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Study of multilayer microstructure by XRD using noncoplanar measurement geometry

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The development of structural materials for nuclear application is of great importance. Along with it, the development of radiation tolerant coatings for the application in reactors is of no less importance [1]. One of the kinds of such protective coatings that often used is nitride-based ceramics due to their specific combination of properties suitable for the nuclear application [2]. Radiation environment induces different kinds of damages in the materials which results in their degradation. One of the radiation induced effects is the appearance of point defects. The presence of boundaries proved to be very effective in reducing the number of such defects. Therefore multilayer systems are considered as coating materials. In the present study we consider multilayer thin coatings ZrN/Si3N4 with different thicknesses of monolayers: unirradiated and irradiated by He+ ions. In order to estimate the effect of radiation on these coatings we investigate the modification of microstructure before and after irradiation.

One of the effective methods used for structural characterizations is the X-ray diffractometry. Due to the presence of texture, performing the measurements in coplanar geometry (e.g. conventional θ/2θ scan) turns out to be not effective: it enables to obtain only two or even one reflection. In order to perform more reliable analysis of microstructure it is necessary to use more reflections. Taking into account the presence of texture one can evaluate the directions in which the best conditions for the observation of different reflections are realized. The use of noncoplanar measurement geometry [3] enables to obtain five reflections for the samples under consideration. Such type of measurement requires a special type of experimental data processing.

In this investigation the diffraction profile broadening is conditioned by the small grain size and instrumental function, the grains being modeled as having an ellipsoidal shape with two equal axes. The measured reflections are connected in one scan for the simultaneous fitting by the theoretical curve. In the result of the fitting procedure the microstructural parameters were estimated.

The results obtained by X-ray diffraction are in good agreement with those obtained from transmission electron microscopy.

[1] Wan, Q. et al. (2016). Surf. Coat. Technol. 305. 165-169.

[2] Wang, H. et al. (2007). Nucl. Instrum. Methods Phys. Res., Sect. B. 261. 1162-1166.

[3] Benediktovitch, A., Feranchuk, I., Ulyanenkov, A., Theoretical Concepts of X-ray Nanoscale Analysis, Heidelberg: Springer, 2013, 318 p.

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