – The Periodic Table – Ionization Potential, Electron Affinity and Electro negativity; Bond Energy, Bond Type and Length – Ionic Bonding – Covalent Bonding – Metallic Bonding

UNIT III: STRUCTURE OF SOLIDS

The Crystalline and the Non-crystalline states- Inorganic solids: Covalent Solids - Metals and Alloys – Ionic Solids – The Structure of Silica and the Silicates; Polymers: Classification of Polymers – Structure of Long Chain Polymers – Crystallinity of Long Chain Polymers; Crystal imperfections: Point Imperfection - The Geometry of Dislocations – Other Properties of Dislocations – Surface Imperfections

UNIT IV: PHASE DIAGRAMS & PHASE TRANSFORMATIONS

The Phase Rule – Single-Component System – Binary Phase Diagrams – Microstructural Changes during Cooling – The Lever Rule – Summary of Phase Diagram Rules – Some Typical Phase Diagrams – Other Applications of Phase Diagrams; Time Scale for Phase Changes; The Nucleation Kinetics – The Growth and the Overall Transformation Kinetics

UNIT V: DIFFUSION IN SOLIDS

Fick's Laws of Diffusion – Solution to Fick's Second Law – Applications Based on the Second Law Solution – The Kirkendall Effect – The Atomic Model of Diffusion

TEXT BOOK:

1. Materials Science and Engineering, V. Raghavan, Prentice-Hall of India Pvt. Ltd, New Delhi, 2007 (Chapters 1 – 8).

REFERENCE BOOKS:

1. Principles of Materials Science and Engineering, William F. Smith, Mc Graw Hill Co, New Delhi, 2006.
2. Materials for Engineers, M.H.A. Kempster, The English University Press, London, 2006.

NMSC 102: NANO STRUCTURES

UNIT I: PHYSICAL CHEMISTRY OF SOLID SURFACES

Surface energy – electro static stabilization: surface charge density, electrical potential at proximity of solid surface, chemical potential. Steric stabilization: solvent and polymer interactions.

UNIT II: ZERO DIMENSIONAL NANOSTRUCTURES

Fundamentals of homogeneous nucleation, fabrication of nanoparticles through homogeneous nucleation, subsequent growth of nuclei, synthesis of metallic nanoparticles, synthesis of semi conductor nanoparticles, synthesis of oxide nanoparticles. Vapor phase reactions, solid state phase segregation.

UNIT III: HETEROGENEOUS NUCLEATION

Fundamentals of heterogeneous nucleation, synthesis of nanoparticles, micelles/ microemulsions, aerosol synthesis, growth termination, spray pyrolysis, template based synthesis, epitaxial shell nanoparticles

UNIT IV: ONE DIMENSIONAL NANOSTRUCTURES

Spontaneous growth, evaporation, condensation and dissolution. Classifications of Spontaneous growth mechanisms. Template filling: colloidal dispersion filling, melt and solution filling, deposition by centrifugation, electro spinning and lithography.

UNIT V: TWO DIMENSIONAL NANOSTRUCTURES

Film growth, vacuum science, super lattices, self assembly, mono layers: organosilicon or alkalsilane derivatives, alkanethiols, carboxylic acids, sulfides, amines and alcohols, Langmuir – Blodgett films and sol – gel films.

TEXT BOOK:

1. Nanostructures and Nanomaterials – Synthesis, properties and applications: Guozhong Cao, Imperial college press, New Jersey, 2004 (Chapters 2 – 5).

REFERENCE BOOKS:

1. Nanotechnology, Richard Booker and Earl Boysen, Wiley Publishing Inc, New Delhi, 2005.
2. Introduction to nanotechnology, charles P. Poole Jr, Frank J. Owens, Wiley Interscience Publication, Singapore, 2003.
3. Nanotechnology basic science and emerging technologies, Michael Wilson, Chapman and Hall Publication, New York, 2002.

NMSC 103: NANO MATERIALS

UNIT I: CLASSIFICATION OF NANOMATERIALS

Nano Particles, Nano Wires and Tubes, Nano layer, Nanopores- Prpoerties of Nanomaterials, Characteristics of Nano particulate materials. Metal matrix nano composites, ceramic nano composites, polymer, nano composites-Nanoclays.

UNIT II: PRODUCTION METHODS

Top down approach: Mechanical milling, Chemical Etching, Electro explosion, (Thermal and Chemical), sputtering (Kinetic), Laser ablation. Bottom-up Approach: Sol-Gel method, Aerosol based processor, Atomic or molecular condensation.

UNIT III: NANOSTRUCTURES FABRICATED BY PHYSICAL TECHNIQUES

Lithography, phase shifting photolithography, EB lithography, X ray lithography, FIB lithography, NAB lithography, Microcontact printing, molding, nanoimprint, dip – pen nanolithography.

UNIT IV: SPECIAL NANOMATERIALS

Carbon fullerenes and nanotubes. Micro and mesophorous materials: ordered, random and zeolites. Core – shell structures, organic – Inorganic hybrids inter calation compounds, nanocomposites and nanograined materials.

UNIT V: APPLICATIONS OF NANOMATERIALS

Molecular electronics and nanoelectronics, nanobots, catalysis of gold particles, band gap engineering, nanomechanics, carbon nanotube emitters, photoelectrochemical cells, photonic crystals and plasmon waveguides.

TEXT BOOK:

1. Nanostructures and Nanomaterials – Synthesis, properties and applications: Guozhong Cao, Imperial college press, New Jersey, 2004 (Chapters 1, 6, 7 & 9)

2. Springer Hand Book of Nanotechnology, Bharat Bhushan, Springer Verlag Publications, Heidelberg, 2004 (Chapters 1 - 4)

REFERENCE BOOKS:

1. Nanotechnology, Richard Booker and Earl Boysen, Wiley Publishing Inc, New Delhi, 2005.
2. Introduction to nanotechnology, charles P. Poole Jr, Frank J. Owens, Wiley Interscience Publication, Singapore, 2003.
3. Nanotechnology basic science and emerging technologies, Michael Wilson, Chapman and Hall Publication, New York, 2002.

NMSC 104: NANO CHARACTERIZATION

UNIT I: CARBON BASED NANOSTRUCTURES

Nomenclature, synthesis and characterization of carbon nanotubes, nanorods, nanowires, graphene sheets, quantum dots and bucky balls including their respective growth mechanisms, properties and applications.

UNIT II: SCANNING PROBE MICROSCOPY

Principle of operation, instrumentation, probes, scanning tunneling microscope, atomic force microscope – Instrumentation and analysis, Principles of non contact atomic force microscopy, applications of semiconductors, insulators and molecules.

