Materials Science & Engineering Master's Defense

Evaluation of the Mechanical Properties of Uranium Dioxide Doped with Oxide Additives

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abstract

The United States Department of Energy (DOE) has always held the safety and reliability of the nation's nuclear reactor fleet as a top priority. Continual improvements and advancements in nuclear fuels have been instrumental in maximizing energy generation from nuclear power plants and minimizing waste. One aspect of the DOE Fuel Cycle Research and Development Advanced Fuels Campaign is to improve the mechanical properties of uranium dioxide (UO_2) for nuclear fuel applications.

In an effort to improve the performance of UO_2, by increasing the fracture toughness and ductility, small quantities of oxide materials have been added to samples to act as dopants. The different dopants used in this study are: titanium dioxide, yttrium oxide, aluminum oxide, silicon dioxide, and chromium oxide. The effects of the individual dopants and some dopant combinations on the microstructure and mechanical properties are determined using indentation fracture experiments in tandem with scanning electron microscopy. Indentation fracture experiments are carried out at room temperature and at temperatures between 450° C and 1160° C.

The results of this work find that doping with aluminosilicate produces the largest favorable change in the mechanical properties of UO_2. This sample exhibits an increase in fracture toughness at room temperature without showing a change in yield strength at elevated temperatures. The results also show that doping with Al_2O_3 and TiO_2 produce stronger samples and it is hypothesized that this is a result of the sample containing dopant-rich secondary phase particles.

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