Advanced Reactor Materials and Materials Performance

NE 795-010

Fall 2021

Tues./Thurs. 11:45AM-1:00PM

3108 Burlington

1. **Instructor**

Dr. Benjamin Beeler

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Office Hours: Wed. 10-11 am

1. **Course Overview**

In this course we will study the behavior of nuclear materials in advanced reactor environments. Students will be introduced to different advanced reactor systems and the materials that are either currently deployed, or plan to be deployed, within those reactors. Specific material phenomena and material evolution will be particularly emphasized, including, but not limited to: fission gas swelling, constituent redistribution, fission product attack, fission gas bubble superlattice, recrystallization, actinide salt chemistry, and radiation damage accumulation. A particular emphasis will be placed upon advanced fuel forms, however this course will also address advanced cladding and coolant systems.

1. **Learning Outcomes**

By the end of this course, the student should be able to:

1. Identify key phenomena affecting the performance of advanced reactor materials
2. Understand the different stages of microstructural evolution in advanced reactor materials
3. Understand the role of reactor environment on material selection
4. Identify key areas delineating light water reactor and advanced reactor material evolution
5. **Pre- or Co-Requisites**

NE 509

1. **Required Text(s)**

None.

Supplemental texts:

Comprehensive Nuclear Materials, R. Konings

Light Water Reactor Materials, Vol. 1 Fundamentals, D. Olander and A. Motta

Fundamentals of Radiation Materials Science, G. Was

An Introduction to Nuclear Materials, K. Murty and I. Charit

1. **Course Requirements**

Examinations: 4 Quizzes: 12.5% each

Projects: Presentation 1: 15 %; Presentation 2: 15 %; Final presentation report 3: 20 %;

1. **Topical Outline:** 
   1. Introduction and Overview
   2. Advanced reactor systems and advanced fuel types
   3. TRISO particles
      1. CO production
      2. Fission gas release and fission product attack
      3. IPyC, OPyC and SiC stress state and fracture
   4. U-Zr (U-Pu-Zr) metallic fuel
      1. Fission gas swelling and release
      2. Constituent redistribution
      3. FCCI
      4. Alpha tearing
   5. Molten salts
      1. Coolant and Fuel Salts
      2. Thermophysical properties and phase diagrams
      3. Corrosion of structural components
   6. U-Mo and U-Si
      1. Monolithic and Dispersion Fuels
      2. Fission Gas superlattice
      3. Recrystallization, grain refinement and amorphization
   7. Advanced Reactor Cladding
      1. ODS
      2. Ferritic-Martensitic Steels
      3. SiC
      4. Concentrated Solid Solution Alloys
   8. Alternate Reactor Concepts
      1. Super critical water reactor
      2. Lead cooled reactor
      3. Micro-Reactors and Small Modular Reactors
   9. (Optional Sub-Topic) Density Functional Theory applied to Nuclear Fuels
2. **Grading**

Letter Grade Percent Grade

A+ 98-100; A 93-97; A- 90-92; B+ 87-89; B 83-87; B- 80-82; C+ 77-79; C 73-76; C- 70-72; D+ 67-69; D 63-66; D- 60-62; F Below 60