NUCLEAR MATERIALS

Introduction

The guidelines outlined in this document are intended to supplement the general information on graduate programs provided by Nuclear Engineering and Radiological Sciences (NERS), the College of Engineering, and the Rackham School of Graduate Studies at the University of Michigan.

Master's and Doctoral Degree Requirements

See the Rackham School of Graduate Studies Academic Policies website for graduation requirements information at: http://www.rackham.umich.edu/policies/academic_policies/. Also, see the supplementary Master's and Ph.D. Graduation Requirements and corresponding checklists for Nuclear Engineering and Radiological Sciences. All checklists should be reviewed in the term prior to graduation for the master's degree and the term in which candidacy is achieved for the doctoral program.

Graduate Advising

Students will be assigned an advisor when they first join the graduate program. However, this assignment is tentative, and students should not be reluctant to change advisors once they have come to understand how their interests mesh with those of the various faculty members in the department. For students carrying out graduate research, the research supervisor is also their academic advisor. Before registering for a future term, the student must discuss courses with the advisor.

Nuclear Materials Research

This guide is intended for graduate students in Nuclear Engineering and Radiological Sciences who are interested in coursework and research in radiation materials science, nuclear materials, detector materials and related topics. The Materials option is primarily designed for students who wish to continue their education in this field through the Ph.D. level. The purpose of this document is to aid you in selecting a sequence of courses of both intermediate and long-term value, both within the NERS Department and the University of Michigan as a whole. The attached course programs give (a) typical undergraduate program in materials, (b) a sample Master of Science / Master of Science and Engineering program, (c) a dual NERS-MSE program, and (d) the Ph.D. requirements. Although a terminal one-year master's program in NERS only can be arranged, it is not recommended at this time. Various topics of research include:

- Materials for the very high temperature gas reactor
- Irradiation-assisted stress corrosion cracking of austenitic stainless steels
- Radiation induced amorphization in ceramics and minerals
- Behavior of irradiated materials in supercritical water
- Deformation and structural transformations in metallic glasses
- Radiation processing of novel patterned nanostructures
- Materials characterization by neutron scattering
- Simulation of neutron irradiation using ions
- Radiation effects at very high doses
- Multi-scale computer simulations of fission and fusion nuclear materials
- Computer simulation of fission gas release in TRISO fuel
- Computational capability for studying pulse shape discrimination of scintillator materials
- Understanding mechanisms of radiation degradation in electronic and optoelectronic devices: a multi-timescale model

Undergraduate Program in Nuclear Materials

The following is a recommended junior- and senior-year program for students with special interests in nuclear materials. It is anticipated that most students electing this program will seek advanced degrees in the Materials option in Nuclear Engineering and Radiological Sciences or in Materials Science and Engineering.

Fall Term Junior Year		**Winter Term Junior Year**	
NERS 311	Elements of Nuclear Eng and Radiological Sciences I	NERS 312	Elements of Nuclear Eng and Radiological Sciences II
EECS 314	Electrical Circuits, Systems, and Applications	NERS 315	Nuclear Instrumentation Laboratory
MATSCIE 350	Structures of Materials	MATSCIE 335	Kinetics and Transport in Materials Engineering
NERS 320	Problems in Nuclear Engineering & Radiological Sciences	NERS 344	Fluid Mechanics for Nuclear Engineers
Fall Term Senior Year		**Winter Term Senior Year**	
NERS 421	Nuclear Eng Materials	NERS 425	Application of Radiation
NERS 441	Nuclear Reactor Theory I	Phys 463	Intro to Solid State Physics
NERS 444	Thermal-hydraulics for Nuclear Systems	MATSCIE 470	Physical Metallurgy
Math 471	Intro to Numerical Methods		NERS Elective
NERS 490-1	Nuclear Reactor Design Codes	NERS 442	Nuclear Power Reactors

Master's Degree

The following is representative of a master's program for students interested in materials. Although this is a self-contained program, it is anticipated that many students electing the program will seek a Ph.D. in the Materials option in Nuclear Engineering and Radiological Sciences or Materials Science Engineering.

