Intermodulation Atomic Force Microscopy
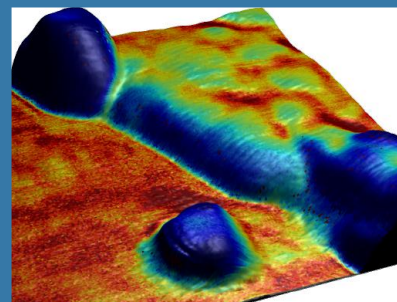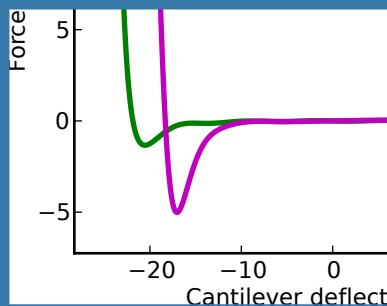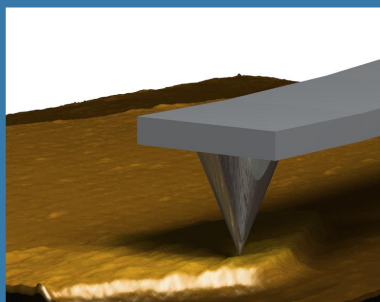
Surface analysis upgrade

✔ Force curve at every image pixel

✔ Surface property maps from arbitrary force model

✔ Use standard cantilevers, scan at standard speed
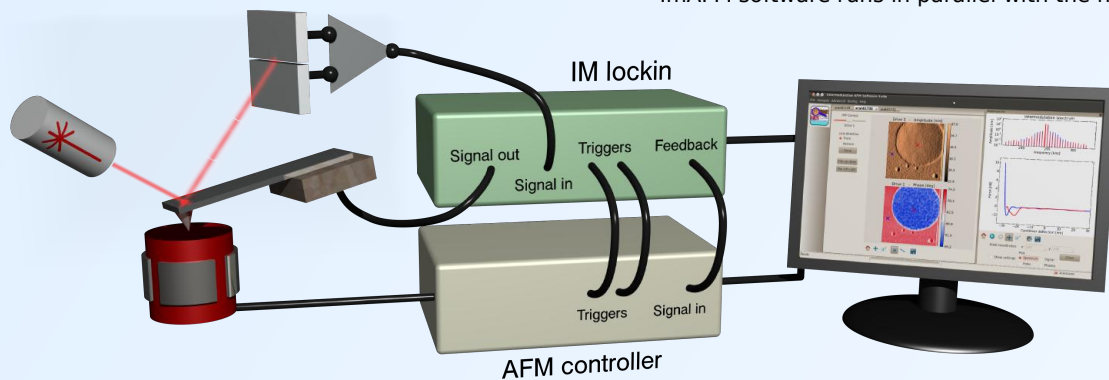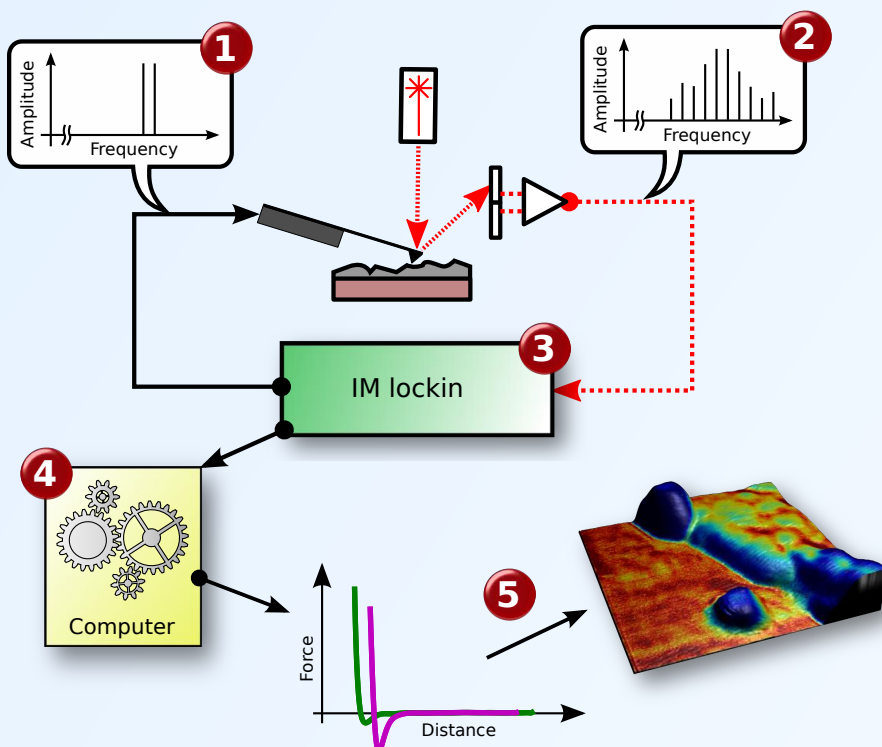

