

The Complete Book on Glass Technology

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Glass is an amorphous solid usually formed by the solidification of a melt without crystallisation. It is an inorganic product of melting, which has been cooled to rigid state without crystallization. Melting is in fact the sole large scale industrial method of glass making. Glass is being used worldwide and has various applications. They are typically brittle and optically transparent. It is widely used in buildings and having industrial applications. The presence of glasses in our everyday environment is so common that we rarely notice their existence. Glass, as a substance, plays an essential role in science and industry. There are various methods of glass making other than melting for example condensation of vapours, conversion of crystals to an amorphous form using mechanical means or irradiation with fast neutrons, dehydration and sintering of gels, etc. Silica (the chemical compound SiO_2) is a common fundamental constituent of glass. The properties of glass can be varied and regulated over an extensive range by modifying the composition, production techniques, or both. In any glass, the mechanical, chemical, optical, and thermal properties cannot occur separately. Instead, any glass represents a combination of properties, and in selecting an individual glass for a product, it is this combination that is important. As an architectural element, glass has become the quite essential product for your home or building. The applications of glass are limited only by your imagination; glass has many applications both internal and external that play a vital role in the function and design of your project. Industrially produced glasses can be divided into groups according to various criteria: composition, appearance, properties, application, method of forming etc. According to their chemical composition glasses are classified as silica glass (quartz glass), water (soluble) glass or sodium silicate glass, crystal glass, heat resistant glass, low alkali glass etc. Glass is finding ever wider applications in modern technology; sealing glasses which have been in use for many years, serve in vacuum tight joining of glass to metal, especially in vacuum electronics, in nuclear technology (protection from radiation, immobilization of radioactive waste by fusion into a chemically, resistant glass, etc.), in agriculture (as carrier of fertilizers with long term effects) and a number of possible application in electronics and many more.

Some of the fundamentals of the book are structure of glass, structure of special melts and glasses, composition of glass, glass formation, crystallization and liquid, optical properties, theoretical strength of glasses, practical strengths of glasses, flaw sources and removal, viscosity of glass forming melts, theoretical principles of glass melting, chemical reactions occurring in glass melting, dissolution of solids in the melt, flow of glass in melting furnaces, physical chemical factors in sol gel processing, deposition of transparent non crystalline, metal oxide coatings by the sol gel process etc.

The present book covers different important parameters of glass technology. The book is

comprehensive guide for researchers, technologists, new entrepreneurs and professionals.

1. GLASS

Definition and Historical Summary

Structure of Glass

Structure of Special Melts and Glasses

Composition of Glass

Glass Formation, Crystallization and Liquid

Immiscibility

Chemical, Mechanical and Physical Properties of

Industrially Important Melts and Glasses

Rheological Properties of Glass Melts

Surface Tension

Density

Thermal Expansion

Elastic Properties

Mechanical Strength

Hardness

Thermal Properties

Electrical Properties

Gas Permeability

Chemical Stability and Surface Properties

Optical Properties

Color of Glasses

Production of Glass

Raw Materials

Melting Units

Melting, Fining and Homogenization

Glass Cooling

Heating and Regulating Glass Melts

Refractory Lining of Melting Units

Vapor-Deposited Glasses

Occupational Health

Forming

Hand Forming

Annealing

Secondary of Finishing Operations

Uses

Silica and Silica-like Glass

Flat Glass

Laboratory Glassware

Light-Sensitive Glass

Display Devices

Glass Fibers

Molded Optics

Glasses for Nonlinear Optical Devices

Economic Aspects

2. OPTICAL PROPERTIES

Introduction

Bulk Optical Properties

Refractive Index

Molar and Ionic Refractivities

Dispersion
Ultraviolet Absorption
Visible Absorption
Ligand Field Coloration of Glasses
Amber Glass
Colloidal Metal Colors
Colloidal Semiconductor Colors
Radiation-induced Colors
Solarization
Infrared Absorption
Infrared Absorption by Bound Hydrogen Species
Infrared Absorption by Dissolved Gases
Infrared Cutoffs or the Multiphonon Edge
Other Optical Properties of Glasses
Photosensitive and Photochromic Glasses
Opal Glasses
Faraday Rotation

3. MECHANICAL PROPERTIES

Introduction
Elastic Modulus
Hardness
Fracture Strength
Theoretical Strength of Glasses
Practical Strengths of Glasses
Flaw Sources and Removal
Strengthening of Glass
Statistical Nature of Fracture of Glass
Fatigue of Glasses
Thermal Shock
Annealing of Thermal Stresses

4. VISCOSITY OF GLASSFORMING MELTS

Introduction
Viscosity Definitions and Terminology
Viscoelasticity
Viscosity Measurement Techniques
Rotation Viscometers
Falling Sphere Viscometers
Fiber Elongation Viscometers
Beam-bending Viscometers
Other Viscometers
Temperature Dependence of Viscosity
Fragility of Melts
Free Volume Model for Viscous Flow
Entropy Model for Viscous Flow
Compositional Dependence of Viscosity
Silicate Melts
Borate Melts
Germanate Melts
Halide Melts
Chalcogenide Melts
Effect of Hydroxyl on Melt Viscosities
Effect of Thermal History on Viscosity
Effect of Phase Separation on Viscosity

