P-73

Study of the surface profiling of silicon based on the method of local anodic oxidation using scanning probe microscopy

V.V. Polyakova[1], I.N. Kots[1], V.A. Smirnov[1], O.A. Ageev[2]

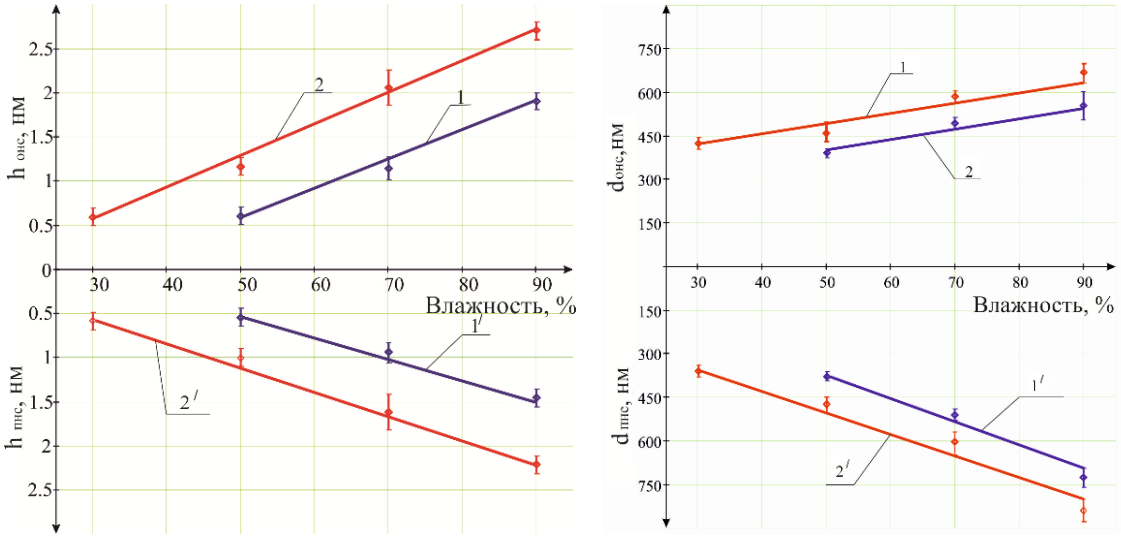
[1]*Southern Federal University, Institute of Nanotechnologies, Electronics, and Electronic Equipment Engineering, Taganrog, Russia*
e-mail: vpolyakova@sfedu.ru, ageev@sfedu.ru

[2]*Southern Federal University, Scientific and Educational Center "Nanotechnology", Taganrog, Russia*

The paper presents the results of studying the methods of nanoscale profiling of the surface of a silicon substrate by the method of local anodic oxidation and liquid chemical etching.

The development of the elemental base of nanoelectronics places high demands on the resolution and accuracy of the technological operations. At the same time, the improvement of the design of the elements leads to a reduction in the minimum dimensions in the formation of elements of micro- and nanoelectronics. Among the methods of lithography, one of the promising is local anodic oxidation (LAO), which provides high spatial resolution, the possibility of profiling the substrate surface without additional photolithography operations, high reproducibility [1]. The method of LAO is implemented using an atomic force microscope (AFM) and allows the formation of oxide nanoscale structures (ONS) on the surface of various materials that can be used in developing and creating elements of micro- and nanoelectronics, resistive memory elements based on memristor structures, lithographic masks, nanowires [2,3]. However, despite the rather large amount of publication on this problem, the regularities of the influence of technological regimes of local anodic oxidation on geometric pairs. The dimensions of the profiled nanosized structures on the silicon surface remain insufficiently studied.

Two methods were developed for profiling the silicon surface. For each of them, at the first stage, on the surface of a silicon substrate, KEF-0.1, the LAO matrix was formed using the Ntegra probe nanoscale laboratory (NT-MDT, Russia) in AFM contact mode using NSG11 cantilevers. According to the first procedure, ONS was removed by liquid etching in aqueous HF (1:3) solution at ambient temperature. As a result, matrices of profiled nanosized structures (PNS) were formed on the silicon surface. Then, the statistical processing of AFM images was carried out using the Image Analysis 2.0 software package, which resulted in the dependence of the geometric parameters of the ONS and PNS of silicon on the relative humidity at different values of the amplitude of the LAO voltage pulses shown in Figure 1.



(а) (б)

Figure 1. Dependence of geometric parameters of nanostructures on relative humidity for different amplitude of voltage pulses (1 - 10V; 2 - 15V): (a) height of ONS and depth of PNS; (b) diameters of ONS and PNS.

According to the second method, silicon ONS obtained by the LAO method at a humidity of 70 ± 1% was used as a mask in liquid etching in a solution of KOH (60%) + IPA (5:1) at 70°C. As a result, a PNS 70 ± 10 nm in height was formed on the silicon surface.

Thus, it is shown that local anodic oxidation is a promising method of probe nanolithography, the use of which allows for surface profiling at the nanometer scale, and can be used to create nanowires, as well as elements of nanoelectronics and nanosystems.

The results of the work were obtained using the infrastructure of the Scientific and Educational Center and the Center for Collective Use "Nanotechnology" of the Southern Federal University.

1. Yu.A. Chaplygin, *Nanotechnology in electronics 3.1* ("TECHNOSPHERE", Moscow), 216 (2016).
2. V.I. Avilov, O.A. Ageev, V.A. Smirnov et al., *Nanotechnologies in Russia* **10**, 214 (2015).
3. M. Baker, A.J. Maguy, K. Vikas, et al., *Nanotechnol Rev*. **3**, 301 (2015).