NATIONAL INSTITUTE OF TECHNOLOGY JAMSHEDPUR

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

Course Structure of M.Tech.

in

Materials Technology

M. Tech (Materials Technology)

CREDIT STRUCTURE

Course Work	**1st Sem**	**2nd Sem**	**3rd Sem**	**4th Sem**	**Total Credits**
Core Courses	16	16	-	-	32
Electives	4	4	-	-	08
Project			20	20	40
Total	20	20	20	20	80

M. Tech. (Materials Technology)

COURSE STRUCTURE

SEMESTER I

S. No.	Course Code	Subject	L-T-P	Credits
1	MM4101	Thermodynamics and Kinetics of Materials	3-0-2	4
2	MM4102	Transport Phenomena in Materials Processes	3-0-2	4
3	MM4103	Principles of Materials Engineering	3-0-2	4
4	MM4104	Solid State Phase Transformations	3-0-2	4
5	MM41XX	Elective I	3-0-2	4
		TOTAL	15-0-10	20

Elective I

S.No	Course Code	Subject
1	MM4105	Advanced Processing of Materials
2	MM4106	Environmental Degradation of Materials
3	MM4107	Dislocation Theory and Plastic Flow
4	MM4108	Advanced Ceramics and Glasses
5	MM4109	Manufacturing Processes
6	MM4110	Mathematical Modeling and Computer Applications in Materials Processing
7	MM4111	Physical Metallurgy of Advanced Materials

SEMESTER II

S. No.	Course Code	Subject	L-T-P	Credits
1	MM4201	Powder Processing and Technology	3-0-2	4
2	MM4202	Characterization of Materials	3-0-2	4
3	MM4203	Deformation and Fracture Behaviour of Materials	3-0-2	4
4	MM4204	Non-Equilibrium Processing of Materials	3-0-2	4
5	MM42XX	Elective-II	3-0-2	4
		TOTAL	15-0-16	20

Elective II

S.No	Course Code	Subject
1	MM4205	MEMS and NEMS
2	MM4206	Fracture Mechanics and Analysis of Engineering Failures
3	MM4207	X-ray Studies of Deformed Crystals
4	MM4208	Joining of Materials
5	MM4209	Nanostructured Materials
6	MM4210	Surface Science and Engineering
7	MM4211	Materials Design

SEMESTER III

S. No.	Course Code	Subject	L-T-P	Credits
1	MM4301	Thesis Part-I Seminar		16 04
			TOTAL	20

SEMESTER IV

S. No.	Course Code	Subject	L-T-P	Credits
1	MM4401	Thesis Part -II		20
			TOTAL	20

SEMESTER I

MM4101 Thermodynamics and Kinetics of Materials: **4 Credits: (3-0-2)**

Thermodynamics basic concepts (state variables, the first law, the enthalpy concept, heat capacity) The second law (reversible and irreversible processes, entropy, Gibbs energy, Hemholtz energy, Gibbs-Duhem equation, Maxwell's relationships) Equilibrium conditions (chemical potential, driving force, the third law, Clausius-Clapeyron equations, Thermodynamic application to materials: Ellingham diagrams; Electrochemistry: Porbaix diagrams; thermodynamics of solutions, construction and interpretation of 2 component phase diagrams. Phase Diagram– Gibbs's Phase rule – Interpretation of mass fractions using Lever's rule –Hume Rothery rules-Binary Iso-morphous system- Binary Eutectic alloy system (Lead-Tin System) –Binary Peritectic alloy system (Iron-Nickel System) – Invariant reactions – Iron-Iron carbide phase diagram- Slow cooling of Hypo and hyper eutectoid steels – Temperature-Time-Transformation (TTT) and Continuous Cooling Transformation (CCT) Diagrams, Phase equilbria in ceramics.

MM4102 Transport Phenomenon in Materials Processes: **4 Credits (3-0-2)**

General equations of heat, mass and momentum balance, laminar, turbulent flow, concept of boundary layer, friction factor, heat and mass transfer coefficients and dimensionless correlations. Laminar and turbulent flow and its application in Metallurgical processes- analysis of metallurgical packed and fluidized bed, fluid-flow in gas-agitated systems. Conductive, convective and radiative heat transfer in metallurgical systems-heat transfer around single bubble/particle, in metallurgical packed and fluidized bed, liquid steel ladles. Mass transfer rates involving diffusion, convection, and its application in homogeneous and heterogeneous systems