Sample curriculum:

Master's Degree Fall Term 1st Year		**Master's Degree Winter Term 1st Year**	
MATSCIE 420	Mechanical Behavior of Materials	NERS/MATSCIE 622 or NERS 524	Ion Beam Modification and Analysis of Materials (Alternating Years) or Nuclear Fuels (Alternating Years)
NERS 441 or NERS 543	Nuclear Reactor Theory Nuclear Reactor Theory II	Phys 463	Intro to Solid-State Physics (If not taken as an undergraduate)
NERS 521	Radiation Materials Science I	NERS 531	Nuclear Waste Management
MATSCIE 550	Fundamentals of Materials Science & Eng	MATSCIE 560	Structure of Materials

Master's Degree Fall Term 2nd Year	
NERS 515	Nuclear Measurements Laboratory
MATSCIE 532	Advanced Thermodynamics of Materials
NERS 599	Master's Project (Requires a Thesis)

A Two-Year Dual Master's Degree in Nuclear Engineering and Radiological Sciences and in Materials Science Engineering

Graduate students who seek a career primarily in materials research and development will need adequate background in both materials science and nuclear engineering and radiological sciences. It is assumed that most students will subsequently seek a Ph.D. degree. For these students, a dual master's degree in NERS and MATSCIE is recommended.

(1) Double degree rules:
- (a) The rules of the Graduate School for dual degrees permit a reduction of the credit hours by one-sixth of the sum of the credit hours required by the two master's programs. Hence a minimum of 50 credit hours is required for the present dual degree program.
- (b) NERS requirements: Refer to NERS graduation requirements.
- (c) MATSCIE requirements: At least 20 course credit hours in MATSCIE (500 level courses and above – no research) and 10 credit hours (home department).

(2) Prerequisites:
- (a) In NERS, same as for any master's candidates.
- (b) In MATSCIE
  MATSCIE 350 (4) or equivalent
  MATSCIE 330 (3) or equivalent
  MATSCIE 470 (3) or equivalent

Sample curriculum:

2 Yr Dual Degree Fall Term 1st Year		2 yr Dual Degree Winter Term 1st Year	
MATSCIE 420	Mechanical Behavior of Materials	Phys 463	Introduction to Solid State Physics
MATSCIE 505	Materials Science of Thin Films	MATSCIE 535	Kinetics, Phase Transformations, and Transport (If not taken as an undergraduate)
NERS 521	Radiation Materials Science I	NERS 522	Radiation Materials Science II*
MATSCIE 532	Advanced Thermodynamics of Materials	NERS 524	Nuclear Fuels

* Offered every other year.

2 yr Dual Degree Fall Term 2nd Year		2 yr Dual Degree Winter Term 2nd Year	
NERS 441 or NERS 543	Nuclear Reactor Theory Nuclear Reactor Theory II	NERS 622	Ion Beam Modification and Analysis of Materials (Offered alternate years)
NERS 515	Nuclear Measurements Lab	NERS 599	Master's Proj (requires thesis)
NERS 599	Master's Proj (requires thesis)	MATSCIE 562	Electron Microscopy I
MATSCIE 560	Structure of Materials	MATSCIE 520	Advanced Mechanical Behavior

Ph.D. Degree

The Ph.D. graduation requirements are detailed in a general NERS handout. For the candidacy exam, students in the Materials option are expected to know the material in the topics covered by the courses from the following list:

Course	Name of Course
NERS 521	Radiation Materials Science I
NERS 522	Radiation Materials Science II
NERS 524	Nuclear Fuels
NERS 622	Ion Beam Modification and Analysis of Materials
MATSCIE 532	Advanced Thermodynamics of Materials
MATSCIE 535	Kinetics, Phase Transformations and Transport
MATSCIE 560	Structure of Materials

Additional materials may be included in the exam, depending on the students' fields of research, such as those in the following elective courses:

Course	Name of Course
NERS 531	Nuclear Waste Management
NERS 590	Transmission Electron Microscopy Laboratory
NERS 590	Computational Nuclear Materials
MATSCIE 520	Advanced Mechanical Behavior
PHYSICS 463	Solid State Physics
MSE 242	Principles of Engineering Materials
EECS 520	Solid State Physics

Primary Faculty in the Materials Option and their Specialties:

Todd Allen	Professor, Nuclear Engineering and Radiological Sciences
Michael Atzmon	Professor, Nuclear Engineering and Radiological Sciences Professor, Materials Sciences and Engineering
Kevin Field	Associate Professor, Nuclear Engineering and Radiological Sciences

Fei Gao	Professor, Nuclear Engineering and Radiological Sciences Professor, Materials Sciences and Engineering
Lumin Wang	Professor, Nuclear Engineering and Radiological Sciences Professor, Materials Sciences and Engineering
Gary Was	Professor, Nuclear Engineering and Radiological Sciences Professor, Materials Sciences and Engineering Walter J. Weber, Jr. Professor of Sustainable Energy, Environmental and Earth Systems Engineering