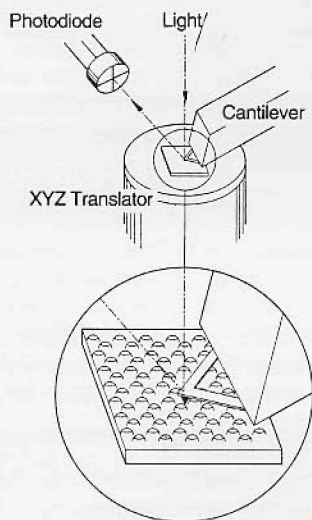


Atomic Force Microscopy A Practical Tool for Problem Solving

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Advanced Surface Microscopy, Inc.

The Scanning Tunneling and Atomic Force Microscopes are becoming well known particularly due to their extraordinary capability of imaging atoms using a simple mechanism. However, atomic resolution is usually not needed to solve most problems in research, development and manufacturing. As a result, some scientists and engineers (mistakenly) regard these new microscopes as more "exotic" than practical.

As a consulting analytical laboratory, we have applied the Atomic Force Microscope (AFM) to many practical processing and materials problems arising in a wide range of industries. Our intent in this article is to describe briefly how an AFM works and how it can be applied in a practical sense - with one example each in biology and material sciences.

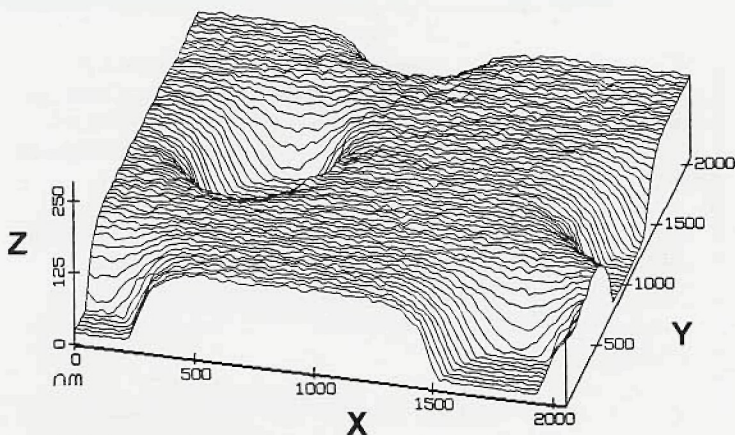


The above illustrates the key components of both the contact and non-contact versions of the AFM.

In the contact AFM, a tiny stylus at the tip of the cantilever gently touches the specimen. As the XYZ translator scans the specimen horizontally in an XY raster pattern, the surface hills and valleys deflect the stylus upward and downward. This deflection is registered by the laser photodiode sensor and the XYZ translator adjusts the specimen up or down (Z) to restore the stylus to its original position. The computer stores the vertical position at each point and assembles the image.

The Z sensitivity of this system (much better than 1 Å) is truly remarkable. The key idea is the optical lever principle. The effective length of the cantilever (ca. 0.05 mm) and the length of the light path to the photodiode (ca. 50 mm) are the two arms of a lever which magnifies the stylus displacement by a factor of ca. 1000. The magnified displacement can then be detected by the split photodiode and its associated difference amplifier.

In the non-contact AFM, the stylus hovers above the specimen surface. The cantilever is vibrated at a high frequency. The laser/photodiode sensor now detects the vibrational amplitude of the stylus, not its deflection. Since the amplitude is affected by the gradient of the interaction force between specimen and stylus, the sensor effectively detects how close the stylus is to the surface. When the Digital Instruments non-contact AFM is operated in "Tapping Mode", the stylus touches the specimen for a fraction of its oscillation period. This localizes the interaction force, thereby achieving high lateral resolution. Because shear and compressive forces are very low, "Tapping Mode" is especially valuable for soft samples, such as polymers (as follows).



The above illustrates pits on an optical disk. This perspective view of a 2 μ field is constructed as a stack of line scans from the original raster pattern. We have selected the vertical (Z) and horizontal (X,Y) ranges independently, to best present the surface structure. Using "dual magnification", the AFM combines the wide field of view capability of a Scanning Electron Microscope (SEM) with vertical resolution and sensitivity which exceed that of a Transmission Electron Microscope (TEM). The ratio of vertical to horizontal magnification can be very large (1000 or more) to allow easy perception of surface relief on very smooth surfaces.