Intermodulation products

Intermodulation AFM

Intermodulation Atomic Force Microscopy (ImAFM) is a new mode of dynamic AFM which gives quantitative force-distance curves at every image pixel. ImAFM achieves this by using a multi-frequency measurement and analysis technique called Intermodulation Spectroscopy. This patented technique works with normal cantilevers and at normal scan speeds. With the Intermodulation Lockin Analyzer and the ImAFM Software Suite from Intermodulation Products AB, it is easy to upgrade your AFM to perform ImAFM.

AFM upgrade

With a few simple connections, the Intermodulation lockin analyzer (IM lockin) can be used with almost any AFM. This only requires access to the cantilever drive input, the photo-diode output and the End-of-Line and End-of-Frame triggers. When scanning, the ImAFM software runs in parallel with the host AFM software.


How it works

1. The IM lockin generates two pure drive tones, close to the resonance frequency of the cantilever.

2. The tip-surface interaction generates intermodulation products — new tones that were not present in the drive.

3. The IM lockin measures the amplitude and phase of 32 intermodulation products and transfers them to the computer for storage and analysis.

4. A computer algorithm reconstructs the tip-surface force from the intermodulation data at every pixel.

5. The user can choose any model to parameterize the tip-surface force. The parameters are color coded on the measured topography.

Cantilever calibration
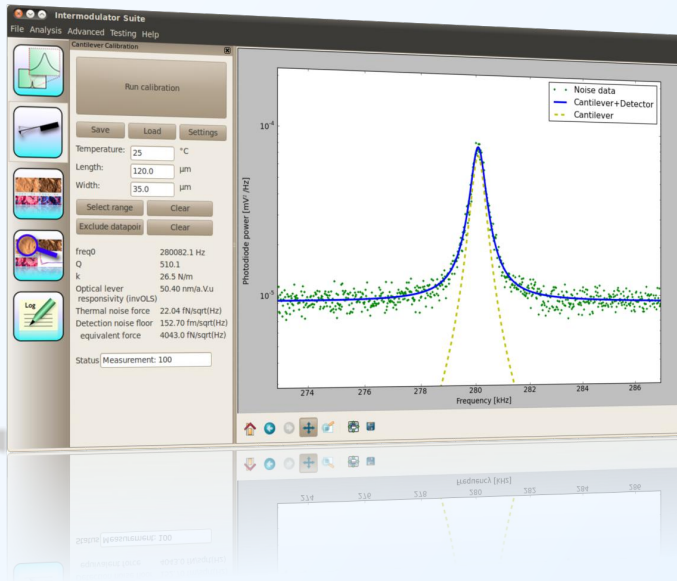
Quantitative AFM would not be possible without an accurate calibration of the cantilever spring constant and the optical lever sensitivity.

ImAFM begins with calibration based on thermal noise measurement*. This calibration is performed without touching the surface, keeping the tip pristine.

*Rev. Sci. Instrum., 77, 013701 (2006).

