Tuskegee University
College of Engineering
Doctor of Philosophy (Ph.D.) in Materials Science and Engineering

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Degrees Offered: Doctor of Philosophy (Ph.D.) in Materials Science and Engineering, Dissertation

The Department of Materials Science and Engineering at Tuskegee University produces graduates who can be successful in industry and national laboratories. We have assembled a multidisciplinary group of faculty members with expertise in various aspects of synthesis, processing, modeling and characterization of advanced materials that may be used for military, industrial, agricultural and healthcare applications.

Admission Requirements

- Applicant must have a Bachelor's or a Master's degree in Materials Science and Engineering or related disciplines from college or university to be considered for admission to the Ph.D. program in Materials Science and Engineering. Student admitted with Bachelor's degree must complete thirty (30) credits of course work at the Master's level and eighteen (18) credits of course work at the Ph.D. level. Student admitted with a Master's degree must complete eighteen (18) credits of course work at the Ph.D. level. The student may be required to complete some pre-requisite courses, if there is a deficiency in the course work in the degrees they have earned.
- Applicants must also have a cumulative GPA of 3.0 or better.
- The minimum acceptable combined GRE score is 1000 (old) or 300 (new).
- Official Transcript from all colleges/universities attended (International Students must have transcripts translated through the World Education Services -WES)
- Completed Application along with the required amount of application fees
- 3 Letters of Recommendation
- Statement of Purpose
- GRE Scores
- Financial Affidavit (International Students –only)
- Test of English as Foreign Language (TOEFL) Scores (International students only)

Advisory Committee

During the first year of his/her study in the Ph.D. program, the student and his/her Major Professor must recommend to the Head of the Department the student's Advisory Committee consisting of a minimum of six members including the Major Professor, the Head of the Department and two members from outside of Tuskegee University for approval. The Advisory Committee shall also serve as the Examination Committee.

Core Courses (12 credits): Required for All Students in the Ph.D. program

MSEG 0601: Physics of Materials– 3 credits
MSEG 0603: Polymer Physics– 3 credits
MSEG 0604: Materials Properties and Characterization– 3 credits
MSEG 0605: Ethics in Research– 1 credit
MSEG 0606: Literature Search and Technical Writing– 2 credits

Elective Courses (6 credits): Determined by Student's Major Professor

Elective courses may be any Ph.D. level courses offered at Tuskegee University or elsewhere. Approval of the Major Professor is necessary for a student to sign up for electives.

Transfer Credits

The student's Advisory Committee may recommend transfer credits for graduate courses taken by the student at

other institutions. Transfer credits may be recommended under both core and elective categories.

Written Qualifying Examination
All students pursuing the Ph.D. degree in Materials Science and Engineering must pass the comprehensive written qualifying examination in no more than two attempts. The examination covers the contents of core courses and several basic courses including chemistry, mathematics, physics, strength of materials and thermodynamics.

Research Proposal
The student must also successfully present a formal proposal of his/her dissertation research to his/her Advisory Committee and the faculty in the Department of Materials Science and Engineering. The proposal presentation must include a thorough review of literature and a plan of research activities and progress to date. A research proposal document of about 15 pages should be submitted to the committee members at least two weeks before the scheduled date of proposal presentation. It should include at least but not limited to: introduction, background, literature review, plan of research, preliminary data on the progress to date, timeline for completion of dissertation work and references.

Admission to Candidacy
Immediately after passing the written qualifying examination and successful presentation of his/her research proposal, the student must submit, to the Dean of Graduate Studies, a completed application for the Candidacy for the degree.

Seminars
A student pursuing the Ph.D. degree in Materials Science and Engineering is required to present several seminars during his/her course of study. The final seminar shall be his/her Final Oral Examination for the degree. The student is required to attend all seminars scheduled by the department.