MM4103 Principles of Materials Engineering: **4 Credits (3-0-2)**

Crystal Structure: Space lattices, Bravais lattices and Reciprocal lattice concept. Miller Indices of planes and directions; Bonding in Solids: Ionic, Covalent, and Metallic bonding. Theory of alloy formation, Solid solution, Substitutional and interstitial solid solution, Hume Rothery Rules, Intermetallic compounds, Normal valency compounds, Electron compounds, Interstitial compounds; Imperfections: Point defects: vacancies, Interstitialcies, Dislocations: Edge & Screw dislocations, Burgers vector; Binary Phase Diagrams: Isomorphous, Eutectic, Peritectic, Eutectoid, Monotectic & Syntectic systems. Phase rule and Lever rule; Iron-Cementite Equilibrium diagrams and its applications; Diffusion: Fick's First and Second law of diffusion. Atomic model of diffusion. Grain boundary, surface and thermal diffusion.Kirkendall Effect, Grube method, Matano method, Interstitial diffusion; Nucleation: Homogeneous and Heterogeneous nucleation, Kinetics of nucleation. Growth and overall transformation kinetics.

MM4104 Solid State Phase Transformation of Materials: **4 Credits (3-0-2)**

Thermodynamics and Kinetics of solid state Phase transformation. Diffusional and Diffusionless Transformations. Diffusional Transformations: Atomic models of Diffusion, Homogeneous and Heterogeneous Nucleation, Strain energy effects. Precipitate Growth. Overall Transformation Kinetics – TTT diagrams. Decomposition of Solid Solutions: Ordering reactions and Spinodal decompositions. Precipitation in Age hardening alloys. Case Studies: Al-Cu, Al-Ag alloys. Precipitation of Ferrite from Austenite. Eutectoid

Transformtions. Pearlite Transformation: Mechanism, Nucleation and Growth and orientation relationship. Bainite Transformation: Mechanism, Nucleation and growth, Orientation relationship, Surface relief, Classical and non-classical morphology, Effect of alloying elements. Massive Transformations, Ordering Transformations. Case Studies: Titanium Forging Alloys. Weldability of Low carbon and Microalloyed Rolled Steels
Diffusionless Transformation: Characteristics of diffusionless transformation. Solid solution of carbon in iron. Martensite Transformation. Thermodynamics and Kinetics. Nucleation and growth, Morphology, Crystallography, Stabilization; Annealing (Full, Homogenizing, Spherodization and Stress-relieving annealing), Normalising, Comparison of Annealing and Normalizing, Hardening and Tempering of steel, Aims and stages of tempering, Effect of Carbon and alloying elements, Tempering of alloy steels and Multiple tempering. Case studies: Carbon and Low alloy quenched and Tempered Steels. Controlled Transformation Steels. Shape Memory Metal: Nitinol.

Elective I:

MM4105 Advanced Processing of Materials: **4 Credits (3-0-2)**

Rapid solidification, Powder processing, Preparation and consolidation of nanopowders, Sintering, Spark Plasma and Microwave sintering, Shock compaction, Severe plastic deformation, Mechanical Alloying, near-net-shape forming, self-sustaining high temperature synthesis, sol-gel processing, zone refining, molecular beam epitaxy, laser processing, EDM, etching, glass-ceramic seals, solid oxide fuel cells, armor ceramics, Processing and manufacturing technologies for non-oxide and oxide based structural ceramics, composites, multifunctional materials; Stereolithography (SLA), selective laser sintering (SLS), direct metal laser sintering; (DMLS) and laser engineered net shaping (LENS), Spray formed tooling for rapid manufacture, Plasma spray coating; Preparation of single crystals, doping, sputter coating, CVD and EVD process.

MM4106 Environmental degradation of material: **4 Credits (3-0-2)**

Degradation of materials: Oxidation, corrosion and wear. Basics of thermodynamics and kinetics of oxidation and corrosion.Pourbaix diagram, Polarization, Mixed potential theory. Passivity, Characteristics of passivation, Degradation of composites; Corrosion: Fundamentals of corrosion studies. Different types of corrosion. Atmospheric, galvanic, pitting, crevice corrosion, intergranular and de-alloying. Stress corrosion cracking, season cracking, Hydrogen damage and radiation damage. Hydrogen embrittlement.Corrosion rate measurement. Weld-decay and knife line attack. Tafel’s extrapolation. Oxidation and hot corrosion of materials at high temperature. Kinetics of oxidation. Pilling-Bedworth ratio. ; Prevention of degradation: Alloying environment, environmental conditioning, design modification, cathodic and anodic protection, organic and inorganic coating, inhibitors and passivators, Wear resistant coating.

