# APPLICATION OF ION-ELECTRON TECHNOLOGY FOR MODIFYING NEAR-SURFACE LAYERS OF A SILICON SUBSTRATE FOR CREATING ELEMENTS OF MICROMECHANICAL SYSTEMS

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For the production of sensors, the principle of functioning of which is based on changing the electrical capacity, methods are used to create volumetric structures with the greatest thickness and minimum clearance between moving and stationary parts of the sensor, for example, plasma chemical etching. It is believed that this technology provides the best ratio of the depth of the etching profile to its width and channel width to its length at the minimum dimensions of the element. At present, depending on the complexity of the MEMS structure, 5 to 25 operations are required to ensure a minimum thickness of a single layer (0.1-10 μm).

The paper presents the results of studying the possibility of using ion beam technology and Double Beam technology (electron and ion beam alignment) used in electron microscopy to create MEMS elements with high-profile three-dimensional structures of small and medium complexity.

The preparatory irradiation of the Si substrate was performed by $He^+$ and $Ar^+$ ion beams at the VOKAL unit, forming an ion beam with a wide continuous Gaussian energy spectrum with an average energy of 10 keV (radiation dose 1 and $5\times10^{17}$ ion/cm$^2$, residual gas pressure below $5\times10^{-5}$ Pa, the irradiation temperature is <50 ° C), and etching (excision of MEMS elements) was carried out with $Ga^+$ ions on an ion microscope "VERSA 3D" under close conditions.

It is established that when a beam of ions is irradiated by a wide energy spectrum, a developed surface relief is formed with a characteristic sub-roughness value of 10-50 nm, which is due to the presence of interstitial gas atoms in the near-surface layer of the material.

It is shown that the maximum penetration depth of Be and Al atoms linearly depends on the irradiation dose of $He^+$ and $Ar^+$ and reaches a depth of 0.5-1.0 μm at the concentration of interstitial atoms of the order of 10-3 at.%. Analysis of the results of treatment with a $Ga^+$ ion beam showed that it is possible to create three-dimensional structures - MEMS elements with parameters of gaps of 0.1-0.2 μm at depths up to 2 μm on an ion-modified Si-site with dimensions of 5-10 μm.