HybriD™ Mode Atomic Force Microscopy (AFM) from NT-MDT - An Interview with Sergei Magonov

Interview by Will Soutter

AZoNano talks to Sergei Magonov about NT-MDT's new HybriD™ AFM Mode, which combines the best aspects of contact and oscillatory modes, opening up new applications of AFM technology.

WS: NT-MDT has just announced a new AFM mode – HybriD™ Mode, or HD-AFM™ Mode. Can you give us an overview of how this new mode works, and what it offers?

SM: HD-AFM™ Mode synergistically combines the best attributes of contact and oscillatory AFM modes.

In contact mode, the probe deflection is directly related to the applied force, but lateral forces may induce tip and sample damage. The resonant oscillatory modes (amplitude modulation, tapping mode, intermittent contact, etc.) greatly reduce the lateral tip-sample forces; however, the measured probe amplitude is related to the tip-sample forces in a very complicated way that precludes quantitative nanomechanical measurements.

A key advantage of the new HD-AFM™ Mode, in which the oscillatory intermittent tip-sample contact happens at frequencies lower than the scanner and probe resonances, is that the probe deflection is directly related to the tip-sample forces.

Our proprietary fast acquisition and processing of deflection curves in the HD-AFM™ Mode helps extract a whole bank of the force data related to the mechanical (adhesion, stiffness, elastic modulus, etc.) and electromagnetic properties (surface potential, dielectric response, magnetic domains) involved in nanoscale tip-sample interactions.

These properties are mapped simultaneously and independently with the imaging of sample topography. Examples of the HD-AFM™ Mode applications that demonstrate current capabilities are available as a webinar and application note.

HybriD AFM™ controller for NT-MDT AFM platforms

WS: What are the main benefits of HD-AFM™ compared to the range of AFM modes already available to users?

SM: The tip-sample forces in HD-AFM™ Mode differ from those in other contact and oscillatory modes by magnitude and duration, therefore, the researchers can expect exciting observations of new effects with improvements in the visualization of morphology and nanostructure for complex materials.

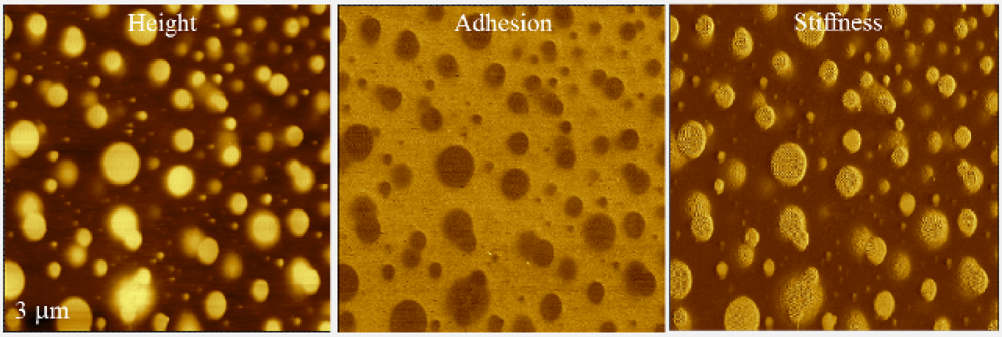
HD-AFM™ Mode opens a pathway towards real-time quantitative studies of local nanomechanical properties on a broader range of materials. Particularly, we believe that this mode can facilitate studies of time-dependent mechanical properties such as viscoelasticity.

WS: What are the main application areas that HD-AFM™ is designed for?

SM: Actually, the practical results obtained with the HD-AFM™ Mode have definitely revealed a wider range of applications than other modes can offer.

The development of the oscillatory non-resonant mode opens the compositional mapping and quantitative nanomechanical studies of materials with elastic modulus larger than 10GPa, which are typically beyond the range of applications using the oscillatory resonant modes.

Imaging biological and material samples under liquid also benefits from the use of HD-AFM™ Mode as the non-resonant method eliminates the forest of resonant peaks during experimental set-up thus significantly improving the ease of use and speed to results.



Hybrid Mode height image (left) and adhesion and stiffness maps, which were obtained in Hybrid mode study of polymer film of polystyrene/polybutadiene blend. This very challenging sample was chosen because of the large mismatch in modulus between the two components and the added complexity of the strong viscoelastic response of Polybutadiene. Although there are currently no adaptive models to accurately calculate both the elastic response of Polystyrene and the viscoelastic response of Polybutadiene when collect in an image map, Hybrid mode does reveal morphology and variations of local properties of this immiscible composition down to tens of nanometers dimensions.

