

Course Title: **Radiation Damage in Materials**
Course Number: **NE 571**
Course Credits: **3 credit hours**

Instructor: Eric Lang
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Office Hours: Open door

Class Meeting Day(s): T/R
Class Location / Room: ME 208
2 75-minute lectures per week

Class Time: 9:30-10:45
Term / Semester: Fall 2023

Course Description:

Fundamentals of radiation damage and long term evolution of damage structure in structural materials for nuclear applications. Radiation damage topics include creation of point defects under irradiation, diffusion and accumulation of point defects, and differences in defect microstructures due to the type of radiation (ion, proton, neutron). Radiation effects topics include degradation of mechanical properties, creep and evolution of microstructure including phase stability and segregation,

Course Goals:

Students will learn about how energetic particles create damage in materials; how the evolution of defects effect the macroscopic properties; how different simulation techniques can be used to model the damage and macroscopic material properties.

Student Learning Outcomes (aka Objectives):

Students should be able estimate the damage created in a material in reactor or under ion beam irradiations
Students should be able to evaluate the effect of radiation on mechanical property changes
Students should be able to describe the various materials comprising the structures in nuclear reactors compare two competing materials for a given application
Students should be able to identify major material related problems encountered in nuclear reactor structures
Students should be able to outline procedure(s) for detecting the problems, suggest investigation techniques and suggest plausible remedial solutions
Students should be able to use SRIM to calculate damage, evaluate energy loss partition, and ion distribution
Students should be able to choose an appropriate experimental method to characterize damaged materials

Textbooks/Supplies/Materials/Equipment/ Technology or Technical Requirements:

Fundamentals of Radiation Materials Science, Was, Gary S., Springer, NY
(ISBN 978-1-4939-3438-6)

Course Requirements:

Homework: Students are encouraged to work together on homework;
Quizzes: Quizzes will be announced in the class (a week in advance)
Final: Exam will be based on quizzes and information provided in lectures. All exams will be closed book. The final will be comprehensive. Relevant formulas, tables, etc. will be provided.
Housekeeping: Attendance is required; be on time, turn off/mute cell phones; avoid distracting yourself, instructor and classmates

Grading:

Term project 30%
Quizzes 35%
Final exam 35%

Syllabus

A brief review of Materials Science and Engineering (0.5 weeks)

- Crystal structures, defects, failure

Radiation Damage Concepts (1 week)

- Elastic scattering
- Collision kinematics, interatomic potentials

Displacement of atoms (2 weeks)

- Displacement probability, Kinchin-Pease model, Displacement energy
- SRIM simulations
- Effects of Crystallinity
- Displacement cross-section

Damage Cascade (2 weeks)

- Binary collision approximation
- Modeling and simulation of irradiation damage:
 - o Molecular Dynamic simulations,
 - o Kinetic Monte Carlo,
 - o Phase field modeling

Point defect formation and clustering (1.5 weeks)

- Properties of point defects, point defect clusters,
- Thermodynamics of point defects: interstitials vs vacancies

Diffusion and rate theory (1 weeks)

- Macroscopic and microscopic diffusion
- Point defect balances, rate theory
- Radiation enhanced diffusion, defect reactions

Evolution of microstructure under irradiation (1.5 weeks)

- Radiation induced segregation
- Dislocations
- Voids and bubbles
- Phase stability under irradiation

Effects of irradiation on material properties (1 weeks)

- Irradiation hardening and deformation
- Irradiation creep
- Embrittlement

Materials Characterization Methods (1 week)

- Electron Microscopy
- X-ray Diffraction
- Mechanical Testing

Other Materials Issues in Nuclear Reactors (Fission and Fusion) (1.5 weeks)

Presentations (1 week)

The Schedule is subject to change. Minor changes will be announced in class, major ones provided in writing.

Accommodation Statement:

Accessibility Services (Mesa Vista Hall 2021, 277-3506) provides academic support to students who have disabilities. If you think you need alternative accessible formats for undertaking and completing coursework, you should contact this service right away to assure your needs are met in a timely manner. If you need local assistance in contacting Accessibility Services, see the Bachelor and Graduate Programs office.