UNIT III: LOW TEMPERATURE SCANNING PROBE MICROSCOPY

Operation at low temperatures, instrumentation, scanning tunneling microscope and spectroscopy, scanning force microscopy and spectroscopy. Dynamic force microscopy: Measurement of a single atomic bond, harmonic oscillator, Dynamic AFM modes, Q – control, dissipation processes measured with dynamic AFM.

UNIT IV: MOLECULAR RECOGNITION FORCE MICROSCOPY

Ligand tip chemistry, fixation of receptors to probe surfaces, single – molecule recognition force detection, principles of molecular recognition force spectroscopy, recognition force spectroscopy: from isolated molecules to biological membranes, recognition imaging.

UNIT V: PROPERTIES EVALUATION

Structural characterization: X-ray diffraction, Smalll angle X-ray scattering, Scanning electron microscopy, transmission electron microscopy, Electron probe microscopy, Gas adsorption, Scanning tunneling microscopy and Scanning probe microscopy. Chemical composition: Optical spectroscopy, Electron spectroscopy and Ionic spectroscopy. Surface plasmon resonance, quantum size effects.

TEXT BOOK:

1. Nanotechnology basic science and emerging technologies, Michael Wilson, Chapman and Hall Publication, New York, 2002. (Chapters 1 – 5).
2. Springer Hand Book of Nanotechnology: Bharat Bhushan Edition, Springer Verlag Publications, Heidelberg, 2004 (Chapters 11 – 16).

REFERENCE BOOKS:

1. Nanotechnology, Richard Booker and Earl Boysen, Wiley Publishing Inc, New Delhi, 2005.
2. Introduction to nanotechnology, Charles P. Poole Jr, Frank J. Owens, Wiley Interscience Publication, Singapore, 2003.

NMSC 105: MICRO MANUFACTURING

UNIT I: INTRODUCTION TO MICROMANUFACTURING

Precision engineering, micromilling and microdrilling, MEMS, Microelectronics fabrication methods, Microinstrumentation, Micromechatronics, Nanofinishing, OVD, MECS, Space micropropulsion, e-beam nanolithography, molecular logic gates, microdevices and nanolevel biosensors, fuel cell.

UNIT II: PRINCIPLES OF MEMS AND MOEMS

Driving principle for actuation, fabrication processes, Mecanical MEMS: Sensors, accelerometer, cantilever capacitative measurement, microphone, gyroscope and actuators. Thermal MEMS: Thermometry, data storage, microplate gas sensor, thermoactuator. Magnetic MEMS: MOEMS, spatial light modulator, digital micro mirror device, GLV.

UNIT III: LASER TECHNOLOGY IN MICROMACHINING

Generation & properties of laser: Monochromacity, directionality, brightness, coherence, spatial profile, temporal profile. Practical lasers and their technology in Micromanufacturing: absorption and reflection of laser and application technology fundamentals. Error compensation methods: geometrical error calibration and compensation schemes.

UNIT IV: CHARACTERIZING ETCHING PROCESS IN BULK MICROMACHINING

Silicon as substrate and structural material, wet etching process, anisotropic etching. Etching control: The stop techniques. Problems with etching in bulk machining: RE consumption and corner compensation. Nanofinishing processes – classifications and descriptions.

UNIT V: FEATURES OF SURFACE MICROMACHINING AND WAFER BONDING PROCESS

Surface micromachining, characterizing surface micromachining process: Isolation layer, sacrificial layer, structural material, selective etching.

TEXT BOOK:

1. Micromanufacturing and Nanotechnology, N.P. Mahalik, Springer-Verlag Publications, New Delhi, 2007 (Chapters 1 – 6).
2. Nanotechnology, Richard Booker and Earl Boysen, Wiley Publishing Inc, New Delhi, 2005 (Chapters 4 – 7).

REFERENCE BOOKS:

1. Nanostructures and Nanomaterials – Synthesis, properties and applications, Guozhong Cao, Imperial college press, New Jersey, 2004.
2. Introduction to nanotechnology, Charles P. Poole Jr, Frank J. Owens, Wiley Interscience Publication, Singapore, 2003.

NMSP 107 NANO MATERIALS LABORATORY

Simple laboratory exercises (any six) to fabricate and characterize nanomaterials by following methods:

(i) Electro chemical etching method
(ii) Electric discharge machining method
(iii) Powder metallurgy route
(iv) Friction stir processing method
(v) Electric arc explosion method
(vi) Laser ablation technique
(vii) Plasma process
(viii) Sol Gel Method
(ix) Chemical vapor deposition method
(x) Physical vapor deposition method

II – SEMESTER

NMSC 201: SURFACE MODIFICATION TECHNIQUES

UNIT I: THIN FILM DEPOSITION METHODS

Vacuum and Kinetic Theory of Gasses, Physical methods of films deposition. Evaporation – thermal, e-beam. Sputter Deposition, Microwave, pulsed laser, Ion Beam. Arc Deposition – Cathodic, Anodic. Molecular Beam Epitaxy. Chemical methods of Film deposition - Electrolysis, Anodization, Spray pyrolysis.

UNIT II: PLATING PROCESSES

Fundamentals of Electrodeposition, plating of nickel, chromium, tin and copper - pulsed plating – electroless plating - electrochemical conversion coating, metalliding, selective plating for repair, Hard anodizing.

UNIT III: DIFFUSION PROCESSES

Principle of diffusion processes - Bording, Aluminising, Siliconising, Chromising, Sursulf - Selection of diffusion processes - Characteristics of diffused layer - micro structure and micro hardness evaluation - properties and applications.

UNIT IV: LASER ASSISTED PROCESSES

Laser beam hardening/ glazing, Laser Surface Melting, Laser Surface alloying, Laser Cladding, Laser cleaning & paint stripping, surface roughening, scabbing, marking, shock hardening.

UNIT V: HARDFACING PROCESSES

Shielded metal arc welding, flux cored arc welding, submerged arc welding, plasma transferred arc hardfacing, friction surfacing processes

TEXT BOOKS:

1. Surface Engineering for Wear Resistance, Kenneth G.Budinski, Prentice Hall, Englewood Cliff, 2000.
2. Surface Engineering, ASM Metals Handbook, Ohio, 2004

REFERENCE BOOKS:

1. Friction and Wear of Materials, Emest Rabinowicz, John Wiley & Sons, New York, 2004.
2. Welding technology and processes, R.S. Parmar, Khanna publishers, New Delhi, 2006.
3. Science and Engineering of Thermal Spray Coatings, Lech Pawlowski, Springer Verlag Publications, Berlin, 2005.

