From High-speed AFM to 4π AFM

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Three areas in which conventional AFM has limitations: (i) low imaging rate, (ii) probe-sample force interaction, and (iii) the planar nature of the sample.

We are developing two high-speed force microscopy techniques. One high-speed AFM (HS AFM) technique is a DC method in which the tip is in continuous contact with the specimen. This routinely allows video-rate imaging (30 frames per second, fps) and has achieved imaging at over 1000 fps, i.e., 100,000 times faster than conventional AFM. Damage to specimens resulting from this high-speed contact-mode imaging is surprisingly less than would be caused at normal speeds. The behavior of the cantilever and tip at these high velocities has been investigated and superlubricity is a key component in the success of this technique.

The other high-speed force microscope is a non-contact method based on shearforce microscopy (ShFM). In this HS ShFM, a vertically-mounted laterally-oscillating probe detects the sample surface at about 1 nm from it as a result of the change in the mechanical properties of the water confined between the probe tip and the sample. With this technique, very low normal forces are applied to the specimen.



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AFMs require planar samples because the probe scans in a plane. It is as if the tip is only 'seeing' the sample from above. We have overcome this limitation be steering the tip of a nanorod in a three dimensional scan with six degrees of freedom using holographically generated traps such that it is possible to scan around a sample.



Phillips DB, *et al.*, *Nanotechnology* **22** (2011) Art. No. 285503. Olof SN *et al.*, *Nano Letters* **12** (2012) 6018-6023.