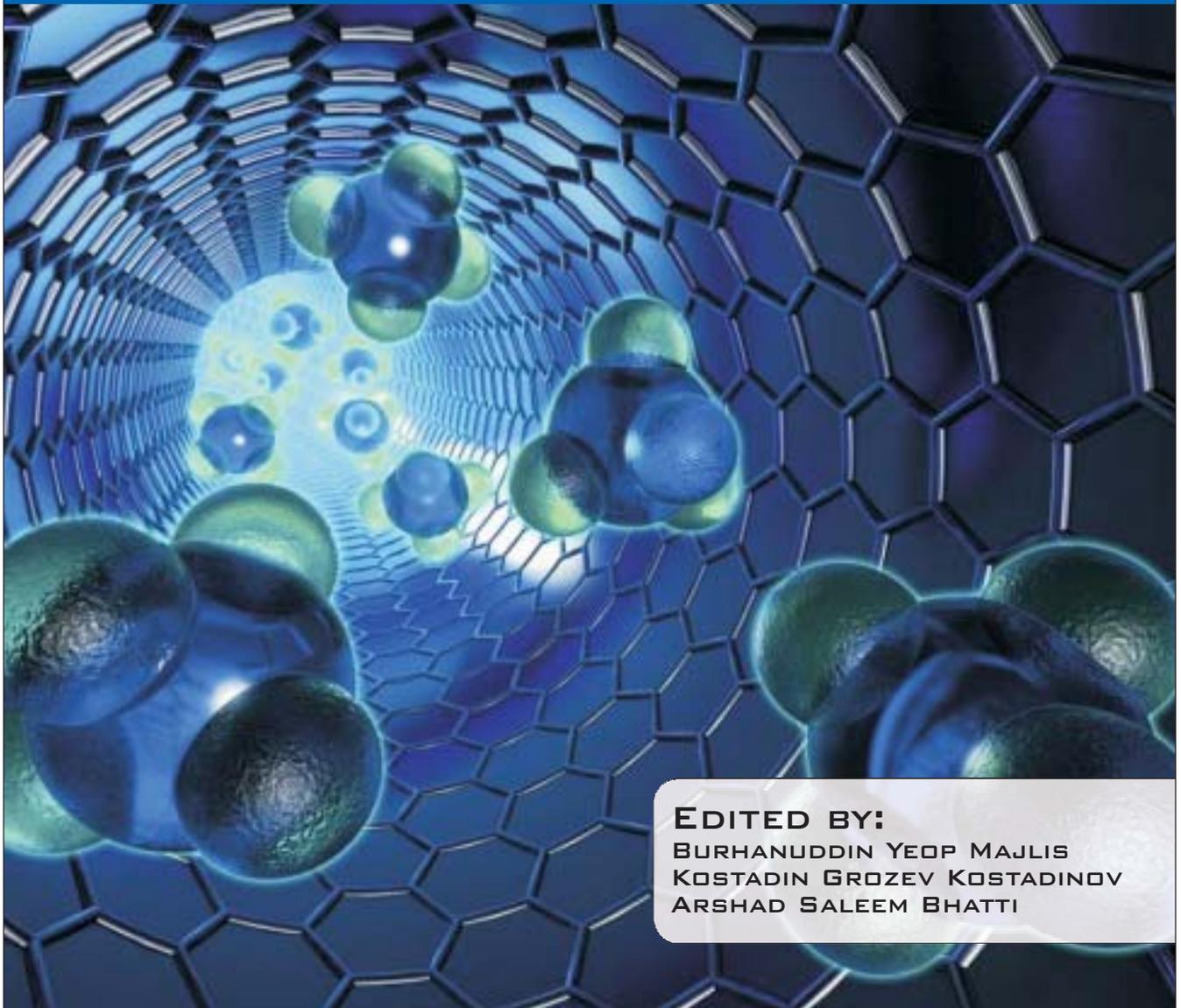


NANOTECHNOLOGY

IN THE EDGE OF CONVERGENCE



EDITED BY:

