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Molecular Devices and Tools for NanoTechnology
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Application Notes

SPM methodology

LITHOGRAPHY WITH SPM

Electrostatic (Charge) Lithography

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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.

The electrization of some of samples is possible with use of disconnected cantilever. Example of the charge writing on the surface of standard silicon grating by silicon cantilever is discussed below. Fig.1 demonstrates the topography of grating that obtained in semicontact mode after moving of the nonvibrating tip along black arrows. Existence of the charge, which was induced by cantilever friction, can explain the holes on silicon oxide (dark tracks on convexities of the grating). These holes appeared on topography owing to strong electrostatic tip-sample interaction, which displace the cantilever resonant peak during scanning in semicontact mode. This displacement leads to the cantilever amplitude changes and corresponding changes of the Z-coordinate of scanner, which is interpreted as topography. If electrostatic tip-sample interaction is attractive (the signs of probe and sample charges are contrary) then charged areas looks like holes. Repulsive interaction gives convexities on topography for charged areas. It is seen from Fig.1 that the bulk silicon oxide (convexities of the grating) is charged contrary to cantilever.

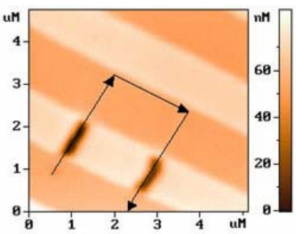

Fig.1.

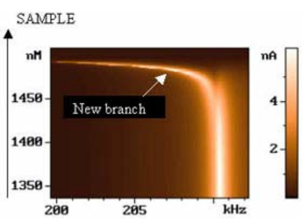

Fig.2.

Fig.2 shows changes of the resonant peak of the cantilever during approach to the sample. On this image horizontal axis corresponds to frequency, vertical axis is Z-coordinate of scanner. Brightness corresponds to the cantilever amplitude in arbitrary units. It is seen from Fig.2 that new branch appears when tip-sample distance becomes small. This new branch has strong dependence on tip-sample distance. The appearance of this branch can be connected with electrization, i.e. electrization is also available when oscillating cantilever strong interacts with the sample. The hole on topography after such procedure is shown on Fig.3. The size of this hole determines minimum possible charged area for a considered sample: 200-300nm. It is evident that minimum possible size of the charged area strong depends on material. Fig.4 shows the example of the more complex pattern: charge signature on originally uncharged flat silicon oxide. Charge Lithography was executed in resonant mode with small tip-sample distance. It should be noted that all these charge patterns only in semicontact mode are seen. The using of the contact mode makes these charged areas invisible. Moreover, all scan will be charged after contact mode. The charged areas can be easily visualized also with Electrostatic Force Microscopy (EFM).

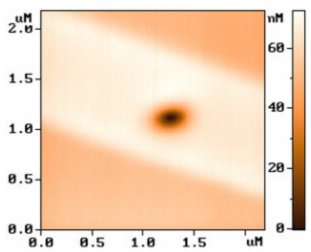

Fig.3.

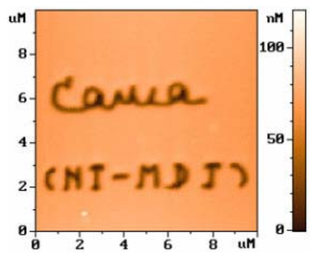

Fig.4.

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