Investigation of the influence of irradiation on Structural properties of AlN ceramics

Kanat Dukenbayev[1], A. Kozlovskiy[2], I. Kenzhina[2], D. Tosi[1], M. Zdorovets[2]

[1]*School of Engineering, Nazarbayev University, Astana, Kazakstan*
[2]*The Institute of Nuclear Physics of Republic of Kazakhstan, Astana, Kazakhstan*

E-mail: *kdukenbayev@nu.edu.kz*

One of the essential tasks of modern materials science is the studying of the interaction of various types of ionizing radiation with structural materials that have a promising application in reactor engineering [1-3]. Moreover, the creation of new radiation-resistant materials must take into account the effect of ionizing radiation on the resistance to defects formation in the structure and their subsequent evolution, which can lead to deterioration in operational properties of materials. Also, the energy losses of incident ions in matter directly affect defects formation in ceramic materials. Ionizing radiation can initiate dynamic processes associated with the violation of the atomic structure of ceramics, as well as the formation of metastable phases that can lead to partial amorphization and structural failure. The appearance of new metastable phases and the subsequent amorphization of the structure are the most common effects in irradiation of ceramic materials: AlN, TiO_2, Si_3N_4, and SrO_2.

The paper presents the results of investigation of defect formation in AlN ceramics under Fe^{+7} - ion irradiation with fluence from 1×10^{11} to 1×10^{14} ion/cm^2. The change in the main crystallographic characteristics, the decrease in the magnitude of Griffith's criterion, and the increase in the average voltage as a result of irradiation are caused by the appearance of additional defects in the structure and their further evolution leading to a change in the degree of crystallinity. For samples irradiated with Fe^{+7} ions to a dose of $1x10^{11}$ ion/cm^2, the formation of pyramidal chillocks is observed on the surface, whose average height is 17-20 nm. An increase in the irradiation dose leads to an increase in chillocks size and their density. At the same time, at large irradiation doses, the formation of conglomerates of chyllocks and grooves on the samples surface is observed. The change in surface morphology, the formation of chyllocks on the ceramic surface, and the dependence of the change in crystallographic characteristics during irradiation make it possible to unambiguously associate the formation of radiation defects in the structure of the ceramic with energy losses in elastic and inelastic interactions of iron ions with lattice atoms.

[1] Liu Yi, et al. Ceramics International 43.16 (2017) 13618-13621.
[2] Jin, Ke, et al. Journal of Applied Physics 115.4 (2014) 044903.
[3] Zhang, Yanwen, et al. Journal of applied physics 95.5 (2004)2866-2872.