
Torsional tapping atomic force microscopy for the study of soft matter and biological systems

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It is well known that the resolution obtainable by AFM is limited by a variety of factors, including the sharpness of the tip, the dynamics of the cantilever, and the noise associated with detecting cantilever motion. In the work presented here, a relatively new addition to the family of AFM methods, torsional tapping AFM, will be described.

In torsional tapping, a T-shaped cantilever with the tip offset from the long axis is driven into torsional oscillation to yield a tapping motion at the tip. Due to the favourable dynamics of torsional oscillation (high resonant frequency and high Q) and the geometry of the optical lever, we find that the detection noise is reduced by a factor of 12 in torsion as compared to regular tapping mode (for the same cantilever in an identical system). The dynamics of the torsional mode also allow increased force sensitivity, as the increase in Q and resonant frequency are greater than the increase in spring constant. Passive bending in the flexural mode of the cantilever effectively limits the tip-sample force in the case of high feedback error signal, ensuring that the tip remains sharp.

The combination of these factors allows carbon “whisker” tips to be used to obtain true molecular resolution on rough, soft surfaces in air. Furthermore, the high resonant frequency and passive flexural deflection of torsional tapping also allow the scan rate to be increased by a factor of 5 as compared to regular tapping mode on the same instrument.

Data collected on a variety of soft matter systems, including liquid crystals, semicrystalline polymers, organic semiconductors, 2d protein crystals and erythrocytes will be presented. The operation and development of the instrument will also be discussed.