Digital Instruments

Veeco Metrology Group

The World Leader In Scanning Probe Microscopy

Scanning Techniques for Scanning Probe Microscopy

Our NanoScope Products let you choose from the most extensive array of scanning techniques available including some which are exclusive to Digital Instruments

Contact Mode AFM

Measures topography by sliding the probe tip across sample surface (Figure 1).

TappingMode™ AFM

Measures topography by tapping the surface with an oscillating probe tip; eliminates shear forces which can damage soft samples and reduce image resolution (patented) (Figure 2).

Non-contact Mode AFM

Measures topography by sensing Van der Waals attractive forces between surface and probe tip held above surface; provides lower resolution than either contact mode or TappingMode (Figure 3).

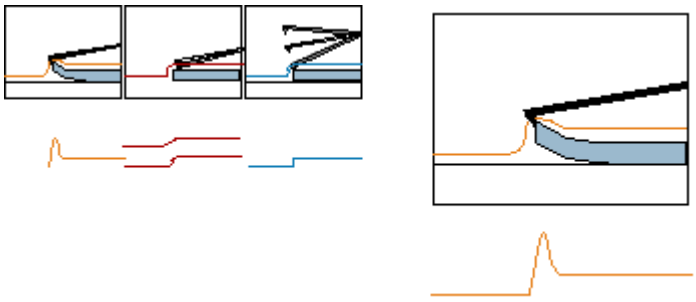

Figure 1: Contact mode imaging (left) is heavily influenced by frictional and adhesive forces which can damage samples and distort image data. Compare this to TappingMode and non-contact mode.

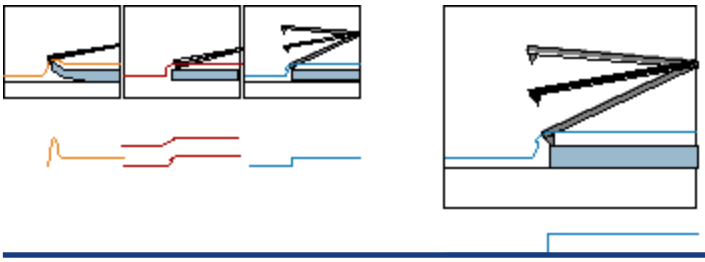

Figure 2: TappingMode imaging (right) eliminates frictional forces by intermittently contacting the surface and oscillating with sufficient amplitude to prevent the tip from being trapped by adhesive meniscus forces from the contaminant layer. Compare this to contact and non-contact mode. An application note is available which provides additional details on TappingMode.

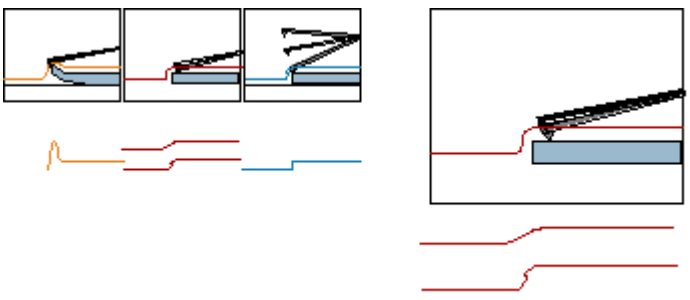

Figure 3: Non-contact imaging (center) generally provides low resolution and can also be hampered by the contaminant layer which can interfere with oscillation. Compare this to TappingMode and contact mode.

LiftMode

A combined two-pass technique that separately measures topography using TappingMode and another selected property (magnetic force, electric force, etc.) using topographical information to track the probe tip at a constant distance above the surface; provides the best resolution and eliminates cross-contamination of images (patented) (Figure 4).

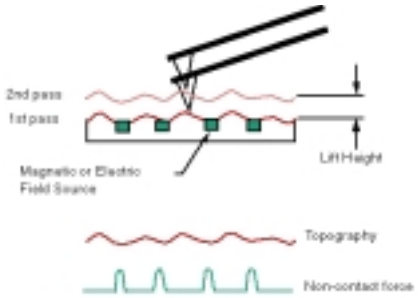

Figure 4: LiftMode is a patented, two-pass technique for measurement of magnetic and electric forces above sample surfaces. On the first pass over each scan, the sample's surface topography is measured and recorded. On the second pass, the tip is lifted a user-selected distance above the recorded surface topography and the force measurement is made.

