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Fuel Cycle Research and Development:

Core Materials Technologies Advanced Materials for Fast Reactor Core Applications

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DOE NE Materials-Cross-Coordination Webinar

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Advanced Fuels Campaign Mission & Objectives in the Fuel Cycle Research and Development Program

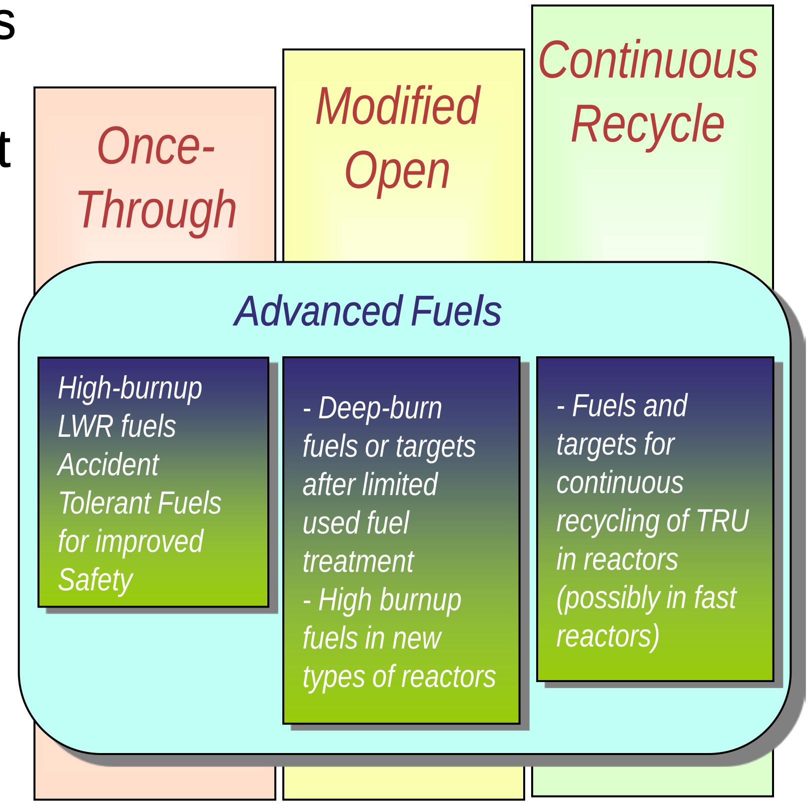
- **Mission**

  Develop and demonstrate fabrication processes and in-pile (reactor) performance of advanced fuels/targets (including the cladding) to support the different fuel cycle options defined in the NE roadmap.

- **Objectives**

  Development of the fuels/targets that
  - Increases the efficiency of nuclear energy production
  - Maximize the utilization of natural resources (Uranium, Thorium)
  - Minimizes generation of high-level nuclear waste (spent fuel)
  - Minimize the risk of nuclear proliferation

- **Grand Challenges**
  - Multi-fold increase in fuel burnup over the currently known technologies
  - Multi-fold decrease in fabrication losses with highly efficient predictable and repeatable processes



