Motivation for the Course

This course is intended to give graduate students in Nuclear Engineering and in Materials Science a background on the special materials problems that occur in nuclear power reactors. Materials in nuclear reactors are subjected to an unusually harsh environment in which high temperatures, a corrosive medium and neutron irradiation damage, combine to cause the materials to fail to perform their design function. This degradation of materials in reactor environments has great economic consequences for the utilities that operate the reactors, and could potentially have safety implications as well. There is thus a great driving force to better understand the mechanisms of materials degradation in nuclear power reactors, specially the synergistic effects of radiation and electrochemistry which are at the root of phenomena such as irradiation assisted stress corrosion cracking.

The course is cross-listed in Nuclear Engineering and Materials Science, and is jointly taught by professors from both, with the idea that an interdisciplinary approach can help develop a mechanistic understanding of these complex phenomena. Whenever possible we will present simple mathematical models to illustrate the nature of the processes, while keeping in mind the full complexity present in the real cases. The aim is to teach the fundamentals of radiation damage, electrochemistry and materials behavior, and apply them all together to the study of specific degradation mechanisms, evaluating the degree of degradation, and quantitatively modeling the processes.

At the end of the course, the students should have accomplished the following educational objectives:

1. Have an overall knowledge of the materials and operation conditions in nuclear reactors.
2. Be familiar with the limiting degradation mechanisms that restrict the use of various nuclear reactor components, and of the current research issues in materials degradation.
3. Understand the basics of thermodynamics of solids and electrochemical solutions, of neutron radiation damage and its effects on materials, and the kinetics of corrosion.
4. Have a working knowledge of the mathematical models that mechanistically describe the degradation processes. Learn to use the relevant computer codes.
5. Have in-depth knowledge of one specific degradation mechanism of their choice for the class project.

Course Grading

Homework: 20%
Exam 1: 25%
Exam 2: 25%
Final Exam: 30%