Nanostructured surfaces

Pattern selection in a surface layer of irradiated foils: effect of the surface layer temperature variations

Kharchenko D.O., Kharchenko V.O., Bashtova A.I., Lysenko I.O.

Institute of applied physics, Natl. Acad. of Sci. of Ukraine. Petropavlivska Str., 58, Sumy 40000, Ukraine.
E-mail: dikh@ipfcentr.sumy.ua

We have studied self-organization of nano-structures at solid surface by means of spatio-temporal evolution of both vacancy ensemble and conjugated temperature field of the surface layer. It was shown that pattern selection processes are realized due coupling between defect concentration and surface layer temperature. Using linear stability analysis the phase diagram for emergence of pattern selection processes is obtained in the plane defects production rate *versus* bath temperature. Assuming stochastic properties of defects production we have shown that its stochastic contribution can reduce the domain of system parameters responsible for pattern selection processes. By using numerical analysis we have shown oscillatory dynamics of both vacancy concentration and the surface layer temperature. It was found that pattern selection processes are accompanied by decaying oscillatory dynamics of dispersions of both vacancy concentration and temperature fields. We have shown that morphology of vacancy islands emergent due to generation of nonequilibrium defects and nonlinear dynamics of the system can be controlled by positive feedback of the surface layer temperature, defect production rate and environment temperature. At low defects production rate spherical vacancy islands (holes) are realized, whereas at elevated defects rate elongated patterns (type of ripples) emerge.

Studying dynamics of distribution functions for the surface layer temperature we have shown that initially unimodal distribution of the temperature field becomes bimodal when stationary vacancy clusters are organized. The local temperature is higher in the vicinity of vacancy cluster locations. Considering dynamics of vacancy concentration distribution function we have shown that transition from initially unimodal distribution toward multimodal one during defects production characterizes formation of vacancy clusters at the surface of examined thinfoil/film. Using typical data for bcc metals irradiated by self-ions (with damage rate up to two orders comparing to neutron irradiation) it was shown that the averaged size of vacancy islands varies in the interval from 30 to 300 nm depending on the defect production rate. The mean size of vacancy islands evolves in oscillatory manner due to realization of pattern selection processes.