NMSC 202: THERMAL SPRAY TECHNIQUES

UNIT I: MATERIALS USED FOR SPRAYING AND PRE-SPRAY TREATMENT

Materials used for spraying: Methods of Powders Production, Methods of Powders Characterization, Feeding, Transport and Injection of Powders, Powder Feeders, Transport of Powders, Injection of Powders. Pre spray treatment: Surface Cleaning, Substrate Shaping, Surface Activation, Masking

UNIT II: FUEL BASED THERMAL SPRAY TECHNIQUES

Principles, Process Parameters, Coating Properties and Applications of: Flame Spraying (FS) - Spray and Fuse Coating (S&F) - Detonation-Gun Spraying (D-GUN) - High-Velocity Oxy-Fuel (HVOF) Spraying, High Velocity Air Fuel Spraying (HVAF).

UNIT III: ELECTRIC POWER BASED THERMAL SPRAY TECHNIQUES

Principles, Process Parameters, Coating Properties and Applications of: Arc Spraying (AS) - Atmospheric Plasma Spraying (APS) - Vacuum Plasma Spraying (VPS) - Controlled-Atmosphere Plasma Spraying (CAPS) - Solution Precursor Plasma Spraying (SPPS) - Cold-Gas Spraying Method (CGSM) - Electro Spark Coating (ESC)

UNIT IV: POST-SPRAY TREATMENT

Heat Treatment, Electromagnetic Treatment, Furnace Treatment, Hot Isostatic Pressing (HIP), Re-melting: Combustion Flame, Laser, TIG and Micro Plasma. Impregnation, Inorganic Sealants, Organic Sealants, Finishing, Grinding, Polishing and Lapping

UNIT V: COATINGS' CHARACTERIZATION

Methods of Microstructure Characterization, Methods of Chemical Analysis, Crystallographic Analyses, Microstructure Analyses, Mechanical Properties of Coatings, Adhesion Determination, Hardness and Microhardness, Elastic Moduli, Strength and Ductility, Physical Properties of Coatings, Thickness, Porosity and Density, Thermal Shock Resistance.

TEXT BOOK:

1. Science and Engineering of Thermal Spray Coatings, Lech Pawlowsky, John Wiley and Sons, New York, 2005.

REFERENCE BOOKS:

1. Plasma Spray Coating, Robert B Heimann, Wiley VCH, Berlin, 2006.
2. A Hand Book of Surface Engineering, KG Budinsky, Prentice Hall, New Jersey, 2003.

NMSC 203: ENGINEERING TRIBOLOGY

UNIT I: ADHESION

Introduction – Adhesion at Solid – Solid Contact – Adhesion Models. Friction: Introduction – Measurement Methods - Inclined Plane Rig – Pin-on-disk Rig – Conformal and Non-conformal Geometry Rig – Environment Control.

UNIT II: FRICTION

Friction Theories: Bowden and Tabor's Simple Adhesion Theory – Modified Adhesion Theory: Junction Growth – Deformation Theory: Ploughing. Other Mechanisms: Hystersis – Ratchet Mechanism – Stick-Slip – Rolling Friction

UNIT III: WEAR

Introduction – Types of Wear – Adhesive Wear – Abrasive Wear – Corrosive Wear – Fatigue Wear – Rolling Contact – Sliding Contact; Minor Forms of Wear – Fretting – Erosion: Solid Erosion – Fluid Erosion – Percussion; Delamination Theory of Wear

UNIT IV: LUBRICATION

Lubrication Theory - Lubricants and their physical properties lubricants standards - Lubrication Regimes Hydrodynamic lubrication - Reynolds Equation, Thermal, inertia and turbulent effects – Elasto hydrodynamic and plasto hydrodynamic and magneto hydrodynamic lubrication - Hydro static lubrication - Gas lubrication.

UNIT V: TRIBOLOGY PERFORMANCE EVALUATION

Tribo-Measurement and Instrumentation - Surface topography measurements - Electron microscope and friction and wear measurements - Laser method - Instrumentation - International standards Wear Debris Analysis – Wear Testing Methods.

TEXT BOOKS:

1. Fundamentals of Tribology: S.K. Basu, S.N. Sengupta, B.B. Ahuja, Prentice Hall of India, New Delhi, 2005.
2. Engineering Tribology, Prasanta Sahoo, Prentice Hall of India, New Delhi, 2005.

REFERENCE BOOKS:

1. Tribology Hand Book, Neale M.J, Butterworth Heinemann press, Canberra, 2005.
2. Principles and Application of Tribology, D.F.Moore. Pergamon Press, London, 2001
3. Basic Lubrication Theory, Ellis A. Cameron, Herward press Ltd., Northampton, 2004.

NMSC 204: CORROSION ENGINEERING

UNIT I CORROSION PRINCIPLES

Introduction – Electrochemical Aspects-Electrochemical Reactions – Polarization – Passivity. Environmental effects: Effect of Oxygen and Oxidizers – Effects of Velocity – Effects of Temperature – Effects of Corrosive Concentration – Effects of Galvanic Coupling

UNIT II: PRIMARY CORROSION TYPES

Galvanic or two-metal corrosion, Pitting corrosion, Intergranular corrosion, Oxidation: Pilling-Bedworth Ratio – Electrochemical and Morphological Aspects of Oxidation – Oxide Defect Structure – Oxidation Kinetics – Effect of Alloying – Catastrophic Oxidation – Internal Oxidation.

UNIT III: SECONDARY CORROSION TYPES

Crevice corrosion: Environmental Factors – Mechanism – Combating Crevice Corrosion – Filiform Corrosion. Selective leaching: Dezincification: Characteristics – Dezincification, Erosion corrosion, Cavitation Damage – Fretting Corrosion. Stress corrosion: Crack Morphology – Stress Effects – Time to Cracking – Environmental Factors – Metallurgical Factors – Mechanisms.

UNIT IV: CORROSION TESTING

Introduction – Classification – Purpose – Materials and Specimens – Surface Preparation – Measuring and Weighing – Exposure Techniques – Duration – Planned-Interval Tests – Aeration – Cleaning Specimens After Exposure – Temperature – Standard Expressions form Corrosion Rate – Warren Test – Pitting – Stress Corrosion – NACE Test Methods – Slow-Strain-Rate Tests – Linear Polarization – AC Impedance-Small-Amplitude Cyclic Voltammetry.

