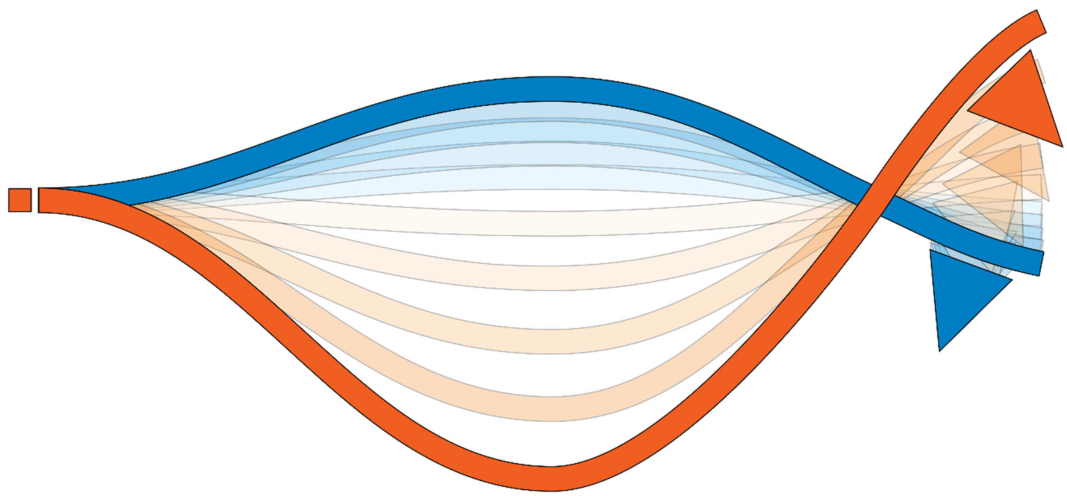
NC-AFM Symposium

August 3rd, 2026,

University of Innsbruck, Austria

The 27th International Conference on Non-Contact Atomic Force Microscopy



Focus on
Multifrequency Applications

2026 NC - AFM INNSBRUCK

Zurich Instruments

scienta omicron

Program overview

09:15-09:30 | Welcome and introduction | Juergen Koeble and Romain Stomp

Opening remarks, symposium orientation and a concise framing of why multifrequency and time-domain methods are becoming central to advanced non-contact AFM and SPM experiments.

09:30-09:50 | Stability, Low Noise, Resolution and Bandwidth: the ingredients for SPM | Juergen Koeble

Low temperatures yield access to ultimate energy resolutions and stability but typically complicate the accessibility for external equipment to the tip-sample region. With the proper design of the SPM platform and modularity, this accessibility can be maintained. The talk highlights the role of high mechanical, thermal and electrical stability; dedicated cabling; precooling stages; low-noise preamplifiers and signal creation; and adequate data acquisition. It also discusses frequency-dependent measurement schemes such as bimodal AFM excitation and multi-harmonic detection, including IETS.

09:50-10:20 | Tweaking the Bond Imaging Technique | PD Dr. Daniel Ebeling

With chemical bond imaging using CO-functionalized AFM tips, the chemical structure and orientation of individual organic molecules can be visualized. This invited talk presents approaches to enhance the method: constant-current AFM and adaptive feedback for imaging adsorption conformations and surrounding metal atoms in a single scan, lateral force microscopy through torsional eigenmodes of qPlus sensors, and active MEMS microcantilever concepts with integrated piezoelectric sensing for multifrequency AFM and higher throughput.

10:20-10:40 | From Multifrequency to Time-Domain Measurements in SPM | Romain Stomp

This talk explores real-time data processing and signal generation for bridging multifrequency and time-domain measurements in scanning probe microscopy. It will provide concrete strategies to optimize SPM setups and enable new measurement methods through flexible detection, control and time-critical orchestration techniques.

10:40-11:10 | Coffee break

Come and chat with the Scienta Omicron and Zurich Instruments teams.

11:10-11:30 | VHFLI Hands-on Tutorial: A New Standard for SPM | Romain Stomp

This tutorial will show how the VHFLI Lock-in Amplifier can serve demanding SPM applications, including time-resolved measurements in a single box. The new graphical workflow and complete time-frequency domain analysis toolbox illustrate how to build complex experiments from a bottom-up approach following the signal path.

