See vibration isolation technology @ www.minusk.com?pdf)

NANOscientific

NanoScientific - August 2014

Vibration isolation and better scan size enables atomic force microscopy (AFMs) to see more at the nanoscale level.

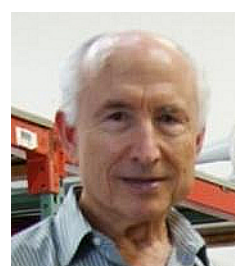
The need for more precise vibration isolation with AFM, though, is becoming critical as resolutions continue to bridge from micro to nano. AFM systems are extremely susceptible to vibrations from the environment. When measuring a very few angstroms or nanometers of displacement, an absolutely stable surface must be established for the instrument. Any vibration coupled into the mechanical structure of the instrument will cause vertical and horizontal noise and bring about a reduction in the ability to measure with the highest resolution.

Expanding AFM capability and scanning range

Since the release of the first commercial atomic force microscope about 25 years ago, technology advances have improved AFM performance. One of these advances has expanded the AFM ability to image biological samples in an aqueous buffer and provide a range of physical data for the sample. Another has increased the imaging speed of AFMs.

Within the past several years, research into AFM design, conducted In the Paul Hansma Research Group, Department of Physics, at the University of California, Santa Barbara, has demonstrated success with AFM imaging of large-scale samples at nanoscale resolutions while extending the range of the Z-axis.

To image at the extreme depths necessary in large-scale cracks and deep microcracks the AFM must have a Z-range of at least 200 microns and a cantilever tip long enough to probe the crack. As the vertical movement of the tip is increased, however, it brings into play a greater possibility for vibration. This issue was solved with the incorporation of negative-stiffness vibration isolation.



Dr. David L. Platus is the inventor of negative-stiffness isolators, and President and Founder of Minus K Technology, Inc. (www.minusk.com). He earned a B.S. and Ph.D. in Engineering from UCLA, and a diploma from the Oak Ridge School of (Nuclear) Reactor Technology. Prior to founding Minus K Technology he worked in the nuclear, aerospace and defense industries conducting and directing analysis and design projects in structural-mechanical systems. He became an independent consultant in 1988. Dr. Platus holds over 20 patents related to shock and vibration isolation

Improving on AFM vibration isolation

Developed and patented by Minus K Technology, negative-stiffness isolators use a completely mechanical concept in low-frequency vibration isolation while achieving a high level of isolation in multiple directions.

The isolator provides 0.5 Hz* isolation performance vertical, and 0.5 Hz horizontal, using a totally passive mechanical system —no air or electricity required, (*Note that for an isolation system with a 0.5 Hz natural frequency, isolation begins at about 0.7 Hz and improves with increase in the vibration frequency. The natural frequency is more commonly used to describe the system performance.)

"The negative-stiffness vibration isolation device has a very low vibrational frequency in the vertical direction, which is critical for atomic force microscopy." said Hansma. Negative-stiffness isolators resonate at 0.5 Hz. At this frequency there is almost no energy present. It would be very unusual to find a significant vibration at 0.5 Hz. Vibrations with frequencies above 0.7 Hz (where negative-stiffness isolators begin isolating) are rapidly attenuated with increase in frequency.

"We like the vibration isolation to be at 0.5 Hz, which we can achieve with the negative-stiffness table," continued Hansma. "Not so much because of the vibrations at that frequency, which are minimal, but because 0.5 Hz is 16x more resistant to transmitting vibrations at a building resonance of 10 or 20 Hz, than compared with a resonant frequency of 2 Hz which would be found with air tables."

Air tables, as vibration isolation systems, deliver limited isolation vertically and less isolation horizontally. They will amplify rather than reduce vibrations in a typical range of 2 to 7 Hz because of the natural frequencies at which air tables resonate. All isolators will amplify at their resonant frequency, and then they will start isolating.

Transmissibility is a measure of the vibrations that are transmitted through the isolator relative to the input vibrations. The negative-stiffness isolators, when adjusted to 0.5 Hz, achieve 93% isolation efficiency at 2 Hz; 99% at 5 Hz; and 99.7% at 10 Hz.

"We did consider active isolation systems for our prototype AFM, as well," explained Hansma. "We played around with a number of them. But, we did not want to add the complication of active feedback, which is inherent in an active vibration isolation system."

Extended AFM range

Using the lab's prototyped combined AFM and RPI techniques, and supported by its passive negative-stiffness vibration isolation system, it has been able to achieve scan ranges exceeding one millimeter, an order of magnitude larger in the Z-axis than any commercially available AFM.

The AFM/RPI system has also proved capable of exploring the molecular origins of fracture resistance in bone tissues to more than 1 mm^2, with acceptable resolution and linearity.