# MI 5: Scanning Probe Microscopy

Time: Wednesday 16:00–16:45 Location: H5

MI 5.1 Wed 16:00 H5

**Contrast of nonlinear response in atomic force microscopy**
— •Daniel Forchheimer[1,2], Robert Forchheimer[3], and David Haviland[1] — [1]Royal Institute of Technology (KTH), Stockholm, Sweden — [2]Intermodulation Products AB, Segersta, Sweden — [3]Linköping University, Linköping, Sweden

A trend in Atomic Force Microscopy (AFM) is towards obtaining more information without increasing the measurement time. This can be achieved by driving the AFM cantilever at multiple frequencies simultaneously, so-called multifrequency AFM. Such drive schemes creates motion not only at the driven frequencies but also at harmonics and mixing frequencies, due to the nonlinear behavior of the force between the tip and the surface with respect to their separation. Although these nonlinear frequency components are weaker by at least an order of magnitude compared to the amplitude at the drive frequencies, we show that they provide excellent contrast when imaging heterogenous materials such as a polymer blend. Multifrequency AFM data also warrants new methods of analysis. We demonstrate how algorithms from the field of machine learning can be used to improve the contrast of images or blindly cluster data of different regions into specific groups.

Reference: D. Forchheimer, R. Forchheimer, D. B. Haviland, Nature Communications, 6, 6270 (2015).

MI 5.2 Wed 16:15 H5

**Liquid helium free scanning probe microscope working at below 10 K** — •Byoung Choi — RHK Technology, Troy Michigan, USA

We developed a closed cycle cryostat base low temperature scanning probe microscope (LT-SPM) that works below 10 K without consuming any liquid cryogen. The basic performance of the microscope was validated in various conditions such as noisy environment and modulated temperature in a sub-atomic scale. The state-of-the-art technique allows the extended time elapsed measurements such as week-long investigation of surface dynamics at low temperature without interrupting the critical moment of the tip while refilling the conventional cryogen tanks. The compact, rigid design of the microscope also allows the study in a variable temperature without the hassle of liquid cryogen consumption. We will presents the time evolution of the surface states at various temperatures between 10 K and 350 K on the 2D electron substrates such as $Bi_2Se_3$, $Bi_2Te_3$ and $TiSe_2$. In the end, we will discuss how the cryogen free LT-SPM can open the new capabilities to surface scientists and researchers in nanotechnology in terms of the economical and practical reason.

MI 5.3 Wed 16:30 H5

**Fast-scanning and quantitative-imaging atomic force microscopy (AFM) combined with advanced optical techniques**
— •Elmar Hartmann, Dimitar R. Stamov, and Torsten Jähnke — JPK Instruments AG, Berlin, Germany

AFM is well known as a multi-purpose and meanwhile indispensable tool for high-resolution studies under natural conditions. Recent tip-scanning AFM developments deliver now insight into the dynamics of macromolecular systems, while simultaneously offering a seamless integration capability with advanced optical techniques.

Collagen type I attracted a lot of attention, due to its large interactome, hierarchical structural and mechanical stability. This study is devoted to non-invasively monitor the kinetics of collagen fibrillogenesis by modifying environmental conditions. We show that fast AFM imaging can successfully be applied to understand the real-time kinetics of collagen I and the fibrillar nanomatrix formation with high spatial and temporal resolution [1].

The newly gained capability of higher imaging velocity has also been used to directly study living fibroblast cells. Here, the dynamics of individual membrane structures of a single cell is investigated with AFM, while simultaneously observing the same cell in the optical phase contrast image and DirectOverlay$^{TM}$ technique. Super-resolution (dSTORM and STED) have been combined with AFM when operated in the Quantitative Imaging (QI$^{TM}$) mode that is based on fast force-distance curves to demonstrate close relationship of cellular structures and nano-mechanical properties.

[1] Stamov et al., Ultramicroscopy, 149, 86 (2015).