MM4107 Dislocation Theory and Plastic Flow: **4 Credits (3-0-2)**

General aspects of deformation in crystalline solids, review of elasticity theory and stress field around stationary and moving dislocation, forces on a dislocation including concepts of self-energy, line tension, Peierls Stress, chemical forces and forces between dislocations for varied configurations of dislocation, kinetics of dislocation flow, dislocations in fcc structures, dislocations in bcc, hcp, ordered and superlattice structures, jogs and intersection of dislocations incorporating concepts of elementary, composite and extended jogs, dislocations dipoles, attractive and repulsive junctions, origin and multiplication of dislocations, dislocation arrays and crystal boundaries; Interpretation of tensile response of crystalline solids including theories related to yielding, flow stress and work-hardnening, dislocations and creations of discontinuities. Interaction of dislocation with point defects: Substitutional and interstitial alloying elements, Vacancies. Precipitates and dispersoids. Dislocations in intermetallics and Ceramics.

MM4108 Advanced Ceramic and Glasses: **4 Credits (3-0-2)**

Processing and evaluation of engineering ceramics. Fracture behavior of ceramic materials, The Weibull distribution, Toughening mechanism. Formation, mechanical properties and uses of fused Alumina, sintered Alumina products, Borides, Carbides, Nitrides, Silicides, Zirconia and partially stabilized Zirconia, Sialons. Abrasives, abrasive operations, natural abrasives, abrasives like Aluminium oxides, Silicon Carbide, Diamond and Boron nitride, miscellaneous synthetic abrasives, raw materials for abrasives, their proportioning, processing, manufacture of abrasives, grinding wheels, their drying, firing and testing. Glassy State; Kinetic and thermodynamic criteria for glass formation, use of Na_2O-SiO_2 and Na_2O-CaO- SiO_2 phase diagrams in glass manufacture, types of glasses and their chemical compositions, Physical properties of glasses, density, refractive index, thermal expansion and thermal stresses, thermal endurance of glass, toughening of glasses, strength and fracture behavior of glass and its articles, surface tension, viscosity and its measurement, effect of temperature and composition on the physical properties of glasses Glass making raw materials, addition of cullet to the batch, reactions amongst the constituents of glass, thermal currents and flow pattern in the glass tank furnace, Defects in glass, bubbles and seeds, cords, stresses and colour inhomogeneity and their remedies, annealing of glasses. Glass ceramics; Nucleation and crystal growth in glasses, nucleation through micro miscibility, nucleating agents, properties and applications of glass-ceramics.

MM4109 Manufacturing Processes: **4 Credits (3-0-2)**

General structure and properties of engineering materials, classification of common materials, their unique properties and applications; metals and alloys, glass and ceramics, polymeric materials and composites, behavior, testing and manufacturing properties of these materials. Concepts of manufacturing, basic principles of engineering manufacturing; shaping, joining, removal and regenerative processes, methods of applications of common manufacturing processes; performing by casting, forging, rolling, melting, injection and compression moulding, extrusion and drawing, press tool work, powder processing etc., finishing by machining, grinding and superfinishing, Non-traditional manufacturing by chemical. electrochemical, electrophysical and mechanical processes

MM4110 Mathematical Modeling and Computer application in Materials Processing:
4 Credits (3-0-2)

Mathematical modeling: Basic equations of diffusive, convective heat, mass, momentum transfer, turbulent system and concept of friction factor, heat & mass transfer coefficients and

correlations. Formulation of mathematical model. Case studies. Numerical solution of partial differential equations.
Physical Simulation: Experimental design based on dimensional analysis, similarity criteria, case studies.
Reactor Design: Ideal reactors (PFR, CSTR), real reactors, characterization of these reactors, chemical performance of reactors, Modeling/design of reactors
Thermodynamic modeling.
Phase prediction using first principles and CALPHAD approach; Structure-property relationship using molecular dynamic simulation; Processing – microstructure correlation using finite element and phase field simulation methods.

