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P98 - An observation of the open pore formation and ion guiding effect in corundum implanted with Ti ions and irradiated with 90 MeV Kr ions

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Open pore formation and ion guiding effect was detected in a modified polycrystalline corundum (α -Al₂O₃). Modification was done via ion implantation (MEVVA implantation) with irradiation using swift heavy ions (SHI irradiation). MEVVA implantation was performed at energies of 50-150 keV, fluence of about 10^{17} Tiⁿ⁺/cm² (n=1,2,3), room temperature (RT). Parameters of SHI irradiation are energy of 90 MeV, fluence of about 10^{12} and 10^{14} Kr¹⁵⁺/cm², residual vacuum of $(6-8) \times 10^{-4}$ Pa, RT. Ti, Al, O were depth-profiled using RBS and ResBS ⁴He⁺ ions (elastic resonance in scattering of ¹⁶O(⁴He,⁴He)¹⁶O at energy in the vicinity of 3.045 MeV). SEM and AFM microscopy was applied for an analysis of the surface morphology. MEVVA as-implanted samples were thin-film layered composite, electrically conducting structures at a dielectric surface with nanoparticles of metallic Ti nanoparticles after SHI irradiation. But at the same time, considerable oxygen enrichment (by half) of the buried modified layers was observed. Last observation is in a good agreement with one of the mechanism of surface oxidation of Fe thin films subjected to SHI irradiation under different regimes described in literature. At normal incidence of a ⁴He⁺ probe beam onto the sample surface of the irradiated corundum a spectrum energy shift was observed in a resonant yield of ⁴He back-scattered on nuclei of ¹⁶O in the buried layers. Similar shift was not observed at grazing incidence of the beam onto the surface. Energy shift may be explained by a so-called “ion guiding-effect” described in detail, for example, in one of the multiple recent reviews in the literature. AFM analysis revealed a formation of “hillocks” of 250 nm in diameter and about 50 nm in height on some areas of the MEVVA as implanted samples. SEM analysis showed a presence of the open pores on irradiated sample surface (MEVVA+SHI) that are charged under an analysing electron beam bombardment. The results of SEM microscopy unexpectedly coincided with observation data of one the experimental work in literature where open stoichiometric pores were observed in an ion crystal (NaCl) after being subjected to MeV electrons at high dose and the simple mechanism of their formation (similar to for Al₂O₃) is theoretically proved. Obtained results suggest that MEVVA+SHI processing may form oriented perpendicular to surface closed cylinder shaped pores of few nm in diameter and several tens of nm in length.

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