Point-and-click force curves
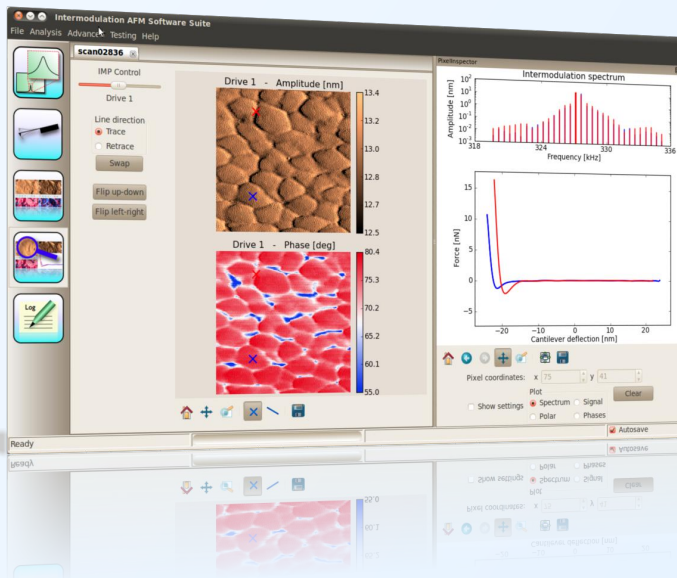
You can instantly view the force curve at any point in your image and compare force curves from different image points with the pixel inspector. The selected pixel is marked with an X which is color coded to the force distance curve in the pixel inspector frame. No more guessing what is causing your image contrast. It is quick an easy to get the actual calibrated force at every point of your image.

Hardware

Intermodulation AFM is possible thanks to a unique signal processing module called the Intermodulation lockin analyzer.

For full specification, see:
www.intermodulation-products.com

For scientific description, see:
Rev. Sci. Instrum. 82, 026109

Surface property maps and force curves generated with the ImAFM system. The force has been parameterized with the van der Waals-DMT model to determine effective stiffness (E*) and the van der Waals attractive force (FvdW). The crosses in the left images indicate the positions for the corresponding force curves in the right images.
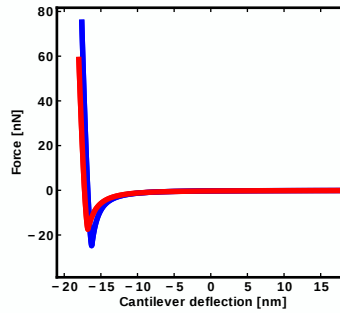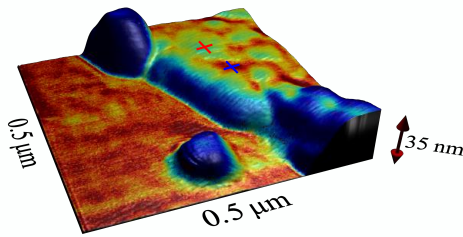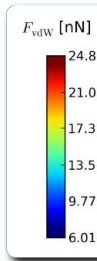
Step edge of a thin film of butyl-acrylate spin coated on silicon oxide.

Note the rings of stronger attractive force on the butylacrylate.

Sample courtesy of Eva Malmström Coating Technology, KTH, Sweden and Henrik Hillborg, ABB, Sweden.
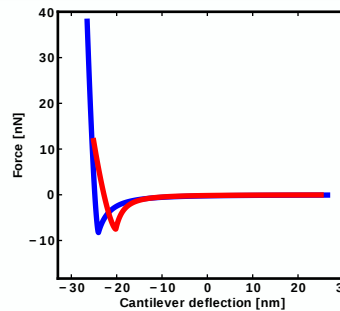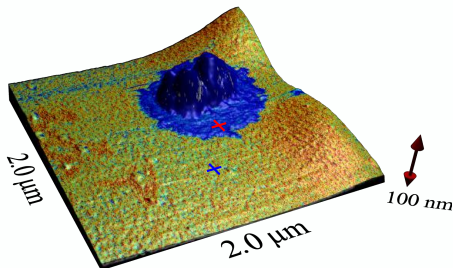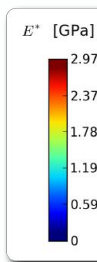
Small droplet of adhesive coating on a Polyethylene terephthalate (PET) substrate.