UNIT V: CORROSION PREVENTION

Metals and Alloys – Metal Purification – Non metallics; Changing Mediums – Inhibitors Cathodic and anodic protection: Cathodic Protection – Anodic Protection – Comparison of Anodic and Cathodic Protection. Coatings: Metallic and other Inorganic Coatings – Organic Coatings – Corrosion Control Standards – Failure Analysis.

TEXT BOOK:

1. Corrosion engineering, Mars G. Fontana, Tata Mc Graw-Hill. New Delhi, 2008.

REFERENCE BOOK:

1. Fundamentals of corrosion, Philip A Schweitzer, Taylor and Francis, USA, 2008.

NMSP 207 SURFACE ENGINEERING LABORATORY

Simple laboratory exercises (any six) to modify and characterize the materials surfaces by following techniques:

(i) Plasma spraying method
(ii) Laser hardening method
(iii) Flame spraying method
(iv) High velocity oxy fuel method
(v) Heat treatment method
(vi) Diffusion coating
(vii) Friction surfacing method
(viii) Plasma transferred arc hardfacing method
(ix) Evaluation of coating thickness, hardness and adhesion strength
(x) Evaluation of corrosion resistance of coating
(xi) Evaluation of wear behavior of coatings
(xii) Evaluation of oxidation behavior of coatings

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NANO MECHANICS

UNIT I: MECHANICAL PROPERTIES

Local mechanical spectroscopy by contact AFM, static methods – mesoscopic samples, scanning nanoindentation: An application to bone tissue. Nanomechanical properties of solid surfaces: Instrumentation, data analysis, modes of deformation, thin films and multi layers and developing areas.

UNIT II: SCANNING PROBE STUDIES OF MONOLAYER FILM PROPERTIES

The importance of adhesion at the nanoscale, techniques for measuring adhesion, calibration of forces, displacements and tips. The effect of liquid capillaries on adhesion, self – assembled monolayers.

UNIT III: PROPERTIES OF MICROMACHINED STRUCTURES

Measuring mechanical properties of films on substrates. Micromachined structures for measuring mechanical properties. Mechanical properties of Nanostructures: Experimental techniques, FEA of nanostructures with roughness.

UNIT IV: THERMO AND ELECTROMECHANICS OF THIN – FILM MICROSTRUCTURES

Thermomechanics of multilayer thin – film microstructures, electromechanics of thin – film microstructures, MEMS packaging, hermetic and vacuum packaging applications, thermal issues and packaging reliability.

UNIT V: MATERIAL ASPECTS OF NANOELECTROMECHANICAL SYSTEMS

Silicon, germanium based materials, metals, alloys, cermets, ceramics, harsh environment semiconductors, GAAS, INP and related III – V materials, Ferro electric materials, polymer materials and future trends.

TEXT BOOK:

1. Springer Hand Book of Nanotechnology: Bharat Bhushan Edition, Springer Verlag Publications, Heidelberg, 2004 (Chapters 21 – 25).
2. Introduction to Nanotechnology, Charles P. Poole Jr, Frank J. Owens, Wiley Interscience Publication, Singapore, 2003 (Chapters 3 – 6).

REFERENCE BOOKS:

1. Micromanufacturing and Nanotechnology, N.P. Mahalik, Springer-Verlag Publications, New Delhi, 2007
2. Nanotechnology, Richard Booker and Earl Boysen, Wiley Publishing Inc, New Delhi, 2005.
3. Nanostructures and Nanomaterials – Synthesis, properties and applications: Guozhong Cao, Imperial college press, New Jersey, 2004.

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NANO TRIBOLOGY

UNIT I: TRIBOLOGY CHARACTERIZATION

Description of AFM/FFM and other measuring techniques, friction and adhesion, scratching wear, local deformation, fabrication/machining, indentation, boundary lubrication, Surface forces and nanorheology of molecularly thin films: Types of surface forces, methods, normal forces between dry and lubricated surfaces, adhesion and capillary forces.

UNIT II: MODES OF FRICTION AND CONTINUUM MODELS

Relationship between adhesion and friction, liquid lubricated surfaces, role of molecular shape and surface structure in friction, Wear on atomic scale: FFM in ultra high vacuum, Tomlinson model, friction experiments on atomic scale, thermal effects on atomic friction, geometry effects of nanocontacts, wear on atomic scale.

UNIT III: SIMULATIONS OF NANOTRIBOLOGY

Molecular dynamics simulation of atomic friction and wear, energy dissipation in noncontact AFM, Molecular dynamics, Friction mechanisms at atomic scale, stick – slip dynamics. Thick films for lubrication: commonly used deposition techniques, chemical characterization and effect of deposition conditions on chemical and physical properties, micromechanical and tribological characterizations of coatings.

UNIT IV: NANOLUBRICATION

Lubricants details, nanodeformation, molecular conformation, lubricant spreading, boundary lubrication studies, bulk to molecular lubrication, thermal activation model & functional behavior of lubricated friction, Thermodynamical models base on small and nonconforming contacts, limitations of Gaussian statistics, fractal mobility in relative lubrication, metastable lubricant systems in large conforming contacts.

UNIT V: CONTROLLING NANOADHESION, FRICTION AND WEAR

Primer to organic chemistry, self – assembled monolayers: substrates, head groups, spacer chains and end groups, Tribo properties of SAMs, Tribological issues in MEMS/NEMS, tribological studies of silicon and related materials, lubrication studies for MEMS/NEMS and component level studies.

TEXT BOOK

1. Springer Hand Book of Nanotechnology: Bharat Bhushan Edition, Springer Verlag Publications, Heidelberg, 2004 (Chapters 17 – 20 & 23)
2. Micromanufacturing and Nanotechnology, N.P. Mahalik, Springer-Verlag Publications, New Delhi, 2007 (Chapters 11 & 12)

REFERENCE BOOKS:

1. Nanotechnology, Richard Booker and Earl Boysen, Wiley Publishing Inc, New Delhi, 2005.
2. Introduction to Nanotechnology, Charles P. Poole Jr, Frank J. Owens, Wiley Interscience Publication, Singapore, 2003.

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THIN FILM COATINGS

UNIT I: FILM DEPOSITION USING POWER BEAMS

Vacuum and Kinetic Theory of Gasses, Methods of films deposition: Evaporation – thermal, e-beam. Sputter Deposition - DC, MF, RF, Microwave, pulsed laser, Ion Beam. Arc Deposition – Cathodic, Anodic. Molecular Beam Epitaxy.

UNIT II: FILM DEPOSITION USING CHEMICAL METHODS

Deposition of Inorganic Films from Solutions. Chemical Vapor Deposition - Electrolysis, Anodization, Spray pyrolysis, polymerization. Other techniques: Langmuir Blodgett, Self-Arrangement Monolayer and Spin Coating.