11:30-12:00 | Need for Speed: Dissipation-based Kelvin Probe Force Microscopy for Quartz Tuning Fork Sensors | Dr. Marco Thaler

Non-contact AFM with quartz tuning forks enables bond-resolved imaging and electrostatic probing at the atomic scale. Conventional Kelvin probe force spectroscopy grids can reach submolecular resolution but typically require several hours. This talk presents dissipation-based KPFM adapted to quartz tuning forks operated in UHV at 8 K, increasing LCPD map acquisition rates by more than an order of magnitude, and introduces a second bimodal heterodyne approach.

12:00-12:20 | Modular and cost-effective SPM Controller for state-of-the-art SPM experiments: a hands-on introduction | Juergen Koeble

This tutorial will introduce the main features and some special modes of operation using its built-in lock-in amplifiers with multifrequency operation in a live demonstration. Attendees will have the opportunity of getting hands-on experience with the core functionality and user interface.

Speakers

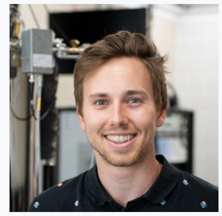
Meet the speakers leading the invited scientific talks, technology sessions and hands-on tutorials.

PD Dr. Daniel Ebeling

Invited speaker

Justus Liebig University Giessen

PD Dr. Daniel Ebeling is a Senior Scientist at the Institute of Applied Physics, Justus Liebig University Giessen in the research group of Prof. André Schirmeisen. His research focusses on deciphering on-surface reaction mechanisms and designing functional organic nanostructures via low temperature atomic force microscopy (AFM). Dr. Ebeling is also developing new multifrequency imaging methods to enhance the AFM capabilities, which he started back in 2012 as a postdoc at the University of Maryland in the research group of Prof. Santiago Solares.



Dr. Marco Thaler

Invited speaker

University of Innsbruck

Dr. Marco Thaler is a postdoctoral researcher in the group of Ass.-Prof. Laerte Patera at the University of Innsbruck, where he also completed his PhD in 2025. His research centers on charge transfer phenomena and on surface synthesis, investigated with non-contact AFM (nc AFM) and scanning tunneling microscopy (STM) under ultra-high vacuum and cryogenic conditions.

Dr. Romain Stomp

Organizing speaker

Zurich Instruments

Romain Stomp is a Principal Application Scientist at Zurich Instruments, working from his French home office when not traveling. As an experimental physicist, he applied Scanning Probe Microscopy (SPM) techniques to single-electron detection in quantum dots and received his PhD from McGill University in Canada. His first work experience, with Nanonis in Zurich and SPECS, centered on transferring SPM to different nanotechnology applications. At Zurich Instruments, Romain enjoys the intellectually stimulating and interdisciplinary approach offered by the broad range of application areas.

Dr. Juergen Koeble

Organizing speaker

Scienta Omicron

Jürgen Köble is Product Manager for Scanning Probe Microscopy with a long-term history at Scienta Omicron. He has been working with Scanning Probe microscopes for more than 25 years. He received his PhD at University of Mainz (Germany) for work on ultrathin magnetic layers. Stages at Scienta Omicron include head of the Applications department and project leader for the development of a cryogen-free STM/AFM. With a general interest in physics Jürgen enjoys being part of a leading company providing solutions to scientists all over the world.

Full scientific abstracts follow on the next page

Tweaking the Bond Imaging Technique

Daniel Martin-Jimenez[1,2,3], Michael G. Ruppert[4], Alexander Ihle[1,2], Qigang Zhong[1,2,5], Hermann A. Wegner[6], André Schirmeisen[1,2], Daniel Ebeling[1,2]

[1] *Institute of Applied Physics (IAP), Justus Liebig University Giessen (Germany)*

[2] *Center for Materials Research (LaMa), Justus Liebig University Giessen (Germany)*

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[6] *Institute of Organic Chemistry, Justus Liebig University Giessen (Germany)*

With the chemical bond imaging technique, i.e., by using CO functionalized AFM tips, it became possible to visualize the chemical structure and orientation of individual organic molecules. This is essential for identifying intermediates and products achieved via on-surface synthesis or for revealing on-surface reaction mechanisms. Here, we present different approaches to enhance the capabilities of the bond imaging method. To quantitatively determine adsorption conformations of bulky molecules constant-current AFM can be applied. [1] Recently, we expanded this method by an adaptive feedback mechanism, which provides in a single image both submolecular resolution on organic molecules and atomic resolution on the surrounding metallic surface (left Figure). [2] This approach is suitable to image adsorption sites of several adjacent highly mobile molecules in a single scan. In the future such a concept could also contribute to autonomous scanning. Furthermore, via the excitation of torsional eigenmodes of qPlus sensors, lateral force microscopy becomes accessible simply by switching the excitation frequency. [3] Recently, we presented a proof of concept for an active microelectromechanical systems (MEMS) microcantilever with integrated piezoelectric sensing, which is interesting for the application of multifrequency AFM techniques and increasing the experimental throughput (right Figure). [4]

