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Postirradiation characterization of AFC metallic fuel alloys concepts.

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A long-term objective of the Advanced Fuels Campaign (AFC) is the investigation into enabling technologies that allow for improving nuclear fuel performance and for the transmutation of minor actinides in sodium fast reactor. As part of this development, candidate fuel compositions and forms are irradiated in a cadmium-shrouded positions at the INL's Advanced Test Reactor (ATR), and they are subsequently examined at the Material Fuel and Complex (MFC) facilities. In addition to and complementary to ATR experiments, systematic characterization of experiments irradiated in true fast reactors (e.g. Phenix, EBR-II, FFTF) are also performed in order to assess ATR simulated fast reactor testing effectiveness.

Recent irradiation experiments have explored new alloys and geometric forms beyond what has historically been irradiated (U-10Zr / U-20Pu-10Zr, 75% smeared density, sodium bonded fuel) to overcome primary limiting performance factors, such as: high swelling rate at higher burnup (design tested: annular fuel, low smear density, alternative alloying metals) and fuel cladding chemical interaction (FCCI) from lanthanides fission products (design tested: additives, liners / coating) and to assess the performance of adding minor actinides (Am, Np) to the metallic fuel systems.

The minor actinides behavior has been assessed through a suite of characterization techniques on three transmutation metallic fuel experiments and focus was concentrated on microstructural evolution under irradiation. Metallic fuel samples were taken from sibling experiments AFC-1H (experiment in ATR) and DOE1 FUTURIX-FTA (experiment in Phenix) both comprising metallic fuel alloys of 35U-29Pu-4Am-2Np-30Zr composition. In addition, samples were analyzed from a unique transmutation experiment in EBR-II, X501, with a fuel composition of U-20.2Pu-9.1Zr-1.2Am-1.3Np.

Regarding the innovative fuel design, engineering scale postirradiation examination have been performed to understand the overall behavior of this new fuel form at relatively low burnup (between 2-4 %FIMA) from various irradiation experiments in ATR (AFC-3 and -4 series). The main alloys studied were U-10Zr annular fuel, U-10Mo, U-10Zr with Pd addition.

Postirradiation examinations at engineering and microstructural scale for transmutation metallic fuel alloys and from AFC-3 series experiments will be presented and discussed in this work.

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