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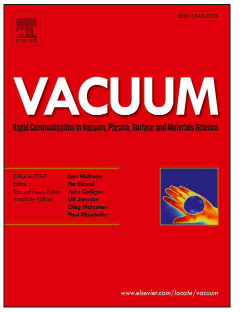

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Influence of irradiation temperature on properties change of AlN ceramics

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Abstract

The paper presents the results of studying the effect of irradiation of Fe^{7+} ions with an energy of 1.5 MeV/nucleon on structural properties of AlN ceramics at an irradiation temperature of 300, 500, 700 and 1000 K. The choice of ion type and irradiation conditions was made by studying the processes of defect formation as a result of particles effect with energies close to fission fragments of nuclear fuel (≤90-100 MeV) and temperatures 0.1 - 0.3 T_{melt}, typical for annealing defects. From the data obtained by the XRD, SEM, EDX methods, it is established that an increase in irradiation temperature above 500 K leads to a reduction in distortions and deformation of the crystal lattice under irradiation. It was found that with an increase in the irradiation dose, amorphous-like grains with a high oxygen content are formed in the structure, which are characteristic for the impurity phase of Al_2O_3, the content of which in the ceramic structure does not exceed 5%. In this case, an increase in the irradiation temperature leads to a decrease in impurity phase concentration in the structure. It has been established that for samples irradiated at high temperatures 700-1000 K, the decrease in strength properties is less than for samples irradiated at a temperature of 300 and 500 K. Such a difference can be explained by partial annealing and annihilation of defects as a result of elevated temperatures. The decrease in thermal conductivity coefficient in irradiated samples is due to an increase in defects concentration in structure, as well as a decrease in their mobility.
Keywords: ceramic materials, heavy ions, hillocks, crystal surface, radiation defects.

Introduction

The development of nuclear industry and nuclear power requires the use of new classes of materials that meet high mechanical, thermal, insulation requirements, and must have high radiation resistance to various types of ionizing radiation [1-3]. One of the classes of new materials corresponding to these requirements are ceramic materials based on oxides or nitrides. Because of their unique physical-chemical, structural, thermal conductivity and insulating properties, ceramics based on aluminum nitride are considered as one of the promising materials of the reactor core of IV generation reactors [4,5]. One of the crucial conditions for the applicability of ceramic materials is their resistance to radiation and ionizing radiation [6-10]. Ionizing radiation can cause structural distortions, non-equilibrium and amorphous regions, capable of causing a significant change in the insulating and heat-conducting properties, may arise in it [11-15]. At present, there are numerous evidences of defects formation, and changes in their form, shape, speed, depending on the type of radiation and irradiation conditions [16-20]. The study of ionizing radiation effect is comparable in energy to fission fragments of uranium nuclei (≤90-100 MeV) on structural properties and operational characteristics of ceramic materials and has both scientific and practical significance. In this case, irradiation with heavy ions at temperatures from 0.1 to 0.3 T_{melt}, characteristic for annealing defects in the structure, makes it possible to estimate the contribution of radiation defects to the change in the structural properties of ceramics, and also to simulate the conditions closest to reality. During irradiation at high temperatures in ceramic materials, point defects become more mobile, that leads to their accelerated migration along the structure and subsequent annihilation. However, an increase in the time and dose of irradiation leads to defects accumulation that does not succeed in