UNIT III: PROPERTIES OF THIN FILMS

Optical properties, electrical properties, magnetic properties, mechanical properties.

UNIT IV: THIN FILM CHARACTERIZATION

Imaging Techniques, Structural Techniques, Chemical Techniques, Optical techniques, Electrical / Magnetic Techniques, Mechanical Techniques

UNIT V: APPLICATIONS FOR THIN FILM OF ADVANCED MATERIALS

Transparent conducting coating, Optical coating, Sensors, Superconductivity, Giant and colossal magneto resistance, super hard coatings, Ferro-electronic effect

TEXT BOOKS:

1. Thin Film Deposition: Principles and Practice, Donald L. Smith, McGrawHill, Singapore, 2001.
2. Plasma techniques for film deposition, Konuma Mitsuharu, Alpha Science, Harrow, UK, 2005.
3. Introduction to surface and thin film processes, John A. Venables, Cambridge University Press, Cambridge, 2000.

REFERENCE BOOKS:

1. An introduction to physics and technology of thin films, Alfred Wagendristel, Yuming Wang, Singapore: World Scientific, 2004.
2. Thin film processes, John L Vossen, Werner Kehn, Academic Press, New York, 2006.
3. Thin film physics, O.S. Heavens, London: Methuen, 2000.
4. Thin film phenomena, Kasturi L. Chopra, McGraw-Hill, New York, 2006.

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ADVANCED POWDER TECHNOLOGY

UNIT I: MANUFACTURE OF METAL POWDERS

Conventional methods and modern methods of metal powder manufacture. Purity of metal powders. Blending techniques.

UNIT II: POWDER CHARACTERIZATION

Problem of size determination. Method of size analysis and surface area assessment. Apparent density and flowability measurement.

UNIT III: POWDER COMPACTION

Mechanical, thermal and thermomechanical compacting processes. Presses used for transmission. Die design and tooling for consolidation of powders. New methods of consolidation. E.g. Powder rolling, Powder forging, Isostatic pressing. Advantages and limitations of these methods.

UNIT IV: THEORIES OF SINTERING

Sintering mechanism, Roll of diffusion, Recrystallization, Pore migration, Pore-growth and coalescence. Liquid phase sintering and related processes. Effect of compacting pressure, sintering temperature and time on sintered properties. Type of sintering furnaces. Sintering atmospheres.

UNIT V: MANUFACTURING AND APPLICATION OF IMPORTANT P/M COMPONENTS

Porous bearing, Electrical contact materials, Metallic filters, Cemented carbides, magnets, Friction materials and Composites.

TEXT BOOKS:

1. Powder Metallurgy-Thumler, Addison and Wesley Publishers, New York, 2006.
2. Powder Metallurgy-Sands and Shakespeare, Wiley Interscience Publication, Singapore, 2003.

REFERENCE BOOKS:

1. Powder Metallurgy-Dixtor R.H. and Clayton, Pergamon Press, New York, 2003.
2. Powder Metallurgy-Gopal S. Upadhayay, Prentice Hall of India, New Delhi, 2002.
3. Cemented Tungsten carbide Production, properties and testing-Gopal S. Upadhayay, Prentice Hall of India, New Delhi, 2005.

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ADVANCED MATERIALS & APPLICATIONS

UNIT I: CONDUCTORS AND RESISTORS

The Resistivity Range – Conduction by Free Electrons – Conductor and Resistor Materials – Superconducting Materials – Properties and Applications of Conductors & Resistors

UNIT II: SEMICONDUCTORS

The Energy Gap in Solids – Intrinsic Semiconductors – Extrinsic Semiconductors – Semiconductors Materials – Fabrication of Integrated Circuits – Some Semiconductor Devices – Properties and Applications of Semiconductors

UNIT III: MAGNETIC MATERIALS

Terminology and Classification – Magnetic Moments due to Electron Spin – Ferromagnetism and Related Phenomena – The Domain Structure – The Hysteresis loop – Soft Magnetic Materials – Hard Magnetic Materials – Properties and Applications of Magnetic Materials

UNIT IV: DIELECTRIC MATERIALS

Polarization – Temperature and Frequency Effects – Electric Breakdown – Ferroelectric Materials Properties and Applications of Dielectric Materials

UNIT V: SPECIAL MATERIALS

Properties and applications of Maraging Steels, Q&T Steels, Nickel alloys, Cobalt alloys, Titanium alloys, Tungsten alloys, Zirconium alloys, Shape memory alloys.

TEXT BOOK:

1. Materials Science and Engineering: V. Raghavan, Prentice-Hall of India Pvt. Ltd, New Delhi, 2007 (Chapters 14 – 17).

REFERENCE BOOKS:

1. Principles of Materials Science and Engineering, William F. Smith, Mc Graw Hill Co, New Delhi, 2006.
2. Materials for Engineers, M.H.A. Kempster, The English University Press, London, 2006.

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SURFACE ENGINEERING MATERIALS

UNIT I: HIGH TEMPERATURE MATERIALS

Thermal properties of materials. High temperature materials problem & solution. High temperature alloys: Steels, Nickel – Cobalt – Tungsten and Zirconium based super alloys, Advances in high temperature alloys.

UNIT II: CERAMIC MATERIALS

Materials preparation, powder processing-uniaxial processing, isostatic processing, hot pressing, hot isostatic processing, soft plastic forming, slip casting, Vapor deposition-physical as well as chemical processes, drying firing, Processing of noncrystalline materials.

UNIT III: METAL MATRIX COMPOSITES

Metal Matrix Composites: Characteristics of MMCs, Various types of Metal matrix composites Alloy vs. MMC, Advantages of MMCs. Limitations of MMCs, Metal Matrix, Reinforcements particles - fibers. Effect of reinforcement - Volume fraction - Rule of mixtures, Processing of MMCs - Powder metallurgy process - diffusion bonding - stir casting, squeeze casting.

UNIT IV: CERAMIC MATRIX COMPOSITES

Ceramics Matrix Composites: Need for CMCs - Various types of CMCs - oxide ceramics - non oxide ceramics aluminium oxide - silicon nitride - reinforcements - particles - fibres - whiskers. Advanced Composites: Carbon/carbon composites - Advantages of carbon matrix - limitations of carbon matrix and Carbon fibres.

UNIT V: BIO MATERIALS

Impact of biomaterials, Performance of implants, Tissue response to implants, Safety & efficacy testing. Mechanical properties of materials, Thermal treatments, Surface improvements, Sterilization. Metals, Ceramics, Synthetic polymers, Biopolymers. Orthopedic Implants: Bore composition & properties, Temporary devices, Joint replacement, knee joint repair.

