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Investigation of the Performance of Different Zirconium Microstructures under Extreme Irradiation Conditions

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Abstract

The safe and continued operation of the US nuclear power plants requires improvement of the radiation resistant properties of materials used in nuclear reactors. Zirconium is a material of particular interest due to its use in fuel cladding. Studies performed on other materials have shown that grain boundaries can play a significant role on the radiation resistant properties of a material. Thus, the focus of our research is to investigate the performance of different zirconium microstructures under irradiation conditions similar to those in commercial nuclear reactors. Analysis of the surface morphology of zirconium both pre- and post-irradiation was conducted with Scanning Electron Microscopy (SEM). Cold-rolled (small-grain microstructure) and annealed (large-grained microstructure) zirconium samples were mechanically polished in order to be irradiated. Room temperature irradiation of zirconium samples was conducted at energies of 100 eV and 1 keV with He^+ ions at a flux of 1 $x10^{20}$ m^{-2} using a gridded ion source. High temperature (350 and 700 ^{0}C) He^+ irradiations were performed at an energy of 100 eV using a gridless end-hall ion source at the same flux. Transmission Electron Microscopy (TEM) was conducted to determine the grain size of the zirconium samples. Preliminary results show greater surface damage on the rolled zirconium samples than on the annealed samples for all irradiation cases. The difference in damage was most evident in high temperature irradiations. These findings suggest that large-grained zirconium may be more suitable for fuel cladding applications. Further testing will be performed using higher fluxes, temperatures and energies.

Keywords

Zirconium, radiation resistance, microstructures, irradiation, rolled, annealed

References

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