BANARAS HINDU UNIVERSITY
INSTITUTE OF TECHNOLOGY
Department of Ceramic Engineering
Faculty of Engineering & Technology

PROSPECTUS OF STUDIES

MASTER OF TECHNOLOGY
IN
CERAMIC ENGINEERING

(W. E. F. the Session 2009-10)
(Approved vide resolution No.: 48 of the meeting of Academic Council held on 4.6.2009 and by the Chairman, EC dt. 28.7.2009)

New

2 YEARS M.TECH. IN CERAMIC ENGINEERING

Course Structure

PART- 1

SEMESTER-I

SUBJECTS		CONTACT HOURS	CREDIT
CR-5101	Advanced Techniques for Materials Characterization	3	11
CR-5102	Phase Equilibria and Kinetics of Ceramic Systems	3	11
AM-5101A	Engineering Mathematics	3	11
	Elective 1*	3	11
	Elective II*	3	11

(to be chosen from the list of electives given below)

Total Theory :	**15**	**55**
Practicals		
CR-5301 Materials Characterization Laboratory	3	3
CR-5302 Plant Equipment & Furnace Design Project	3	3
Total Practicals :	**6**	**6**
TOTAL FOR SEMESTER I :	**21**	**61**

***List of Electives**

CR-5103	Fuel Technology and Furnace Engineering	CR-5107	Ceramic Fabrication Process
CR-5104	Nano-Ceramics	CR-5108	Technology of Ceramics White wares
CR-5105	Bio- Ceramics	CR-5109	Ceramic Materials and Applications
CR-5106	Advanced Refractory Engineering		

SEMESTER-II

SUBJECTS	CONTACT HOURS	CREDIT
Open Elective (from other departments/schools)	3	11
Elective III	3	11
Elective IV	3	11
Elective V	3	11
Elective VI (to be chosen from the list of electives given below)	3	11
Total Theory :	**15**	**55**
Practicals		
CR-5401 Laboratory (Electronics Ceramic, & Glass)	3	4
CR-5402 Laboratory (Cement/Whit ware and Refractory)	3	4
CR-5403 Seminar	2	0
Total Practicals :	**8**	**8**
TOTAL FOR SEMESTER II	**23**	**63**
TOTAL FOR PART I		**124**

List of Electives:

CR-5201	Advanced Glass Technology	CR-5205	Engineering Ceramics and Composites
CR-5203	Cement Process Engineering	CR-5206	Industrial Furnaces, Instrumentation and Control
CR-5204	Electrical & Electronic Ceramics	CR-5207	Science of Ceramic Materials

2 YEARS M.TECH. IN CERAMIC ENGINEERING

PART- II

SEMESTER-III

SUBJECTS		CONTACT HOURS	CREDIT
CR-6301	Seminar on Dissertation	-	8
CR-6302	Dissertation – Interim Evaluation	-	15
TOTAL FOR SEMESTER III:		**-**	**23**

SEMESTER- IV

SUBJECTS		CONTACT HOURS	CREDIT
CR-6401	Dissertation - Open Defence	-	8
CR-6402	Dissertation - Evaluation	-	15
TOTAL FOR SEMESTER IV			**23**
TOTAL FOR M.TECH DEGREE COURSE:			**46**

DETAILED SYLLABE

2 YEARS M.TECH. (CERAMIC ENGINEERING) PART- I

SEMESTER- I

CR-5101: Advanced Techniques for Materials Characterization (Credits-3)

X-ray diffraction. Diffraction under non-ideal conditions. Atomic scattering and Geometrical structure factors. Factors influencing the intensities of diffracted beams. Powder X-ray diffractometer. Applications of XRD in ceramic materials.

Study of the morphology, aggregation, size and microstructure of ceramic materials using. Optical microscope, quantitative phase analysis.

Principle of electron microscopy. Construction and operation of Transmission Electron Microscope and Scanning Electron Microscope. Electron diffraction by crystalline solids; selected area diffraction. Atomic Force Microscope. Mechanism of image formation in SEM and its processing. Electron microprobe analysis (EDAX and WDS). Preparation of ceramic samples for electron microscopic studies. ESCA and PES.

Spectrophotometric analysis of ceramic materials: Basic laws of spectrophotometry and its application in micro analysis in UV/ Visible range, effect of reflectance factor on optical analysis, construction and working principle of spectrophotometer, importance of additive absorbances in multiple analysis of materials.

Infrared spectrophotometry : General aspects of IR spectroscopy and its application in structural analysis of ceramic systems, sources of IR radiations, Optical systems and operation of FTIR spectrophotometers. Samples preparation, IR analysis and structural co-relations.

