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Formation of vacuum electronics elements by a combination of methods of focused ion beams and plasma layer etching on SiC

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Vacuum electronics is one of the most important areas of development of micro- and nanoelectronics [1-3]. Due to the significant growing of the electronic and microelectronic industry, the need for new materials is increasing dramatically. Particular importance is the reliability of electronic products and their resistance to various environmental influences. It is known that the effectiveness of electronics devices, especially those working in extreme conditions, significantly depends on improving performance, energy saving and reliability of the element base, including the ability of this work. One of the materials on the basis of which it is possible to produce electronic devices that meet such stringent requirements is SiC. Silicon carbide has chemical stability, high resistance to elevated temperatures and radiation, the possibility of doping it with acceptor and donor impurities. In connection with this fact, the development of devices with field emitters based on SiC is relevant.

Experimental samples, which are plates of purified silicon carbide, were placed in the vacuum chamber of the FIB module and oriented so that the flow of accelerated ions would fall on the substrate in the direction of the normal. The working vacuum during the exposure of the beams was maintained at the level of $1 \div 2 \times 10^{-4}$ Pa. At this stage, an array in the form of pointed emitters was formed on the SiC surface.

The carbon nanoscale layer was formed using the atomic layer etching technique in fluoride plasma. SF_6 was used as a fluorine-containing gas, thanks to which it was possible to etch the near-surface SiC layer [4-6]. Moreover, their crystal lattice was used to remove only Si and the formation of a thin carbon layer on the surface of the samples.

The study of the surface topology at each iteration was carried out using scanning electron microscopy and atomic force microscopy.

At the end of a series of experimental studies, it was found that the presented technology for the production of graphene films on the surface of SiC plates by the method of plasma atomic layer etching makes it possible to obtain a carbon structure in accordance with specified parameters at lower temperatures than during thermal destruction of SiC substrates.

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1. N. Chekurov, K. Grigoras, A. Peltonen, S. Franssila, I. Tittonen, *Nanotechnology* **20**, 5 (2009).
2. T. Nishinaga, X. Q. Shen, *Appl. Surf. Sci.* **82**, 141 (1994).
3. A. Tseng, *J. Micromech. Microeng.* **14**, R15 (2004).
4. V.S. Klimin, I.N. Kots, V.V. Polyakova, A.A. Rezvan, O.A. Ageev, *Proc. of SPIE* **11022**, 110221R (2019).
5. M. Schmidt, Z. Johari, R. Ismail, H. Mizuta, H. Chong, *Microelectron. Eng.* **98**, 313 (2012).
6. V.S. Klimin, A.A. Rezvan, O.A. Ageev, *J. Phys.: Conf. Ser.* **1124**, 071020 (2018).