Force Modulation

Measures relative stiffness of surface features; new technology from Digital Instruments provides substantially improved resolution relative to other designs (patented) (Figure 5).

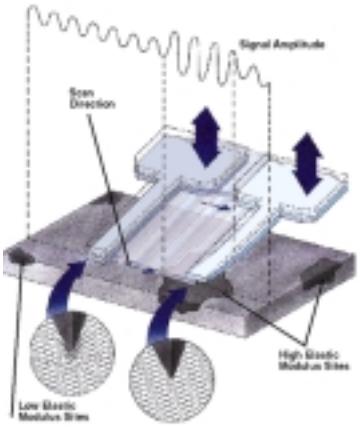

Figure 5: Diagram of Force Modulation principles showing probe scanning a low elastic modulus material from left to right. Signal amplitude increases when tip encounters higher elastic modulus (stiffer) sites.

Lateral Force Microscopy (LFM)

Measures frictional forces between the probe tip and the sample surface (Figure 6).

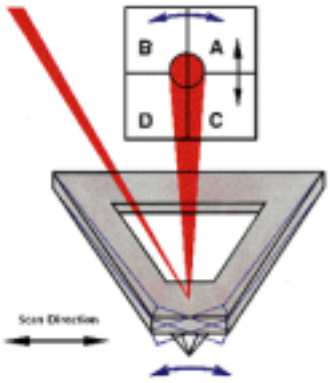

Figure 6: Scanning and detection with lateral force microscopy (LFM). For LFM, the probe is scanned sidewise and the friction signal is calculated as (A+C)-(B+D). The degree of torsion of the cantilever supporting the probe is a relative measure of surface friction caused by the lateral force exerted on the scanning probe. Note that for contact mode, the deflection signal is calculated as laser spot intensity for quadrants (A+B)-(C+D) .

Scanning Thermal Microscopy

Measures temperature distributions on the sample surface (Figure 7).

Magnetic Force Microscopy (MFM)

Measures magnetic force gradient and distribution above the sample surface using amplitude, phase or frequency shifts; best performed using LiftMode to track topography (Figure 8).

Phase Imaging

Measures variations in surface properties (stiffness, adhesion, etc.) as the phase lag of the cantilever oscillation relative to the piezo drive (Figure 9).

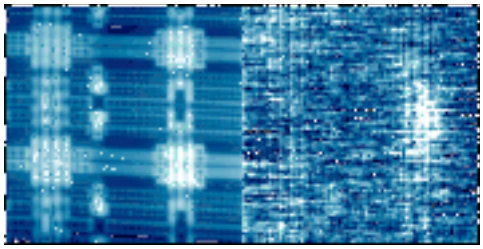

Figure 7. SThM can be used to examine semiconductor and magnetic sensor circuits for temperature gradients. Applications include evaluation of magnetoresistive (MR) thin film head performance for data storage and identification of hot spots indicative of IC circuit failure.

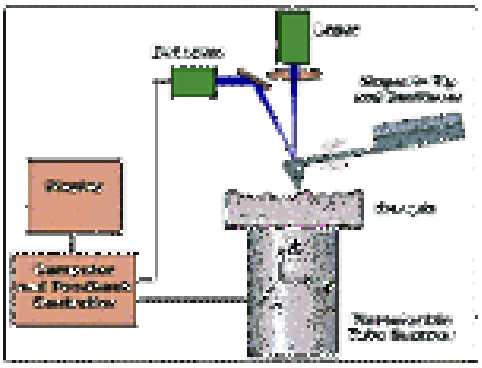

Figure 8.