Fluorescence and Phosphorescence spectroscopy: Basic principle, geometrical optics, construction, working principle and use of fluorescence spectrometers in materials analysis. XRF and on-line analysis of ceramic materials.

Electron Spin Resonance spectroscopy in ceramic systems. DTA, TGA and DSC with suitable examples of glass and ceramic materials.

CR-5102: Phase Equilibria and Kinetics of Ceramic Systems (Credits -3)

Interpretation and mathematical analysis of phase equilibria of binary, ternary and quaternary ceramic materials. Isophlethal and isothermal studies with emphasis on solid solution systems. Nucleation and non-equilibrium phenomena.

Kinetics of solid state reactions occurring at elevated temperatures. Solid-liquid and dissociation reactions.

Theory of nucleation, grain growth, sintering and crystallization in ceramics and glass forming systems.

Recommended Books:

1. Phase diagrams for ceramists by Elvin
2. Phase diagrams Vol.-I: Alper & Alper

AM-5101A; Engineering Mathematics (Credits 3)

Tensor Algebra: Elements of tensor algebra and tensor calculus. Applications to mechanical deformation and theory of elasticity.

Probability and statistics: Normal (Gaussian) distribution, Normal test, t-test, Chi-square test for goodness of fit, F-test, Simple analysis of variance, Control charts for attributes and variables, Sampling inspection plans, Stochastic processes and queing theory.

Operation Research: Principles of optimization, Graphical and simplex methods for solving linear programming problems, assignment problems, transportation problems, dynamic programming, use of machine simulation, determination of operating rules.

PRACTICAL

CR-5301: Materials Characterization Laboratory (Credit: 2)

CR-5302: Plant Equipment & Furnace Design Project (Credit: 2)

ELECTIVES

CR-5103: Fuel Technology and Furnace Engineering (Credits 3)

Fuels (gaseous, liquid, solid), their availability, properties and utilization in firing the industrial furnaces. Electrical energy-uses in furnace heating, advantage and cost. Essential features of burners. Flame temperature of fuels and achieving maximum efficiency. Principles of automatic control in furnaces, control of furnace atmosphere. Measuring and controlling of furnace temperature.

Different type of industrial furnaces, critical comparison of sources of heat energy, strength and durability of regenerators and recuperators. Heat saving devices. Safety measures.

CR-5104 : Nano-Ceramics (Credits 3)

Introduction to nanotechnology, its emergence and challenges classification of nano-materials: Zero, one, two and three dimensional nano-structured materials.

Synthesis of nano-particles through homogenous and heterogeneous nucleation, kinetically confined synthesis of nano-particles synthesis of nano-wire, rod, tubes and thin films. Special nano-materials: carbon, carbon fulrenes and carbon, nano-tubes, nano and microporous materials, core shell structure and nano-composites.

Electrical, magnetic, optical, thermal and mechanical properties of nano-structured materials.

Applications of naon-materials in molecular electronics, nano-electronics, catalysis, photoelectrochemical cells, photonics, quantum well, quantum dot and quantum wire devices.

Recommended Books-

1. Nano structure and nano-materials by Guozhong (AO.(Imperial College Press), London), 2004.

2. Introduction to Nano technology by Charles P. Poole, Jr and Frauk J. Owens. (Wiley Interscience , New Jersey, 2003.

3. Nano-structured materials: Processing , properties and Potential Applications by Carl. C. Koch. (Noyes Publication and William Andrew Publishing) New Yark. 2002.

CR-5105: Bio-ceramics (Credits 3)

Definition and scope of bio-materials. Structure-property relationship of biological materials, structure of proteins, polysaccharides, structure-property relationship of hard tissues cell, bone, teeth and connective tissues.

Structure, properties and functional behaviour of bio-materials. Tissues response to implants (bio-compatability, wound healing process), body response to implants, blood compatability. Classification of bio-ceramic materials for medical applications. Alumina and zirconia in surgical implants, bioactive glasses and their clinical applications, A.W. machinable and phosphate glass ceramics. Dense and porous hydroxyl apatite calcium phosphate ceramics, coatings and resorbable ceramics. Carbon as an implant. CMC and PMC composites. Characterization of bio-ceramics. Regulation of medical devices.

Books Recommended:

1. Introduction to Bio-Ceramics – L. L. Hench and J. Wilson.
2. Biomaterials: An introduction by Ethridge.
3. Introduction to biomaterials by J. B. Park.

