Preface

By the second half of the twentieth century, a new branch of materials science had come into being — crystalline materials research. Its appearance is linked to the emergence of advanced technologies primarily based on single crystals (bulk crystals and films).

At the turn of the last century, the impending onset of the "ceramic era" was forecasted. It was believed that ceramics would play a role comparable to that of the Stone or Bronze Ages in the history of civilization. Naturally, such an assumption was hypothetical, but it showed that ceramic materials had evoked keen interest among researchers.

Although sapphire traditionally has been considered a gem, it has developed into a material typical of the "ceramic era." Widening the field of sapphire application necessitated essential improvement of its homogeneity and working characteristics and extension of the range of sapphire products, especially those with stipulated properties including a preset structural defect distribution.

In the early 1980s, successful attainment of crystals with predetermined characteristics was attributed to proper choice of the growth method. At present, in view of the fact that the requirements for crystalline products have become more stringent, such an approach tends to be insufficient. It is clear that one must take into account the physical–chemical processes that take place during the formation of the real crystal structure, i.e., the growth mechanisms and the nature and causes of crystal imperfections.

In recent years, certain successes have been achieved in the understanding of crystal formation mechanisms, the morphological stability of the crystallization front, the role of impurities, thermal and concentration flows in the melt, and other factors that influence the formation of structural defects. However, it is the establishment of the relation between the parameters of the real crystal article and the conditions of its attainment that remains the task of paramount importance in obtaining crystals possessing predetermined characteristics. This task necessitates a detailed analysis of the raw material, crystal growth medium, heat and mass transfer at both the liquid–solid interface and in the bulk of these phases, as well as the processes of cooling of the crystals and their subsequent thermal and mechanical treatment.

Theoretical investigations into the process of crystallization, performed on different substances including sapphire, have not yet resulted in creation of a general theory of real crystal formation, and there is a large gap between the theory and practice of crystal growth. Now, it is undoubted that the real crystal structure stores the "genetic" information on the process of formation of crystals and the forecast of their future behavior during treatment and service. The authors' ideas of the embodiment of this information in the "granular" substructure of the crystals are considered in the present book.

This book considers all known methods for the growth of sapphire and modification of its properties, the fields of sapphire application, as well as the most exhaustive data on the crystal structure and physical–chemical properties. The authors believe that this book, which helps to estimate the unique potential of sapphire, will be useful for specialists in crystal growth technologies, designers of new apparatuses, sales managers, scientists, and engineers who use sapphire articles.

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