NEW SPM DEVELOPMENTS FOR CHARACTERIZATION AND CREATION OF NANOSTRUCTURES

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For the characterization of nanostructures in a range of materials from inorganic to biomolecular, SPM is the main technique used. SPM techniques are also being developed for the creation of structures at the tens of nanometre scale. Although SPM has many extremely important advantages in these areas, nevertheless it also has some inherent disadvantages that need to be addressed. In particular, in AFM, the interaction between the imaging tip and the specimen surface is a force interaction that in some circumstances can cause the distortion or plastic deformation of nanostructures in more delicate specimens. SPM techniques to control or reduce this interaction force will be presented. The second major disadvantage of SPM in general is the relatively slow frame rate in imaging. This has several consequences for the technique: the inability to follow processes that occur on timescales shorter than around ten seconds, the inability to invested large areas of the specimen surface, and the impracticality of using SPM to create nanostructures over a large area. New techniques for increasing imaging rates will be presented.

For the reduction of imaging forces, two techniques will be discussed: (i) active Q-control and (ii) non-contact transverse dynamic force microscopy (TDFM). The normal forces between the probe and specimen occurring in intermittent-contact imaging in liquid depend directly on the quality factor (Q) of the resonant cantilever probe. In liquid, where the probe is heavily damped and the Q value is small, the forces are increased and damage to the specimen is frequently observed. So, one method of reducing such damage is to increase the effective Q value of the cantilever through a feedback technique. In the TDFM, the normal forces are already very low as the specimen surface is sensed by the vertically mounted probe through sub-nanometre water layer between the tip of the probe and the specimen. The structure of this water confined in the gap results in changes to the complex mechanical properties of the water which the probe detects and which are used to control the separation of the probe and specimen. This technique is producing some of the highest resolution images to date of biomolecules such as DNA.

Resonant scanning microscopy (RSM) is a new technique for SPM imaging at high speed. It overcomes the difficulties resonance and inertia which limit imaging rate in conventional SPM, by using a high-frequency and high-Q resonating stage to scan the specimen with respect to the probe scan speeds of more than 100 frames/second have been achieved. This technique has been applied to both scanning near-field optical microscopy and to atomic force microscopy, and examples of applications will be presented.