

Preface

Glass-ceramics are a special group of materials whereby a base glass can crystallize under carefully controlled conditions. Glass-ceramics consist of at least one crystalline phase dispersed in at least one glassy phase created through the controlled crystallization of a base glass. Examples of glass-ceramics include the machinable glass-ceramics resulting from mica crystallization, the low thermal expansion glass-ceramics resulting from β -eucryptite and β -spodumene crystallization, high toughness glass-ceramics resulting from enstatite crystallization, high mechanical strength resulting from canasite crystallization or the high chemical resistance glass-ceramic resulting from mullite crystallization.

These materials can provide a wide range of surprising combinations of physical and mechanical properties as they are able to embrace a combination of the unique properties of sintered ceramics and the distinctive characteristics of glasses. The properties of glass-ceramics principally depend on the characteristics of the finely dispersed crystalline phases and the residual glassy phases, which can be controlled by the composition of the base glass, the content and type of mineralizers and heat treatment schedules. By precipitating crystal phases within the base glasses, exceptional novel characteristics can be achieved and/or other properties can be improved.

In this way, a limitless variety of glass-ceramics can be prepared with various combinations of different crystalline and residual glassy phases. With the appropriate knowledge on the right way to modify the chemical compositions and the heat treatment schedules, one can effectively control the phase contents, scale the developed properties and control the final product qualities. Consequently, a skilled glass-ceramist is able to play with the constituting chemical elements and their contents in the composition to regulate the different ceramic properties.

Admittedly, the success in controlling functional properties is much more difficult if opposing properties such as high hardness and good machineability are desired. Similarly, achieving good chemical resistance in the presence of high content of alkalis and alkaline earths or rendering inactive glass ceramics into bioactive glass ceramics through composition modification are difficult to reconcile. Thus there are some real challenges and some serious limitations to what can be achieved.

This book includes five parts. The first part provides the context in which the classification and selection criteria of glass and glass ceramics for medical and dental applications are observed. This part starts with an introduction to medical glasses and glass ceramics, their classification and the specific criteria for various applications in order to show the clinical context in which the materials are being asked to perform. The grouping and arrangements of ions in silicate based glasses and glass ceramics are considered.

The second part deals with the manufacturing, design and formulation of medical glasses and provides a detailed description of theoretical and practical aspects of the preparation and properties of glasses. This part explains theoretically and practically how it is possible to predict final glass properties such as density, thermal expansion coefficient and refractive index from the starting chemical compositions. Next this part focuses on the manufacturing of the glasses and shows how to calculate and formulate the glass batches, melt, and cast glasses. The part also explains how to predict the right annealing point, transition point, and glass softening temperature of the base glasses.

The third part presents the manufacturing and methodology, the assessment of physical and chemical properties and the development of colour and fluorescence in medical glasses and glass ceramics. In addition, the microstructural optimization which is responsible for most of the valuable ceramic properties is considered. This part also explains how to optimize the microstructure so as to reach a uniform microcrystalline glass ceramic microstructure and gives examples of practical optimization such as mica and leucite-mica glass ceramics. The last chapter of this part deals with the selection of the glass compositions such that the materials can develop the correct colour and have the desired fluorescence. It also provides the ways for the development of colours and fluorescence in UV and visible light regions and a reliable quantitative measurement of colour and fluorescence in dental glasses and glass ceramics.

The fourth part presents a detailed description of the most prevalent clinically used examples of dental glass ceramics namely; leucite, mica and lithium disilicate glass ceramics, together with the encountered scientific and technical problems. This part explores in details the chemical composition, developed crystalline phases and the criteria for choosing the right chemical composition for different applications as veneering ceramics for coating metal alloys and glass ceramics for CAD/CAM applications. Appropriate solutions for common scientific and technical problems encountered with their industry and applications are discussed. The part also explores how to control and modify the chemical, thermal, mechanical, optical and microstructural properties of glass ceramic systems.

The fifth part provides a brief description of the chemical compositions, bioactivity and properties of bioactive glasses and glass ceramics for medical applications. This part also discusses different models of bioactive glass ceramics such as apatite, apatite–wollastonite, apatite–fluorophlogopite, apatite–mullite, potassium fluorrichterite and fluorcanasite glass ceramics.

The primary function of this book is to provide anybody with an interest in medical and dental glasses and glass ceramics with the wherewithal to start making their own

glasses and glass-ceramics. Even if that is not their ambition then this book provides the reader with a greater understanding of the delicate interplay between the various factors that control the final properties of medical and dental glasses and glass-ceramics. This book is a valuable source of information for scientists, clinicians, engineers, ceramists, glazers, dental research students and dental technicians in the field of glasses and glass ceramics, and appeals to various other related medical and industrial applications.

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