The use of the resonant spectroscopy for analisys of the tip-sample interaction

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During scanning in semi- or non-contact modes the changes of the both form and place of cantilever resonant peak are observed. These changes are the results of various kind tip-sample interactions. For more complete characterization of these interactions it is useful to obtain resonant curves (RC) in each point of scan at certain tip-sample distance (full resonance spectroscopy (FRS): *amplitude*(f, x, y), where f is frequency). Then the acquired data can be treated and different parameters of interaction can be determined. For example, the presence of the force derivative leads to changing of the resonant peak place (Fig.1). These frequency changes can be either calculated from obtained spectroscopy data or measured simultaneously with topography. Different dissipation processes cause changes of peak form (Fig.1). As a result maximal amplitude, width at half maximum (WHM) or quality factor Q of cantilever RC can be determined in each point of scan. This technique can be applied to study magnetic dissipation processes [1,2]. Method of magnetic dissipation imaging described in [1,2] obtains dissipation image faster, but FRS allows more detail analyzing of the tip-sample interaction without electronic modification. Maps of cantilever frequency, amplitude and quality factor changes can be obtained simultaneously for same area with this technique.

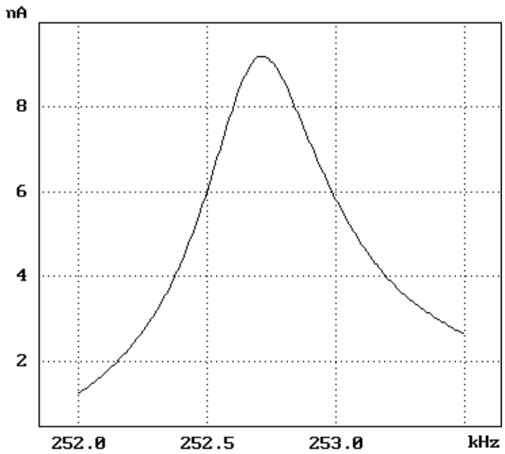

Fig.1. Solid and dotted lines mark RC of cantilever at the places with different damping.

Magnetic dissipation is caused by cyclic magnetization reversal in the sample induced by tip (or vice versa). This dissipation can be quantified [2]. Its value strong depends on tip type and scanning parameters. Results of spectroscopy *amplitude(f, x, y)* applied to garnet film are shown on Fig.2. SPM Solver P47 (NT-MDT, Russia) and FeNiCo thin film tip were used in this work. Measurements were carried out in normal conditions. Higher value of measuring signal corresponds to lighter areas for all images. The stripe domains are seen on both maximal amplitude (Fig.2a) and WHM (Fig.2b) distributions. Darkest areas on Fig.2a correspond to maximal damping (minimal amplitude). Predominant position of darkest areas nearly domain walls can be explained by moving of domain walls by the tip [2]. Maximal damping is observed at the end of the stripe domain (inside white square on Fig.2b: largest WHM corresponds to maximal damping). FRS helps to study any dissipation processes existing during scanning. If the sample consists of areas with different viscosity (e.g. polymer blend) then dissipation can be measured by force-modulation technique. Sample containing of polyethylene layers with different viscosity was measured with FFS in such a way (Fig.3). Decreasing maximal amplitude and increasing WHM for more soft regions are seen.

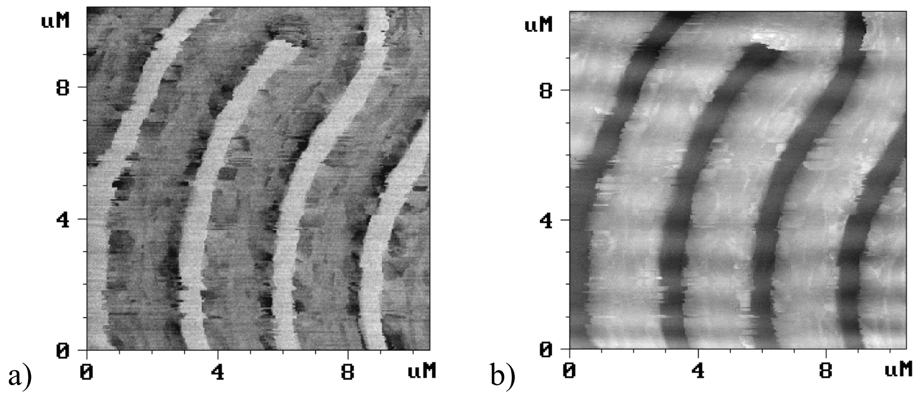

Fig.2. Dissipations images on garnet film. a) maximal amplitude of cantilever RC; b) distribution of WHM of cantilever RC. Both images were obtained simultaneously.

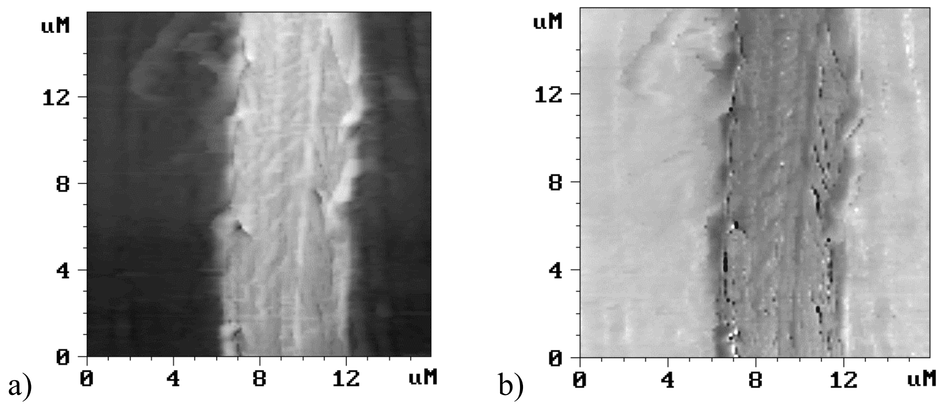

Fig.3. Dissipations images on polyethylene layers with different viscosity. Images were obtained by force-modulation technique. a) maximal amplitude of cantilever RC; b) distribution of WHM of cantilever RC.

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2. R. Proksch, K. Babcock, J. Cleveland, Appl. Phys. Lett. 74(3), 1999, 419-421.