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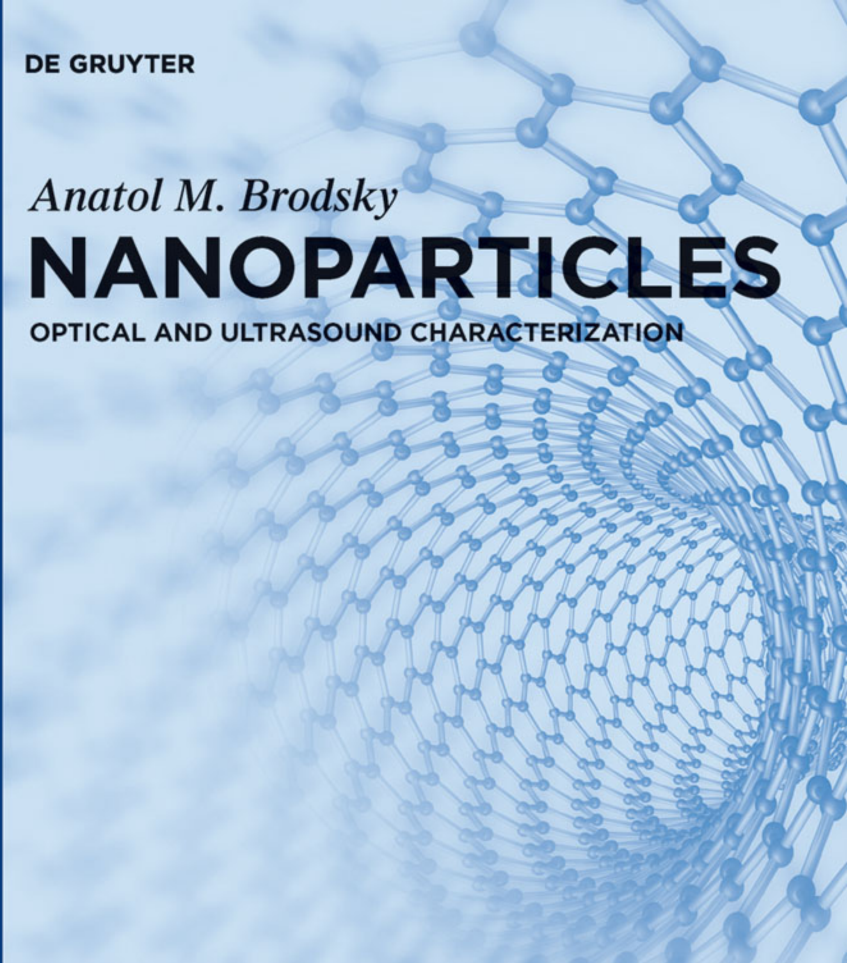

Anatol M. Brodsky

NANOPARTICLES

OPTICAL AND ULTRASOUND CHARACTERIZATION

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Preface

Recent advances in the experimental and theoretical description of light and ultrasonic waves scattering in media with hard and soft nano non-uniformities (objects with nanometer dimensions) are considered here. Described results are important for the perfection of the fast in-line control of the industrial processes, medical diagnostics, biological studies, construction of quantum information devices and environmental monitoring.

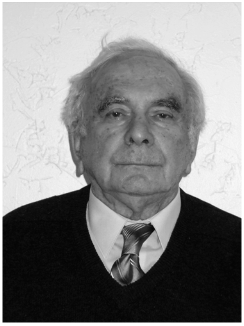
The development of the theory described in this book would be impossible without experimental results of graduate students B. Anderson, S. Smith, G. Mitchell, M. Hamad, and S. Ziegler under the supervision of Professor L. Burgess at the University of Washington Chemistry Department.

The central results in ultrasonic diffraction spectroscopy of media with nanoparticles were received and described in articles by Professor M. Stautberg Greenwood at Pacific Northwest National Laboratory and her coauthors, including the author of this book, who proposed the described theory of the corresponding effects.

For help in the difficult work of the preparation of the manuscript the author is obliged to J. Forster, S. Brodsky, and M. Oakley.

Seattle, August 2011 *Anatol M. Brodsky*

About the Author



Professor emeritus Dr. Anatol M. Brodsky received his BS in physical chemistry at the Moscow State University (USSR) in 1948; his PhD in physical chemistry at the Institute of Petrochemistry of the USSR Academy of Science, Moscow, in 1953; and his DSc in chemical physics at the Institute of Chemical Physics of the USSR Academy of Science, Moscow, in 1960. Professor Brodsky was the leading scientist at the Institute of Electrochemistry of the USSR Academy of Sciences and professor at the Moscow State University until he emigrated to the United States in 1989. From 1991 to 2007 he taught at the University of Washington in Seattle. He is currently professor emeritus.

Contents

1 Introduction

Coherence effects in the propagation of optical and other classical and quantum waves in nonuniform on molecular and mesascopic scales media have attracted a great deal of attention during the past 20 years. Because both constructive and destructive interference of multiple scattered waves can occur in such media, a variety of peculiar effects, including fluctuational waveguiding and wave localization, can take place. The consequences of such effects in random systems and especially in media with randomly distributed nanononuniformities (nonuniformities with nanometer dimensions) are qualitatively different from those occurring in wave scattering in uniform media. The propagation of electromagnetic waves in random structures had traditionally been described using a photon diffusion model. In typical diffusion models it is assumed that the phase information is partly or completely lost after a finite number of scattering events, as described by the transport mean free path, l_{mp}, which is the distance electromagnetic waves travel in the medium before their phase characteristics are randomized and photon diffusion approximation can be applied. However, phase effects can in fact survive in random media after multiple light-scattering events at relatively long distances and can lead to nontrivial phenomena not predicted in the framework of diffusion theory. A possibility of manifestation of such phase-dependent interference effects in multiscattering media was suggested in pioneering works by Watson [1] and remains a subject of great interest [2–17].

The realization of such effects in optics was first experimentally confirmed in 1984 by Kuga and Ishimaru [4] and in 1985 in the works by Van Albada and Langedijk and Wolf and Maret [5,6]. In these experiments the characteristics of the back-scattered light were measured using incoherent intensity detection methods. Our study of the coherence loss in backscattered light in nanononuniformation media described in Chapters 2 and 3 can be considered as a further advancement of the previously mentioned works using coherent signal detection. Coherence effects are especially important in the study of media with both randomly and regularly distributed nanoparticles.