World Skill Development Institute

Glass and Ceramics Technology

Course Duration – 6 months.

The technology of glass ceramics are now a day wide field involving a great variety of raw materials, manufacturing processes, as well as products, and of considerable diversity in theoretical background. The manufacture of traditional glasses and ceramics is based on the utilization of the most widely occurring natural raw materials. Glass is an inorganic product that is typically produced by melting a mixture of silica, soda and calcium compound with the desired metallic oxides that serve as colouring agents. The glass industry covers products such as silicate glasses, phosphate glasses, germanate glasses, halide glasses, nitrate glasses etc. Glass products are used widely in households, construction, laboratories and consumer items such as bangles, beads, pearls, etc. A ceramic is an inorganic, nonmetallic solid prepared by the action of heat and subsequent cooling. Ceramic materials may have a crystalline or partly crystalline structure, or may be amorphous (e.g., a glass). Because most common ceramics are crystalline, the definition of ceramic is often restricted to inorganic crystalline materials, as opposed to the noncrystalline glasses. Commercial application of glass ceramics are dinnerware, fine mesh screens, cookware, burner covers, semiconductor doping sources etc. The domestic glass industry is facing increasing competition in the global, as well as domestic markets. State of the art technology in manufacturing is becoming increasingly important in the industry. Modern technology and operations are replacing traditional methodologies in fibre glass composites. The demand for ceramic and glass products is growing globally with over 90 percent of the total demand for advanced ceramic materials coming from electronic goods and allied industries, thanks to the product ability to withstand extreme environmental conditions.

This course majorly deals with types of glasses, silicate glasses, boric oxide and borate glasses, phosphorus pentoxide and phosphate glasses, germanium dioxide and germanate glasses, titanate glasses, nitrate glasses, glasses based on water, halide glasses, modern glass working, monax and pyrex glass, electric welding, photo electric cells, glassy metals, analysis of glass, glass ceramics, ceramics as electrical materials, analysis of ceramics etc.

The technology of glass ceramics are now a days a wide field involving a great variety of raw materials, manufacturing processes, as well as products, and of considerable diversity in theoretical background. The manufacture of traditional glasses and ceramics is based on the utilization of the most widely occurring natural raw materials. The efforts have been made to provide maximum and latest

information about processing of glass and ceramics and their products in this course. This course is an invaluable resource for entrepreneurs, technocrats, manufacturers of glass and ceramic products, research scholars etc.

