Investigation of Diffusion Processes at Metal Target Irradiation by Pulsed Plasma Flow

A. M. Zhukeshov[1], Z. Mazhit[*2]

[1]Al-Farabi Kazakh National University, Almaty, 050040, Kazakhstan
[2]after S. Toraigyrov Pavlodar State University, Pavlodar, 140003, Kazakhstan
*Z.Mazhit: z.mazhit@psu.kz

Pulsed irradiation of metals and alloys by plasma flows and ion beams follows by an emergence of significant temperature gradients and thermo mechanical stresses in near-surface region of a target [1-3]. Processes of heat and mass transfer are intensified. Diffusion is stimulated by temperature growth. Diffusion coefficients are increased on 5-8 orders of magnitude in compare with their stable values, corresponding to the irradiation in continuous regime. A depth of impurity particles penetration doesn't exceed the value of projectile path length in metals. At deceleration of the impurity particles their collisions with atoms nuclei cause atoms displacement of crystal lattice sites. Because of medium continuity a dominant mechanism of structural damages creation could be atom-atomic collisions cascades, which involve large area, several times exceeding a volume of near-surface region of the target. It is obvious, that the large part of diffusion flow is transferred within displacement cascades [1].

At high temperature plasmas impact on the target hot ions reach the surface practically with no energy loss. Since electrons are more mobile to neutralize ion charge a cold electron flow from the edge plasma emerges. Because of interaction of hot electrons with the cold ones the energy of electrons, hitting upon the surface, is less on order than the energy of falling ions. Corresponding estimates for plasmas interaction with diverter plane, the first edge of thermonuclear reactor, are proposed in [4]. So the predominant factor is the interaction of ions with solid.

A purpose of the article is to estimate magnitudes of concentrations of implanted ions, vacancies and interstitial atoms at impact of pulsed nitric plasma flow on a sample of stainless standard prepared austenitic steel.

Non-uniform heating of the target has been determined by the heat transfer equation [1-3]. Diffusion equations system for nitrogen ions, vacancies and interstitial atoms of the target, initial and border conditions are written. A simulation is accomplished for the next parameters of the plasma flow: the surface density of absorbed energy flow, q_0=50 J/cm^2; the pulse duration, τ=10 μs.

At first approach the impurity ions (nitrogen) penetration process is supposed to be isothermal, besides subsurface layers of the target is close to the melting temperature. Of interest is the process flowing during time interval of an order of the pulse duration, with the embedded impurity diffusion in subsurface layers being thermal-stimulated.

Temperature space profiles at different time moments and concentration space profiles of the embedded ions, vacancies and interstitial atoms have been obtained. The space profiles of temperature and embedded ions concentration space profiles have been compared with experimental data. The profiles agree with them.

References

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