BURHANUDDIN YEOP MAJLIS
KOSTADIN GROZEV KOSTADINOV
ARSHAD SALEEM BHATTI



Commission on
Science and Technology for
Sustainable Development in
the South (COMSATS)



Centre for Science & Technology
of the Non-Aligned and other
Developing Countries
(NAM S&T Centre)

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FOREWORD

Not many countries of the world were part of industrial revolutions of the 18th and 19th Century. The advent of semiconductors in electronics devices and ensuing wave of digital revolution in the 20th Century had broader participation, but the political conditions in most of the developing countries were not conducive enough to let them become a participant of major breakthroughs. With its weak capacity in S&T, the remedial measures taken by the developing world were focused on technology transfer from the industrialized countries. However, this approach led to continued dependence on the West. Learning from history, the developing countries are increasingly conscious of the need of a paradigm shift in the efforts towards acquiring new technologies. This is based on two principles: i) to leap-frog in cases where an S&T approach implemented in the West gave rise to undesirable consequences or was superseded by subsequent advances, and ii) to become technology-development partners in those cases where the West is also in the process of learning. The nanotechnology research falls in the second category. Nanotechnology is a revolution in the making and to miss out on its development would be another major opportunity lost for the countries of the political South. On the other hand, efforts by national governments and IGOs, such as COMSATS and NAM-S&T Centre, can lead to successful assimilation of a variety of new technological approaches, under the umbrella of nanotechnology.

It is well understood that the ability to manipulate matter at nano scale will fundamentally change the way we manage our industrial production, address health issues, grow food and produce energy. The word revolution will be truly applicable as nanotechnology gains momentum and becomes part and parcel of our lives. COMSATS would like to see all its Member States to be partners in this venture. The international programmes and activities of COMSATS are always focused towards its main objective of creating S&T capacity in traditional and emerging fields, through a mechanism involving cooperative action of Member States and other international organizations. It is, therefore, a matter of honour and pleasure to be a part of the effort by the Universiti Kebangsaan Malaysia (UKM), Malaysia, and the NAM-S&T Centre, to bring together experts of nanotechnology active at the cutting edge of diverse scientific disciplines. The range of issues considered and the broad spectrum of institutions that participated in the meeting truly reflect the essential multi-disciplinary characteristics of nanotechnology.

The present book, based on a highly informative and invigorating conference, is expected to help create impetus for wider and stronger efforts to gain mastery of an inevitably game-changing technological revolution. COMSATS is committed to give full support and encouragement to the progress taking place in developing countries relevant to nanotechnology.

(Dr. I. E. Qureshi)
Executive Director COMSATS

PREFACE

Nanotechnology is fast becoming a part of household consumer commodities owing to the progress made in the field during the last couple of decades. The tools developed to fabricate ultra-small devices following Moore's law were realized to design and synthesize materials at nano-scale. This opened a new horizon of science, i.e. to understand the matter at a molecular scale. This also opened doors for the synthesis of matter with pre-determined properties. The route, which started with top-down approach of nanotechnology, soon transferred to the bottom-up route. The bottom-up approach was a mimic of Nature's way of producing functional materials and devices. It was realized that characteristics or properties of matter when synthesized at nano-scale become enhanced due to large surface-to-volume ratio. Matter with nanometer dimensions has a large number of dangling bonds available at the surface to dominate its bulk characteristics, which enhance its interaction with the surroundings, may it be for catalysis, photocatalysis or some chemical or biological reaction. Soon it was understood that nanotechnology was an enabling technology. Since then, a lot of effort is being made through bottom-up approach to address problems in various disciplines of science.

