EXPERIMENT 3. NANOMECHANICAL MEASUREMENTS ON DIFFERENT MATERIALS USING CONTACT MODE AFM

3.1 Introduction

In this experiment you will be measuring and comparing the relative stiffness of several samples.

Both the sample and tip can be imagined as one-dimensional springs defined by the symbols k_s and k_1 respectively. The stiffness of the sample (k_s) can be approximately determined by picturing the sample as a one-dimensional spring during a small elastic indentation with a cantilever (k_c). The effective spring constant is of the sample and cantilever is:

$$\frac{1}{k_{sys}} = \frac{1}{k_s} + \frac{1}{k_c} \qquad (1)$$

Based upon equation 1, the cantilever spring constant can be calculated if the sample spring constant is much greater than the cantilever spring constant ($k_s >> k_c$) using a calibration sample of much higher stiffness. The system spring constant, S_{sys}^{cal} in volts/m is the gradient of the force-displacement curve. Assuming a cantilever spring constant of 0.1-0.3 N/m, a sample spring constant can be approximated by,

$k_s \approx k_1 (S^{cal}{}_{sys}/S_{sys} - 1)^{-1}$

$S^{cal}{}_{sys}$ is the slope of the curve for a calibrating sample

S_{sys} is the slope of the material.

3.2 Experiment

In this experiment you will be acquiring the Force-Distance curves for different materials, which can be subsequently used to calculate the materials stiffness. Use the sample with the highest S_{sys} as the calibration sample.

Procedure:

Place the sample in the specimen stub and insert in the AFM. After having approached the sample to the tip, go to the CALIBRATE menu on the Advanced True Image Software™. Go to FORCE CALIBRATION and to SET PARAMETERS. The software will present the range of separation between the tip and the sample in units of volts. These values are 20volts above and below the current Z position of the sample. Use these parameters for acquiring the Force-Distance curve, to avoid crashing the tip to the surface. Press OK. Again go to the CALIBRATE menu, then FORCE CALIBRATION and to SCAN. The instrument will begin moving the sample towards the tip. If the plot obtained does not cover the attraction and repulsive regions of the Force-Distance curve, go to SET PARAMETERS again and change the range of scanning distances and do a new SCAN. Once you acquired the Force-Distance curve save in your disk. The files can be transformed to text files (*.txt) and opened with any spreadsheet for further analysis.

Reference

Ratner B.D., Tsurkruk, V.V., Scanning Probe microscopy of Polymers, ACS Symposium Series 694, Oxford University Press, 1998.