NON-DESTRUCTIVE IMAGING OF SINGLE MOLECULES AND BIOLOGICAL NANOSTRUCTURES BEYOND VIDEO RATES

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The advantages of atomic force microscopy (AFM) for the study of biomolecular structures are well-known and mean that it is possible to follow biological processes occurring in the AFM in conditions close to physiological. However, one of the most severe limitations of the AFM technique is that scan rates are too slow to follow many dynamic processes in real time. The principal reason for the limitation in the imaging speeds stems from the fact that scanning probe microscopy, and AFM in particular, is based on mechanical microscopes; as such, imaging speeds are limited by the inertia and resonances of the scanning systems and of the AFM cantilever probe. At high imaging speeds, the bandwidth of the feedback system (to maintain, for example, constant force or RMS tapping amplitude) also becomes a limiting factor.

A logical solution to the mechanical limitations is to decrease the mass and increase the stiffness of the scanning system and the cantilever in order to decrease their response times by reducing inertial effects and increasing resonant frequencies. Over the last ten years, such AFM systems have been under development in several laboratories worldwide[1]. The engineering demands of such an approach are formidable. The cantilever in such instruments is about 10 μm in length and about 1 μm in width. This is clearly close to the limit for use with an optical lever and leaves little room for further improvements to increase scanning speed.

The solution to high-speed imaging pursued by the Bristol group[2] and presented here is different to the above method. Instead of avoiding resonance in the scanning system, resonance is used to scan the probe in the fast-scan direction. Two implementations of this high speed scanning system have been developed. The first is a high-speed scanning near-field optical microscopy (SNOM), which achieves 120 frames per second, the high Q value of the tuning forks used resulting in remarkably stable imaging. In the case of high-speed AFM, imaging rates beyond 60 frames/s can be regularly achieved. The damage to specimens resulting from this high-speed contact-mode imaging is surprisingly very considerably less than would be caused at normal speeds. The reason for this is now understood and will be described briefly in this presentation.

[1] T Ando, N Kodera, E Takai, D, K, A Toda, *PNAS* **98** (2001) 12468
[2a] ADL Humphris, JK Hobbs, & MJ Miles, *APL* **83** (2003) 6
[2b] ADL Humphris, MJ Miles, & JK Hobbs, *APL* **86** (2005) 034106