Academic Integrity:

The University of New Mexico believes that academic honesty is a foundation principle for personal and academic development. All University policies regarding academic honesty apply to this course. Academic dishonesty includes, but is not limited to, dishonesty in quizzes or assignments; claiming credit for work not done or done by others; hindering the academic work of other students; misrepresenting academic or professional qualifications within or outside the university; and nondisclosure or misrepresentation in filling out applications or other university records. All students are expected to maintain the highest standards of honesty and integrity in academic and professional matters. The University reserves the right to take disciplinary action, including dismissal, against any student found responsible for academic dishonesty or failing to meet the standards. Any student judged to engage in academic dishonesty may receive a reduced or failing grade for work in question and/or the course. The University's full statement on academic honesty and the consequences for failure to comply is available in the college catalog and in the Pathfinder.

Title IX:

In an effort to meet obligations under Title IX, UNM faculty, Teaching Assistants, and Graduate Assistants are considered “responsible employees by the department of Education (see pg 15 - <http://www2.ed.gov/about/offices/list/ocr/docs/qa-201404-title-ix.pdf>). This designation requires that any report of gender discrimination which includes sexual harassment, sexual misconduct and sexual violence made to a faculty member, TA, or GA must be reported to the Title IX Coordinator at the Office of Equal Opportunity (oeo.unm.edu). For more information on the campus policy regarding sexual misconduct, see: <https://policy.unm.edu/university-policies/2000/2740.html>.

COVID-19 Health and Awareness:

UNM is a mask friendly, but not a mask required, community. To be registered or employed at UNM, Students, faculty, and staff must all meet UNM's Administrative Mandate on Required COVID-19 vaccination. If you are experiencing COVID-19 symptoms, please do not come to class. If you have a positive COVID-19 test, please stay home for five days and isolate yourself from others, per the Centers for Disease Control (CDC) guidelines. If you do need to stay home, please communicate with me at (505) 277-0772 or by email; I can work with you to provide alternatives for course participation and completion. UNM faculty and staff know that these are challenging times. Please let me, an advisor, or another UNM staff member know that you need support so that we can connect you to the right resources. Please be aware that UNM will publish information on websites and email about any changes to our public health status and community response.

Support:

Student Health and Counseling (SHAC) at (505) 277-3136. If you are having active respiratory symptoms (e.g., fever, cough, sore throat, etc.) AND need testing for COVID-19; OR If you recently tested positive and may need oral treatment, call SHAC. LoboRESPECT Advocacy Center (505) 277-2911 can offer help with contacting faculty and managing challenges that impact your UNM experience.

Connecting to Campus and Finding Support:

UNM has many resources and centers to help you thrive, including opportunities to get involved, mental health resources, academic support including tutoring, resource centers for people like you, free food at Lobo Food Pantry, and jobs on campus. Your advisor, staff at the resource centers and Dean of Students, and I can help you find the right opportunities for you.

Respectful and Responsible Learning:

We all have shared responsibility for ensuring that learning occurs safely, honestly, and equitably. Submitting material as your own work that has been generated on a website, in a publication, by an artificial intelligence algorithm, by another person, or by breaking the rules of an assignment constitutes academic dishonesty. It is a student code of conduct violation

that can lead to a disciplinary procedure. Please ask me for help in finding the resources you need to be successful in this course. I can help you use study resources responsibly and effectively. Off-campus paper writing services, problem-checkers and services, websites, and AIs can be incorrect or misleading. Learning the course material depends on completing and submitting your own work. UNM preserves and protects the integrity of the academic community through multiple policies including policies on student grievances (Faculty Handbook D175 and D176), academic dishonesty (FH D100), and respectful campus (FH CO9). These are in the Student Pathfinder (<https://pathfinder.unm.edu>) and the Faculty Handbook (<https://handbook.unm.edu>).

Library and Tutorial Services UNM-Main campus provides many library services and some tutorial services for distance students. For library services, go to <http://www.unm.edu/libraries/> to link to a specific library or to contact a librarian. For tutorial services, go to <http://caps.unm.edu/online> to explore UNM's online services.

Weather Policy: In the event of severe weather conditions UNM may close. Please call 277-SNOW to check UNM's status during questionable weather conditions.