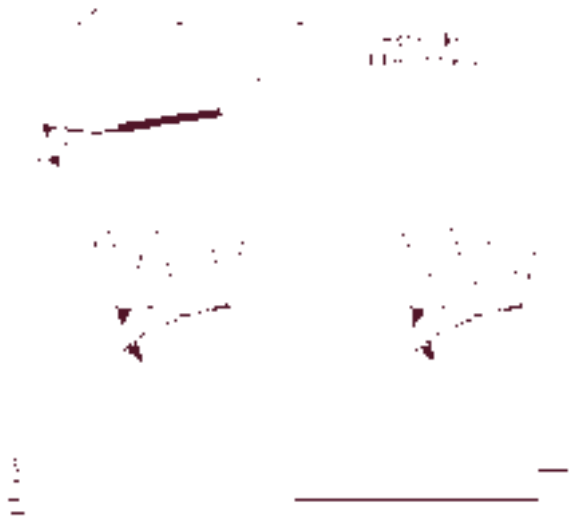

Figure 9. Phase Imaging is a powerful extension of TappingMode™ Atomic Force Microscopy (AFM) that provides nanometer-scale information about surface structure often not revealed by other SPM techniques.

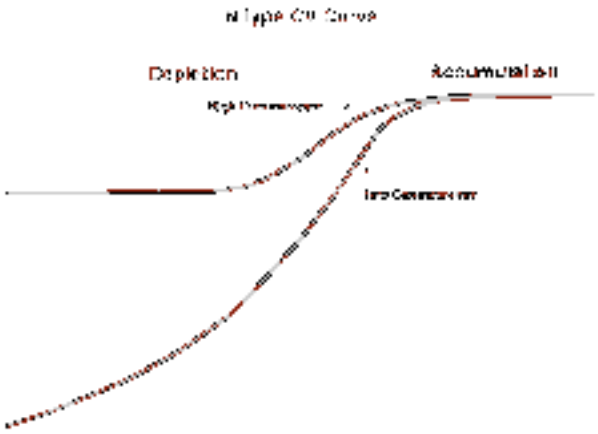

Figure 10.

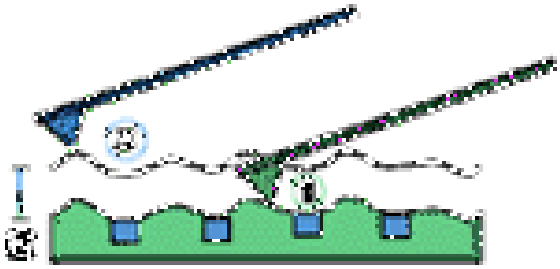

Figure 11: The Extender Electronics Module offers phase and frequency detection capabilities for enhanced magnetic and electr force microscopy that eliminate artifacts and improve image quali The Extender module also allows measurement of sample surfac potential. It is recommended for all users performing magnetic or electric force measurements and for specialized applications requiring microscopic measurement of surface voltage.

Scanning Capacitance Microscopy

Measures carrier (dopant) concentration profiles on semiconductor surfaces (Figure 10).

Electric Force Microscopy (EFM)

Measures electric field gradient and distribution above the sample surface; best performed using LiftMode to track topography (Figure 11).

Nanoindenting/Scratching (IMHO)

For indenting and scratching thin films and other surfaces (Figure 12).

Scanning Tunneling Microscopy (STM)

Measures topography of surface electronic states using the tunneling current which is dependent on the separation between the probe tip and a highly conductive sample surface.

Lithography

Macro language provides user control of probe tip to write patterns in either STM or AFM contact mode.

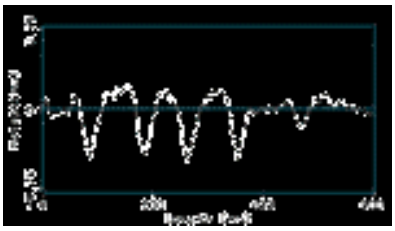

Figure 12.

Digital Instruments
Veeco Metrology Group

112 Robin Hill Road
Santa Barbara, California 93117
T: (800) 873-9750
T: (805) 967-1400
F: (805) 967-7717
Email: info@di.com
www.veeco.com, www.di.com
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