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Migration behavior of silver in SiO2-SiC double layer

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In nuclear fuels, thin film diffusion barriers are necessary to prevent the release of radioactive waste products. The combination of chemically stable silicon carbide (SiC) and silicon oxide (SiO2) layers was considered to be beneficial in preventing the release of silver from TRISO particle fuel, at normal reactor operating temperatures (between 800 and 1000 ℃). However, it is important to investigate the efficiency of the SiO2–SiC double layer at higher temperatures, similar to temperatures under accident conditions. In this study, 300 keV silver (Ag) ions were implanted into polycrystalline SiC to a fluence of 1×1016 ions/cm2 in vacuum at room temperature and 600 ℃. The as-implanted SiC samples were coated with SiO2 layers to a thickness of about 100 nm, using DC magnetron sputtering. After SiO2 deposition, the samples were subjected to sequential isochronal annealing at temperatures ranging from 1100 to 1400 ℃ in steps of 100 ℃ for 5 hours, using a vacuum tube furnace. The thickness of the SiO2 layers before and after annealing as well as and the migration behavior of Ag in the SiO2–SiC double layer were investigated using Rutherford backscattering spectrometry (RBS) and annular bright-field scanning transmission electron microscopy (ABF-STEM). Our investigations show no diffusion of Ag in SiC after annealing at 1100, 1200 and 1300 ℃. However, annealing at temperatures from 1100 to 1300 ℃ caused partial sublimation of SiO2 layer and thermal etching of SiC surface. Moreover, RBS results showed that annealing at 1400 ℃ resulted in the complete sublimation of SiO2 layer from the surface of SiC, while thermal etching of SiC caused a shift in the Ag depth profile towards the surface. This indicates that SiO2 is not suitable for use as an additional diffusion barrier for SiC where temperatures in a nuclear reactor can reach 1600 ℃ during accident conditions.

Notes

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