Nanostructuring and nonlinear near-field diagnostics of nanoscale objects on a surface with femtosecond laser radiation and atomic force microscopy

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Atomic force microscopy has become a useful tool for surface nanostructuring and diagnostics on nanoscale with nanometer resolution. To form and study nanostructures on the surface by an atomic force microscope (AFM) tip, we used different regimes of interaction. In the first part of this paper we present the results of nanostructure formation on the surface of polymer films at the mechanical interaction of AFM tip with the sample [1] (Fig. 1). It was shown that both craters (on polymethylmethacrylate (PMMA), polystyrene) and hillock-like nanostructures (on positive photoresist) can be formed on the polymer surface. The craters are produced when the pressure of the tip exceeds the compression strength of the material of the target. The convex nanostructures on the photoresist are formed due to the strong adhesion tension exceeding tensile strength of photoresist.

The second part of the paper is devoted to expanding diagnostic capabilities of the AFM by its combination with optical microscopy. The nonlinear optical response generated during nonlinear interaction of the conductive AFM tip with a single gold nanoparticle in femtosecond laser field is studied both experimentally and theoretically [2] (Fig. 2). We showed that spatial distribution of the nonlinear optical response generated while scanning the surface by the conductive AFM tip irradiated by femtosecond laser pulses expands capabilities for obtaining realistic images of metallic nanoobjects located on the surface. Such method allows more detailed investigation of not only the characteristic sizes of the nanoparticles, but also their shape. This information can be recovered by comparing the experimental measurements with calculation results for the reference objects.

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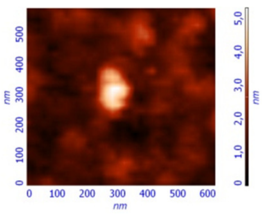
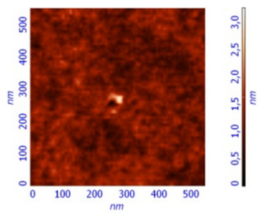
a)  b) 

Fig. 1. a) Hillock-like nanostructure on the positive photoresist and b) crater on the PMMA formed by the silicon AFM tip

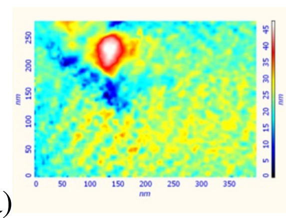
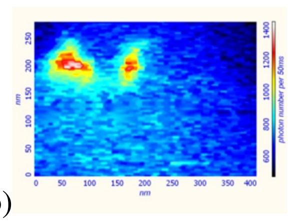
a)  b) 

Fig. 2. a) Surface topography, b) spatial distribution of the photoluminescence for different mutual positions of the AFM tip and the gold nanoparticle in the focus of the femtosecond beam.

References.

[1] A. N. Stepanov, D. A. Yashunin, *Journal of Surface Investigation. X-ray, Synchrotron and Neutron Techniques* **4**, 803 (2010).
[2] A. I. Smirnov, A. N. Stepanov, D. A. Yashunin, *Proc 13th International Conference on Transparent Optical Networks* (ICTON 2011, Stockholm, Sweden, June 26-30, 2011), 1, (2011).