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Structural changes of swift heavy ion irradiated spark plasma sintered ZrC/SiC solid solution

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High temperature nuclear reactors use TRISO (tristructural isotropic) fuel particles for containment of radioactive fission products. TRISO particles consist of uranium oxide coated uniformly with low density pyrocarbon, high density inner pyrocarbon, silicon carbide (SiC), and dense outer pyrocarbon. In these particles, SiC is the main barrier for containing solid fission products. These particles retain most fission products with the exception of silver, europium at temperatures below 1000 ℃. It has been suggested that it would be advantageous to add a thin ZrC layer (in addition to the normal SiC layer) or replace SiC layer with ZrC. This is because ZrC has a high melting temperature of 3540 ℃, low neutron capture cross section, corrosion resistance to fission products, relatively low density, excellent thermal stability and high hardness. There are few studies on the irradiation resistance of ZrC and ZrC/SiC that have been reported. This study investigates the effects of swift heavy ions on the structural changes of spark plasma sintered ZrC/SiC solid solutions.
The microstructure changes of spark plasma sintered ZrC/SiC solid solution irradiated by swift heavy ions at different fluences from 10 12 to 3×10 14 ion/cm 2 at room temperature were studied using the synchrotron-based X-ray diffraction (XRD) characterisation. The surface morphology of the ZrC/SiC samples was analysed using an ultrahigh resolution field-emission scanning electron microscopy (FE-SEM, Zeiss Ultra Plus). Raman spectroscopy was also used to study changes in vibration modes of the ZrC/SiC structure. The synchrotron-based XRD results showed that as the Xe 26+ ion fluences increased during irradiation, the peaks of the XRD pattern broadened and shifted to the left. This is an indication of crystal structure distortion and strain in the material. The crystallize size and the volume of the lattice changed with change in ion fluences. The changes in the surface morphology with ion fluences were not very significant. The evolution of free carbon was observed to decrease in the samples as the ion fluencies decreased. This means that there was some level of crystallization and structural rearrangement of the material. The detailed discussion of the structural changes of the irradiated ZrC/SiC samples at different ion fluences will be presented in the paper.

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