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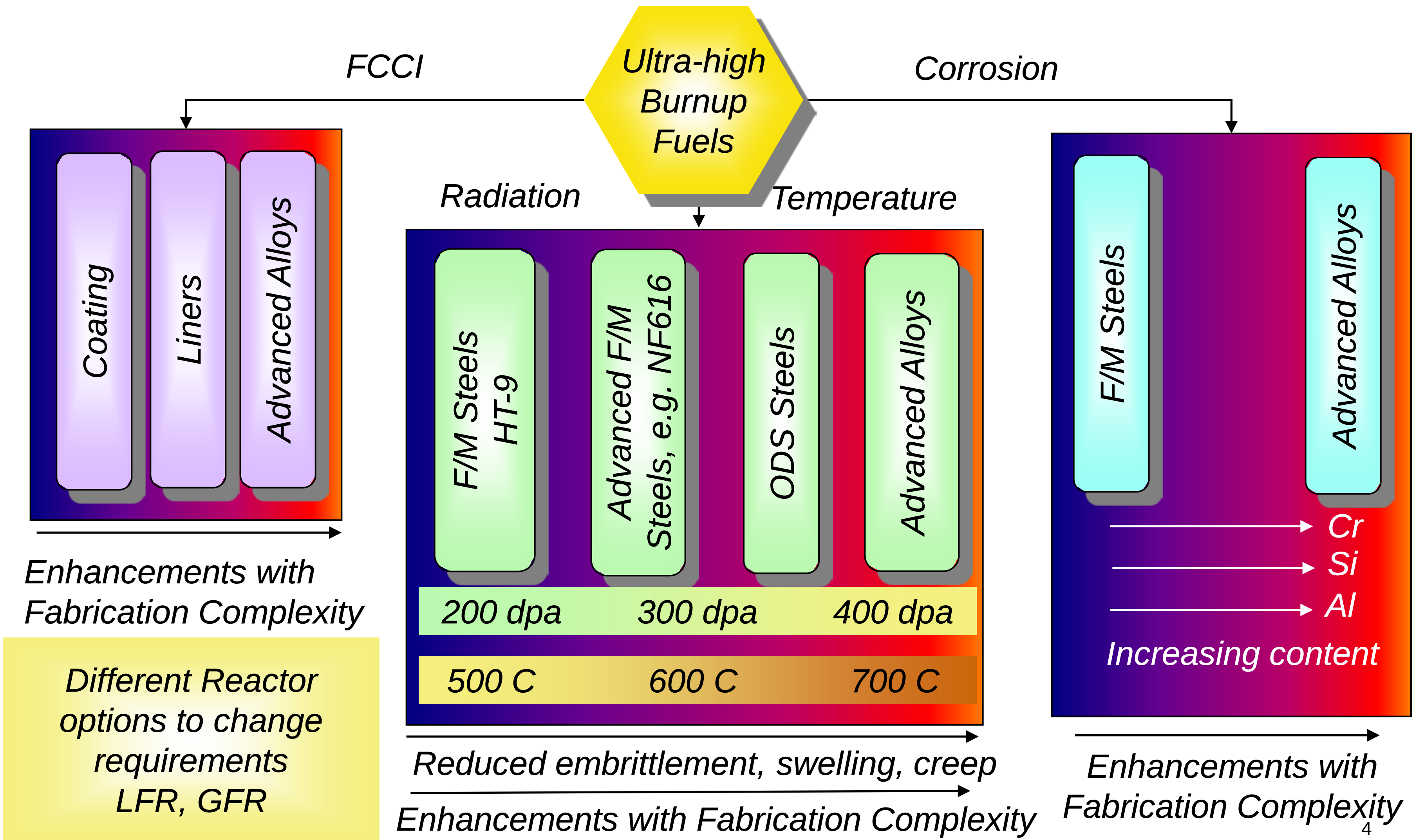
Approach to Enabling a Multi-fold Increase in Fuel Burnup over the Currently Known Technologies

Ultimate goal: Develop advanced materials immune to fuel, neutrons and coolant interactions under specific reactor environments

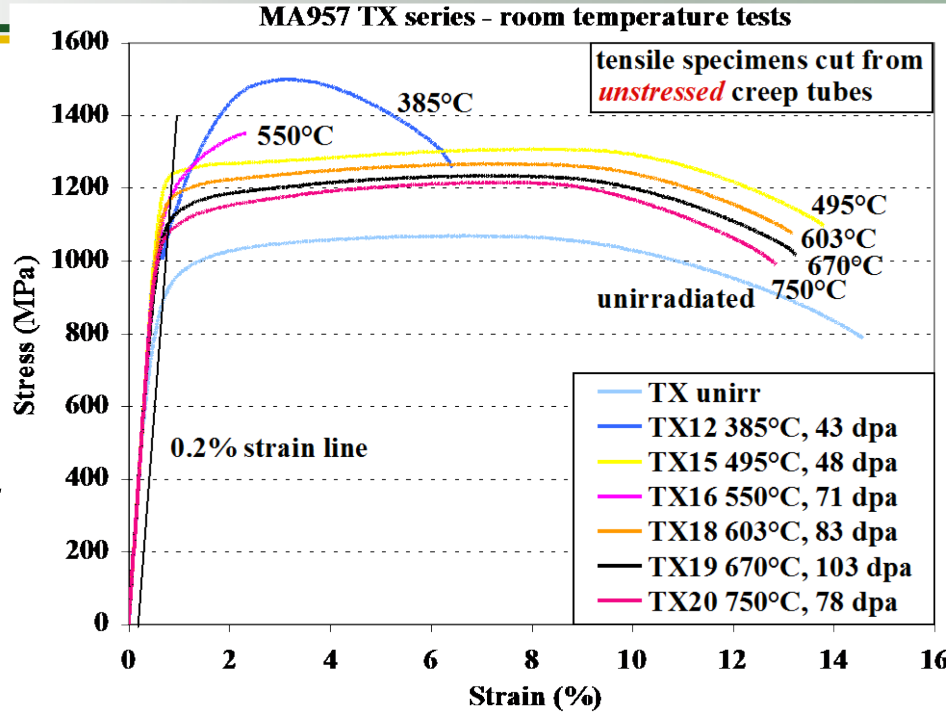


Objectives

- **Qualify HT-9 to Radiation Doses >250 dpa**
  - Test previously irradiated materials (ACO3 duct and FFTF/MOTA specimens)
  - Measure data for model development – rate jump testing
  - Extend irradiation data to higher doses – Re-irradiation of specimens in BOR-60
- ***Develop Advanced Radiation Tolerant Materials***
  - *High dose irradiation testing*
  - *High dose ion irradiation testing*
  - *Scale up ODS processing (15 kg milling runs complete)*
  - *Tube production and weld development*
- **Develop Coatings and liners to prevent FCCI**
  - Diffusion couple test
  - TiN coating on tube

