

## Electronic Properties of Materials

EMA 3413 Section 9766

**Class Periods:** T 4<sup>th</sup> period, 10:40am – 11:30am; R 4<sup>th</sup>-5<sup>th</sup> periods, 10:40am – 12:35 pm

**Location:** FLG 280

**Academic Term:** Spring 2020

### **Instructor:**

Jiangeng Xue

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(352) 846-3775

Office Hours: Fridays 1:00-2:30pm, 237 RHN, or by appointments

### **Teaching Assistants:**

Please contact through the Canvas website

- David Camera, [davidmcamero@ufl.edu](mailto:davidmcamero@ufl.edu), RHN 200, office hours TBA

### **Course Description**

Atomistic and quantum-mechanical description of the electrical, optical, magnetic and thermal properties of materials. This course deals with metals, alloys, semiconductors, polymers, dielectrics and amorphous materials. Special emphasis is given to technology applications of electronic materials.

### **Course Pre-Requisites / Co-Requisites**

EMA 3010. Students are also expected to have taken calculus, differential equations, and undergraduate-level general physics and chemistry courses.

### **Course Objectives**

Upon completion of this course, students should be able to:

- Describe the behavior of electrons in solids using both classical and quantum theories
- Relate the (microscopic) behavior of electrons to the (macroscopic) physical properties of solids
- Compare the electrical, optical, and magnetic properties of different types of solid materials
- Design suitable materials for specific electrical/optical/magnetic applications

### **Materials and Supply Fees**

M/A

### **Professional Component (ABET):**

This is a 3-credit course. It provides 3 credits towards engineering sciences.

### **Relation to Program Outcomes (ABET):**

The following outcome and coverage table applies to students in the Materials Sciences and Engineering undergraduate program:

Outcome	Coverage*
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	High
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	Medium

3. an ability to communicate effectively with a range of audiences	
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	

\*Coverage is given as high, medium, or low. An empty box indicates that this outcome is not covered or assessed in the course.

#### **Required Textbooks and Software**

- Principles of Electronic Materials and Devices
- S. O. Kasap
- 4th Ed.
- ISBN: 978-0-07-802818-2

#### **Recommended Materials**

- Electronic Properties of Materials
- R. E. Hummel
- 4<sup>th</sup> Ed.
- ISBN: 978-1441981639

#### **Course Schedule**

Table below is a list of topics to be covered in the lectures along with the corresponding reading assignment in the textbook. This list is subject to change. Actual dates for quizzes and exams will be announced ahead of time.

Section Subject	Lecture	Date	Lecture Topic	Reading Assignment
Overview	1	1/7	Syllabus and course overview	
Elementary Materials Science Concepts	2	1/9	Atomic structure and bonding	3-24
	3	1/9	Thermal expansion and thermally activated processes	25-55
	4	1/14	Crystals and defects	55-82
Conduction in Solids	5	1/16	Drude model	125-137
	6	1/16	Matthiessen's and Nordheim's Rules	137-157
	7	1/21	Hall effect, thermal conduction, ion transport	157-176
Quantum Physics	8	1/23	Wave-particle duality	213-231
	9	1/23	Schrödinger equation and infinite potential well	231-241
	10	1/28	Uncertainty principles and tunneling	241-257

	11	1/30	Hydrogen atom	257-278
	12	1/30	Helium and periodic table	278-283
		<b>2/4</b>	<b>Review 1 (Lectures 2-12)</b>	
		<b>2/6</b>	<b>Exam 1 (in-class)</b>	
Modern Theory of Solids	13	2/6	Band structures of metals and semiconductors	313-334
	14	2/11	Effective mass and density of states	334-342
	15	2/13	Fermi-Dirac statistics	343-346
	16	2/13	Quantum theory of metals	346-364
	17	2/18	Phonons	374-384
Semiconductors	18	2/20	Intrinsic semiconductors	411-426
	19	2/20	Extrinsic semiconductors	426-435
	20	2/25	Temperature dependence	435-447
	21	2/27	Carrier recombination and diffusion	447-468
	22	2/27	Optical absorption/direct and indirect bandgap semiconductors	469-473, 495-505
		<b>2/29-3/7</b>	<b>Spring Break/No Class</b>	
		<b>3/10</b>	<b>Review 2 (Lectures 13-22)</b>	
		<b>3/12</b>	<b>Exam 2 (in-class)</b>	
Semiconductor Devices	23	3/12	Schottky junctions and Ohmic contacts	477-492
	24	3/17	Semiconductor pn junctions	527-553
	25	3/19	Semiconductor pn junctions (cont.)	527-553
	26	3/19	MOSFETs	624-635
Dielectric Properties	27	3/24	Permittivity	659-671
	28	3/26	Polarization mechanisms	671-679
	29	3/26	Dielectric constant, dielectric loss, and dielectric strength	679-687, 696-718
	30	3/31	Piezoelectricity, ferroelectricity, and pyroelectricity	719-733
Optical Properties	31	4/2	Light wave and optical constants	849-873, 890-898
	32	4/2	Refraction, reflection, absorption, scattering, luminescence	875-890, 898-920
Optoelectronic Devices	33	4/7	Light emitting diodes	566-586
	34	4/9	Solar cells	586-598
		<b>4/9</b>	<b>Review 3 (Lectures 23-34)</b>	
		<b>4/14</b>	<b>Exam 3 (in-class)</b>	
Magnetic Properties	35	4/16	Magnetization and magnetic materials	767-796, 801-812
	36	4/16	Superconductivity	829-838
		4/21	Final Review	
		<b>4/30</b>	<b>Final Exam (7:30am-9:30am)</b>	

