NANOTECHNOLOGY COMMERCIALIZATION

MANUFACTURING PROCESSES AND PRODUCTS

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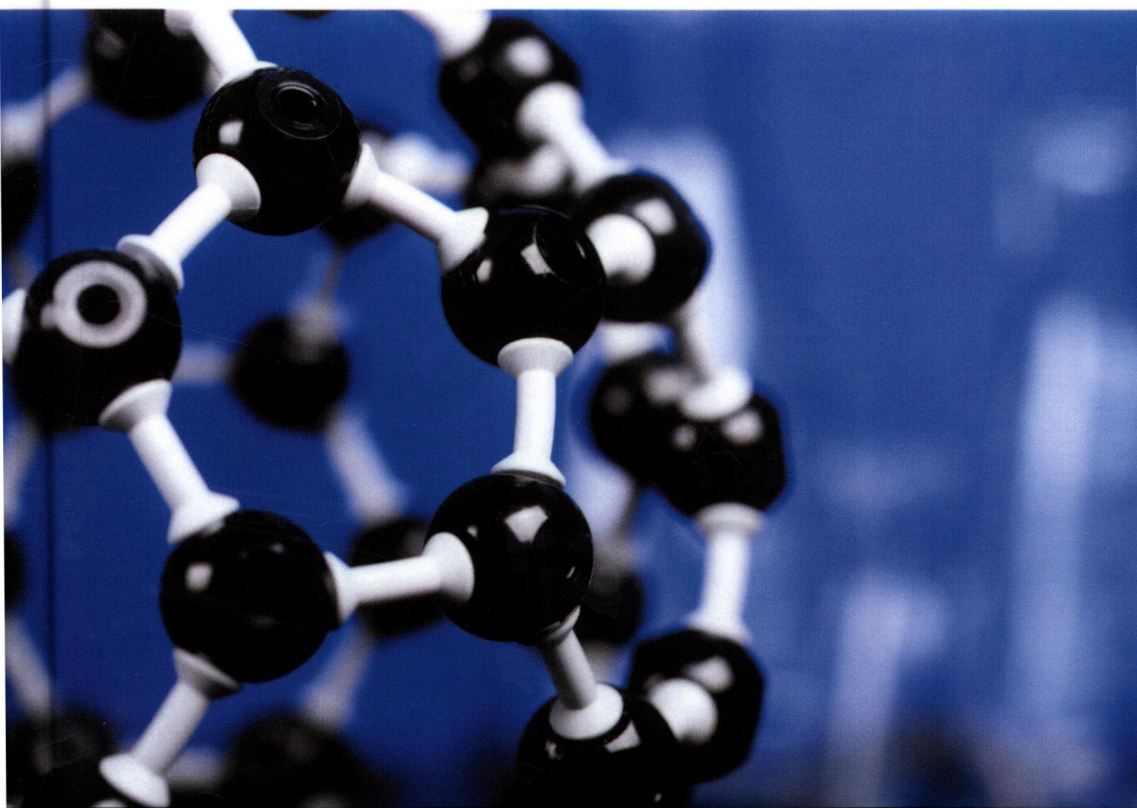

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A fascinating and informative look at state-of-the-art nanotechnology research, worldwide, and its vast commercial potential

Nanotechnology Commercialization: Manufacturing Processes and Products presents a detailed look at the state of the art in nanotechnology and explores key issues that must still be addressed in order to successfully commercialize that vital technology. Written by a team of distinguished experts in the field, it covers military, space, and commercial transport applications, as well as applications for missiles, aircraft, aerospace, and commercial transport systems. The next series will examine applications in solar and photovoltaics, medical sensing, imaging and power applications, including smart grids, CNT power cables. Future series will examine fuel cells and large-scale energy storage systems, touch screen technologies for computers and cellphones, and small-scale applications for maximizing battery life while minimizing battery size.

The drive to advance the frontiers of nanotechnology has become a major global initiative with profound economic, military, and environmental implications. This book describes current research in the field and details its commercial potential—from work bench to market.

- Examines the state of the art in nanotechnology and explores key issues surrounding its commercialization
- Takes a real-world approach, with chapters written from a practical viewpoint, detailing the latest research and considering its potential commercial and defense applications
- Presents the current research and proposed applications of nanotechnology in such a way as to stimulate further research and development of new applications
- Written by an all-star team of experts, including pioneer patent-holders and award-winning researchers in nanotechnology

The major challenge currently faced by researchers in nanotechnology is successfully transitioning laboratory research into viable commercial products for the 21st century. Written for professionals across an array of research and engineering disciplines, *Nanotechnology Commercialization: Manufacturing Processes and Products* does much to help them bridge the gap between lab and marketplace.