MM4111 Physical Metallurgy of Advanced Materials: 4 Credits (3-0-2)
Ferrous alloys: Alloy Steels - General Introduction, Maraging Steels (Heat-treatment Cycle, Aging behavior), High-Strength Low-Alloy Steels (Role of Microalloying of Steels), Advanced High Strength Steels (Role of Alloying Elements), Dual-Phase Steels, Multi-phase TRIP, Stainless Steels (Fe-Cr-Ni System, Schaeffler Diagram, Precipitation of Carbides/Nitrides, Microstructural Aspects of Various Types of SS, Ni-free Duplex SS, Embrittlement Phenomena), Tool Steels (Secondary Hardening, Types of Carbides), Factors affecting performance, Concept of δ-TRIP Steel), Bearing Steels (Metallurgical & Engineering Requirements of Steel, Microstructural Aspects, Microcracking, Spheroidise Annealing, Inclusions, Aerospace Bearings) Non-ferrous alloys: Nickel-Based Superalloys (Microstructural features, Role of Alloying Elements, Strengthening Mechanisms, Heat-Treatments, Dispersion-Hardened Superalloys), Titanium Alloys (Deformation Modes, Effect of Alloy Addition on Phase Diagrams, Alloy Classification, Phase Transformations, Microstructures, Hardening Mechanisms of Alfa- & Beta- Phases, Microstructure in Dependent of Processing, Basic Correlation between Microstructure & Mechanical Properties, Ti-based Intermetallic Compounds), Aluminum Alloys (Microstructures of Al-Si Alloys, Modified/Unmodified Al-Si Alloys, Aging Process in Al-4%Cu alloy), Brass, Bronze
Physical metallurgy concepts of special alloys: Bulk Nanostructured Steels – the Latest Development in Steels, Mechanically Alloyed Metals, Shape Memory Alloys, Metallic-glass Forming Alloys, Nuclear Power Plant Alloys (Irradiation Damages in Microstructure, Irradiation Hardening, Concepts of ODS Steels)

SEMESTER II

MM4201 Powder Processing and Technology: 4 Credits (3-0-2)

Different methods of Powder Production, Characterization of Powders, Compaction of metal powder, die compaction, Isostatic compaction, Injection molding, Pressureless Sintering: Mechanism and Method, Laser Sintering, Spark Plasma Sintering, Microwave Sintering, Hot pressing/ Isostatic Pressing, Dynamic Consolidation/Explosive Compaction, Powder forging/ rolling/ extrusion, Post Sintering process, Application of Powder Metallurgy: Nanostructured Materials, Heterogeneous Microstructures.

MM4202 Characterization of Materials: 4 Credits (3-0-2)

Optical Metallography techniques like polarized light microscopy, DIC, fluorescence, etc.; Diffraction Methods like texture measurement, residual stress analysis, EXAFS, neutron diffraction, etc.; Electron Optical and related techniques like TEM, SEM, EDS, WDS/EPMA, CBED, HREM, EELS, etc.; Surface Analysis and related techniques like Auger, XPS, SIMS, RBS, STM, AFM, etc.; Thermal Analysis like DTA, DSC, TGA, TMA, etc.; Spectroscopy Techniques like optical emission spectroscopy, atomic absorption spectrometry, x-ray spectrometry, infrared spectroscopy, Raman spectroscopy, electron spin resonance, nuclear magnetic resonance, Mossbauer spectroscopy, etc.; Electrical Resistivity measurement.

MM4203 Deformation and Fracture Behavior of Materials: 4 Credits (3-0-2)

Dislocation Theory: Introduction, dislocation reaction, cross slip and climb of dislocations, Dislocation sources and dislocation multiplication, Dislocation pile ups; Tensile behaviour of Metals: True stress-true strain curve, Strain hardening coefficient, Instability in tension, Effect of strain rate and temperature on flow properties; Fracture: Griffith's theory of brittle fracture, Mechanism of brittle and ductile fracture, Fractographic aspects of fracture, Notch effects; Impact Behaviour: Notch bar impact test, Transition temperature phenomenon, Instrumented Charpy test; Theories of solid solution strengthening, theories of precipitation strengthening, theories of polycrystalline strengthening, theories of deformation in coarse multiphase systems, study of the relation between stress, strain, strain rate and temperature for plastically deformable bodies, deformation mechanism maps. Creep: Mechanisms and Maps. Stress rupture test, Life Prediction. High Temperature alloys, superplasticity in solids, Environmental assisted cracking, Stress corrosion cracking, hydrogen embrittlement, corrosion fatigue. Deformation behaviour of irradiated materials.