TEXT BOOKS:

1. Principles of Materials Science and Engineering, William F. Smith, Mc Graw Hill Co, New Delhi, 1996.
2. Materials for Engineers, M.H.A. Kempster, The English University Press, London, 1996.

REFERENCE BOOKS:

1. Introduction to Metal Matrix Composites, T.W. Clyne and P.J. Withers, Cambridge University Press, 1993.
2. Composite materials, K.K.Chawla, SpringerVerlag, 1987.

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SURFACE CHARACTERIZATION TECHNIQUES

UNIT I: X-RAY METHODS

Production and detection of X-Rays; Bragg's law - Diffraction Methods - laue, rotation crystal and powder methods. Intensity of diffracted beams - Atomic scattering factor - structure factor - Multiplicity factor Absorption and temperature factors - cameras, Laue, Debye-scherrer, Seeman Bohlin focussing cameras, High and Low temperature cameras. diffractometer - General features and general optics. Counters: proportional, scintillation and Geiger counters.

UNIT II: MEASUREMENT TECHNIQUES

Elementary steps - Indexing cubic and other crystals - Determination of no of atoms in unit cell and atom positions (introduction only) precise lattice parameters measurement Calibration - Errors - phase diagram determination - order-disorder transformation - residual stress measurements,

UNIT III: TRANSMISSION ELECTRON MICROSCOPY

Principles and applications - Description of the electron microscopes resolving power - electron optics - Aberrations - Specimen preparation - electro chemical thining - ion milling - replica technique- bright and darkfield imaging and HRTEM - selected area diffraction using EDX, WDX, and EELS techniques of compositional analysis

UNIT IV: SCANNING ELECTRON MICROSCOPY

Constructional features - detectors - secondary electron and back scattered electron detectors – channeling pattern – compositional and topological contrast - failure analysis using AFM, STEM and elemental analysis using EPMA.

UNIT V: THERMAL ANALYSIS TECHNIQUES

Laser flash diffusivty apparatus, Differential scanning calorimetry, High temperature dilatometry, Differential thermal analysis and associated tests.

TEXT BOOKS:

1. Elements of X-Ray Diffraction, B.D. Cullity, Addision Wesley Publishing Co., Massachusetts, 2007.

2. Experimental Techniques in Physical Metallurgy, Cherepin and Mallik, Asia Publishing House, New Delhi, 2002.

REFERENCE BOOKS:

1. Transmission electron microscopy of metals, G. Thomas, John wiley and sons, New York, 2006.
2. Microscopy and micro techniques, R. Marimuthu, Khanna publishers, New Delhi, 2005.

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ENGINEERING CERAMICS

UNIT I: DEFINITION & SCOPE OF CERAMICS AND CERAMIC MATERIALS

Classification of ceramic materials, Areas of applications. Refractories: Classification of Refractories, Modern trends and developments, Basic raw materials, Elementary idea of manufacturing process technology, Flow diagram of steps necessary for manufacture, basic properties and areas of application.

UNIT II: CERAMIC PROCESSING RELATED TO DEVELOPMENT OF MICROSTRUCTURE

Consolidation of solid powders by heat, Sintering, Driving force of sintering, Different types of solid state sintering, Recrystallisation and grain growth, Pressure associated with sintering. Hot pressing and hot isostatic pressing (HIP). Structural imperfections, Surfaces, Interfaces and Grain boundaries, Atom mobility in glasses and ceramics.

UNIT III: CERAMIC PHASE EQUILIBRIUM DIAGRAMS TECHNIQUES OF DETERMINING PHASE DIAGRAMS

One -, two -, and three - components phase diagrams. Examples. Phase composition versus temperature. Non-equilibrium phases. Typical ceramic systems like zirconia - calcium oxide / magnesium oxide / ceria , calcia - silica , magnesia - silica, soda - lime - silica , lime - alumina - silica etc.

UNIT IV: PROPERTY DETERMINATION OF CERAMICS

Plastic deformation, viscous flow and creep, Thermal and compositional stresses, Elasticity, anelasticity and strength, Thermal Properties - Thermal conductivity, Specific heat, Thermal expansion, Thermal stress. Comparative thermal behaviour of ceramics.

UNIT V: APPLICATIONS OF CERAMICS

Carbides, Boron carbide, Silicon carbide, Titanium carbide, Zirconium carbide, Hafnium carbide & Uranium carbide. Nitrides: Boron, Silicon & Aluminium nitrides. Silicide: Molybdenum disilicide. Borides. Sialon. Graphites. Cermets & Composites. Ceramics used in advanced applications: Nuclear energy, Magneto- hydrodynamic generation, Gas turbine blades, Abrasives, Aerospace, Diesel engines.

TEXT BOOKS:

1. Introduction to Ceramics - W.D Kingery, John Wiley and Sons, New Delhi, 2006.
2. Engineering Materials – Ceramics, composites and polymers, A.K. Bhraghava, Prentice Hall of India, New Delhi, 2005.

REFERENCE BOOKS:

1. Handbook of advanced ceramics, Vol: I & II, S. Somia, F. Aldinger and K. Koumoto, Elsevier publications, London, 2003.

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LASERS AND LASER PROCESSING OF MATERIALS

UNIT I: CONSTRUCTION OF LASERS

Stimulated emission phenomenon. How the laser works: Construction, Simulated emission phenomenon. Types of Industrial Lasers: CO, CO2, Solid-state, Diode, Excimer Lasers. Comparison between Lasers. Basic laser optics: The nature of electro magnetic radiations, Interaction of electro magnetic radiations with matter.

UNIT II: BASIC LASER OPTICS

Reflection/absorption: Effects of Wavelength, Temperature, Surface films, Angle of Incidence, Materials and Surface roughness. Refraction, Interference, Diffraction. Laser beam Characteristics: Wavelength, Coherence, Mode & beam diameter and Polarization.

UNIT III: LASER WELDING

Process arrangement, process mechanisms: Keyholes and plasmas. Operating characteristics, process variations – pulsed and hybrid lasers, Applications.

UNIT IV: LASER SURFACE TREATMENT

Laser heat treatment, laser surface melting, laser alloying, laser cladding, particle injection, Surface texturing and enhanced electroplating. Laser: CVD, PVD. Laser cleaning & paint stripping, surface roughening, scabbing, marking, shock hardening.