THOMAS O. MENSAH, PhD, is currently the President and CEO of the Georgia Aerospace Systems, an advanced aerospace composite manufacturing company, which has supplied nanoscale composite structures for unmanned aerial vehicle systems to the US Department of Defense. He is a Fellow of the National Academy of Inventors and is a holder of 7 US Patents. He has previously worked at AT&T Bell Laboratories and Corning Glass Works. He is a Director of AIChE Nanoscale Engineering Forum.

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Preface

The Frontiers of Nanotechnology Book Series has the objective of advancing techniques for scale-up and transition of nanotechnology processes to industry. This book provides insight into the current status of advanced nanotechnology processes and their scale-up to semi-industrial and full-scale industrial levels, while addressing key scale-up challenges.

The impact such understanding has on full-scale nanotechnology manufacturing on business and marketing strategy, including expansion and execution, is necessary after years of major investments in the technology worldwide.

This book has the objective of also providing relevant technical and engineering framework and the latest innovative work in the area of nanotechnology manufacturing and scale-up. Chemical engineering and industrial engineer methods were adopted in addressing the manufacturing challenges.

In this first volume of the Frontiers of Nanotechnology Series, authors from leading US agencies, including Department of Defense, the National Science Foundation, National Laboratories, private companies, and leading US universities as well as international experts, have examined challenges in transitioning this technology from research to large-scale manufacturing environment. I want to express my gratitude to all of the authors for tackling such an important but complex engineering subject.

Researchers from US Army ARDEC Huntsville, national agencies, and leading universities and engineering departments, such as Georgia Institute of Technology, University of Texas, Austin, Purdue University, Auburn University, University of Rhode Island, University of West Virginia, Ohio State University, Florida State University, as well as the South China University and others have contributed significantly to this book.

In this first book of the Frontiers Series, authors have focused on the chemical engineering aspects of nanotechnology scale-up such as the chemistry and nanocatalyst applications in commercial processes, mixing and integration into solutions, analyzing interfacial aspects of nanotube dispersion, a critical

step in nanomanufacturing, and an important challenge in scale-up. Statistical analysis for controlling continuous processing and predicting nanomaterials performance of sheets of nanostructures, fundamentals of nanomanufacturing using spray techniques are also covered.

Also presented in this book are high-temperature ablative materials for rocket motors and reentry vehicles for space applications, including finite element modeling of transport phenomena in ablative materials performance, advanced missile shell structures and nanocomposites incorporating nanosensors for advanced military applications, and vacuum-assisted resin transfer molding processing of nanocomposites including finite element analysis of processes. Also examined is the use of mechanical properties of fabricated composites as a method of evaluating process control and product performance. The authors have also explored applications of bioinspired approaches for fabricating nanocircuits, and finally toxicity, environmental, and safety issues regarding nanomaterials processing are presented in the last two chapters.

Environmental, safety, and toxicity of carbon nanotubes is important in the commercialization process since workers can be exposed to these nanoparticles, with serious health implications and adverse economic impact on the profitability of nanomanufacturing companies. EHS (Environmental Health and Safety) area must be addressed through engineering methods for this industry to thrive and be sustainable.

I want to thank all my coeditors, professors Ben Wang, Georgia Tech Manufacturing Institute; Jessica Winters, Ohio State University; Virginia Davis, Auburn University; and Geoffrey Bothun, University of Rhode Island, for assisting me as chapter contributors and reviewers of the technical manuscripts for this important book.

I want to express my special gratitude to Mike Roco at the National Science Foundation, a champion of the National Nanotechnology Initiative, NNI, in the United States for authoring the overview chapter for the book and giving me insights into critical gaps that exist in the commercialization of nanotechnology.

There is a paradigm shift in engineering design of processes as demonstrated by the US National Materials Genome project and key parts of this approach were employed in some of the work presented in this book, and it is our hope that this approach will continue to guide all future research into the scale-up of nanotechnology.

Thomas O. Mensah

Editor in Chief

Dr Thomas Mensah is a fellow of the National Academy of Inventors (NAI), fellow of the American Institute of Chemical Engineers (AIChE), and associate fellow of the American Institute of Aeronautics and Astronautics (AIAA). He holds seven US patents in fiber optics awarded in a 6-year time frame.

He worked at AT&T Bell Laboratories and Corning Glass Works and was one of the key innovators and inventors of large-scale processes that moved fiber optics from the research laboratories to manufacturing and commercial environments in the United States. He is currently the president of Georgia Aerospace Systems and served as a coprincipal investigator on the Carbon Nanotube Weapons Platform Development for the US Department of Defense. He also served as the director at large of the Nanoscale Engineering Forum at AIChE. This forum continues to organize feature conferences and technical sessions and symposium in nanotechnology at AIChE Annual Meetings around the country.

Contents