The Development of Metallic Fuels for Actinide Transmutation

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Abstract

Idaho National Laboratory (and its predecessor Argonne National Laboratory-West) has a long tradition in studying the properties and behavior of metallic fuels for performance in fast reactor applications. Over the past 10+ years, efforts have been specifically directed towards closing the fuel cycle and studying the fabrication, properties, and reactor performance of (U,Pu,Np,Am)Zr alloy systems. Uranium free fuel compositions intended for accelerator based transmutation technologies, uranium bearing fuel compositions intended for fast reactor based transmutation technologies, and fuel compositions including fission product lanthanide element carryover from the molten salt electrochemical separations process ("pyro-processing") have been studied to date. Fabrication technologies have been developed and issues such as americium volatility addressed to success. The pre-irradiation characterization of the alloys including phase diagram and thermophysical property measurements, microstructure, room temperature as-cast phase and thermal cycled phase formation, variable high temperature XRD phase identification, transition temperatures including melting points, enthalpies of transition and heat capacity by DTA and DSC, thermal expansion by dilatometry or TMA, thermal diffusivity, and thermal conductivity. Post-irradiation examination of low and high burnup fuel samples is proceeding with results limited to date to non-destructive examination (NDE) and preliminary optical microscopy (metallography). Of particular interest is the recent application of advanced measurement techniques to the fuels, in both pre- and post-irradiation studies, and the use of these results in conjunction with fuel modeling and simulation efforts. Studies to date include employment of a focused ion beam (FIB) on irradiated fuels to create lamella for EBSD analysis to experimentally reveal grain orientation in the irradiated fuel, which can then be input to the computational effort to investigate the effect on fission gas migration. These type studies will be overviewed as well as possibly other advanced instrumentation studies on transmutation fuels from atom probe tomography, 50 μm spatial resolution thermal diffusivity, micro-focus X-ray diffraction, and electron probe microanalysis.