### **Attendance Policy, Class Expectations, and Make-Up Policy**

- Attendance is not required, but expected and strongly recommended.
- Electronic devices are allowed in classrooms; however, the use of such electronic devices should not cause distractions to other students. Cell phones should be turned off or set to vibrate.
- Excused absences are consistent with university policies in the undergraduate catalog (<https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx>) and require appropriate documentation.

- Other than emergency situations, you must notify the instructor of your scheduled absence for quizzes and exams and discuss make-up options **at least one week prior to your absence**; failure to do so may not allow you to make up for the missed quiz or exam.
- E-mail communications with the instructor and TA should originate from your authenticated UF email account or through Canvas. Make sure you include “EMA 3413” in the subject line of your email to ensure timely response.

### Evaluation of Grades

Assignment	Points	Percentage of Final Grade
Homeworks (weekly)*	0	0
Quizzes (10-12, 15 min each)†	25 each	25%
Exams (3, 50 min each)§	100 each	45%
Final Exam (comprehensive, 120 min, April 30)	100	30%
<b>Total**</b>		<b>100%</b>

\* Homework sets will be assigned on a weekly basis in general. No submission is required; however, students are strongly recommended to solve the assigned questions on your own before referring to the solution guides (which will be available in e-Learning).

† There will be weekly quizzes (except in weeks with exams) to be held at the beginning of the Thursday lectures, which will cover the topics taught in the previous week. Two lowest scores (including no-shows) among all quizzes will be discarded when computing the total points for the final grade.

§ There will be three in-semester exams, tentatively scheduled on Feb. 6, March 12, and April 14. Any change to these dates will be announced at least one week ahead of the actual exam dates.

### Grading Policy

Final letter grade will be assigned based on a student’s overall performance during the semester. The following scale will be used as a guideline.

Percent	Grade	Grade Points
90.0 - 100	A	4.00
87.0 - 89.9	A-	3.67
84.0 - 86.9	B+	3.33
80.0 - 83.9	B	3.00
77.0 - 79.9	B-	2.67
74.0 - 76.9	C+	2.33
70.0 - 73.9	C	2.00
67.0 - 69.9	C-	1.67
64.0 - 66.9	D+	1.33
60.0 - 63.9	D	1.00
55.0 - 59.9	D-	0.67
0 - 54.9	E	0.00

More information on UF grading policy may be found at:

<https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

### Students Requiring Accommodations

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, <https://www.dso.ufl.edu/drc>) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

### Course Evaluation

Students are expected to provide feedback on the quality of instruction in this course by completing online evaluations at <https://evaluations.ufl.edu/evals>. Evaluations are typically open during the last two or three weeks

of the semester, but students will be given specific times when they are open. Summary results of these assessments are available to students at <https://evaluations.ufl.edu/results/>.

### ***University Honesty Policy***

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code (<https://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

### ***Commitment to a Safe and Inclusive Learning Environment***

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Robin Bielling, Director of Human Resources, 352-392-0903, [rbielling@eng.ufl.edu](mailto:rbielling@eng.ufl.edu)
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, [taylor@eng.ufl.edu](mailto:taylor@eng.ufl.edu)
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, [nishida@eng.ufl.edu](mailto:nishida@eng.ufl.edu)

### ***Software Use***

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

### ***Student Privacy***

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

### ***Campus Resources:***

#### *Health and Wellness*

#### **U Matter, We Care:**

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact [umatter@ufl.edu](mailto:umatter@ufl.edu) so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

**Counseling and Wellness Center:** <http://www.counseling.ufl.edu/cwc>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

**Sexual Discrimination, Harassment, Assault, or Violence**

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, [title-ix@ufl.edu](mailto:title-ix@ufl.edu)

**Sexual Assault Recovery Services (SARS)**

Student Health Care Center, 392-1161.

**University Police Department** at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

Academic Resources

**E-learning technical support**, 352-392-4357 (select option 2) or e-mail to [Learning-support@ufl.edu](mailto:Learning-support@ufl.edu).  
<https://lss.at.ufl.edu/help.shtml>.

**Career Resource Center**, Reitz Union, 392-1601. Career assistance and counseling. <https://www.crc.ufl.edu/>.

**Library Support**, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

**Teaching Center**, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.  
<https://teachingcenter.ufl.edu/>.

**Writing Studio, 302 Tigert Hall**, 846-1138. Help brainstorming, formatting, and writing papers.  
<https://writing.ufl.edu/writing-studio/>.

**Student Complaints Campus**: [https://www.dso.ufl.edu/documents/UF\\_Complaints\\_policy.pdf](https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf).

**On-Line Students Complaints**: <http://www.distance.ufl.edu/student-complaint-process>.