

## SPM methodology

### LITHOGRAPHY WITH SPM

#### Force Lithography

S.V. Lemesenko, S.A. Saunin (NT-MDT)

Term Probe Nanotechnology has been assigned to a local change of any properties of the surface by SPM tip, and the process itself has been called Nanolithography. The Probe Nanotechnology is the complex of techniques of controlled producing of nanometer functional elements on the surface of solid substances including individual molecules and atoms with the possibility of their visualization and control. There are two main methods of effecting the surface of the solid substance by SPM Probe: mechanical - controllable pressing by the tip and electrical - application of voltage to the conductive cantilever in pre-selected points. Both lithography methods are available with every NT-MDT AFM.

With standard silicon or silicon nitride cantilevers Force Lithography is applicable for relatively soft substrates and no qualitative change of modified surface happens but only local change of surface morphology. Electrophysical properties are not changing with this method. Fig.1 shows the surface of polycarbonate film on a silicon substrate after force lithography. A regular array of pits has been created by rigid ( $F_c=40\text{N/m}$ ) silicon cantilever operating in the semi-contact mode of AFM after the Force Lithography has been applied to points pre-set by program by bigger force under normal conditions. Distance between pits is about 25nm. This example demonstrates the possibilities of AFM to controllable modification of the surface on nanometer scale.

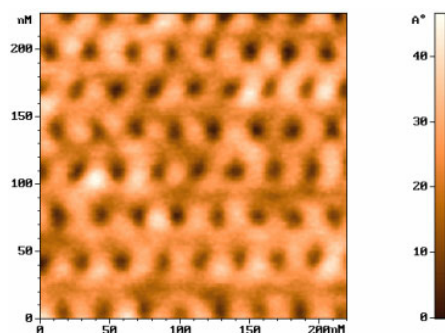


Fig.1. AFM image of polycarbonate film surface after application of Force Nanolithography.

In some cases after force lithography the convexities are observed instead of the pits. It means that a tip extracts material of the soft sample. Fig.2 demonstrates this possibility. Drawing of the more complicated pictures is also possible. Fig.3 shows the face, which was obtained by using raster image (PCX-file). Voltage lithography provides more quality image for such complex object.

For the Force Lithography on polycarbonate film semi-contact one-beam silicon cantilevers with the force constants that range from 10 to 100 N/m are recommended. Force Lithography can be executed on the surface of hard materials when special hard cantilever is used (for example, cantilever with diamond tip).