UNIT V: LASER CLEANING

Mechanisms of laser cleaning all types including: selective vaporization, spallation, photon pressure, laser shock cleaning, transient surface heating, ablation, dry and steam laser cleaning etc.,

TEXT BOOK:

1. Principles of Lasers, Orazo Svelto, Springer Verlag Publications, New Delhi, 2008.

REFERENCE BOOKS:

1. Laser Materials Processing by William M. Steen, Springer Verlag Publications, New Delhi, 2004.
2. Semiconductor Lasers, Vol.: I & II, Eli Kapon, Elsevier Publications, New Delhi, 2008.

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PLASMA PROCESSING OF MATERIALS

UNIT I: INTRODUCTION TO THERMAL SPRAYING

Coatings in industrial environment, surface coating techniques, history of thermal spraying, synergistic nature of coatings, applications of thermally sprayed coatings. Principles of thermal spraying: Characterization of flame Vs plasma spraying, concept of energy transfer processes, unique features of the plasma spray process.

UNIT II: THE PLASMA STATE AND CHARACTERISTIC PLASMA PARAMETERS

Definitions only – Langmuir plasma frequency, Debye Screening length, Landau length, Collision path frequency, collision frequency. Classification of plasmas: all types. Plasma generation: all types. Design of plasmatrons principles and working only: Arc discharge generators, electrode supported, electrodeless, hybrid devices. Stabilization of plasma arcs: wall, convection, electrode and other stabilization methods.

UNIT III: INJECTION OF POWDERS AND FEED MATERIAL CHARACTERISTICS

Solid wires, rods and filler wires. Powders: Atomization, fusion & crushing, compositing, agglomeration, momentum transfer, connected energy transmission. Particle diagnostics: Determination of velocity temperature and number densities. Coating diagnostics: Microstructure, Porosity, Adhesion, chemical & morphological characteristics, Residual stress measurements. Mechanical properties evaluation of coatings, Burner Rig Test.

UNIT IV: INDUSTRIAL COATINGS

WRCs and CRCs: carbides, cemented carbides, oxides, metallic coatings, super alloy coatings, refractory metal coatings, diamond coatings, TBCs, BCCs, CBCs, HTSCs, SOFCs etc.,

UNIT V: ADVANCED LAYER COATINGS

Coating requirements, design of novel advanced layer coatings, Gradient layers, thermodynamic equilibrium in layered coatings, extended solid solutions, double layer, triple layer and multilayered coatings.

TEXT BOOKS:

1. Plasma – Spray Coating Principles and Applications by Robert B. Heimann, VCH – GmbH Weinheim Publications, Germany, 2006.
2. Science and Engineering of Thermal Spray Coatings, Lech Pawlowski, Springer Verlag Publications, 2005.

REFERENCE BOOKS:

1. Fundamentals of Plasma Physics, J.A. Bittencourt, Springer Verlag Publications, New Delhi, 2006.

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APPLIED PROBABILITY & STATISTICAL INFERENCES

UNIT I:

Introduction to probability theory – Random variable – Probability density and distribution functions – Standard distributions: Geometric, Hypergeometric, Binomial, Poisson, Normal, Log-Normal, Exponential, Gamma, Beta and Weibull distributions – Applications – Baye's Theorem – Chebysev's Theorem.

UNIT II:

Sampling distributions of statistical parameters – Standard error – central limit theorem – t, F and Chi-square distributions - Estimation – Point estimation - Interval estimation for population means, standard deviation, proportion, difference in mean, ratio of standard deviations, proportions - Maximum likelihood estimation, least square estimation and bayesian estimation.

UNIT III:

Testing of Hypothesis - Parametric test – small samples – Tests concerning proportion, means, standard deviations – Test based on Chi-square, goodness of fit and test of independence.

UNIT IV:

Non-parametric test – run test, sign test, U-test, H-test and kolmogorov-Smirnov (k-s) test – spearman rank correlation coefficient test.

UNIT V:

Experimental designs – completely randomised blocks– Latin square – Analysis of variance – Methods for one, two factor models, concepts of factorial design, fractional factorial design, response surface methods and central composite designs.

TEXT BOOK:

1. Probability and Statistics for Engineers, Irwin Miller & E. John Freund., Prentice Hall of India, Pvt, Ltd, New Delhi, 2007.
2. Applied Statistics and Probability for Engineers, D.C. Montgomery & G.C. Runger, John Wiley and Sons, USA, 2004.

REFERENCE BOOKS:

1. Engineering Statistics, Bowker and Libermann, Prentice Hall of India, Pvt, Ltd, New Delhi, 2000.
2. Statistics for Management, Richard Levin.I. Prentice Hall of India, Pvt, Ltd, New Delhi, 2006.
3. Introduction to Statistics, Ronald E. Walpole, Macmillan Inc., New York, 2002.
4. Introduction to Probability and Statistics for Engineers and Scientists, Walter A. Rosenkorantz, McGraw Hill, 2007.

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MECHANICAL BEHAVIOUR OF MATERIALS

UNIT I:

Tensile behaviour, Derivation of tensile strength, yield strength, ductility, modulus of elasticity, resilience and toughness from stress strain curves, comparison of stress-strain curves for different materials - True Stress - Strain Curve, Notch tensile test - Tensile properties of steel - strengthening mechanisms - Strain hardening - Strain aging - Yield point phenomena - Solid solution strengthening - Martensite Strengthening - Grain refinement, Hall-Petch relation**.**

UNIT II:

Hardness & toughness behaviour: Hardness Measurements: Brinnell hardness, Meyer's hardness, Vickers hardness, Rockwell hardness and Microhardness - Relationship between hardness and the flow Curve - Hardness at elevated temperatures - Toughness measurements Temprature Curves, Drop weight test, explosion crack starter test, Dynamic tear test and Robertson crack arrest test - Fracture Analysis Diagram.

UNIT III:

Fatigue behaviour, Goodman diagram, Soderberg diagram, Gerbar diagram - Cyclics stress strain Curve - Low cyle fatigue - Strain life Equation - Fatigue mechanisms - High cycle fatigue - Effect of following paramenters, Fatigue crack propagation - Fatigue under combined stresses - Cumulative fatigue damage - Design for fatigue.

UNIT IV:

Fracture behaviour, Types of fracture in metals, Griffth theory - Metallographic aspects of fracture - Fractography - Notch effect - Concept of fracture curve - Fracture under Combined Stresses - Environment sensitive fracture, Fracture mechanics, J-integral and R-curve.

UNIT V:

Time dependant mechanical behaviour: Creep curve - Stress rupture Test - Structural changes during creep - Mechanisms of creep deformation - Deformation mechanisms maps - Introduction to high temperature alloys - Predication of long time properties - Creep under combined stresses - Creep- Fatigue Interaction.

