

# **The Complete Book on Glass and Ceramics Technology (2nd Revised Edition)**

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Ceramics also known as fire clay is an inorganic, non-metallic solid article, which is produced by the art or technique of heat and subsequent cooling. The ceramics industry in India came into existence about a century ago and has matured over time to form an industrial base. From traditional pottery making, the industry has evolved to find its place in the market for sophisticated insulators, electronic and electrical items. The ceramic industry has been modernizing continuously, by newer innovations in product design, quality etc.

Glass is an inorganic product typically produced by melting a mixture of silica, soda and calcium compound with desired metallic oxides that serves as coloring agents. Indian glass industry will increase on the sidelines of real estate growth across retail, residential and office estate. Glass production involves the fusion of several inorganic substances. These various substances include products such as silica sand, soda ash, dolomite and limestone, representing together 99% of all the raw materials, excluding recycled glass.

Glass-ceramics are mostly produced in two steps: First, a glass is formed by a glass-manufacturing process. The glass is cooled down and is then reheated in a second step. In this heat treatment the glass partly crystallizes. In most cases nucleation agents are added to the base composition of the glass-ceramic. These nucleation agents aid and control the crystallization process. Glass-ceramics are fine-grained polycrystalline materials formed when glasses of suitable compositions are heat treated and thus undergo controlled crystallization to the lower energy, crystalline state. It is important to emphasize a number of points in this statement on glass ceramics. Glass ceramics has helped the electronics industry build much smaller and highly efficient transistors, leading to advances in all types of devices.

The book covers almost all important aspects of Glass and Ceramic Industry: Properties, Applications, Manufacturing, Processing and Photographs of Plant & Machinery with Supplier's Contact Details. The major contents of the book are 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 book will be useful to the consultants, technocrats, research scholars, libraries and existing units and new entrepreneurs who will find a good base to work further in this field.

## 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  $\text{Na}_2\text{O}$ - $\text{CaO}$ - $\text{SiO}_2$  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  $\text{Na}_2\text{O}$ - $\text{B}_2\text{O}_3$ - $\text{SiO}_2$  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  $H_2O$ - $H_2O$

- C. Other Aqueous Solutions
- D. Structure of Water
- E. Hydrogen Bonding in  $\text{KHSO}_4$

## 9. HALIDE GLASSES

- A.  $\text{BeF}_2$  Glasses
  - 1.  $\text{BeF}_2$
  - 2. Model Relationships between Fluorides and Oxides
  - 3. Binary Fluorberyllate Systems
  - 4. Microphase Separation
- B. Other Fluoride Glasses
- C.  $\text{ZnCl}_2$  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 tube 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  
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The Fleming Valve  
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#### 17. PHOTO-ELECTRIC CELLS

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Photo-Emissive Cells  
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#### 18. VACUUM TECHNIQUE

Diffusion Pumps  
Theory  
Jet Design  
Working Substance  
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Heating  
Joints  
The Importance of Wide Tubing  
Use of a Reservoir  
Connections and Taps  
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#### 19. LEAKS, OUT-GASSING AND SEALING OFF

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Out-Gassing  
The Electric Furnace

Sealing Off

'Clean-up' and 'Getters'

## 20. MEASUREMENT OF LOW PRESSURES

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Construction

Other Indications of Pressure

## 21. GLASSY METALS

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Properties

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Formation

Preparation

Applications

## 22. ANALYSIS OF GLASS

Methods of Analysis

Composition Analysis

Chemical Methods for Individual Constituents

Procedure

Procedure

Procedures

Procedure

Procedures

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

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

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## Commercial Applications

### 24. Ceramics

#### SCOPE

### 25. RAW MATERIALS

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Nonclay Minerals

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Forming Process

Thermal Treatment

Methods of Thermal Treatment

Physical and Chemical Changes During Thermal Treatment

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The Indian Industry

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Production and Trade

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Optical Properties

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Elastic Properties

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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

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Clay Products, Whitewares, and Porcelains

Enamels and Glazes

Glass and Glass Ceramics

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Newer Ceramics

Methods of Analysis

Determination of The Chemical Composition



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Sample Dissolution  
Procedure  
Analysis  
Emission Spectroscopy  
X-Ray Diffraction  
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## 31. PHOTOGRAPHS OF MACHINERY WITH SUPPLIERS CONTACT DETAILS

### About NIIR

**NIIR PROJECT CONSULTANCY SERVICES (NPCS)** is a reliable name in the industrial world for offering integrated technical consultancy services. NPCS is manned by engineers, planners, specialists, financial experts, economic analysts and design specialists with extensive experience in the related industries.

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Our Detailed Project report aims at providing all the critical data required by any entrepreneur vying to venture into Project. While expanding a current business or while venturing into new business, entrepreneurs are often faced with the dilemma of zeroing in on a suitable product/line.

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