Atomic Force Microscopes (AFM) images show critical information about surface features with unprecedented clarity. The AFM can examine any rigid surface, either in air or with the specimen immersed in a liquid. "Minor" (and major) variations from a "smooth" surfaces are shown dramatically. On one hand, the AFM can resolve very tiny features, even single atoms, that were previously unseen. On the other hand, the AFM can examine a field of view larger than 125 microns (0.005 inch), so that you can make comparisons with other information, e.g. features seen in the light microscope or hazes seen by eye. The AFM can also examine rough surfaces, since its vertical range is more than 5 microns. AFM output includes both 3-dimensional images and quantitative data analysis (such as feature sizes, surface roughness and area, and cross-section plots).

In addition to its superior resolution, the AFM has the following key advantages:

- Compared with SEMs, the AFM provides extraordinary topographic contrast, direct height measurements and unobscured views of surface features (no coating is necessary).
- Compared with TEMs, 3-dimensional AFM images are obtained without laborious sample preparation and yield far more complete information than the 2-dimensional profiles available from cross-sectioned samples.

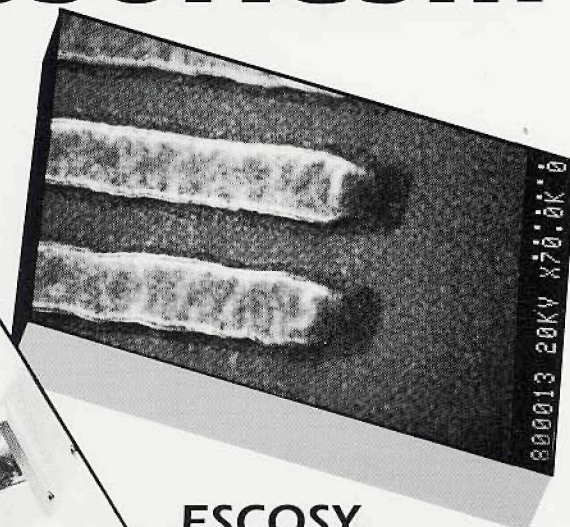
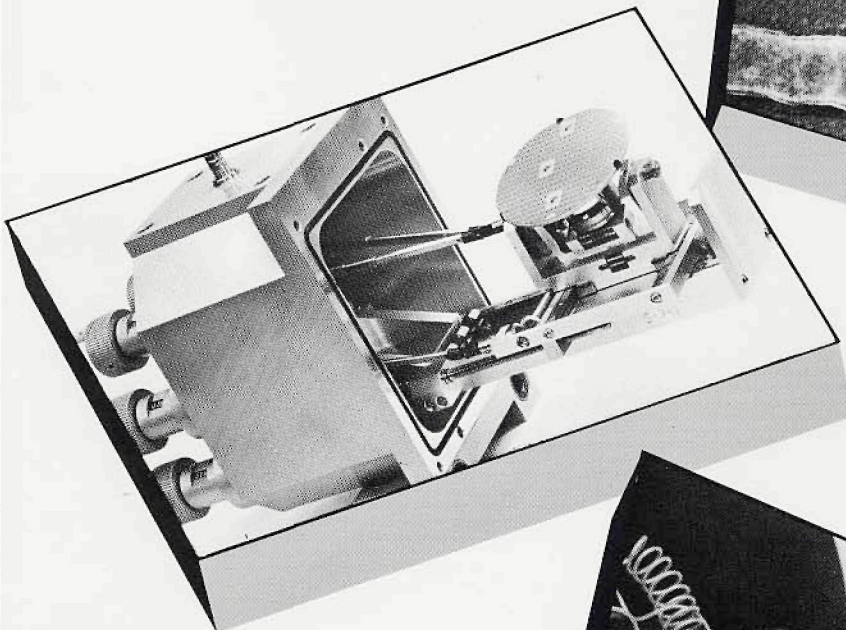
The AFM is being used to solve processing and materials problems in a wide range of technologies affecting the electronics, telecommunications, biomedical, chemical, automotive, aerospace and energy industries. The materials under investigation include thin and thick film coatings, ceramics, composites, glasses, synthetic and biological membranes, metals, polymers, and semiconductors. And the AFM is being applied to studies of phenomena such as: abrasion, adhesion, cleaning, corrosion, etching, friction, lubrication, plating and polishing.