CR-5106: Advanced Refractory Engineering (Credit- 3)

Manufacture and properties of conventional and non conventional refractories. Application of sintering, microstructure and phase diagram in refractory technology and their influence on refractory property. Application of refractories in metallurgical and non metallurgical industries. Latest development and trends of refractories for iron and steel making. Functional refractories e.g. purging, refractories, tap note refractories, refractory lance ceramic fitters, vacuum forward insulating products. Borides, corbids, nitrides and silicids. Refractory for nuclear reactors. Refractory metals and refractory coatings innovation in refractory material and application. Non destructive testing. Methods used in refractory technology. Status of refractory industries and research in India.

CR-5107: Ceramic Fabrication Processes (Credits 3)

Raw Materials: Processing of raw materials, powder preparation by solid state reactions, chemical methods and vapour phase reactions. Freeze drying and spray drying and sol-gel processing of ceramic powders.

Colloidal Processing: Types of colloids, electrostatic and polymeric stabilization of colloids, rheology of colloidal suspensions. Clay water system, thixotropy, slip casting and tape casting.

Powder consolidation and forming of ceramics: Packing of particles, additives and their selection in the forming processes. Extrusion, dry and semi-drying pressing methods, isostatic pressing, hot pressing. Plastic forming methods, injection moulding. Drying of formed bodies and removal of binders.

Sintering of Ceramics: Driving forces for sintering, defects and diffusion in solids, solid state and viscous sintering, liquid phase sintering, grain growth. Clinkering and vitrification. Microstructure control during firing. Microwave sintering.

Recommended Books:

1. Processing and Sintering of Ceramics by M. N. Rahman.

CR-5108: Technology of Ceramic White Wares. (Credit-3)

Engineering aspects of structural clay and white ware products, low and high temperature characterization of raw materials such as clay, quartz and feldspar, utilization of various industrial and agricultural wastes as raw materials, effect of aging and weathering . Slip preparation, dewatering of slip and control of slip properties, structure and behavior of extended clay, microstructure of flow pattern, piston and auger extension, effect of extension, lamination and other faults, drying. Effect of processing methods on physical properties of bodies, grain growth, sintering and vitrification in white wares, effect of composition, temperature and furnace atmosphere on microstructure quality control, mechanization and relevant automation. Manufacture of double layer stoneware, various tiles, sanitary fittings, face bricks, colored bricks and other related products, architectural aspects of clay products.

CR-5109: Ceramic Materials and Applications (Credit 3)

Traditional Ceramics: Silicates and alumino silicate ceramics in pottery, porcelain and heavy clayware. Fabrication, drying and firing. Oxide Refractory Ceramics their high temperature characteristics and applications in ferrous, nonferrous metallurgy and glass industries.

Glass: Types of Glasses, Melting, refining and homogenization of glass melt. Refraction and colors in glasses. Toughening of glasses. Application of glasses in storage (containers), structural and automobiles.

Non-oxide Ceramics: Silicon Carbide, Silicon Nitride**,** SIAlONs, Borides. Application of non-oxide ceramics for refractory and structural application.

2 YEARS M.TECH. (CERAMIC ENGINEERING) PART -I

SEMESTER- II

Open Elective	**(Credit: 3)**
Elective III	**(Credit: 3)**
Elective IV	**(Credit: 3)**
Elective V	**(Credit: 3)**
Elective VI	**(Credit: 3)**

PRACTICAL

CR-5401: Laboratory (Electronics Ceramic, Glass)	**(Credit: 2)**
CR-5402: Laboratory (Cement/Whit ware and Refractory)	**(Credit: 2)**
CR-5403: Seminar	**(Credit: 1)**

ELECTIVES

CR-5201: Advanced Glass Technology (Credits 3)

Structure and nature of glasses, transformation range behaviour, dependence of physico-chemical characteristic of glasses on their constituents. Strength of glass and glass articles. Thermal and ion exchange toughening. Coatings on glass.

Technological aspects of chemical durability of glasses and reaction with water. Extraction of various constituents from glasses. Effect of various factors on the rate controlling mechanism.

Redox equilibria in glasses and their industrial applications in coloration, decolorization and refining of glasses as well as preparation of special glasses, Redox number of glass, its calculation from batch raw materials and uses. Importance of transition metal ions in glass, interaction of radiation in glass. Magnetic properties of glasses. Solubility of gases at high temperature in glasses. Phenomena of reboiling in industrial glass preparation process. Oxygen ion activity and its influence on redox equilibria and application.

Principle and manufacture of sheet glass by float process, TV picture tubes, glass containers, glass fibres and optical glass fibres. Processing, properties and application of glass ceramics.