Text Books:

1. Mechanical Metallurgy, George E.Dieter, Mc Graw Hill Book Company, New York, 2006.
2. Mechanical Metallurgy, M.A.Meyers and K K.Chawla, Prentice Hall Inc., Englewood Cliffs, 2002.

Reference Books:

1. Deformation and Fracture Mechanics of Engineering Materials, R.W. Hertzberg, John Wiley & Sons, Inc., New York, 2003.

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HEAT TREATMENT AND MATERIALS PROCESSING

UNIT I: SOLID HEAT TREATMENT

Energy conservation, 1-D conduction - Heat equation solution review, Phase transformations: Glass-ceramics. Radiation, Dimensional analysis: Furnace wall, Transient graphs: Thermal spray, Finite differences and heat conduction Polymer extrusion.

UNIT II: LIQUID-SOLID PROCESSING

Moving boundary and planar melting: Vacuum arc remelting, Continuous solidification Continuous casting, Conduction-limited solidification: Injection molding, Liquid-limited solidification Casting, precipitation and Complex structure formation

UNIT III: FLUID BEHAVIOR

Shear stress, Drag force on a sphere Precipitation, bubbles. Friction factor: tubes, plates. Turbulent fluid flow, turbulent transport, batch reactors fermentation, Continuous flow reactors fermentation

UNIT IV: DEFORMATION PROCESSING

Deformation mechanisms: Polymers, metals, Non-Newtonian fluids. Viscoelasticity Stress-strain and sheet forming Polymers, metals. Consolidation processes: Sintering, HIP, CM etc.,

UNIT V: VAPOR-SOLID PROCESSING

Evaporation kinetics, transport of Zirconia in PVD. Rate/temperature/structure maps. Various thin films Growth: epitaxial/strained, incoherent. Masking and patterning. Advanced structure formation: Polymer, sputter, VLS. Life Cycle Analysis and Systematic process selection

TEXT BOOKS:

1. Materials Selection in Mechanical Design, Michael Ashby, Prentice Hall of India Pvt, Ltd, New Delhi, 2000.
2. Heat and Mass Transport Phenomena in Materials Processing, D.R. Poirier and G.H. Geiger, Marcel Dekker Publications, New York, 2003

REFERENCE BOOKS:

1. Solidification Processing, Merton Fleming, New Age International (P) Limited, publishers, New Jersey, 2006.
2. Introduction to Heat and Mass Transfer, Incropera and DeWitt, Oxford University Press, London, 2004.

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PRECISION ENGINEERING

UNIT I: CONCEPTS OF ACCURACY

Introduction - concept of accuracy of machine tools - spindle and displacement accuracies - Accuracy of numerical control systems - Errors due to numerical interpolation - Displacement measurement system and velocity lags.

UNIT II: GEOMETRIC DIMENSIONING AND TOLERANCING

Tolerance zone conversions - Surfaces, features, features of size, datum features-Datum, oddly configured and curved surfaces as datum features, equalizing datums-Datum feature of size representation-form controls, orientation controls - Logical approach to tolerancing.

UNIT III: FUNDAMENTALS OF NANOTECHNOLOGY AND MEASURING SYSTEMS

Processing system of nanometer accuracies - Mechanism of metal processing - Nano physical processing of atomic-bit-units Nanochemical and electrochemical atomic-bit processing. In processing or in-situ measurement of position of processing point-Post process and on-machine measurement of dimensional features and surface-mechanical and optical measuring systems.

UNIT IV: NANO-POSITIONING SYSTEMS OF NANOMETER ACCURACY AND REPEATABILITY

Guide systems for moving elements - Servo control systems for tool positioning - Computer Aided digital and ultra precision positition control.

UNIT V: APPLICATIONS AND FUTURE TRENDS IN NANO TECHNOLOGY

Nano-grating system-Nanolithography, photolithography, electron beam lithography-Machining of soft metals, diamond turning, mirror grinding of ceramics-Devlopment of intelligent products-Nano processing of materials for super high density Ics-Nano-mechanical parts and micromachines.

TEXT BOOK:

1. Precision Engineering in Manufacturing, RL Murthy, New age International Limited, Mumbai, 2006.

REFERENCE BOOKS:

1. Geometric Dimensioning and Tolerancing, Jamesd Meadows, Marcel Dekker Inc., New Jersey, 2005.
2. Nanotechnology, Norio taniguchi, Oxford university press, London, 2006.

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FINITE ELEMENT ANALYSIS

UNIT I: FINITE ELEMENT ANALYSIS

Historical Background – Weighted residual methods – Basic concept of FEM - variational formulation of B.V.P. – Ritz method – Finite element modeling – Element equations – Linear and quadratic shape functions – Bar, beam elements – Applications to heat transfer

UNIT II: FINITE ELEMENT ANALYSIS OF 2D PROBLEMS

Basic boundary value problems in 2 Dimensions – triangular, Quadrilateral, higher order elements – Poissons and Laplaces equation – Weak formulation – Element Matrices and Vectors – Application to solid mechanics, Heat transfer, Fluid Mechanics.

UNIT III: ISO – PARAMETRIC FORMULATION

Natural Co-ordinate systems – Lagrangian Interpolation Polynomials – Isoparametric, Elements – Formulation – Numerical Integration – 1 D, 2 D, Triangular elements – rectangular elements – Illustrative examples.

UNIT IV: SOLUTION TO PLANE ELASTICITY PROBLEMS

Introduction to theory of elasticity – Plane stress – Plane strain and Axisymmetric formulation Principles of virtual work, Element matrices using energy approach.

UNIT V: SPECIAL TOPICS

Dynamic analysis – Equation of Motion – Mass matrices – Free vibration analysis – Natural frequencies of Longitudinal – transverse and torsional vibration – Introduction to transient field problem. Non linear analysis. Use of softwares – h and P elements – special element formulation.

TEXT BOOKS:

1. Applied Finite Element Analysis, L.J. Segerline, John Wiley, New York, 2004.
2. Finite Element Method in Engineering, S.S. Rao., Pergamon Press, London, 2002.
3. Finite Elements in Engineering, Chandrupatla and Belagundu, Prentice Hall of India Private Ltd., Mumbai, 2007.

REFERENCE BOOKS:

1. Concepts and Applications of Finite Element Analysis, Cook, Rober Davis, John Wiley and Sons, New York, 2006.
2. Outline of Finite Element Analysis, Buchaman. G.R., Schaum's, McGraw-Hill Company, New Jersey, 2004.