Effect of Crystallization on Viscosity

5. STRUCTURE OF GLASSES

Glass Formation

Models of Glass Structure

The Structure of Oxide Glasses

Submicrostructural Features of Glasses

Miscibility Gaps in Oxide Systems

General Discussion

6. GLASS TECHNOLOGY

The Characteristics of Glass

Properties of Molten Glasses

Viscosity

Crystallization

Surface Tension

Density

Specific Heat

Thermal Conductivity

Electrical Conductivity

Theoretical Principles of Glass Melting

Chemical Reactions Occurring in Glass Melting

Dissolution of Solids in the Melt

Flow of Glass in Melting Furnaces

Homogenization

Volatilization

Refining and Solubility of Gases

Flat Glass and Tube-forming Processes

The Forming of Glass Fibres

Properties of Glass

Mechanical Properties

Thermal Properties

Optical Properties

Electrical Properties

Chemical Durability

Principle Types of Industrial Glasses

Silica Glass (quartz glass)

Sodium-Silicate Glass (water glass)

Sheet and Container Glass; the System $\text{Na}_2\text{O}-\text{CaO}-\text{SiO}_2$

Crystal Glass; the System $\text{K}_2\text{O}-\text{CaO}-\text{SiO}_2$ and $\text{K}_2\text{O}-\text{PbO}-\text{SiO}_2$

Heat-Resistant Glasses of the System $\text{Na}_2\text{O}-\text{B}_2\text{O}_3-\text{SiO}_2$

Coloured Glasses

Opal Glasses

Optical Glasses

Glass Fibres

Other Types of Oxide Glasses and Products

Chalcogenide Glasses

7. NITRIDATION OF SILICA SOL-GEL THIN FILMS

Introduction

Experimental Methods

Results and Discussion

Film Shrinkage

Refractive Index

SIMS Depth Profiles

Auger Analyses

Enhancing the Nitridation Reaction with a Chlorine Pretreatment

8. MODIFICATION OF OXIDES BY POLYMERIZATION PROCESS

Introduction

Introduction of Chemical-Structural Variations in Inorganic Polymers

Theoretical Bases

Experimental

Effect on Properties

Effect on Densification and Viscosity

Effect on Crystallization and Crystalline Transformations

9. DRYING AND FIRING MONOLITHIC SILICA SHAPES FROM SOL-GELS

Introduction

Experimental Technique

Results and Discussion

10. SOL-GEL-DERIVED INDIUM-TIN-OXIDE COATINGS

Introduction

Properties of Sol-Gel Derived ITO Coatings

Characteristic Properties of ITO-Coatings for Window-Systems Derived from Dip Coating

Optical Properties

Architectural Properties

Mechanical Properties

Chemical Properties

Long-Term Stability, Weatherability, Outdoor Tests

Properties of an Insulating Glass Unit (One Pane ITO-Coated)

11. RELATIONSHIPS BETWEEN THE SOL-TO-GEL AND GEL-TO-GLASS CONVERSIONS

Introduction

Gelation

Gel-to-Glass Conversion

Experimental

Results & Discussion

Physical Properties

Shrinkage and Densification

Isothermal Shrinkage Experiments

12. MONOLITHIC XERO-AND AEROGELS FOR GEL-GLASS PROCESSES

Introduction

Main Steps in Gel Processing

Cracking During the Drying Process

Analysis of Causes of Cracking

Effect of Capillary Forces

Concept of Moisture Stress

Mechanical Resistance of the Gel

Ways of Avoiding Cracking During Drying

Monolithic Aerogels

Conclusion

13. BEHAVIOR OF MONOLITHIC SILICA AEROGELS AT TEMPERATURES ABOVE 1000°C

Introduction
Densification of the Gel
Experimental Procedure
Results and Discussion
Conclusion
14. TiO₂ COATED GLASS BEADS

Introduction
Experimental
Materials
Instrumentation
Preparation of Catalysts
Hydrogenation Experiments
Results and Discussion
Features of Glass Beads Coated with TiO₂
Catalytic Activity of Pd Dispersions on TiO₂ Coated
Glass Supports

15. DEPOSITION OF TRANSPARENT NON-CRYSTALLINE METAL OXIDE COATINGS BY THE SOL-GEL PROCESS

Introduction
Dip-Coating Technique
Single-Layer Coatings with Refractive Index Gradient
Experimental Work
Results and Discussion
SiO₂-B₂O₃-Na₂O System
SiO₂-BaO System

16. PHYSICAL CHEMICAL FACTORS IN SOL-GEL PROCESSING

Introduction
Gel Synthesis
Principles of Gelation
Silica Gel
TiO₂ Gels
SiO₂-B₂O₃ Gels
SiO₂-TiO₂ Gels
Na₂O-SiO₂ Gels
Drying
The Gel-Glass Conversion
Conclusions

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