Books:

1. Hank book of Glass Manufactur, F.V.Tooley, Vol. 1 & 2

2. Glass Science and Technology , Vol. I and II, Ed. D.R. Uhlmann and N. J. Kredl, Academic Press, London.

3. Chemistry of Glasses, Ed. Amal Paul, Chapman Hall, London

4. High Performance Glasses, Ed. M. Cable and J. M. Parker, Blachie , New Yark, USA.

5. Optical and Spectroscopic Properties of Glasses, Gan Fuxi., Spinger-Verlag, USA.

CR-5203: Cement Process Engineering (Credits 3)

Design and control of cement compositions, particle size distribution in raw materials, Detailed study of rotary kiln and shaft kiln. Solid-state reactions, sintering and clinkering in cement.. The constitution of Portland cement, Crystal structure of anhydrous cement compounds, clinker and hydration products. Phase equilibrium in cement hydration. The chemistry of hydrated cement compounds. Hydration of anhydrous cement and cement compounds. Its method of investigation.. The principles and techniques of high temperature phase analysis in clinker formation. Studies of the important systems in the phase formation in different types of cements. Effect of impurities and role of minor components in cement formation and its hydration.

High temperature cement and refractory castables, hydrated calcium silicate products other than hydraulic cements. Polymer cement interactions. Polymer cement concrete, Polymer impregnated concrete, Macro-defect-free (MDF) products, Fiber reinforced concrete and protective coatings.

CR-5204: Electrical & Electronic Ceramics (Credits 3)

Symmetry and other criteria of ferro-electricity, ferroelectric transitions in $BaTiO_3$, $PbTiO_3$ and other related materials. Effect of compositional modifications and grain size. Relaxor ferroelectrics. Performance categories of ceramic capacitors with typical compositions. Powder synthesis, electroding and packaging of discrete, multilayer and barrier layer capacitors.

Symmetry considerations and equations of state for piezoelectric and electrostrictive effects. Poled ferroelectric ceramics. Measurement of coupling factor and strain coefficient. Phase diagram, preparation and properties of PLZT ceramics. Thin films of PZT. Piezoelectric positioners, loud speakers and gas ignitors. Pyroelectric and electro-optic ceramics with their applications. NTC and PTC thermistors, ZnO varistors. Classification and structural features of super-ionic solids. Applications in oxygen sensors, fuel cells, high density energy storage batteries. Magnetic ceramics and their crystal structure. Effect of composition on magnetic behaviour. Processing, microstructure, properties and applications of magnetic ceramics.

Recommended Books:

1. Ceramic Materials for Electronics by R. C. Buchanan (Marshal Dekker, New Yark.
2. Principles of Electronic Ceramics by L. L. Hench & J. K. West (John Wiley & Sons.)

CR-5205: Engineering Ceramics and Composites (Credits 3)

Toughening Mechanisms in ceramics: Transformation toughening and crack bridging. Processing and evaluation of engineering ceramics. Formation, properties and uses of fused alumina, sintered alumina products, aluminium oxide alloys, borides, carbides, nitrites, silicides, zirconia and partially stabilized, zirconia, sialons. Wear resistant ceramic products. Application of thermal plasma technology in synthesis of engineering ceramics.

Mechanical properties of continuous fibers reinforced ceramic matrix composites, whisker, ligament and platelet rein-forced ceramic matrix composites. Creep rupture in ceramic and composites. Application of engineering ceramic materials in extreme conditions, such as, aerospace, launch pads, space shuttles, automobile engineering, coatings, anti-ballastic materials.

CR-5206: Industrial Furnaces, Instrumentation and Control (Credits 3)

Classification of furnace. Detailed study of industrial furnace used in refractories glass, ceramics, cement, ferrous and non-ferrous industries with respect to their design calculations keeping process parameters in view.Role of multilayer lining, combustion, gas flow and heat transfer in furnaces. Physico-chemical considerations in designing of furnaces.Measurement of temperature, pressure, draft etc. in furnace system and their control. Efficiency and fuel conservation. Use of top electrode for electric melting. Pollution control option for furnace noise, flaring and disposal.

CR-5207: Science of Ceramic Materials (Credits 3)

Bonding and crystal structure of ceramics. Effect of bonding and crystal structure and micro-structure on properties of ceramics. Point defects in ionic compounds. Effect of partial pressure of oxygen and temperature on defect concentration. Non-stoichiometry. Effect of alliovalent impurities on concentration of defects. Optical and electronics properties of ceramic materials.

Synthesis of ceramic powders, nano-particles and their consolidation. Sintering and grain growth mechanisms.

Theoretical fracture strength, Griffith's theory of brittle fracture, toughness and fracture toughness, factors influencing the strength of ceramic materials. Toughening mechanisms, transformation toughening, R-curve behaviour and designing with ceramics. Weibull modulus. Creep and fatigue in ceramic materials.

Thermal expansion, thermal conductivity, thermal stresses and thermal shock resistance. Spontaneous microcracking. Thermal tempering.