Continued - - -

About the author: Don Chernoff is President of Advanced Surface Microscopy, Inc., an independent analytical/contact research laboratory. Don holds a Ph.D. in Physical Chemistry and has more than 12 years industrial research experience. For over 6 years, he has been active in the field of scanning probe microscopy (SPM and AFM), helping to solve materials and processing problems for a wide range of industries. The company also provides comprehensive research services for problem solving, including surface chemical analysis and electron microscopy. Tel: (800)374-8557

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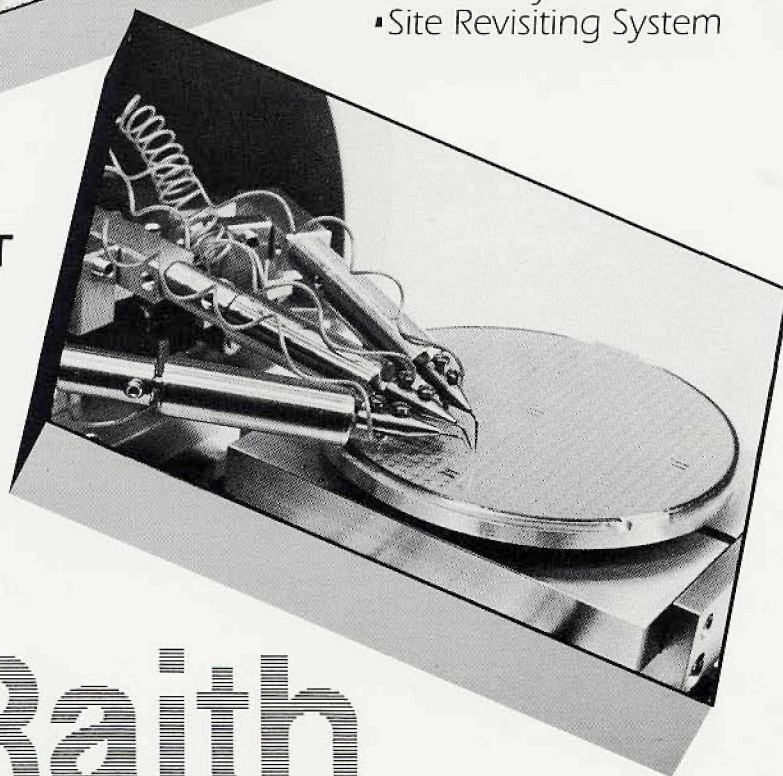


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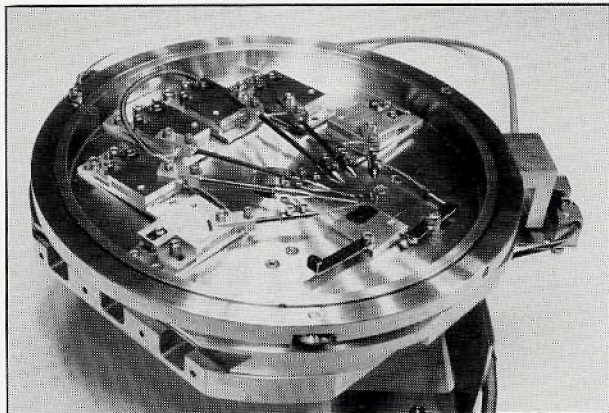
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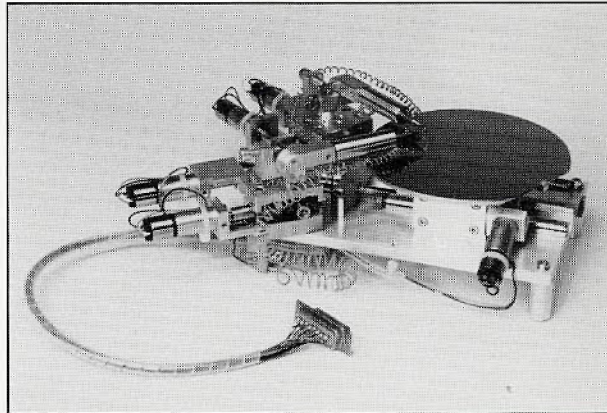
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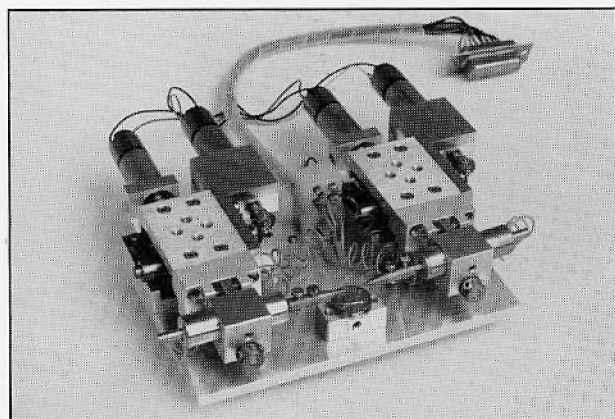
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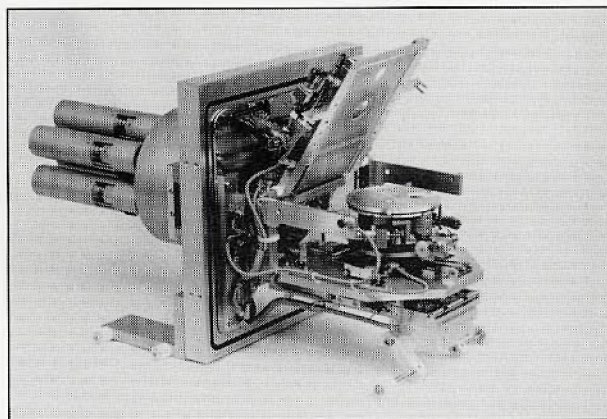
6 PROBE MODULE ON HITACHI S-808 SAMPLE HOLDER