This ushered a new era in the research community bringing scientists belonging to biosciences, chemistry, physics, and engineering together for addressing the problems faced by humanity at large, e.g. clean environment, clean and pure water, and health related issues. It is quite apparent that sciences are coming together to address the issues faced by humanity and there is a greater need for them to work jointly, and in a complementary manner. The common point is nanotechnology, which is inviting scientists with varied fields of specialization to join hands for research. The predefined boundaries of discrete scientific disciplines are merging fast into a broader canvas of Science and Technology. The potential to improve the properties of materials by reducing their size has shown incredible results in various areas directly affecting the human race. The developed countries have realized the importance of interdisciplinary research and set-up such laboratories, where nanotechnology is the focus of research for scientists from various disciplines. This is what the developing countries should also follow. Keeping this in view, the International Workshop on 'Nanotechnology in the Edge of Convergence' was held at Bangi, Selangor, Malaysia, on 24-27 November 2011.

The NAM S&T Centre in collaboration with COMSATS and the University of Kebangsaan (UKM), Bangi, Malaysia, organized the activity, which brought together scientists from the developing countries, especially from NAM and COMSATS Member States to share their experiences and research. This book compiles the proceedings of the event, which also included presentations on the country reports highlighting the national efforts in terms of research in the field of Nanoscience and Nanotechnology. The progress made in the field by Bangladesh, Egypt, India, Mauritius, Indonesia, East Africa and Malaysia is presented in the book. The theme of the event brought together scientists working in different areas of science to share their knowledge and experience, who realized that there is a need for setting up national initiatives similar to the ones implemented by developed countries. As can be depicted from the list of papers, the main focus of research being carried out is in the field of Nanobiotechnology addressing health and environmental issues in the Member States.

This book contains research papers on synthesis of catalyst nanoparticles of WO_3 , TiO_2 , sulfate functionalized TiO_2 , Mn_2O and ZnO for photocatalysis, and sensor applications. In addition to this, a large number of papers discuss research in the field of nanobiotechnology, and use of nanotechnology and MEMS technology for cancer treatment. These talks reflect the status and potential of nanotechnology in the member countries. The event provided an excellent opportunity for participating scientists to develop further links to share and resolve local issues and problems mostly related to environment, energy and healthcare.

INTRODUCTION

Manipulation of matter on atomic and molecular scales, while involving development of new and advanced materials or devices possessing at least one dimension sized from 1 to 100 nanometers, involves the usage of the branch of science referred to as Nanotechnology. In recent years, this field of science has gathered enormous significance and made tremendous advancements while providing us with a variety of applications in a range of fields, viz. materials sciences, surface science, organic chemistry, molecular biology, semi-conductor physics, micro-fabrication, electronics, energy, medicine, etc. Nanotechnology offers a new focus for research with a targeted approach to manufacture from the 'bottom-up' principle using techniques and tools that are being developed today to make complete, high-performance products, showing its potentiality in the form of improved water-purification systems, energy systems, healthcare, food production and communications, etc. Nanotechnology possibly holds solutions to world's problems related to water, agriculture, nutrition, health and energy but at the same time, it has also raised concerns and speculations about the toxicity and environmental impact of nanomaterials, as well as their potential effects on global economics, that have led to a debate among advocacy groups and governments on the necessity of special regulation on nanotechnology.

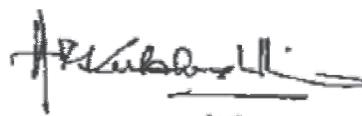
In order to provide a forum for the academicians, scientists and researchers active in the fields of Nanoscience and Nanotechnology, to deliberate upon various issues and create awareness on this field's significance, the Centre for Science & Technology of the Non-Aligned and Other Developing Countries (NAM S&T Centre), New Delhi, India, in collaboration with the Commission on Science and Technology for Sustainable Development in the South (COMSATS), Islamabad, Pakistan, and the Institute of Micro-engineering and Nanoelectronics (IMEN), Universiti Kebangsaan Malaysia (UKM), Malaysia, organised a 4-day International Workshop titled 'Nanotechnology in the Edge of Convergence' at Bangi, Selangor, Malaysia, on 24-27 November 2011. The United Nations Educational, Scientific and Cultural Organization (UNESCO) was among the major sponsors for this scientific event. This Workshop was attended by 54 research professionals and academicians from 19 countries, namely Bangladesh, Bulgaria, Cambodia, Egypt, India, Indonesia, Iraq, Kenya, Malawi, Mauritius, Morocco, Myanmar, Nepal, Pakistan, Sudan, Tunisia, Uganda, Vietnam and the host country Malaysia, and from the NAM S&T Centre.