MM4204 Non-Equilibrium Processing of Materials: 4 Credits (3-0-2)

Introduction to non-equilibrium processing. Thermodynamics of meta-stable phase formation: Free energy of elements and alloy phases-determination of free energy of meta-stable phases, lattice parameter of the super-saturated phase; Kinetics of meta-stable phase formation – Nucleation of metastable and alloy phases. Grain growth rate of metastable phases. Rapid solidification: Methods, constitution and microstructure formation, properties performance and applications. Mechanical Alloying: process, mechanism of alloying, consolidation, synthesis of non-equilibrium phases, industrial applications. Laser processing: principles, classification, laser quenching, laser surface-alloying and cladding, laser annealing, laser beam joining, micro joining. Thermal plasma processing: advantages, principles of plasma generation, plasma processing systems, processing of materials by

plasma spraying. Spray forming: Principles, applicability, non-equilibrium phenomena in spray forming, effects of non-equilibrium features on mechanical/physical properties.
Physical Vapor Deposition and Chemical Vapor Deposition: basic principles, processing and application. Bulk amorphous alloys.

Elective II

MM4205 MEMS and NEMS: **4 Credits (3-0-2)**

Micro and nano mechanics – principles, methods and strain analysis, an introduction to micro sensors and MEMS, Evolution of Microsensors& MEMS, Microsensors & MEMS applications, Microelectronic technologies for MEMS, Micromachining Technology – Surface and Bulk Micromachining, MicromachinedMicrosensors, Mechanical, Inertial, Biological, Chemical,Acoustic, Microsystems Technology, Integrated Smart Sensors and MEMS, Interface Electronics for MEMS, MEMS Simulators, MEMS for RF Applications, Bonding & Packaging of MEMS, Conclusions & Future Trends. Nanoelectromechanical systems (NEMS) – a journey from MEMS to NEMS, MEMS vs. NEMS, MEMS based nanotechnology – fabrication, film formation and micromachining, NEMS physics – manifestation of charge discreteness, quantum electrodynamical (QED) forces, quantum entanglement and teleportation, quantum interference, quantum resonant tunneling and quantum transport, Wave phenomena in periodic and aperiodic media – electronic and photonic band gap crystals and their applications, NEMS architecture, Surface Plasmon effects and NEMS fabrication for nanophotonics and nanoelectronics, Surface Plasmon detection – NSOM/SNOM

MM4206 Fracture Mechanics and Analysis of Engineering Failures:

4 Credits (3-0-2)

Stress intensity factor, Stress analysis of cracks, Strain energy release rate, Derivation of relationship between strain energy release rate and stress intensity factor, Crack-tip plastic zone, Dugdale’s plastic strip model. ; Fracture mode transition: Plane stress versus plane strain, Crack opening displacement, Plane strain fracture toughness (K_{IC}) testing, Fracture toughness determination with elastic plastic analysis (J_{IC}), Concept of R-curve and fracture toughness measurement using it, Microstructural aspect of fracture toughness, Optimizing microstructure and alloy cleanliness to enhance fracture toughness; Fatigue stress life approach, Basquin’s equation, Fatigue strain life approach, Low cycle fatigue, Coffin-Manson’s equation, Fatigue total strain life relation, Fatigue life calculation using this approach, Neuber’s analysis for notched specimens; Fatigue crack growth rate, Paris law, Fatigue life calculation using this approach, Mechanism of fatigue crack nucleation and propagation, Factors affecting fatigue crack growth rate, Influence of load interaction, Short fatigue crack; Stress corrosion cracking and K_{ISCC} determination, Corrosion fatigue, Temper embrittlement, Hydrogen embrittlement, Liquid metal embrittlement, Neutron embrittlement; Fractographic analysis of ductile, brittle, fatigue and high temperature fractured surfaces; Failure Analysis: Steps involved in it. Case studies of some engineering failures.

MM4207 X ray studies of deformed crystals: **4 Credits (3-0-2)**

Reciprocal lattice and its relation with diffraction; factors affecting the intensity of diffracted beam, calculation of integrated intensity; estimation of stress, texture and other defects; interaction between electrons and matter; principles of transmission electron microscopy, elements of electron optics, electron lenses - their aberration,. Resolving power, depth and field of focus; kinematical theory of electron diffraction, geometry of electron diffraction and their applications, microdiffraction, trace analysis, bright-field and dark-field image contrast; principles and applications of SEM, principles of microanalysis.