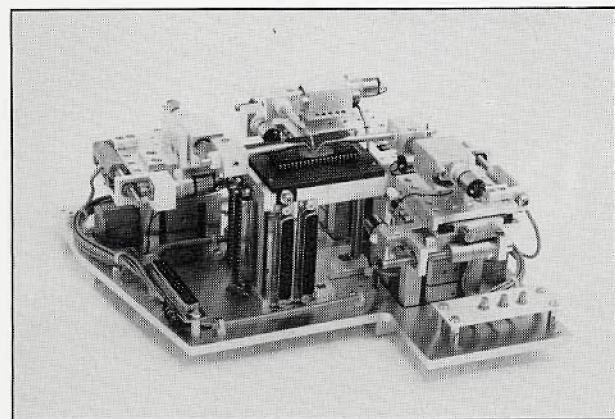
STANDARD WAFER PROBING MODULE



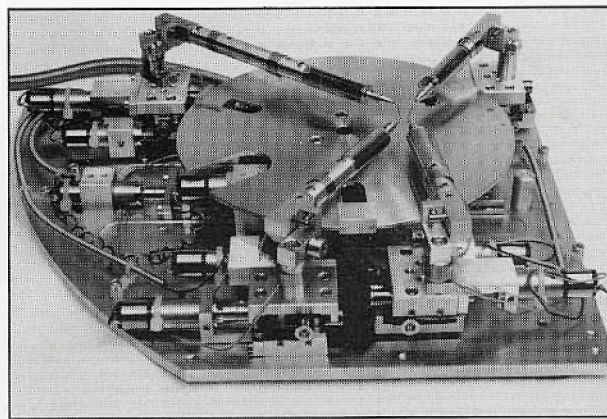
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WAFER PROBECARD STAGE FOR CAMBRIDGE SEM

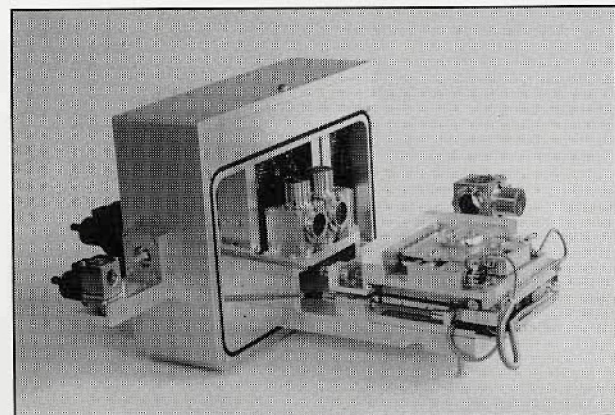


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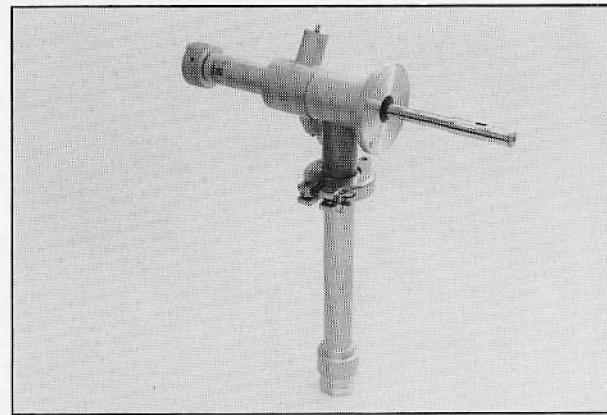


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