Dissertation
The final draft of the thesis/dissertation must be filed with the student's Advisory Committee at least 30 days before the date listed in the university calendar for final copies to be submitted during the semester in which the student expects to graduate. The student must present to the Dean of Graduate Programs a "Preliminary Approval Sheet" (PAS) bearing the signature of the Major Professor before the final oral examination may be scheduled and before copies of the thesis/dissertation are distributed to members of the Examining Committee.

After the "Preliminary Approval Sheet" has been signed, it should be submitted to the Dean of Graduate Programs before the final examination is scheduled and before the final draft of the thesis/dissertation is prepared for final approval. Approval of the thesis/dissertation in its final form rests with the Examining Committee.

LIST OF CORE COURSES

MSEG 0601	**PHYSICS OF MATERIALS**. CR. 3. To gain an understanding of the nature of materials based on the physical principles on which the properties of materials depend. The basic relationships introduced in undergraduate physics and chemistry courses are extended using the concepts of quantum mechanics to relate the properties of materials to their internal structure and external environment. Optical, electrical, thermal and magnetic properties of metals, semiconductors and insulators will be covered.
MSEG 0603	**POLYMER PHYSICS**. CR. 3. Principles of polymer physics will taught. Emphasis is placed on classification of polymers, molecular sizes, polymer blends, morphology, time-independent elasticity, linear viscoelasticity and yield, and yield and fracture polymers**.**

MSEG 0604	**MATERIALS PROPERTIES AND CHARACTERIZATION**. CR. 3. A multidisciplinary course offering a practical hands-on experience with various analytical equipment and analysis of advanced composite materials including nanomaterials. Focus on sample preparation, principles and applications of various microscopy, thermal and mechanical methods. Covered topics include AFM, SEM, TEM, EDX, X-ray, TGA, DSC, DMA, TMA, tensile, compression and flexure tests.
MSEG 0605	**RESEARCH ETHICS**. CR. 1. The course will provide students an understanding of ethical issues in scientific research. Moral complexities in the engineering profession will be highlighted. Case studies will be used to illustrate how to analyze and resolve identified ethical issues.
MSEG 0606	**LITERATURE SEARCH AND TECHNICAL WRITING**. Cr. 2. To prepare the MSEG Ph.D. and MS candidates for writing professional papers, making presentations, and preparing theses/dissertations. To accomplish this objective, the literature related to material science and engineering is surveyed. The tools for searching the material science and engineering literature are explored. The instructors will critically analyze abstracts, formal papers and theses/dissertations related writings prepared by the students.
MSEG 0800	**Research.** CR. 24.

LIST OF ELECTIVE COURSES

MSEG 0607	**PROPOSAL DEVELOPMENT**. Cr. 3. In this course emphasis will be placed on technical research proposal writing. Focus will be placed on solicitation search, critical review of the literature on the research subject, development of the proposed research idea, highlights of the proposed research innovation, development of research work plans and tasks, projected outcome and deliverables, and cost proposal development.
MSEG 0610	**Advanced Materials Science and Engineering.** Cr. 3. This course introduces students coming from various disciplines to materials science and engineering. Different types of advanced materials, modern material needs, processing techniques, properties and application will be discussed. Material degradation upon exposure to various environments, proper selection of material and design consideration, economic and recycling issues of materials will be taught. **Prerequisite: MENG 0318: Materials Engineering**
MSEG 0611	**MOLECULAR MODELING OF POLYMERS AND NANOCOMPOSITES**. Cr. 3. To introduce students to the fundamentals of molecular modeling and to put that knowledge to use in a class project. Mini- projects and homework sets will be assigned as needed. Mini-projects require computer calculations. Homework sets will be drawn from the text and from literature sources.
MSEG 0612	**NANOSCALE SCIENCE AND ENGINEERING**. CR. 3. This course aims to introduce students to nanoscale materials science and technology. It will cover topics such as nanoscale material synthesis, properties and applications. It will also emphasize the theory, modeling and simulation approaches used to understand the synthesis mechanisms and morphological changes in nanoscale materials systems, as well as the properties of materials at the nanoscale. The course will have a balanced materials science (main thrust of the course) mechanics, physics and chemistry and technology flavor. **Prerequisites: graduate standing or senior undergraduate**
MSEG 0613	**MECHANICAL BEHAVIOR OF MATERIALS**. CR. 3. Principles of mechanical behavior of engineering materials will be taught by integrating aspects of materials science and solid mechanics. Emphasis is placed on structure and deformation in materials, mechanical testing, stress-strain relationships, complex and principal states of stress and strain yielding and fracture of cracked bodies. **Prerequisite: MENG 0316**