Analysis of High Dose Neutron Irradiated MA957 Tubing Underway at PNNL

- **Irradiation conditions**
  - (385° C, 18-43 dpa)
  - (412° C, 110 dpa)
  - (500-550° C, 18-113 dpa)
  - (600-670° C, 34-110 dpa)
  - (750° C, 33-120 dpa)
- **Status**
  - First set of room temp tensile tests complete.
  - Initial microstructural exams using APT complete.
  - In-reactor creep and swelling response analyzed.
  - 500 dpa ion irradiations complete with measured swelling.
- **Current post-irradiation results:**
  - Tensile: No loss in ductility at all but lowest irradiation temperature exhibits higher strength.
  - In-Reactor Creep: Comparable to HT-9 in creep resistance to up to 550° C, much better resistance at 600° C and higher.
  - Swelling: No swelling after 110 dpa neutrons. Slight swelling after 100 dpa ions, 4.5% max swelling after 500 dpa ions:
  - Microstructure from APT: See next slide.



Scale Up Production of 14YWT Ferritic Alloy (Heat FCRD-NFA1)

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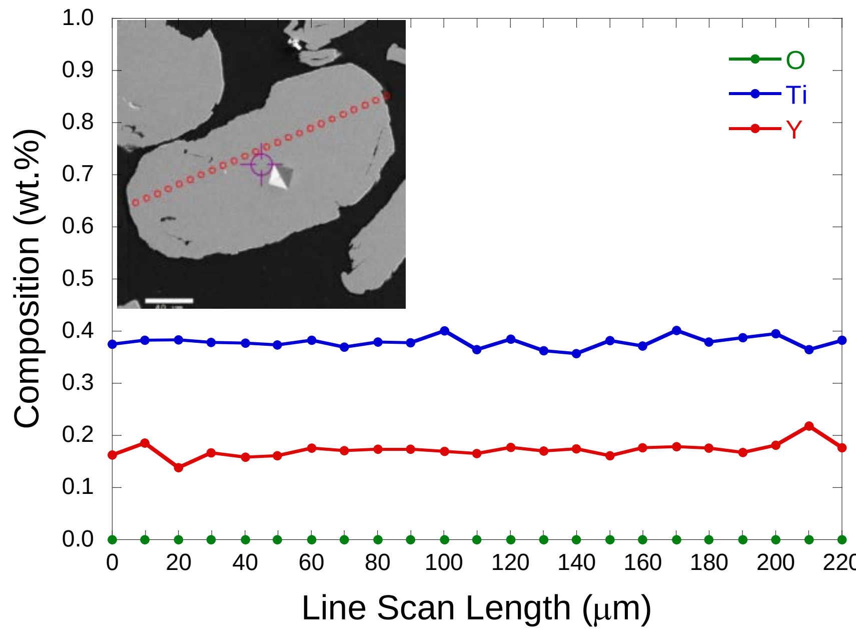
- 4 of 4 ball milling runs completed by Zoz
  - V540-01: 15 kg of coarse (>150 μm) powder
  - V540-02: 15 kg of medium (45-150 μm) and fine (<45 μm) powder
  - V540-03: 15 kg medium, fine and small amount of V540-01 coarse powder
  - V540-04: 15kg medium, fine powder mixed with yttria for the oxide dispersion.

V540-02 Ball Milled 40 h	
MET. SPECIMEN NO: 12-0581	
LOAD in grams: 200	
Indent no.	HV
1	723.57
2	744.47
3	726.78
4	713.14
5	700.18
6	768.03
AVERAGE =	729.36
STD =	23.99

- EPMA showed 40 h ball milling distributed Y uniformly in fine and medium powders
- 40 h ball milling did not distribute Y uniformly in coarse powders
- Mechanical testing underway.



High Toughness ODS Ferritic Alloy Development in FC R&D (I-NERI)

- ***Development and Characterization of Nanoparticle Strengthened Dual Phase Alloys for High Temperature Nuclear Reactor Applications***
- **To develop high toughness NFAs* for high temperature (700ºC) high dose (>300 dpa) applications: 100 MPa√m over the range of RT - 700°C.**
- **Use grain boundary strengthening/modification techniques.**
- ***ORNL (TS Byun & D.T. Hoelzer) – KAERI (JH Yoon)***
- ***Dec. 1, 2010 – Nov. 30, 2013***

***** *Nanostructured Ferritic Alloys (NFAs) vs. Oxide Dispersion Strengthened (ODS) Alloys*

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Core Materials Research and Development – 5 Year Plan