# Influence of Ion Irradiation of the Surface Graphite and Carbon Fibers

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**Abstract – Surface treatment of graphite and carbon fibers by $N^+$-beams have been carried out and changes in morphology of surface of graphite and carbon fibers have been investigated by using scanning electron microscopy.**

## 1. Introduction

Ion beam irradiation is a prospective method of simultaneous treatment of surface of carbon materials [1]. In this paper, we study the changes in morphology and structure of graphite and carbon fibers after ion irradiation.

## 2. Materials and research methods

The samples were commercially graphite and carbon fiber. The carbon fiber studied in this experiment was PAN based high module type. Diameter of carbon fiber is from 5 to 9 μm. Ion irradiation graphite and carbon fiber carried out by means of a plasma ions source with the hollow cathode, developed in Institute of Electrophysics UrD of the RAS [2] The accelerating voltage is 30 kV. The doze of ions varied from $10^{15}$ up to $5.10^{18}$ $cm^{-2}$.

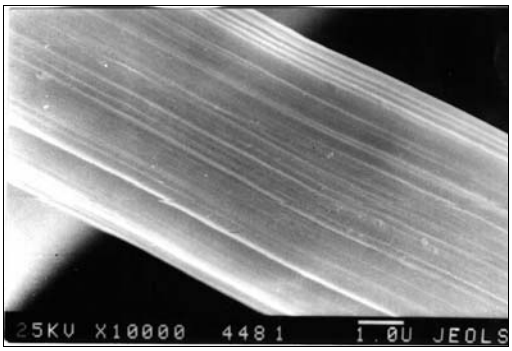
Topography of a surface of graphite investigated by means of a scanning electronic microscope (ion-electron microscope Quanta 200 3D).

The surface of fibers after $N^+$-irradiation ($10^{17}$ – $10^{18}$ $cm^{-2}$) consists of interchanging hollows and projections enclosed transversely to the axis of the fiber (Fig. 1, *c*).

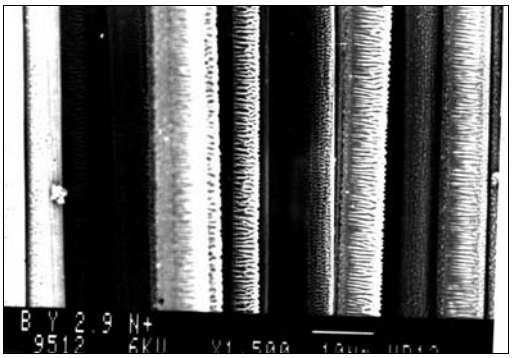
In other words, the fiber is composed of a great number of disks which are located on the top of each other perpendicularly to the axis of the fiber (special, this is appreciably to Fig. 1, *c*).

Crater with growth of a dose of an ion irradiation of graphite (MPG 6) the quantity of craters on graphite surface is increased (Fig. 2); at the same time the quantity of small craters (on diameter) are decreased, and the number of large craters are increased. Depth of craters (graphite type MPG 6), height of roughnesses (pirographite and a carbon fiber) reaches 1.5–2.5 microns at a doze $10^{18}$ ion/$cm^2$.

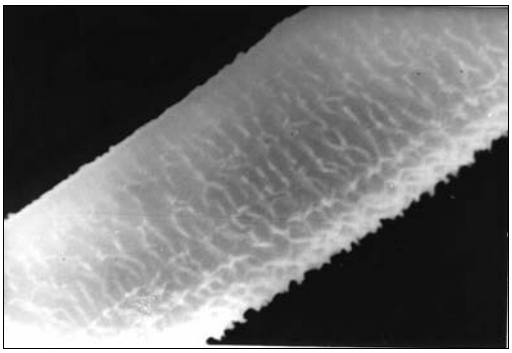
As a result of ion irradiation of pirographite essential change of topography of it$^s$ surface is observed. With growth of a doze of irradiation, occurring accumulation of internal pressure in near surface layer leads exfoliation (Fig. 3, *a*) and even the curvature of a part of the top layers (Fig. 3, *b*) is observed.




*a*




*b*

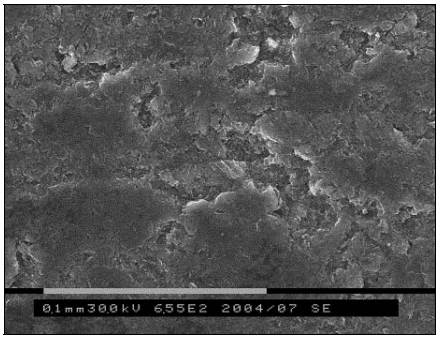


*c*

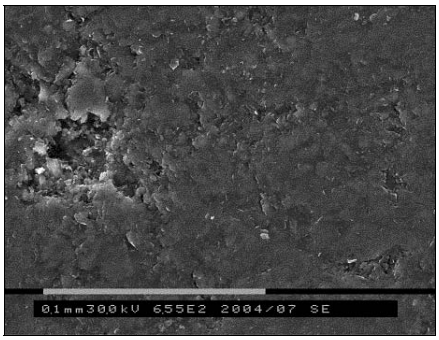
Fig. 1. SEM micrographs of carbon fibers before (*a*) and after (*b*, *c*) ion irradiation (*a* – unirradiated carbon fiber; *b* – $N^+$, $10^{17}$ $cm^{-2}$; *c* – $N^+$, $10^{18}$ $cm^{-2}$)

Thickness modified, with the changed structure, of near surface layer reaches 2 microns (Fig. 4, *a*), that is connected with dispersion, and is possible, even intensive etching of a surface pirographite an ion beam.