1. GLASS

Structure

Composition

Single-Phase Glasses

Glass-Ceramics and Phase-Separated Glasses

Properties

Manufacture and Processing

2. TYPES OF GLASSES

A. Chemical Composition

B. Devitrification of Fused Silica

1.The Phases of Silica

2. Crystalline Phases Produced by the Devitrification of Fused Silica

3. Effect of Impurities on the Rate of Devitrification of Vitreous Silica

4. Effect of Atmosphere on the Rate of Devitrification

5. Detailed Studies of Devitrification Kinetics

6. Comparison of Calculated and Measured Growth Rates

C. The Kinetics Of Melting Of Quartz And Cristobalite

1. Superheating of Quartz and Cristobalite Melting

2.Evidence for Residual Crystalline Structures in Fused Silica

D. Viscosity of Fused Silica

3. SILICATE GLASSES

A. Binary Systems

1. Alkali Silicate Systems

a. Structural considerations

b.Glass formation in the alkali silicate systems

c.Phase diagrams of the alkali silicate systems

d. The kinetics of devitrification

2. Binary Systems Containing Alkaline Earth Oxides

B. THE NA2O-CAO-SIO2 SYSTEM

1. Structural Considerations

2. The Glass-forming Region

3. The Phase Diagram

4. Devitrification Kinetics

C. SOME SPECIAL SILICATE GLASSES

1. Alkali Aluminosilicates

2. Invert Glasses

4. BORIC OXIDE AND BORATE GLASSES

A. The Preparation and Properties of Boric Oxide Glass

B. Glass Formation in Binary Borate Systems

1. Ranges of Glass Formation

2. Phase Diagrams

3. Chemical Bonding in Systems Containing Highly Polarizable Cations

C. Ternary Systems

1. The Na2O-B2O3-SiO2 System

2. Aluminoborate Systems

D. The Structure of Vitreous Boric Oxide and Borate Glasses

1. Vitreous Boric Oxide

2. Alkali Borate Glasses

5. PHOSPHORUS PENTOXIDE AND PHOSPHATE GLASSES`

A. Phosphorus Pentoxide

1. Structure and Polymorphism

2. Polymorphic Transformations and Melting

3. Viscosity and Melt Allotropy

B. Glass Formation in Binary Phosphate Systems

1. Regions of Glass Formation

2. The Structure of Phosphate Glasses

3. Paper Chromatography of Phosphate Glasses

4. Devitrification Kinetics of Sodium Metaphosphate Glass

5. The Role of B_2O_3 and Al_2O_3 in Phosphate Glasses

6. GERMANIUM DIOXIDE AND GERMANATE GLASSES

A. Germanium Dioxide

1. Structure and Allotropy

2. GeO_2 Glass : Viscosity

B. Glass Formation in GeO_2 systems

1. Experimental Results

2. Phase Diagrams

3. The Structure of Alkali Germanate Glasses and Mels

Tellurite and Vanadate Glasses

A. Tellurite Glasses

1. Glass Formation

2. The Structure of TeO_2 and Tellurite Glasses

3. Viscosity of Tellurite Melts: Liquidus Temperatures

B. Vanadate Glasses

1. Glass Formation

2. Liquidus Temperature in Vanadate Systems

3. The Structure of V_2O_5 and Vanadate Melts

Miscellaneous Oxide Glasses

A. Aluminate Glasses

1. Glass-forming Compositions

2. Liquidus Temperatures; Structure

B. Glasses Base Ga_2O_3

C. Carbonate Glasses

D. Titanate Glasses

E. Glasses Based on As_2O_3, Sb_2O_3 AND Bi_2O_3

1. Glass-Forming Behaviour of the Oxides

2. Binary Systems

F. Glasses Based on MoO_3 AND WO_3

G. Sulphate and Selenite Glasses

7. NITRATE GLASSES

A. Glass-Forming Systems

B. The System KNO_3-$Ca(NO_3)_2$

C. Theories of Glass Formation

1. Structural Considerations

2. Kinetic Considerations

D. The Mechanism of Melting

8. GLASSES BASED ON WATER

A. Vitreous Water

B. The System H2O-H2O

C. Other Aqueous Solutions

D. Structure of Water

E. Hydrogen Bonding in KHSO4

9. HALIDE GLASSES

A. BeF2 Glasses

1. BeF2

2. Model Relationships between Fluorides and Oxides

3. Binary Fluorberyllate Systems

4. Microphase Separation

B. Other Fluoride Glasses

C. ZnCl2 Glasses

10. CHALCOGENIDE GLASSES

A. COMPARISON WITH OTHER SYSTEMS

A. Comparison with Other Systems

B. Structure and Melting Behaviour of Elements in Groups IV, V and VI

C. Sulphur, Selenium and Tellurium

1. Sulphur

2. Selenium

3. Tellurium

D. Binary Glasses

1. Chalcogenides with Group V Elements

2. Chalcogenides with Group IV Elements

E. Ternary Glasses

1. Glasses Based on Arsenic Chalcogenides

2. Glasses Containing Both Group IV and Group V elements

F. Halogen-Containing Glasses

G. Viscosity of Binary Glasses

H. Phase Diagrams of Binary Chalcogenide Systems

I. Structures of Chalcogenide Compounds and Glasses

1. Chalcogenides of Group IV Elements

2. Chalcogenides of Group V Elements

3. Structures of the Chalcogenide Glasses

11. MODERN GLASS WORKING

General Considerations and Equipment

Physical Properties of Glass

General Considerations and Equipment

Physical Properties of Glass

Kinds of Laboratory Glass

Soda-Glass

The Glass Working Flame. The Blowpipe

Other Types of Blowpipe

The Hand Blowpipe

The Compressed Air

The Glass Working Bench

Bloom and Devitrification

Annealing

Storing and Cleaning Glass

12. FUNDAMENTAL OPERATIONS.

Skill

Cutting Glass Tubing

Instruments in use for Starting the Crack

(1) The Glass Knife.

(2) Steel Files.

(3) Specially hardened Steel Wheels.

(4) Diamond.

Methods of Propagating the Crack

(a) Mechanical.

(1) Manual Pressure.

(2) Impact.