This book is mainly based on the deliberations of the above-mentioned scientific event of the NAM S&T Centre and includes 19 country papers and research articles, as well as a set of recommendations titled 'Bangi Recommendations on Nanotechnology', placed as an Annexure of the book, which were unanimously adopted at the conclusion of the Workshop.

I acknowledge with gratitude the deep involvement and determined efforts of Prof. Dato' Dr. Burhanuddin Yeop Majlis, Director, Institute of Microengineering and Nanoelectronics (IMEN) of the Universiti Kebangsaan Malaysia (UKM), in Bangi, Selangor, Malaysia; Prof. Dr. -Eng. Kostadin Kostadinov, Assoc. Prof. on Robotics and Automation and Scientific Secretary of Bulgarian Academy of Sciences, Sofia, Bulgaria; and Prof. Arshad Saleem Bhatti, Dean, Faculty of Science, Department of

Physics, COMSATS Institute of Information Technology (CIIT), Islamabad, Pakistan, in editing this valuable publication. I am also indebted to the entire team of the NAM S&T Centre, particularly Mr. M. Bandyopadhyay, Dr. V.P. Kharbanda, Ms. Bidisha Pal and Mr. Pankaj Buttan in compiling the presented papers, liaising with the authors and editors, and giving a final shape to the volume.

I am confident that the content of this book would serve as a valuable reference material not only for the scientists, academicians and researchers, but also for the concerned authorities and policy-makers of the developing countries.



Prof. Dr. Arun P. Kulshreshtha,
Director and Executive Head,
Centre for Science & Technology of Non-Aligned
and Other Developing Countries
(NAM S&T Centre)

About the Book

Manipulation of matter on atomic and molecular scales, while involving development of new and advanced materials or devices possessing at least one dimension sized from 1 to 100 nanometres, involves the usage of the branch of science referred to as Nanotechnology. In recent years, this field of science has gathered enormous significance and has gained tremendous advancements while providing us with a variety of applications in a range of fields, viz. materials sciences, surface science, organic chemistry, molecular biology, semi-conductor physics, micro-fabrication, electronics, energy, medicine, etc. Nanotechnology offers a new focus for research with a targeted approach to manufacture from the 'bottom-up' principle using techniques and tools that are being developed today to make complete, high performance products, showing its potentiality in the form of improved water purification systems, energy systems, healthcare, food production and communications, etc. Nanotechnology possibly holds solutions to world's problems related to water, agriculture, nutrition, health and energy but, at the same time, it has also raised concerns and speculations about the toxicity and environmental impact of nanomaterials, as well as their potential effects on global economics that has led to a debate among advocacy groups and governments on the necessity of special regulations on nanotechnology.

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The present publication is an outcome of the above scientific event and reflects the status of research on Nanosciences and Nanotechnology in various developing countries, as well as latest developments in this area. The publication will serve as a valuable reference material for the researchers, academicians and experts working in this fast emerging field.



COMSATS Headquarters,
4 Floor, Shahrah-e-Jamhuriat,
Sector G-5/2, Islamabad, Pakistan.
Ph: (+92-51) 9214515-7, Fax: (+92-51) 9216539
Email: comsats@comsats.org.pk
Website: www.comsats.org



Core 6A, 2nd Floor, India Habitat Centre,
Lodi Road, New Delhi, India.
Telephone: (+91-11) 24645134,
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