Preface

Only a few classes of real solid materials may be considered as infinitely extended homogeneous systems characterized by their atomic short-range order and the condition that the local order is realized in the same way in the whole sample. Important examples are ideal single crystals and homogeneously disordered systems. The term "infinitely extended" is, of course, not quite exact and should be discussed with respect to a certain physical property. It means that the boundary or surface of a system does not affect the property of the system. The heterogeneity of a solid must be taken into account if the property under consideration is determined not only by the atomic short-range order but also by the spatial extent of regions with equal short-range order, the shape of these regions, the interface area between different regions, the correlation of shape and size of adjacent regions, the topological arrangement etc. Such phenomena appear, e.g., in polycrystalline metals and alloys, powders, ceramics, porous materials, glasses and random composites.

Most of the materials mentioned above exhibit elements of both heterogeneity and randomness. Therefore, one must look for stochastic models which are appropriate to describe those structures. The models should be mathematically well-defined, and it should be possible to calculate characteristic quantities which correspond to experimentally accessible structure parameters.

The mathematical branch of stochastic geometry supplies a large body of mathematical models for the description of stochastic structures and of statistical methods for their analysis. An excellent review is given by *Stoyan, Kendall & Mecke (1987)*. This book provides a foundation of stochastic geometry and a summary of the current state of mathematical research. It supplies the mathematical background for potentially far-reaching use in applied sciences.

In the present book stochastic models are considered which seem to be most useful for the investigation of stochastic systems within the framework of solid state physics and materials research. Important examples for such models are random mosaics and stochastic two-phase systems.

The formal description of geometrical characteristics of a stochastic structure model is, of course, far from a physical theory. However, the proposed models offer the opportunity to calculate a series of structural parameters that may be essential for the discussion of physical properties. This is quite important since, in general, the experimentally accessible structural parameters do not coincide with the parameters that are relevant to the considered property.

The experimental methods commonly used for structural investigations reveal information about first and second order characteristics of the material. For example, a real sample may be investigated by density measurement, X-ray or neutron scattering and electron microscopy. Then a convenient model is chosen. The characteristics of the model which correspond to the experimental data are calculated and compared with them. If the experimental and theoretical data agree sufficiently the model may be accepted and used as a structural base for the investigation of physical properties of the considered material.

The examination of models through the comparison of model parameters with experimental data is a critical point in structure research of stochastic heterogeneous materials. Therefore, the relationships between models and experimentally accessible structure parameters are explained in some detail for the most important methods of the structure investigation in a separate chapter.

The book does not give a summary of all stochastic models that have been applied to

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heterogeneous materials. There is also no detailed discussion of physical theories that use aspects of a structural description of stochastic heterogeneous systems.

The aim of the book is to point out that the mathematical branch of stochastic geometry is an excellent base for a rigorous treatment of stochastic heterogeneous materials, and to demonstrate the applicability of models and methods of stochastic geometry to structural and physical problems of solid state physics and materials research.

In the first chapter, models and methods of stochastic geometry are explained. The compilation includes random point fields, stochastic mosaics and germ-grain models. The results presented in the first chapter are used in the second one to simulate various types of stochastic heterogeneous structures and to analyze them. This analysis is done with respect to the structural parameters accessible by means of density measurements, small-angle and wide-angle scattering experiments , optical and electron microscopy, and stereological methods. Applications to special problems are discussed in chapter 3. The models and methods introduced in chapters 1 and 2 are proved to be powerful tools not only for the geometrical description of stochastic heterogeneous materials but also for the quantiative investigation of structure-property relationships.

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