MM4208 Joining of Materials: **4 Credits (3-0-2)**

Introduction: Principle, Theory and Classification of welding and other joining processes; Manual metal arc (MMA): Equipment requirement, electrodes for welding of structural steels, coating constituents and their functions, types of coatings, current and voltage selection for electrodes, Arc welding power sources; Conventional welding transformers, rectifiers and current and voltage. The influence of these power sources on welding. Metal transfer; Submerged arc welding (SAW): Process details, consumables such as fluxes and wires for welding mild steel, Variations in submerged arc welding process; Gas metal arc welding (GMAW) or MIG/ MAG welding: Process details, shielding gases, electrode wires, their sizes, and welding current ranges. TIG welding: Process details, power sources requirements, electrode sizes and materials, current carrying capacities of different electrodes, shielding gases, application of process. Resistance welding: General principle of heat generation in resistance welding, application of resistance welding processes; Process details and working principle of spot, seam, and. projection welding, electrode materials, shapes of electrodes, electrode cooling, selection of welding currents, voltages; Welding metallurgy of carbon and alloy steels, Cast irons, Stainless steels, Al- and Cu-based alloys. Weldability and Heat affected zones (HAZ); Welding defects and detection techniques; Soldering and brazing: Difference between the processes, consumables used, methods of brazing, fluxes used, their purposes and flux residue treatment. Friction Stir welding

MM4209 Nanostructured Materials: **4 Credits (3-0-2)**

Nanocrystals, thin films & coatings, definitions, Effect on properties and phase stability in lower dimension compared to the bulk state, Materials at Reduced Dimensions, Two-dimensional nanostructures – surfaces and films, One-dimensional nanostructures –nanotubes and wires, Zero dimensional nanostructures – fullerenes, nanoparticles, nanoporous materials, Nanoclays, Graphene, polyhedral oligomericsilsesquioxane (POSS) nanoparticles, Colloidal MonodispersedNanocrystals, nanocrystals of ferrites, oxides and chalcogenides, core-shell nanoparticles, micelle assisted nanoparticles, surfactant coated nanoparticles, microemulsion synthesis, self-assembly routes, Inorganic-organic hybrid materials, hydrophobic and hydrophilic nanoparticles, water-dispersable nanoparticles, Synthesis routes, Sol-gel technique, Nonaqueous Sol–gel route for Metal Oxide nanoparticles, hydrothermal synthesis, co-precipitation, preparation of nanocomposites, Properties and applications at nanoscale, Electrical, Mechanical, Magnetic, (Electro)Chemical, Optical, Thermal and thermoelectric properties, Health and regulatory issues with Nanomaterials

MM4210 Surface Science & Engineering: **4 Credits (3-0-2)**

Introduction to surface Engineering, Differences between surface and bulk, Properties of surfaces, surface energy concepts, degradation of surfaces, wear and its type, Adhesive, Abrasive, Fretting, Erosion wear, Surface fatigue, Different types of Corrosion and its prevention, Galvanic corrosion, Passivation, Pitting, Crevice, Mircobial, High-temperature corrosion, Corrosion in nonmetals, polymers and glasses, Protection from corrosion through surface Modifications Changing the surface metallurgy: Localized surface hardening (flame, induction, laser, electron-beam hardening, Laser melting, shot peening), Changing the surface chemistry: Phosphating, Chromating, Anodizing (electrochemical conversion coating), Carburizing, Nitriding, Ion implantation, Laser alloying, boriding, Organic coatings (paints and polymeric or elastomeric coatings and linings), Hot-dip galvanizing (zinc coatings), Ceramic coatings (glass linings, cement linings, and porcelain enamels), Advanced surface coating methods: Gaseous State (CVD, PVD etc), Solution State (Chemical solution deposition, Electrochemical deposition, Sol gel, electroplating), Molten or semimolten State (Laser cladding and Thermal spraying) Characterization of surface and coatings, Surface Characterization (physical and chemical methods, XPS, AES, RAMAN, FTIR etc), Structural Characterization, Mechanical Characterization (Adhesion, Hardness, Elastic Properties, Toughness, Scratch and Indentation etc.), Tribological Characterization, Corrosion tests.

MM4211 Materials Design: 4 Credits (3-0-2)

Physical properties of materials – review; Property measurements techniques and limitations; Ashby diagrams-interpretations; Materials selection for: stiffness-limited design, strengthlimited design, fracture-limited design; Creep behavior of materials: design of materials for high temperature; Materials processing: classification and choice for design; Phase prediction using first principles and CALPHAD approach; Structure-property relationship using molecular dynamic simulation; Processing – microstructure correlation using finite element and phase field simulation methods.