WS: How did you come up with the idea to develop this new mode?

SM: One of our goals is to continuously improve and provide new capabilities to benefit research in the scientific community, and we believed that could impact key areas of compositional mapping and quantitative nanomechanical properties.

From an instrumentation perspective, part of the new HD-AFM™ Mode arose from a practical implementation based on the novel technology developments of our electronic controllers, which recently brought substantial benefits to our microscopes by reducing the noise of the probe amplitude detection (down to 25fm/sqrtHz) and through fast data acquisition and processing.

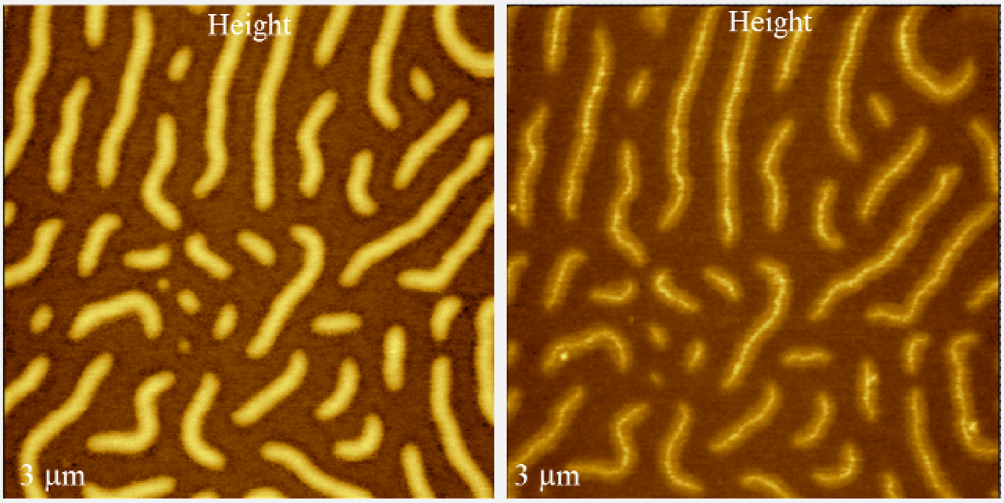
This technology formed a solid platform for expansion of the AFM functions and the introduction of the HD-AFM™ Mode.

WS: How will HD-AFM™ set NT-MDT's instruments apart from your competition?

SM: Our mission is to provide customers with a comprehensive suite of scanning probe microscopy capabilities to help make their research leading-edge and most efficient. Regarding the HD-AFM™ Mode itself, we believe its operation is superior to other non-resonant oscillatory modes available in the market and we are currently proving that with comparative studies on a challenging set of samples.

Moreover, with the addition of HD-AFM™, the NT-MDT microscopes are now equipped with the broadest range of capabilities on the market. Our instruments enable researchers to conduct advanced single-pass electric studies in amplitude modulation mode, which provides simultaneous measurement of topography, surface potential, and dielectric response.

We are also working towards quantitative electrical property analysis based on such data. The chemical characterization of materials is achieved by the combination of AFM with confocal Raman scattering in our NT-MDT Spectra microscope. The single-pass electric measurements and HD-AFM™ Mode studies are also available in this instrument.



Brush macromolecules on mica substrates are visualized in the height images obtained in amplitude modulation and Hybrid mode, whereas only in the latter case side chains are clearly resolved. Sample of brush macromolecules – courtesy of Prof. S. Sheiko (UNC).

WS: Which AFMs in the NT-MDT range will the new mode be available for? What will the upgrade process be like for users?