MSEG 0614	**Materials and Environment.** Cr.3. The impact of the environment on polymeric, metallic and ceramic materials is examined. Mechanisms of interaction between materials and the environment are considered. The effects of heat, moisture, UV light, ozone, radiation, acid rain and corrosive environments are included in this study of the effect of the environment on materials. The impact of materials on the environment is surveyed. Case studies and the current literature will be utilized throughout.
MSEG 0616	**Biomaterials.** Cr. 3. Principles and applications of natural and synthetic biomaterials for medical applications. Methods of analysis, including microscopy, spectroscopy and mechanical strength analysis will be introduced.
MSEG 0622	**KINETICS OF MATERIALS**. CR. 3. Activated rate theory, solid-state diffusion, atomic theory, solid-state diffusion, atomic theory of diffusion kirkendall effect, Darken equations, high diffusivity phenomenon and chemical reaction kinetics, pertinent to transformations.
MSEG 0623	**THEORY OF ELASTICITY**. CR. 3. Stress-Strain relations, strain energy, general methods of elasticity, reciprocal theorems, energy methods and variational principles. The Rayleigh-Ritz and Galerkin methods. Finite difference and relaxation method. Tensor application. **Prerequisites: MENG 0416 and MATH 0461. Graduate Standing.**
MSEG 0624	**POLYMER CHEMISTRY**. CR. 3. A survey course on polymeric materials. Areas covered are the synthesis and reactions of polymers, thermodynamics and kinetics of polymerization, the physical characterization of polymers and the fabrication, testing and uses of polymers. These topics are integrated into both the lecture and the laboratory. **Prerequisites: Organic Chemistry 321 & 323; Physical Chemistry 402 & 404**
MSEG 0625	**THERMODYNAMICS OF MATERIALS SYSTEMS**. CR. 3. The laws of thermodynamics applied to the stability of material phases, crystal imperfections, solubility, oxidation, surface and interface energy, and transformation. Application of the laws of Thermodynamics to Material Systems: chemical reactions, phase equilibria and transformations, oxidation, theoretical phase diagram generation and non-ideal solution theory. **Prerequisite: MSEG 0625**
MSEG 0627	**FRACTURE MECHANICS**. CR. 3. Basic principles and applications of fracture mechanics by integrating aspects of materials science and solid mechanics. Emphasis is placed on linear elastic and nonlinear elastic- plastic fracture mechanics theories; practical knowledge of fracture toughness evaluation of metals, polymer and ceramic composites; fatigue crack propagation. **Prerequisite: MENG 0416**
MSEG 0628	**FINITE ELEMENT METHOD**. Cr. 3. Principles of finite element analysis, variation principles, displacement polynomials and shape functions, element family, application to 2D and 3D continuum problems, application to thermal and fluid flow problems, computer program development. **Prerequisites: Graduate standing and instructor's approval.**
MSEG 0629	**MICROSTRUCTURAL ANALYSIS OF MATERIALS**. Cr. 3. To provide an integrated treatment of the science of microstructural analysis which emphasizes the interaction of the specimen with the electron beam used to probe the microstructure. The three main aspects of microstructural morphology, phase identification, crystallography, and microanalysis of the chemical composition will be covered. Following an introduction, the principal methods of characterization, e.g., diffraction analysis, scanning and transmission electron microscopy, and chemical microanalytical techniques will be taught. Some laboratory assignments will also be incorporated in this course. **Prerequisite: MSEC 0604**
MSEG 0640	**NON-DESTRUCTIVE EVALUATION TECHNIQUES**. Cr. 3. Basics of NDE of metals and advanced materials, ultrasonics, modal analysis, acoustic emission, acousto-ultrasonics, acoustic impact testing, X-ray radiography. Eddy-current testing, and laser measurements.

