The inner workings of atomic force microscopy

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Understanding the inner workings of atomic force microscopy

Atomic Force Microscopy

Bert Voigtländer

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More than 30 years after its invention, atomic force microscopy (AFM) has grown into a mainstream technique. It is employed in fields ranging from biology to material sciences and is a central tool of nanoscience. It applies to a huge range of samples and environments, from cryogenic to high temperatures and ultrahigh vacuum to liquids. The latest applications include not only the ability to produce topographic images from the several-micrometer range down to the atomic scale, but also the ability to map the physical—mechanical, electrical, chemical, and biological—properties of surfaces with unprecedented spatial resolution. Nowadays, commercial instruments enable researchers to quickly get images of their samples with a minimal knowledge of the operation principles. However, reaching the optimal image resolution or, more importantly, interpreting those images and property maps soundly requires a good understanding of how those instruments work. *Atomic Force Microscopy* by Bert Voigtländer covers those fundamentals.

Atomic Force Microscopy aims to be a comprehensive text that covers most technical aspects of its subject, and it is written with graduate students and newcomers to the field in mind. In just over 300 pages and 18 chapters, it manages to cover the most important aspects of AFM to help readers understand the practical and theoretical concepts behind it. Because of the complexity of the apparatus, the book tackles many practical engineering problems shared between instrumentation and nanoscience, including piezoelectricity, lock-in amplifier detection, motorized positioners and scanners, and vibration isolation.

The quest for exhaustivity and completeness also led Voigtländer to include some basic concepts in the first third of the book, which covers harmonic oscillators, Fourier transforms, and analog and digital electronics. More advanced readers may want to skip those early chapters. They may also want the chapter on linearized dynamic modes to get to the point more quickly and assume more mathematical background knowledge. However, advanced undergraduate students and scientists not familiar with physics will certainly appreciate the slower progression.

The other two-thirds of the book presents necessary background information about force-scanning microscopy and meticulously discusses the most commonly used operation modes of AFM, from static contact to dynamic FM-AFM. *Atomic Force Microscopy* covers most of today's technology fairly and realistically, which is valuable when marketing from manufacturers often oversells the features and capabilities of their instruments. The theoretical content is rigorous and pedagogically effective, giving readers a broad and deep understanding of the subject. Each chapter contains a solid bibliography to guide further learning.

Readers hoping to study a single application of AFM can certainly focus their attention on selected chapters. However, they will probably miss out on pertinent information provided by the frequent comparisons of different modes, with pros and cons of each mode depending on operating conditions. I suggest that instead, readers complete an initial reading (perhaps skipping the basic first chapters and the more technical final chapters) and then keep the book at hand as a reference work. That advice may seem daunting for newcomers given the book’s length, but a more comprehensive reading is certainly worth the time for anyone planning to use the technique regularly. It will also be helpful for anyone wanting to dig further into the specialized literature. For a shorter and lighter introduction with less emphasis on equations, readers may turn to *Atomic Force Microscopy* by Peter Eaton and Paul West (2010).

Whether readers are just starting in the field or running an AFM daily, Voigtländer's *Atomic Force Microscopy* will be an excellent companion. It will usefully complement the user manual or the application notes of any instrument. I wish it had been available when I was beginning my journey in nanoscience instrumentation 15 years ago, and I will certainly use it as a reference book for all the students coming through our laboratory's door from now on.

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Ludovic Bellon uses statistical physics to study the thermal noise of in- and out-of-equilibrium microcantilevers and other nanoscale phenomena. His work includes developing new instruments in the field of atomic force microscopy.