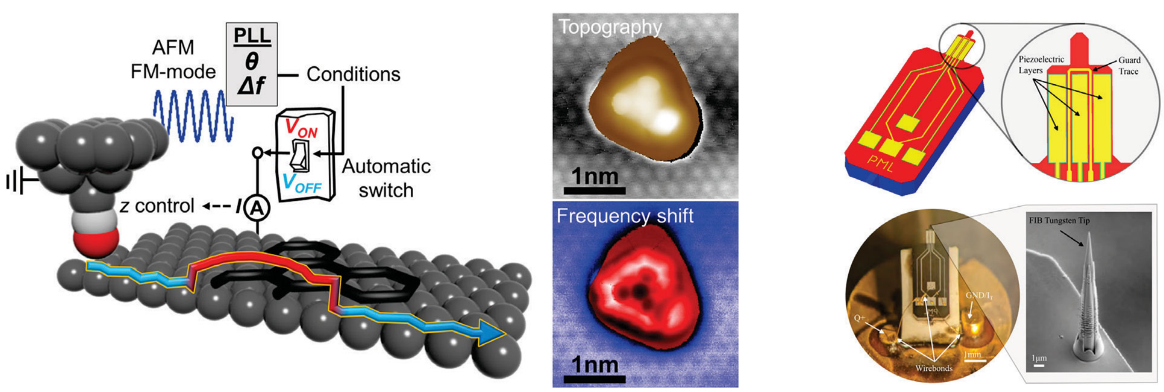

Figure: (left) Adaptive feedback for imaging molecules and surface atoms in a single scan. [2] (right) Piezoelectric MEMS cantilever with tungsten tip. [4]

[1] *Phys. Rev. Lett* **122**, 196101 (2019)
[2] *Nanotechnology* **35**, 475703, (2024)
[3] *Nanoscale* **14**, 5329 (2022)
[4] *Nanoscale* **17**, 10600 (2025)

Need for Speed: Dissipation-based Kelvin Probe Force Microscopy for Quartz Tuning Fork Sensors

Marco Thaler[1], Benjamin Achatz[1], Jonathan Hein[1,2], Romain Stomp[3] and Laerte Patera[1]

[1] *Department of Physical Chemistry, University of Innsbruck, Innsbruck, Austria*

[2] *Experimental Physics 2, University of Würzburg, Würzburg, Germany*

[3] *Zurich Instruments AG, Zurich, Switzerland*

Non-contact atomic force microscopy (nc-AFM) with quartz tuning forks[1] enables imaging of individual chemical bonds[2] and probing of electrostatics at the atomic scale[3]. In nc-AFM, local contact potential differences (LCPD) can be mapped using Kelvin probe force spectroscopy (KPFS) by acquiring grids of frequency shift versus bias spectra. While this approach has been pushed to submolecular spatial resolution[4], the acquisition of an LCPD map typically requires several hours.

Here, we adapt dissipation-based Kelvin probe force microscopy (KPFM), originally proposed for cantilever-based AFM[5], to quartz tuning forks operated in ultra-high vacuum (UHV) at low temperature (8 K). Compared to the KPFS-grid approach, the proposed technique increases the acquisition rate by more than an order of magnitude, ultimately limited only by the phase-locked loop bandwidth. Furthermore, a second method is demonstrated exploiting the heterodyne approach, where the tuning fork is operated in bimodal mode.

[1] Giessibl, F. J. The qPlus sensor, a powerful core for the atomic force microscope. Rev. Sci. Instrum. 90, 011101 (2019).

[2] Gross, L., Mohn, F., Moll, N., Liljeroth, P. & Meyer, G. The chemical structure of a molecule resolved by atomic force microscopy. Science 325, 1110–1114 (2009).

[3] Gross, L. et al. Measuring the charge state of an adatom with noncontact atomic force microscopy. Science 324, 1428–1431 (2009).

[4] Mohn, F., Gross, L., Moll, N. & Meyer, G. Imaging the charge distribution within a single molecule. Nat. Nanotechnol. 7, 227–231 (2012).

