

## 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:** WM 100

**Academic Term:** Spring 2019

### **Instructor:**

Jiangeng Xue

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(352) 846-3775

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

### **Teaching Assistants:**

Venkata Kolluru, [kvs.chaitanya@ufl.edu](mailto:kvs.chaitanya@ufl.edu)

### **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 and college physics courses.

### **Course Objectives**

Understanding the fundamental electronic properties of solid materials

### **Materials and Supply Fees**

N/A

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

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

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

Outcome	Coverage*
a. Apply knowledge	High
b1. Conduct experiments	
b2. Statistical design of experiments	
c. Design	
d. Function on teams	
e. Solve problems	
f. Professional and ethical responsibility	
g. Communicate	
h1. Economic impact	
h2. Global, societal, and environmental impact	
i. Lifelong learning	
j. Contemporary issues	Low
k. Techniques, skills, and tools for degree program	

\*Coverage is given as high, medium, or low. An empty box indicates that this outcome is not part of 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	1/8	Syllabus and course overview	3-76
Elementary Materials Science Concepts	2	1/10	Atomic structure and bonding	3-25
	3	1/10	Thermal expansion and thermally activated processes	25-49
	4	1/15	Crystals and defects	49-76
Conduction in Solids	5	1/17	Drude model	114-125
	6	1/17	Matthiessen's and Nordheim's Rules	125-139
	7	1/22	Hall effect	145-148
Quantum Physics	8	1/24	Wave-particle duality	191-207
	9	1/24	Schrodinger equation and infinite potential well	208-217
	10	1/29	Uncertainty principles and tunneling	217-230
	11	1/31	Hydrogen atom	231-253
	12	1/31	Helium and periodic table	254-258
Modern Theory of Solids	13	2/5	Band structures of metals and semiconductors	285-303
		<b>2/7</b>	<b>Exam 1 (in-class)</b>	
		<b>2/7</b>	<i>No class/Instructor travel</i>	
	14	2/12	Effective mass and density of states	303-311
	15	2/14	Fermi-Dirac statistics	312-315
	16	2/14	Quantum theory of metals	315-320
	17	2/19	Phonons	337-342
Semiconductors	18	2/21	Intrinsic semiconductors	374-387
	19	2/21	Extrinsic semiconductors	388-396
	20	2/26	Temperature dependence	396-407
	21	2/28	Carrier recombination and diffusion	407-422
	22	2/28	Optical absorption/direct and indirect bandgap semiconductors	427-431, 448-452
		<b>3/2-9</b>	<i>Spring Break/No Class</i>	
Semiconductor Devices	23	3/12	Schottky junction and Ohmic contacts	435-440, 443-445
	24	3/14	pn junction and diode	476-498
	25	3/14	pn junction and diode	476-498
	26	3/19	MOSFET	532-541

	27	3/21	Light emitting diode	543-551
	28	3/21	Solar cells	551-563
		<b>3/26</b>	<b>Exam 2 (in-class)</b>	
Dielectric Properties	29	3/28	Permittivity	583-594
	30	3/28	Polarization mechanisms	595-603
	31	4/2	Dielectric constant, dielectric loss, and dielectric strength	603-614, 620-631
	32	4/4	Piezoelectricity, ferroelectricity, and pyroelectricity	638-653
Magnetic Properties	33	4/4	Magnetization	685-696
	34	4/9	Magnetic material classes	696-704, 740-744
	35	4/11	Superconductivity	729-740
Optical Properties	36	4/11	Light wave and optical constants	773-787, 804-811
	37	4/16	Refraction, reflection, absorption	789-803, 811-816
	38	4/18	Scattering, luminescence	816-825
	39	4/18	Review	
	40	4/23	Optional: Organic (opto)electronics	
		<b>5/2</b>	<b>Final Exam (12:30pm-2:30pm)</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.

### **Evaluation of Grades**

<b>Assignment</b>	<b>Points</b>	<b>Percentage of Final Grade</b>
Homework Sets (~12)*	20 each	10%
Quizzes (~12, 15 min each)†	25 each	30%
Midterm Exams (2, 50 min each)§	100	30%
Final Exam (comprehensive)§	100	30%
<b>Total**</b>		<b>100%</b>

\* Homework sets will be assigned on a weekly basis in general; two lowest scores (including non-submissions) will be discarded when computing the total points for the final grade.

† There will be weekly quizzes (except in weeks with midterm exams) to be held toward the end of the Thursday lectures. Two lowest scores (including no-shows) among the quizzes will be discarded when computing the total points for the final grade.

§ Up to 5 bonus points may be included in the midterm and final exams at the discretion of the instructor.

\*\* One bonus percentage point will be given to students who complete the profile picture in e-Learning according to instructions, by Jan. 19.

## **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.

<b>Percent</b>	<b>Grade</b>	<b>Grade Points</b>
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.

## **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: <http://registrar.ufl.edu/catalog0910/policies/regulationferpa.html>

## ***Campus Resources:***

### ***Health and Wellness***

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

If you or a friend is in distress, please contact [umatter@ufl.edu](mailto:umatter@ufl.edu) or 352 392-1575 so that a team member can reach out to the student.

**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 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>.