

Video rate AFM for the real time characterisation of Polymers and Biological Systems

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Atomic force microscopy (AFM) has many advantages over other microscopy techniques for the study of both synthetic polymer systems and biological structures. Its ability to acquire high-resolution images under ambient conditions and also in liquid environments is particularly important for biomolecular systems and both biological and polymer systems benefit from the lack of radiation damage associated with electron microscopy. However, in its conventional implementations, AFM suffers from low image acquisition rates, which are typically less than one frame per minute. This results in two significant disadvantages of this and indeed other SPM techniques: (i) the inability to follow processes occurring in much less than a one-minute time period, and (ii) the inability to image large areas of the specimen because there is no low-magnification mode and the low imaging rate means it is impractical to image large areas by multiple scans.

This limitation in imaging rate is a consequence of the instruments associated with these techniques, and AFM in particular, being essentially mechanical microscopes with the associated problems of inertia, resonance and response times of the scanning system, the feedback electronics and mechanics, and the force measurement, in AFM. One solution to the mechanical limitations is to decrease the mass and increase the stiffness of the scanning system and the cantilever in order to move the microscope's response into a different time regime. Remarkable progress has been achieved with this approach in several groups worldwide.

An alternative solution based on contact mode AFM [1] will be presented here which routinely allows video-rate imaging (30 fps) and in recent developments of this instrumentation has allowed imaging of a biological specimen at over 1000 fps. Such a method may allow processes occurring in just a few milliseconds to be followed. Damage to specimens resulting from this high-speed contact-mode imaging is surprisingly very considerably less than would be caused at normal speeds. The nature of tribological forces at the nanoscale and high shear rates is of great interest in general and in this new technique in particular.

[1] ADL Humphris, MJ Miles, & JK Hobbs, *Applied Physics Letters* **86** (2005) 034106.