

3.15 Electrical, Optical, and Magnetic Materials and Devices
Caroline A. Ross
Fall Term, 2004

Instructor

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Class Meetings

Lectures – Mon and Weds. 9.30 – 11, Room 56-114
Recitation – Friday 9-10 Room 12-142, or 11-12, Room 12-142.

Ross Office Hours

After class, or by appointment. Please contact me by email to arrange additional meetings.

Assignments

There are two exams during class hours, and one Final Exam. A term paper is due in November. There will be problem sets due most weeks except for exam and term paper weeks. Due dates are listed in the schedule below.

Grade

30% for Exam I and II combined (15% each)
30% for Paper
30% for Final Exam
10% for Problem sets

Students are encouraged to work in small groups (2-3 students) to complete the problem sets. Each student must work *individually* to complete the paper and exams.

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Teaching Schedule

Date	Lectures	Assignments
W 8 Sept.	Overview, carrier fundamentals	
M 13 Sept.	Drift and diffusion of carriers	PS1 out (Semiconductor fundamentals)
W 15 Sept.	Recombination and generation	
M 20 Sept.	PN junction at equilibrium	PS1 due ; PS2 out (PN junctions)
W 22 Sept.	PN junction under bias	
M 27 Sept.	PN junction: ideal diode	PS2 due ; PS3 out (PN, Transistor, MOS)
W 29 Sept.	Bipolar junction transistor	
M 4 Oct.	FETs and MOS	
W 6 Oct.	Exam 1 (up to bipolar transistor)	Exam 1
M 11 Oct.	<i>Columbus Day</i>	
W 13 Oct.	Photodetectors and photovoltaics	
M 18 Oct.	Solar cells	PS3 due ; PS4 out (Photodevices)
W 20 Oct.	LEDs	
M 25 Oct.	Lasers	PS4 due ; PS5 out (LEDs, lasers)
W 27 Oct.	Heterostructure lasers	
M 1 Nov.	Displays	PS5 and term paper topic due
W 3 Nov.	Optical fibers	
M 8 Nov.	Photonic Devices	
W 10 Nov.	Exam 2 (up to photonics)	Exam 2
M 15 Nov.	Magnetic fundamentals	
W 17 Nov.	Magnetic materials	Term paper due ; PS6 out (magnetic fundamentals)
M 22 Nov.	Soft materials, transformers	
W 24 Nov.	Hard materials, permanent magnets	PS6 due ; PS7 out (magnetic devices)
M 29 Nov.	DC motors	
W 1 Dec.	Magnetic hard disks and tapes	PS7 due
M 6 Dec.	Magneto-optics	
W 8 Dec.	MRAMs, CDs and DVDs	
13-17 Dec	Finals week	Final exam

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Required Texts

R.F. Pierret, *Semiconductor Device Fundamentals*, Addison-Wesley 1996, (ISBN: 0-201-54393-1) [This is similar to Volumes 1-4 of the "*Modular Series of Solid State Devices*" listed below].

D. Jiles, *Introduction to Magnetism & Magnetic Materials*, 2nd Ed., Chapman & Hall 1998. (ISBN: 0-412-79860-3)

[or R.C. O'Handley, *Modern Magnetic Materials*, Wiley 2000 (ISBN 0-471-15566-7)]

References on Reserve

Electronic Materials Science: For Integrated Circuits in Si and GaAs, J.W. Mayer and S.S. Lau, Macmillan, 1990 (ISBN: 0-02 378140-8).

Electronic Materials, N. Braithwaite and G. Weaver, 2nd ed. Butterworths, 1998 (ISBN: 0-408-02840-8).

Elementary Solid State Physics, M. Omar, Addison-Wesley, 1975 (QC176.038).

Introduction to the Electronic Properties of Materials, D. Jiles, Chapman and Hall, 1994 (TK 7871.J55 1993).

Electrical Properties of Materials, 6th Edition, L. Solymar and D. Walsh, Oxford, 1998. (ISBN 0-19-856272-1)

Introduction to Magnetic Materials, B. Cullity, Addison-Wesley, 1972. (QC753.2.C84).

Modular Series of Solid State Devices, Series Editors, G.W. Neudeck and R.F. Pierret, Addison-Wesley.

Vol. 1: *Semiconductor Fundamentals*, R.F. Pierret (TK7871.85.P485)

Vol. 2: *The PN Junction Diode*, G.W. Neudeck (TK7871.86.N48)

Vol. 3: *The Bipolar Junction Transistor*, V.W. Neudeck (TK7871.96.B55.N48)

Vol. 4: *Field Effect Devices*, R.F. Pierret (TK7871.95.P53)

Vol. 6: *Advanced Semiconductor Fundamentals*, R.F. Pierret (TK7871.85.P483 1987).

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Assigned Paper

Due

A proposed paper topic is due Nov. 1. The topic should consist of a paragraph describing the device and the major materials issues associated with it, citing at least 2 – 3 references.

The completed paper is due November 17, at the beginning of class.

Purpose

To provide students an opportunity to synthesize concepts learned in the course in an in-depth examination of a *device* employing electrical, optical, or magnetic materials. Emphasis will be placed on the development of individual writing and literature review skills.

Organization of the Paper

1. **Introduction** (Interest and relevance, 1-2 paragraphs)
2. **Principles of Operation** (This should be as brief as possible, but it needs to inform the reader how the device works so that s/he can appreciate the materials choices that need to be made)
3. **Materials Choices** (Describe what materials are used in the device and why)
4. **Present Limitations and Opportunities for Materials Improvements** (How are the properties of the existing materials limiting device performance? Where is the technology heading, and what new materials might be used in future generation devices?)

Sections 3 and 4 should comprise the bulk of your report.

Sample Subjects

- Light Emitting Diodes, e.g. yellow, IR, UV
- Semiconductor Lasers e.g. blue, IR ...
- High Power Lasers, e.g. Ruby, Nd: YAG
- Semiconducting Thermoelectric Devices
- Phosphors e.g. 'Indiglo'
- Ferroelectric RAMs or Magnetic RAMs
- Pressure and Temperature Transducers
- A Quantum well device
- Conducting Polymer Devices, e.g. organic transistors
- Fibers for Optical transmission
- Fiber Amplifiers for Telecommunications
- Photonic Switches
- Magnetic Recording Media, e.g. perpendicular media
- Phase change media
- Rewritable Magneto-optical Data Storage
- Magnetic Bearings
- Amorphous Metal Transformers
- Rare-earth Permanent Magnet Motors
- Superconducting High-Field Magnets
- An Electronic Device made from High-Tc Superconductors

Typical Length

8-10 pages

NOTE: You must select a paper topic which is clearly distinct from your co-op or UROP research experience. Papers which represent a simple extension of these research efforts will not be accepted. Please discuss any possible conflicts with the instructor.