Impact of pulsed plasma beam on the thermal erosion and the surface structure of graphite

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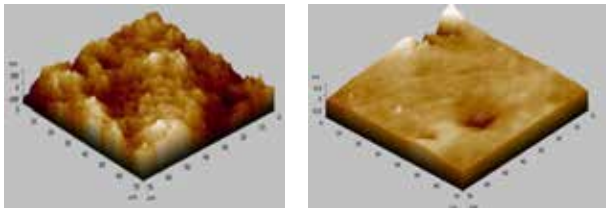
Among materials prospective as plasma-face materials for first wall of fusion reactor a priority is given to the materials with low atomic number, high threshold for physical sputtering, high thermal conductivity, low chemical activity to hydrogen, high thermal resistance and melting point. According to modern point of view, preferred plasma-face materials for tokamaks and future Generation IV reactors should be based on the carbon, beryllium and tungsten. Tungsten is one of the most promising materials for protection of tokamaks diverter plates.

The effect of plasma beam impact on the surface structure changes and thermal erosion of ARW graphite are experimentally studied in present work. For experiments was prepared graphite specimens with dimensions 1×1×0.5 mm^3 from the plate of ARW graphite, which usually used in nuclear reactors. Crystalline structure, surface morphology and weight of specimens were studied before plasma treatment by the X-ray difractometry, atomic force microscopy (AFM), scanning electron microscopy (SEM) and by weighing for determination of weight and hydrostatic density. Examples of AFM images of specimen surface before and after plasma treatment are shown in **Figure 1 a,b**.



a b

Figure 1. Surface morphology of graphite specimen before (a) and after (b) plasma treatment

From **Figure 1,a** can be seen high degree of surface roughness. As follow from X-ray difractometry specimen is polycrystalline graphite with hexagonal structure. Weight of specimens before and after plasma impact is given in **Table 1**.

Table 1. Weight of graphite specimens before and after plasma treatment

#	Weight before treatment m_1, g	Weight after treatment m_2, g	Δ m, G
1	0.772	0.768	0.004
2	0.811	0.810	0.001

Exposure of specimens by pulsed plasma beam was carried out on plasma accelerator of Kazakh National University. Each specimen was undergo by 13 impulses, duration of impulse was 2.5 microseconds, period between impulses was 10 min, energy release in each impulse was Q = 10 J/cm^2/

Investigations of the structure and weight loss by the same methods as before plasma treatment shows:

1. Crystalline structure of treated samples does not change significantly.

2. Surface of specimens become much smoother, compare **Figures 1a** and **1b**. That indicates that thermal erosion of the surface under irradiating by plasma beam takes place. Probably, there has been a melting of the surface under laser beam treatment. Results of the weightings of the specimens before and after treatment (see **Table 1**) is confirms thermal erosion at laser beam treatment.

So, main effects of the laser beam exposure on the surface structure are thermal erosion and surface smoothing.

We also have undertaken theoretical calculation of the mass lost of graphite under laser beam treatment. The calculation was performed in the framework of a model based on the solution of heat conduction equation under pulse release of heat on the surface and determination the depth temperature distribution, taking into account only the sublimation of graphite and the heat radiation from the irradiated surface. Under this model were calculated distribution of temperature fields and the rate of evaporation of graphite depending on the time. According to estimated calculations the mass loss of graphite sample constitute $5 \cdot 10^{-3}$ g, which is consistent with experimental results.