MATSCEN 6295: Superconducting Materials and Properties

Course Description

Introduction to superconducting materials and phenomena. It will focus on the description of various materials and their properties in terms of basic superconducting phenomena, and the influence of materials-based properties on these phenomena.

Transcript Abbreviation: Supercond Mat Prop
Grading Plan: Letter Grade
Course Deliveries: Classroom
Course Levels: Graduate
Student Ranks: Masters, Doctoral
Course Offerings: Autumn, Spring
Flex Scheduled Course: Never
Course Frequency: Every Year
Course Length: 14 Week
Credits: 2.0
Repeatable: No
Time Distribution: 2.0 hr Lec
Expected out-of-class hours per week: 4.0
Graded Component: Lecture
Credit by Examination: No
Admission Condition: No
Off Campus: Never
Campus Locations: Columbus
Prerequisites and Co-requisites: Grad standing in MATSCEN, WELDENG, Engineering, or Math and Physical Sciences, or permission of instructor.
Exclusions:
Cross-Listings:

Course Rationale: Provide graduate students with a structured introduction to this class of materials.

The course is required for this unit's degrees, majors, and/or minors: No
The course is a GEC: No
The course is an elective (for this or other units) or is a service course for other units: Yes

Subject/CIP Code: 14.1801
Subsidy Level: Doctoral Course

Programs

Abbreviation	Description
MATSCEN	Materials Science and Engineering

Course Goals

To understand and be able to perform calculations using critical state models
To gain familiarity with London Equations, Meissner effect, Type I and Type II superconductivity, fluxons, and, from a phenomenological point of view the energy gap, cooper pairs, coherence length, and the specific heat jump.
To have familiarity with Ginzburg-Landau equations and the fluxon lattice.
To develop a working knowledge of materials aspects of NbTi, Nb3Sn, Bi-2212, Bi-2223, MgB2, YBCO, and selected new materials. This includes crystal structure, the phase diagram, processing, and defect structures.

To develop a working knowledge of flux pinning
To gain familiarity with processing-properties and structure properties aspects of practical superconducting materials, including the effects of anisotropy, grain boundaries, and processing route on structure and properties.

Course Topics

Topic	Lec	Rec	Lab	Cli	IS	Sem	FE	Wor
Basic phenomena: Zero resistivity, Meissner effect, critical fields, temperatures, currents.	4.0							
London Equations, Magnetization, Type I, Type II, energy gap, penetration depth, coherence length, specific heat	3.0							
M-H properties of Type II superconductors, Description of the current carrying state, magnetic penetration states, and fluxons in terms of the GL equations and the fluxon lattice	3.0							
Vortex line energy, vortex line interactions, high and low fields. Flux pinning, flux creep, and flux flow. The critical state model. Flux jumps.	3.0							
Grains, grain sizes, colonies and structures in YBCO, BSSCO, MgB2, oxipnictides, and low Tc superconductors. Microstructures of wires, films, and bulk samples of superconductors of interest. Coated conductor architecture and fabrication processes.	3.0							
Fabrication processes of metal vs oxide Superconductors. Texture in YBCO and BSSCO conductors. Chemical homogeneity and crystalline anisotropy.	3.0							
Flux pinning including grain boundary, point, volume pinning, kappa pinning. High Tc superconductors, flux lattice melting, irreversibility fields, new fluxon phase diagram. Collective pinning, flux creep and flux flow in high Tc superconductors.	3.0							
Anisotropy in superconductors and its consequences. 2D and 3-D superconductors. The description of various superconductors of interest from this perspective including YBCO, BSSCO, MgB2, oxipnictides, and low Tc superconductors using existing models.	3.0							
Electronic Phase Diagrams for YBCO and the Oxipnictides, and Multi-gap superconductors. The competition between magnetic and superconductive ordering, the role of doping, and electronic phase diagrams in materials of interest.	3.0							

Grades

Aspect	Percent
Six problems sets	25%
Mid-Term	40%
Final	35%

Representative Textbooks and Other Course Materials

Title	Author
Handbook of Superconducting Materials, Vol I; Superconductivity, Materials, and Processes	D.A. Cardwell and D.S. Ginley, IOP Publishing 2003
Introduction to Superconductivity, 2nd edition	M. Tinkham, McGraw-Hill, New York (1996)

ABET-EAC Criterion 3 Outcomes

Course Contribution		College Outcome
	a	An ability to apply knowledge of mathematics, science, and engineering.
	b	An ability to design and conduct experiments, as well as to analyze and interpret data.
	c	An ability to design a system, component, or process to meet desired needs.
	d	An ability to function on multi-disciplinary teams.
	e	An ability to identify, formulate, and solve engineering problems.
	f	An understanding of professional and ethical responsibility.
	g	An ability to communicate effectively.
	h	The broad education necessary to understand the impact of engineering solutions in a global and societal context.
	i	A recognition of the need for, and an ability to engage in life-long learning.
	j	A knowledge of contemporary issues.
	k	An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

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