The past decade has seen dramatic growth in scanning probe microscopy (SPM) technology, both in functionality and in broader acceptance. Market research conducted in mid-2007 by The Microscopy and Imaging Place, Inc. (McKinney, TX) indicates that approximately 20% of microscopists now use atomic force microscopy (AFM) or scanning tunneling microscopy (STM), with numbers reaching nearly 25% for industrial laboratories. Because of their ability to measure a wide assortment of physical and chemical parameters with nanoscale resolution, AFM and STM have become the instruments of choice for nanotechnology.

Interestingly, this technology has taken a dual development path. On one side, these instruments have evolved into ultrahigh-end, exotic AFM/Raman hybrids or amalgams of AFM and ultramicrotomy. On the other, they have emerged as very simple instruments for classroom use or limited routine analysis.

The challenge with mainstreaming an instrument as diverse as an SPM is loss of functionality, especially in resolution and choice of imaging mode. As seen in Figure 1, the unique dual-head approach of SolverNext (NT-MDT, Zelenograd, Russia) meets this challenge, offering a full range of conventional SPM measuring techniques in one sleek, easy-to-use system, making SPM available to the mainstream.

The next-generation SPM

The core of this device is the integrated availability of multiple heads. As explained in the side bar and illustrated in Figure 1, SolverNext is delivered with both AFM and STM, with a third position for easy insertion for specialized heads for imaging in liquid or nanoindentation. Figure 2a illustrates imaging in liquid using protein deposited on mica, still in buffer solution (scan size: 320 × 320 nm), an important application for biological and pharmaceutical laboratories. For more industrial situations, Figure 2b demonstrates multiple nanoindentations on a sapphire surface, with the accompanying approach curves showing the amplitude and frequency dependencies (Figure 2c).

Unlike most AFM systems, that operate in open air, the SolverNext heads sit within an environmental chamber. Sliding the door down encases the sample in a temperature- and humidity-controlled environment, ensuring consistent and reproducible results.
chamber. The enclosure eliminates the drafts and thermal currents as well as the parasitic electromagnetic fields and electrostatic-free staging that can disturb the cantilever as it scans, causing erroneous images. Temperature within the chamber can be controlled between ambient conditions and 150 °C, and both the chamber temperature and relative humidity can be read directly from an on-board liquid crystal display panel. The door is also deeply tinted, providing additional safety against stray laser reflections. Although extremely versatile, SolverNext uses space wisely, taking up relatively little bench space.

**Easy operation boosts accessibility to a broader population**

Well-executed alignment is always the first step to good microscopy. However, alignment has been a tedious process in conventional scanning probe microscopy. First, the area to be measured must be found and carefully placed under the scanning area of the cantilever. Next, a laser is centered on the back of the cantilever. Finally, the beam from the laser is centered onto the photodiode, which will record the measurement. Each step requires a delicate touch on precisely machined centration screws.

SolverNext dramatically simplifies the entire alignment process. First, the sample is viewed through an integrated optical microscope. The user sees the image directly and can readily identify the region of interest. A mouse click on that area causes the stage to automatically move that region under the cantilever. Stepper motors, driven by a proprietary NT-MDT algorithm, automatically locate the cantilever position, then align the laser to the cantilever, and, finally, center the beam on the photodiode. The whole process is literally click-and-play.

Even scan area can be automatically selected. On conventional research-level systems, one scanner head must be exchanged for another to move from a routine scan size to the smaller areas used for high-resolution imaging. However, SolverNext uses a simple voltage system. High-voltage mode activates a capacitance, closed-loop scanner for 100 × 100 × 10 μm scans. The closed-loop sensors compensate for inherent imperfections in the piezoelectric scanners such as scan nonlinearity, creep, and hysteresis. A click of the mouse activates a low-voltage, open-loop scanner for high-resolution scans over a 3 × 3 × 2 μm area.

**MAC + PC: The best of both operating systems**

The MAC versus PC war has been raging for decades within the microscopy community. While MACs have been revered for their imaging management and processing capability, they have never enjoyed the breadth of support programming that characterizes the PC world. NT-MDT is the first instrument company to capitalize on both operating systems.

Historically, there have been several approaches to coupling the two operating systems. One involves running the MAC operating system (MAC OS) as the primary operating system with Windows (WIN) running in a separate window. The
scanning capacitance microscopy (SCM). It will even do nanolithography.

Figure 4a and b show the difference in magnification generated by changing the size of the scan. The 10 μm × 10 μm scan in Figure 4a is a much better representation of the hills and valleys generated by the latex microspheres, while the increased magnification of the 2 μm × 2 μm scan in Figure 4b is not very useful. Shifting to phase image (Figure 4c) uses the delicate hard and soft domains within the surface to generate contrast. For these smaller features, the smaller scan is a better fit.

Figure 5 demonstrates magnetic force imaging. In the case of this computer hard drive disk, the actual surface has no real structure. The three-dimensionality imaged here elucidates the magnetic domains within the surface that comprise the bits and bytes of the stored data.

The scanning tunneling head operates in both constant height and constant current modes and provides insight into electron barrier height, density of states, and current versus height [I(c)] and current versus voltage [I(V)] spectroscopy. For those readers unfamiliar with the power of these diverse techniques or confused by the variety of acronyms, the NT-MDT Web site (www.NT-MDT.com) offers not only an extensive glossary, but animated explanations of all the commonly used techniques.

Applications and operating modes

Those new to SPM are often astounded by the alphabet soup used to describe the nearly 40+ different imaging modes that fall under this broad umbrella. Figures 4 and 5 demonstrate just a few of the many techniques available on this system.

The atomic force head provides both contact and noncontact modes ranging from topography and phase imaging to magnetic force microscopy (MFM); force and frequency modulation; and electrical measurements including spreading resistance imaging (SRI), electromotive force (EMF), scanning Kelvin microscopy (SKM), and nanotomography expands 3-D imaging. Am. Lab. 2005, 37(10), 42–4.


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