

# Preface

This book is the result of contributions from senior researchers in the various areas of nanotechnology which presents a review of the current state of development. Authors possess extensive experience in both theoretical and practical aspects in relevant subjects and have presented insights into both material development and aspects of practical end applications. Nanotechnology as one of the main drivers of products and services still lacks more focused and clear guidance on commercialization. The focus of this book is to indicate challenges and possible opportunities, fostered by discoveries in nanotechnology, towards real market products and services. Numerous novelties have emerged pertaining to both theoretical foundations to further build upon knowledge, and practical applications especially in sectors of energy, advanced manufacturing, biomedicine, environment sustainability and preservation. Along with great enthusiasm for these innovations, issues related to possible dangers of new nanomaterials and their long-term effects have started to be perceived, strongly indicating the need for a more comprehensive approach. Science has made large steps by taking advantage of the discoveries in the nanoworld, but at the same time this new field is at its infancy, facing different controversies especially regarding practical applications in real products.

Areas of nanotechnology commercialization are very diverse and it is not possible to include all of these in one book. However, some areas can be distinguished due to their prominent already proven results. The study of the multi-scale phenomena of the micro- and macroscale effects simultaneously with nanostructures and their mutual influence is a must, in aiming to develop real products. Together with all the parameters and variables important for the proper functioning, green products and environmental preservation are one of the obligatory constraints to consider, especially in nanotechnologies and nanomaterials. Possible toxicity and detrimental environmental effects therefore need to be well characterised and evaluated.

This book covers diverse areas in which nanoscience and nanotechnology have led to significant technological advances and practical applications, with special emphasis on novel types of nanomaterials and their applicability into a new generation of nano- and microdevices. Different nanomaterials are reviewed with a

focus on several practical application areas and their commercial utilization. Production technologies of nanomaterials are presented as one of the challenges today—efficient commercial scale production of nanomaterials to satisfy the needs for large quantities. Both the fabrication and storage of nanoparticles impose great challenges and the costs, in general, with scarcely available technologies, which are still too costly and slow for mass production.

The energy sector has shown perhaps the most prominent recent advancements in nanotechnology commercialization, if energy production, storage and power devices are considered altogether. Ferroelectric and piezoelectric nanomaterials as well as nanomaterials for sustainable energy production and storage have already led to different practical applications, and these are reviewed along with basic theoretical foundations. The integration of nanostructured thermoelectric materials in micropower generators based on nanostructured materials is presented. Examples of several developed thin-film thermogenerators are shown, as basic elements for portable devices in microelectronics. A review of existing solutions and developing challenges is given regarding sustainable energy production, photovoltaics, solar cells, hydrogen economy and improved classes of batteries as contributions to green products and circular economy. Novel, highly promising areas in nanotechnology are also shown, such as voltage-driven nanospintronics, from theoretical and future application aspects. Recent advances in information processing nanotechnologies are also described, as well as friction characterisation at the nanolevel.

Health-related products represent another area which has taken great advantage of the nanotechnology revolution, especially in cosmetics, drug delivery systems and improved medical implants. Cosmetic products have incorporated different nanoparticles and gained highly improved effects, such as skin revitalization, and some insights into this area are collected in this book. Novel drug delivery systems have been increasingly developed and modelling of such structures is very important for proper system design and maintenance in the long run, as well as for the determination of influential properties. Methodologies in modelling of self-healing materials with nanocontainers are reviewed as one example in designing these systems that incorporate nanoparticles. Contributions and possibilities shown by nanotechnology in ophthalmology are also reviewed.

Material properties change when going from macro-bulk characteristics down to micro- and nanoscales. Nanoparticles synthesized so far have changed traditional materials in such extent that this area alone shows great further opportunities and completely justifies enormous investments into fabrication, processing, storage, transport and utilization of various classes of new nanomaterials, starting from its basic form—nanoparticles. The health sector is one of the major drivers of economies today with gigantic profits and return on investments. Moreover, the commercialization of research results from nanotechnologies is very strong in this area, with some of the largest investments ever in the history of our world. Several proven nanomaterials have been reviewed in this book pertaining to biomedicine. The use of silver nanoparticles and related nanomaterials in the cosmetic industry, and the potential for iron-based nanomaterials in biomedicine are reviewed, also

with recognised challenges and possible threats of non-controlled use of nanomaterials.

Potential applications are great and commercially realised products can exhibit large benefits, but long-term effects still need to be studied and considered, especially when it comes to medical products and environmental sustainability. Innovation in practical commercial products, ranging from consumer goods, medical implants, power devices to large civil constructions and heavy loaded structures, in nanotechnologies is confronted with demand for new sustainable green products. We believe that this book will provide young researchers and professionals with valuable insights into opportunities offered by these new technologies, from aspects of different expertise: medical, engineering, physics, chemistry and material science, while emphasizing safety as an important input, to motivate them to pursue further research and practical applications in this broad and multifaceted field of science.

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