Preface

Atomic force microscopy (AFM) was invented in 1985 by G. Binnig, C.F. Quate, and Ch. Gerber. Since then it has successfully achieved many outstanding results on micro-/nanoscales and even on atomic/molecular scales by simple contact measurements, although contact AFM cannot achieve atomic resolution in a stable manner. In 1994 F.J. Giessibl succeeded in obtaining an atomically resolved AFM (noncontact [NC]-AFM) image of the Si(111)-(7 × 7) surface under a weak attractive tip–sample interaction in UHV at room temperature (RT) by utilizing a frequency modulation (FM) detection method. Soon the NC-AFM successfully accomplished atomically resolved imaging on various surfaces.

In 2002 "Noncontact Atomic Force Microscopy" (NC-AFM Volume 1) edited by S. Morita, R. Wiesendanger and E. Meyer was published from Springer, which introduced the principles of NC-AFM and remarkable progress achieved by NC-AFM such as true atomic resolution and observation of insulators with atomic resolution. Then in 2009 NC-AFM Volume 2 edited by S. Morita, F.J. Giessibl, and R. Wiesendanger was published by Springer, which introduced achievement of three-dimensional (3D) measurements (mapping) of atomic forces, mechanical manipulation of individual atoms, and atom-by-atom mechanical assembly such as construction of embedded atom letters at RT. One of the most surprising unexpected progresses was atomic/submolecular resolution imaging even in liquids. Since then the NC-AFM has developed further. This book deals with the outstanding progresses and applications obtained after the publication of NC-AFM Volume 2.

At first, in Chap. 1, S. Morita briefly introduces the history, present status, and remarkable technical progresses. Then, in Chap. 2, M.Z. Baykara and U. Schwarz highlight the present status and future prospects of 3D force field spectroscopy. In this NC-AFM Volume 3, many groups utilize 3D or multidimensional force field spectroscopy including current. In Chap. 3, P. Hapala et al. discuss the history and recent progress of simultaneous AFM/STM measurements with atomic resolution.

In Chap. 4, Y. Sugimoto et al. explain a novel atom manipulation using inter-nanospace transfer to assemble various atom clusters composed of a defined number of atoms confined in nanospace at RT. In Chap. 11, R. Pawlak et al. report on the various manipulation modes of a molecule such as the rotation of the dicyanophenyl end group, vertical manipulation of long molecular chains, and lateral manipulation of single porphyrin at low temperature (LT). In Chap. 5, A.J. Weymouth and F.J. Giessibl introduce the phantom force induced by the potential difference within the sample that reduces the potential drop in the junction. Hence it causes a decrease in the electrostatic attraction between tip and sample. If the resistance within the sample is high enough, the phantom force can be dominant. In Chap. 6, M. Kisiel et al. report on mechanisms of energy loss under noncontact friction condition different from the most common Joule dissipation.

In Chap. 7, A. Schwarz and S. Heinze report that magnetic exchange force spectroscopy has possibilities to compare the data quantitatively with first principles electronic structure calculations and to open a new route to induce magnetization reversal events. In Chap. 8, M. Ashino and R. Wiesendanger review damping force spectroscopy and show its possibility to reveal subsurface vibrational modes.

In Chap. 9, F. Kling et al. introduce self-assembly of organic molecules on insulating surfaces with special emphasis on structures stable at RT. Chapters 10–12 introduce atomic-scale contrast in AFM images on molecular systems by Pauli repulsive force at LT. In Chap. 10, F. Schulz et al. discuss the factors influencing the atomic scale imaging of graphene nanoribbon, the graphene moiré on Ir(111), and BPPA molecules. In Chap. 11, R. Pawlak et al. report 3D-force field of C_{60}, a single porphyrin, and LCPD mapping of metal-phtalocyanin on thin insulating films at LT. In Chap. 12, B. Schuler et al. review the contrast mechanism of atomic resolution on molecules with functionalized tips and compare different tip functionalizations. In Chap. 3, P. Hapala et al. discuss high-resolution Pauli repulsive force, scanning tunneling hydrogen microscope (STHM), and IETS-STM images of molecular systems with functionalized tips. In Chap. 14, R. Temirov and S. Tautz explain the mechanism of STM with single molecule force sensors.

In Chap. 13, S. Jarvis et al. discuss a prototype of a mechanically-actuated atomic switch: the flipping of bistable dimers on the Si(100)-c(4×2) active surface, and compare it with H:Si(100) passivated and chemically inert surface. In Chap. 15, C. Barth discusses the identification of surface ions on the nanostructured (001) Suzuki surface of Mg^{2+} and Cd^{2+} doped NaCl single crystals. In Chap. 16, M. Heyde et al. report on the atomic structure of two-dimensional (2D) vitreous silica simultaneously obtained by AFM/STM. In Chap. 17, D. Gao et al. describe how one can produce, control, and characterize sharp metal coated tips and how these tips can achieve atomic resolution on insulating bulk surfaces.

In Chap. 18, B. Reischl et al. simulate solid–liquid interfaces in model AFM systems. In Chap. 19, K. Kobayashi and H. Yamada review recent progress in FM-AFM in liquids based on 2D/3D force mapping, and visualize molecular-scale hydration structures as well as that of local electric double layer forces. In Chap. 20, T. Fukuma reports on advanced instrumentation of FM-AFM using a small cantilever and high-speed phase detector to enable direct visualization of atomic-scale interfacial phenomena at 1 frame/sec. In Chap. 21, Y. Yokota and K. Fukui report on electrochemical issues, especially potential-dependent interface structures of adsorbates and electrolyte solutions. In Chap. 22, T. Uchihashi et al. review high-speed AFM that can capture protein molecules in action at submolecular spatial and sub-100 ms temporal resolution, without disturbing their biological function. They demonstrate various observations of dynamic events on proteins.

We thank all the authors for their contributions to this book. We also thank Springer for their fruitful collaborations. It is hoped that this book will accelerate this field toward rapid and continuing growth and that it will stimulate further efforts to develop atomic/molecular tools based on mechanical methods.

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