(b) The Application of Heat.

(1) The Electrically Heated Hot Wire.

(2) Hot Glass Rod.

(3) The Blowpipe Flame.

(4) Hot Iron Wires.

The Importance of good Glass Cutting

Rotating the Tube in the Flame

Bending Glass Tubing

Bending Wide Tubing

Drawing Out and Constructing A Tube

Bordering

Sealing a Tube

Blowing Bulbs

(a) At the end of a Tube.

(b) In the middle of the Tube.

Joining Two Tubes of the Same Diameter

Method I.

Method II.

To Blow a Hole in the Side of a Tube

Composite Operations

Joining Two Tubes of Unequal Diameters

Blowing Larger Bulbs

(a) From a Bulb in the Middle of a Tube.

(b) From a Larger Tube Sealed On.

T-Joints

Internal Seals

(a) Inner tuber unsupported.

(b) Inner tube supported.

Closed Circuits of Tubing

13. MONAX AND PYREX GLASS

General

Monax Glass

Physical Properties

Cutting

Bending

Blowing

Small Joints

Large Joints

Annealing

Pyrex Glass

Physical Properties

Cutting

Bending

Blowing

Joints

Annealing

14. SEALING METALS INTO GLASS

Platinum

Copper-Clad Wire

Tungsten

Copper to Glass

15. ELECTRIC WELDING

General

Resistance Welding

Strength of Welded Wires

ARC Welding

16. VACCUM TUBES

The Conduction of Gases

The Electrodes

Positive Rays

X-ray Fluorescence

The Fleming Valve

The De Forest Valve

17. PHOTO-ELECTRIC CELLS

General

Photo-Emissive Cells

Cell Construction

Working the Cell

Photo-Voltaic Cells

Cuprous-oxide-copper

Other Semi-Conductors

18. VACUUM TECHNIQUE

Diffusion Pumps

21. GLASSY METALS

Structure

Properties

Thermal Behaviour

Formation

Preparation

Applications

22. ANALYSIS OF GLASS

Methods of Anylysis

Composition Analysis

Chemical Methods for Individual Constituents

Procedures

Calculate the zirconium content as zirconium dioxide, ZrO_2.

Procedures

Calculate the antimony as antimony trioxide, Sb_2O_3.

Calculate the antimony content of the sample as antimonous oxide, Sb_2O_3.

Procedures

Redox State Determinations

Chelometry

Procedures

Flame Spectroscopy

Method for Alkali Metals in Glass by Flame Emission Spectrometry.

Procedure

Emission Spectroscopy

X-Ray Emission Spectroscopy

Spark Source Spectrometry

Electroanalytical Methods

Coulometry.

Determination of Properties

Spectrophotometry

Procedure

Procedure

Microscopy

Electron Microprobe Analysis

23. GLASS-CERAMICS

The Glass-Ceramic Process

Properties

Commercial Applications

24. Ceramics

SCOPE

25. RAW MATERIALS

Clays

Nonclay Minerals

Special Materials

26. FORMING PROCESS

Material Preparation

Forming Process

Thermal Treatment

Methods of Thermal Treatment

Physical and Chemical Changes During Thermal Treatment

27. CERAMICS POTTERY

The Indian Industry

Raw Materials

Manufacture

Production and Trade

28. PROPERTIES AND APPLICATIONS

Composition and Microstructure

Chemical Properties of Ceramic Materia's

Optical Properties

Thermal Properties

Elastic Properties

Strength

Electrical and Magnetic Properties

Composites and Cermets

Uses of Ceramics

29. CERAMICS AS ELECTRICAL MATERIALS

Electrical Conduction Phenomena

Ionic Conduction in Ceramics

Electronic conduction in Ceramics

Nonstoichiometric and Solute-Controlled Electronic Ceramics.

Ceramics With High Electronic Conductivity or With Nonlinear Behaviour

Mixed Conduction in Ceramics

30. ANALYSIS OF CERAMICS

Abrasives

Cements, Lime, and Gypsum

Clay Products, Whitewares, and Porcelains

Enamels and Glazes

Glass and Glass Ceramics

Refractories

Newer Ceramics

Methods of Analysis

Determination of The Chemical Composition

Sampling

Sample Dissolution

Procedure

Analysis

Emission Spectroscopy

X-Ray Diffraction

Microscopy.