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MATERIALS RESEARCH SOCIETY SYMPOSIUM PROCEEDINGS VOLUME 255

Hierarchically Structured Materials

Symposium held December 2-6, 1991, Boston, Massachusetts, U.S.A.

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MATERIALS RESEARCH SOCIETY

Pittsburgh, Pennsylvania

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Preface

This volume contains the proceedings of a symposium on hierarchically structured materials held during the Fall 1991 Materials Research Society Meeting in Boston, Massachusetts. The symposium explored new and developing research into hierarchically structured materials from the perspective of materials science (metallurgy, ceramics, and polymers), physics, mathematics, chemistry, biology, and engineering. Our motivation for organizing this symposium stemmed from the fact that materials found in nature display hierarchical architectures over many length scales and, as a consequence of this hierarchical architecture, possess unique properties. When synthetic materials are manufactured with the purpose of tailoring their properties through control of the microstructure, the control is generally confined to a specific length scale. The hierarchical architecture of cellulose aggregates in wood or collagen-based aggregates in biocomposites (e.g., skin, cartilage, bone, and seashell) are excellent examples of nature's way of designing composites for multifunctional applications by efficient and ecologically balanced process methodologies. This symposium focused on the fundamental understanding of structures and the unique properties of naturally occurring hierarchically structured systems in order to critically evaluate processing procedures for assembling hierarchically structured novel synthetic materials with similar unique properties. The symposium provided an opportunity for researchers from various fields to amalgamate the various perspectives. The refereed papers collected here give the results of research and development work from universities, industry, and government laboratories and demonstrate the need for collaborative efforts among these research institutions as well as among researchers working in all scientific and technical fields.

Nearly 60 papers were presented in eight sessions, which covered the following areas: (i) structures, properties, and design rules in natural hierarchical materials, particularly the basis of hierarchy in biological hard and soft tissues such as tendon, seashells, and silks; (ii) structures and design rules in synthetic hierarchical materials, which concentrated on polymer blends, liquid crystals, and steels, and the possible pathways to produce these hierarchical structures; (iii) composite structures and mechanical properties, which focused on the mechanical property-microarchitectural relationships in both synthetic and natural composites, with a special emphasis on lamination; (iv) pattern formation in synthetic and natural composites, which addressed the question of how structural evolution may be controlled from nanometer to higher scales of dimensions; (v) electronic, optical, and magnetic properties of hierarchically structured materials, which addressed the question of how these nonlinear properties can be controlled by the hierarchy in the structure; (vi) scaling and structural characterization of hierarchical structures, which included statistical mechanics of phase transformations in hierarchical structures, mathematical descriptions of hierarchical tilings, scaling relationships in cellular structures, and imaging and spectroscopical characterization of hierarchical materials; (vii) processing of synthetic hierarchical structures, including self-assembled layers, and a biomimetic approach to synthetic composite design and processing; and finally, (viii) molecular design of hierarchical structures, including those of natural examples and the initial work on the genetic design of proteins and self-assembled macromolecules and their structural buildup, a first step towards biotransduction.

The idea to organize a symposium of this nature was first discussed on several occasions with our friend Dr. Donald R. Ulrich. Don was a strong believer in many of the concepts presented in this volume. We dedicate this volume to him in appreciation of his free-spirited approach to research and the support he provided to the scientific community.

İlhan A. Aksay
Eric Baer
Mehmet Sarikaya
David A. Tirrell

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Acknowledgments

Many individuals contributed to the success of this symposium. First, we would like to thank the speakers, without whose interest and contributions this meeting would not have been possible. Their timely reviews of the papers are also gratefully acknowledged.

We are indebted to our session chairs who directed the sessions and guided the discussions. In addition, to the symposium organizers, the session chairs included:

Lorna J. Gibson, Massachusetts Institute of Technology

Richard W. Siegel, Argonne National Laboratory

George Mayer, Institute for Defense Analysis

David L. Kaplan, U.S. Army Natick Research, Development, and Engineering Center

This symposium was sponsored by the Washington Technology Center and Battelle, Pacific Northwest Laboratory.

Special thanks are also due the peer reviewers for their conscientious review of all the manuscripts in this proceedings. We are grateful to Melba Wallace and Marie Mills of the University of Washington for their help in coordinating the publication of this proceedings.

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