We can see how the soft material in the coating is spread out in a thin layer, not noticable in the topography.
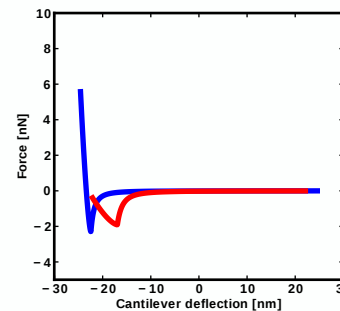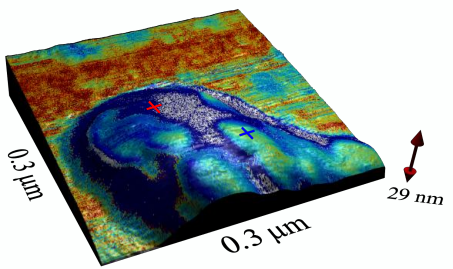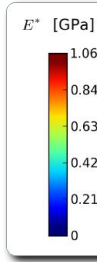
Sample courtesy of Soheil Saadatmand, Polymer Technology, KTH, Sweden.
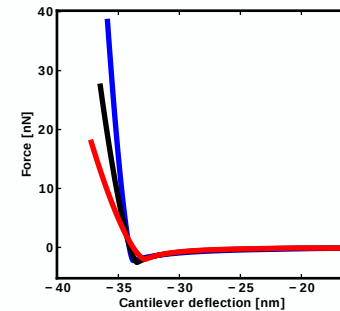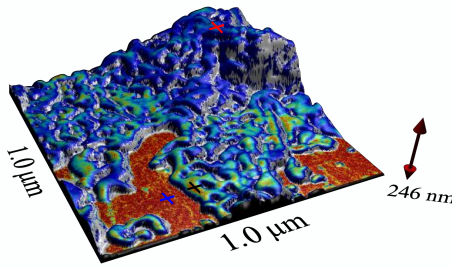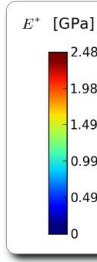
Dilute polycaprolactone (PCL) in butanol, deposited on a silicon substrate.

Note the three distinct stiffnesses. The hard substrate, the semi-hard thin layer of polymer and the soft thick layer of polymer.
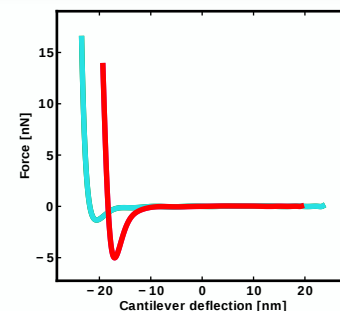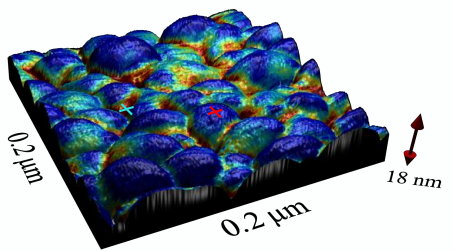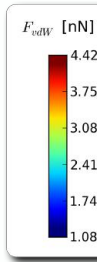
Sample courtesy of Nima Sanandaji and Ulf Gedde, Polymeric materials, KTH, Sweden.

Dilute polycaprolactone (PCL) in butanol, deposited on a silicon substrate.

The stiffess contrast indicates inhomogeneous structure in the polymer island.

Sample courtesy of Nima Sanandaji and Ulf Gedde, Polymeric materials, KTH, Sweden.

Nanoparticles covered with protein layer.

The strong attractive force in the crevasses between the particles is a result of the surface topography.

Sample courtesy of Olga Krivosheeva and Per Claesson, Surface and Corrosion Science, KTH, Sweden.