[5] Miyahara, Y. & Grutter, P. Force-gradient sensitive Kelvin probe force microscopy by dissipative electrostatic force modulation. Applied Physics Letters 110, 163103 (2017).

Stability, Low Noise, Resolution and Bandwidth: the ingredients for SPM

Jürgen Köble[1,*], Eleni Anargirou[1], Martin Schmid[1], Bernd Günther[1]

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Scienta Omicron with its decades of experience in Scanning Probe Microscopy in ultra-high vacuum continuously provides new solutions or improvements of existing SPM platforms to the SPM community.

Low temperatures yield access to ultimate energy resolutions and stability but typically complicate the accessibility for external equipment to the tip-sample region. With the proper design of the SPM platform and modularity the accessibility can be maintained.

Prerequisites for accurate and time-efficient SPM measurements are high mechanical stability, temperature stability as well as electrical stability. Dedicated cabling, proper precooling stages, low-noise preamplifiers, low-noise signal creation and finally adequate data acquisition all contribute to the final measurement result.

Flexibility in terms of signal frequency (e.g. for multifrequency applications) can be obtained by choosing well-adapted high frequency cable lines. Optical frequencies can be adjusted by choosing the proper optical elements like customized lenses or parabolic mirrors. Finally, choosing the proper signal generation, preamplifiers and detectors complete the requirement list for frequency-dependent measurement schemes.

Examples for multifrequency applications are found in particular in bimodal AFM excitation schemes or multi-harmonic detection like IETS.

From Multifrequency to Time-Domain Measurements in SPM

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With the increasing complexity of modern-day experiments, reliable information recovery is more important than ever before, in terms of signal strength, artefact-free measurements or other environmental decoupling. In addition, for Scanning Probe Microscopy (SPM), it is equally important to distinguish between various force contributions, the most common ones being the topography or the electrostatic force, but that can be extended to a wealth of other tip-sample interactions, depending on the sample properties and its coupling to stray fields. Multifrequency techniques can thus act as a good force discriminator, it can also probe non-linear interaction with a good approximation or be sensitive to time-varying phenomena. These convoluted responses require multiple demodulator measurements as well as time-dependent excitation and detection.

In this talk, I will review some of the latest advances in Kelvin Probe Force Microscopy (KPFM) that rely on Heterodyne [1] and Dual Heterodyne [2] techniques as an illustration for reducing topographical artifacts while increasing time-resolution or measurements speed. Such resonant and multifrequency techniques can also be applied to recover time dependent phenomena.

The combination of all those recent instrumentation developments in a single unit enables researchers with better integrated solutions into more complex setup. To this end, the brand-new VHFLI lock-in amplifier that combines multifrequency demodulation with Arbitrary Waveform Generator (AWG) will be introduced. Such instrumentation allows for very precise timing and data capture of various pulsed and periodic signals.

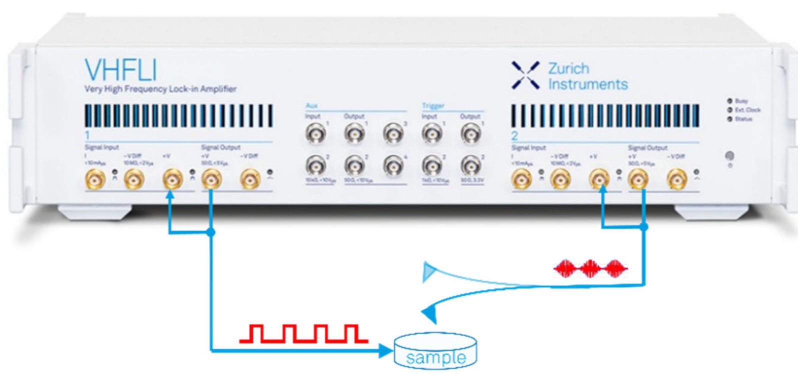

Figure: New VHFLI lock-in amplifier that combines Arbitrary Waveform Generation and multifrequency detection.

[1] Sugawara, Y.; Kou, L.; Ma, Z.; Kamijo, T.; Naitoh, Y.; Li, Y. J. Appl. Phys. Lett., 100, 223104 (2012).

[2] Grévin B., Husainy F., Aldakov D. & Aumaître C. Dual-heterodyne Kelvin probe force microscopy. Beilstein J. Nanotechnology 14, 1068–1084 (2023).