Preface

Ordinary human experience spans a range of space scales from meters to thousands of kilometers, the longest lengths a mere billion or so times larger than the shortest. The progress of nanophysics and nanotechnology has been marked by the scientist's growing familiarity with sizes that are very much shorter than those that are experienced in our lives.

Around 465 BC, Democritus' atomic hypothesis considered that all matter consists of invisible solid particles called atoms, homogeneous, indestructible, and can differ in size and shape. Democritus had postulated the first serious estimation of a length much shorter than a human naked eye observation and later, in the Modern Era, the atomic postulates of chemistry were enough to explain quantitatively several transformations of matter. However, it was necessary to wait till the twentieth century for decisive experimental evidences of atomic and molecular realities and their interpretation by quantum physics. This century, due to the enormous progress in experimental physics, we became used to the lowermost length scales and thanks to the recent development of advanced scanning local probes we are now familiar with images of atoms and molecules as real entities. Even more surprisingly, we are now in possession of the tools that allow us to control with a high precision the manipulation of these entities at the nanoscale.

It is remarkable that our experiments and theories have become sufficiently reliable so that we can now get pictures at the nanometer scale with some confidence that we know what we are talking about.

Since the 2000 Nanotechnology Initiative announced in the US, the financial resources for Nanophysics and Nanotechnology have been increased all over the world, and even some years earlier I already had led work in Nanophysics, in particular single-particle experiments. In my group, projects in single-molecule experiments and weak interactions, which include molecular beams and nanoscopic/spectroscopic analysis have been conducted (electron transfer dynamics in atom-polyatomic molecule collisions and negative fullerene conformers worth a mention).

My privilege of having attended the First Advanced School on Scanning Tunneling Microscopy organized by the Nobel laureate in Physics H. Rohrer, enabled my group over the following years to be involved in the development and training of various techniques belonging to the SPM family (STM, AFM, SNOM).

Before this enthusiastic outlook, a collaboration in Nanotribology and Scanning Local Probes was timely expected and in 1996 Prof. Bharat Bhushan organized with myself the NATO Study Advanced Institute on Micro/Nanotribology (Sesimbra-Portugal), where important and interesting results covering many areas of this field were presented. Soon after the invention of the initial relevant members of the Scanning Probe Microscopies family (STM, AFM) it was discovered that part of the information in the images resulted from friction and so AFM in particular could be used as a tool for Nanotribology. With the advent of more powerful computers, atomic scale simulations have been able to predict the observed phenomena. Development of the field Micro/Nanotribology has attracted numerous physicists and SPMs in Nanotribology have an immense impact in the field of Advanced Nanotechnology for Energy and Ultra-sensitive Detection of several interactions. Tribology is the science and technology of two interacting surfaces in relative motion and Micro/Nanotribology studies are needed to develop a fundamental understanding of interfacial phenomena in Micro/Nano-electromechanical Systems (MEMS/NEMS).

On the other hand, the advances in scanning probe microscopy (SPM) involve properties and size scales of critical relevance to energy-related materials. The design and control of materials at the nanoscale are the foundation of many new strategies for energy generation, storage, and efficiency.

So this book starts to address scanning probe microscopy (SPM) methods in several nanoscale functionalities that have been successfully implemented in energy storage and conversion applications. Novel phenomena and properties have been explored and revealed. Such studies on some electric energy storage devices is bridging our gaps in the understanding of some local phenomena, such as aging at the nanoscale.

This approach is opening new aspects of Nanophysics and Nanotechnology which can never be attained by studies using non in-situ and non-local techniques. Mainly the author deals here with Scanning Probe Microscopies but the topics are not limited to them.

An important viewpoint here is to focus the reader's attention on the original concepts and ideas that can be achieved by studying the physics of Scanning Probe Microscopies applied to the study of electric energy storage devices.

Thankfully, all the results described here reflect a clear motivation toward sustainable energy applications, in particular, energy efficiency.

This research book integrates knowledge from both the energy science and instrumentation points of view and is intended for two types of readers: postgraduate students in Nanophysics and Nanotechnology and researchers in academia who intended to become active in the field of Nanophysics for Energy. It should also serve as a good text for postgraduate courses in Advanced Nanotechnology and Applied Nanophysics.

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