MSEG 0641	**COMPOSITE MATERIALS**. CR. 3. Introduction to composite materials; fibers, matrix and interface; mechanical and chemical aspects; design, chemical synthesis, manufacturing and processing methods; mechanical testing methods; understanding of failure mechanisms based on static, fatigue, impact and other properties; microstructural consideration. **Prerequisite: MENG 0318**
MSEG 0642	**MECHANICS OF COMPOSITES**. CR. 3. Classification and characterization of composite materials; mechanical behavior of composite materials; stress-strain relation for anisotropic materials; invariant properties of an orthotropic lamina; strength concepts and biaxial strength theories; classical lamination theory and theory of an anisotropic elastic continuum; equations of laminated anisotropic plates. **Prerequisite: MSEG 0641**
MSEG 0643	**ELECTRONIC MATERIALS PROCESSING I**. CR. 3. Theory and current technology for Si integrated circuit fabrication processes, including crystal growth, wafer preparation, epitaxy, oxidation, photolithography, diffusion, ion implantation, thin film deposition by chemical vapor deposition (CVD), etching and metallization, process simulation.
MSEG 0644	**ELECTRONIC MATERIALS PROCESSING II**. CR. 3. Materials processing for III—V compound semiconductor devices and integrated circuits. Materials requirements for high speed devices and process technology for the fabrication of these devices, self-aligned structures and integrated circuit processing, quantum well structures and their properties, processing of light emitting diodes and semiconductor lasers.
MSEG 0645	**SYNTHESIS AND CHARACTERIZATION OF ELECTRONIC MATERIALS**. CR. 3. Principles of materials growth and characterization for electronic and photonic materials. Bulk and epitaxial growth, chemical vapor deposition (DVD), plasma enhanced CVD (PECVD), Metallorganic CVD (MOCVD), molecular beam epitaxy (MBE), activated source MBE technologies, corresponding characterization techniques for evaluation of material quality, including theoretical basis for these techniques.
MSEG 0646	**PROCESSING OF ADVANCED SEMICONDUCTOR DEVICE STRUCTURES**. CR. 3. Processing and physics of operation of Si high power devices, SiC high-power and high-temperature devices, advances in GaN device structures. A comparative study of advanced semiconductor materials and their processing technologies.
MSEG 0647	**SPECIAL TOPICS IN ADVANCED SEMICONDUCTOR DEVICES**. CR. 3. Advanced bipolar devices and fabrication technology, heterojunction bipolar transistors, advanced/MOS devices the BICMOS process.
MSEG 0663	**SPECIAL FUNCTIONS.** CR. 3. Infinite series of functions, improper integrals. Gamma function, beta function, digamma and polygamma functions. Error function and related functions. Elliptic integrals. Legendre polynomials, Legendre series and theory conveyance. Hermite polynomials, Laguerre polynomials, Bessel functions of the first kind. Integrals of Bessel function. Orthogonality of Bessel functions and recurrence formulas.
MSEG 0690	**SPECIAL TOPICS**. Cr. 3. Advanced topics in materials science and engineering. **Prerequisite: Graduate standing and approval of major professor and instructor**
MSEG 0801	**CONTINUOUS REGISTRATION**. Cr. 0.
MSEG 0802	**CANDIDATE FOR DEGREE.** Cr. 0.

Additional details that are not shown in this document may be found on the website of the Department of Materials Science and Engineering and in the TU's Graduate Handbook.