On a surface carbon fibers and pirographite after ion irradiation (especially, $N^+$ $5.10^{17}$ – $10^{18}$ $cm^{-2}$) the cellular structure are formed. The form of a cell represents a figure very close under the form to a triangle (Fig. 4, *b*).

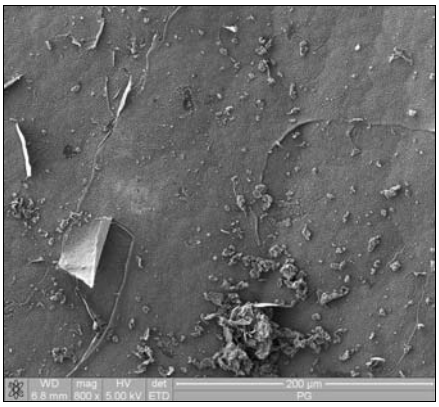



*a*

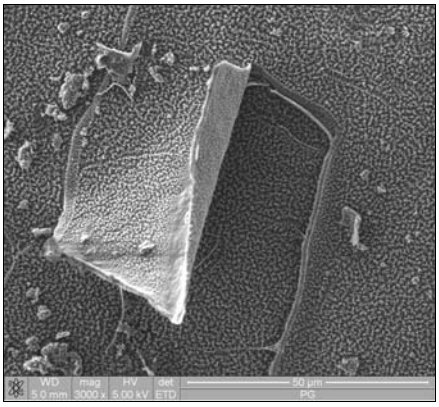



*b*

Fig. 2. Topography of graphite surface after $N^+$ irradiation: *a* – $10^{16}$ $cm^{-2}$, with small craters; *b* – $2 \cdot 10^{17}$ $cm^{-2}$, with large crater

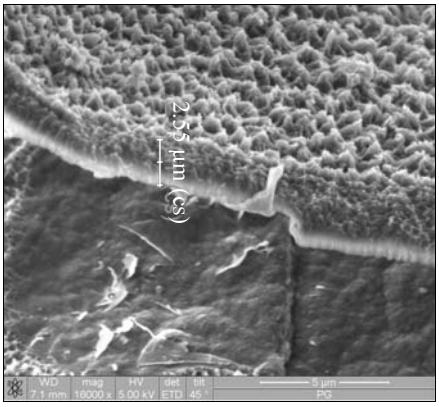


*a*

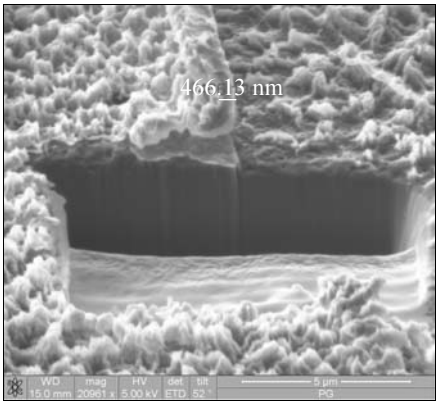


*b*

Fig. 3. Surface of pirographite after ion irradiation ($N^+$, $10^{18}$ $cm^{-2}$ ): *a* – ×800; *b* – ×3000




*a*




*b*

Fig. 4. Thickness of near surface pirographite after ion irradiation ($N^+$, $10^{18}$ $cm^{-2}$): *a* – ×16000; *b* – ×8000

## 3. Conclusion

The topography of a surface, and structure near surface layer of graphite after low-energy $N^+$-ions irradiation are studied.

The structure of a surface: graphite (type MPG6), a carbon fiber and pirographite after ion beam irradiation essentially differs from each other.

To growth of a doze of an ion irradiation there is a change of morphology of a surface of graphite: the roughness of a surface grows, there are occurrence craters the various size and the form, on the irradiated surface is formed mesh (for pirographite ) and, in case of a carbon fiber, so-called “disk” (the fiber after ion irradiation processing represents a set of the disks combined by the basis to each other) structure of a surface.

## References

[1] N.V. Gavrilov, A.E. Ligachev et. al., *in Proc. 12th Int. Conf. of High Power Particle Beams,* Vol. 2, Haifa, Israel, 1998, pp. 1004–1007.

[2] N.V. Gavrilov, *in Proc. of 7th Int. Conf. on Modification of Materials with Particle Beams and Plasma Flows,* Tomsk, 2004, pp. 8–12.