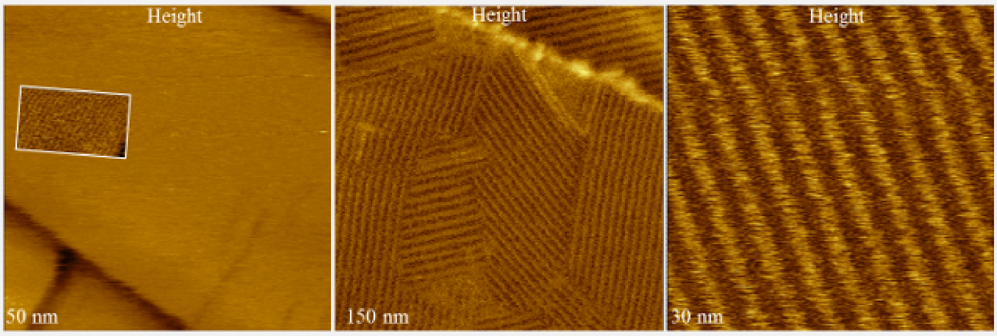
SM: The HD-AFM™ Mode is available on all four of our major instrument platforms; NTEGRA, NEXT, Spectra, and LIFE. The implementation of HD-AFM™ Mode is directly related to a novel fast data acquisition module that can be added for recent electronic controllers. Contact your local NT-MDT representative for upgrade details specific to your microscope.

WS: Are there plans to extend the new capabilities to the other instruments in your product range?

SM: Such plans not only exist, they are already being implemented!

WS: Can you give us any clues about what other developments to expect from NT-MDT in the near future?

SM: Generally speaking, the practical realization of true quantitative nanomechanical and quantitative electrical property measurements at the nanoscale, in broad frequency and temperature ranges, is on our path. Efforts in this direction could be easily coupled to the increasing interest of researchers in chemical characterization by combining AFM with spectroscopic methods.



Height images obtained in Hybrid Mode of alkane layers of different chain lengths demonstrate the high-resolution capability of this technique enabling the ability to resolve the packing of individual chains (inset image) in the image of C390H782 lamellae. Sample of C390H782 alkane – courtesy of Prof. G. Ungar (Sheffield University).

WS: Where can we find more information about HD-AFM™, and NT-MDT AFM products in general?

SM: There are application notes and datasheets available on the NT-MDT website. In addition, a recording of our recent webinar with Virgil Elings and Sergei Magonov, *New HD-AFM™ Mode; Your Path to Controlling Forces for Precise Material Properties* is available to view and download.

About Sergei Magonov

Dr. Sergei Magonov received a doctorate in physics and mathematics from the Moscow Institute of Physics and Technology. Sergei has published over 200 peer-reviewed papers, 1 book, and 15 book chapters.

He is now CEO of NT-MDT Development, an R&D subsidiary that was established for the development of novel experimental and applications capabilities using NT-MDT microscopes.

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Primary Activity

Component Supplier

Company Background

NT-MDT Co. was established in 1991 with the purpose to apply all accumulated experience and knowledge in the field of nanotechnology to supply researchers with the instruments suitable to solve any possible task laying in nanometer scale dimensions. The company NT-MDT was founded in Zelenograd - the center of Russian Microelectronics. The products development are based on the combination of the MEMS technology, power of modern software, use of high-end microelectronic components and precision mechanical parts. As a commercial enterprise NT-MDT Co. exists from 1993.

Now the NT-MDT team develops for you the complete line of SPMs which cover most of scientific and industrial applications. The first NT-MDT device was designed in 1990 and was called STM-MDT-1-90 (Scanning Tunneling Microscope). Till now, this first microscope duly runs in the Institute of Cristallography RAS (Russia). STM-4 was developed in 1993. The device model Solver appeared in 1995 starting the Solver product line. The same year the model Solver P47 was made. 1998 was marked by Solver LS, Stand Alone SMENA systems. Special SPM for biological applications called Solver BIO supplemented NT-MDT product line in 1999.

The next year we developed X, Y Scanning stage for closed-loop operation.

Now we can offer you the whole SPM line including AFMs, STMs, SNOMs for almost all possible applications and we continue development of new powerful tools for you. . We also supply a wide range of silicon probes and calibration gratings production, design and development that allows us to understand and meet your requirements better.

550 employees include Ph.D. scientists, many leaders in their field. More than 600 installations in 39 countries, more then 15 year in the SPM market, worldwide distribution of our devices. Our clients are Universities and colleges, laboratories, government and private industrial companies, research centers and small scientific companies on the nanotechnology field

NT-MDT Co. has two mottos - "Fairness, Intellect, Quality" and " What seems the future to others is the present for us".
The bases to successful development are: the best "brains", the best components, high technologies, up-to-date marketing and control. In summary we have: powerful software, best electronics, best mechanics, micro robotics and sales in the world market.

Territories Serviced

Worldwide