Materials 723, Functional Materials
2022-2023

Course Outline:
This course is intended for Materials Science and Engineering graduate students seeking an in-depth knowledge of functional materials. The course will cover inorganic semiconductor materials, ferroelectric materials and magnetic materials.

The course is also suitable for graduate students in other departments who wish to improve their depth of understanding in these topics.

This course is recommended as preparation for graduate students wishing to take **Materials 760, Electronic Materials** in January 2023.

Instructors:

1) **Igor Zhitomirsky**
2) **Adrian Kitai**

Contact Information:

Igor Zhitomirsky

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Adrian Kitai **Office Hours: By appointment**
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LECTURES:
3 hours per week, specific time to be determined

Lecture Schedule:
Week of Sept 2: Organization of lectures
Week of Sept 9 to week of Oct 14: Dr. Zhitomirsky's lectures (6 weeks)
Week of Oct 21 Midterm recess
Week of Oct 21 to week of Nov 25: Dr. Kitai's lectures (6 weeks)

Project Presentations:
Week of Dec 2

Texts and Reference materials:
Adrian Kitai, Principles of Solar Cells, LEDs and Related Devices, 2nd edition, Wiley 2018

M.E.Lines and A.M.Glass, Principles and Applications of Ferroelectrics and Related Materials, 1977 Thode Library QC 596.5 .L56 1977, also available electronically

N.Spaldin, Magnetic Materials, Fundamentals and Applications, 2003, Thode Library TK 7872 .M25H54 2003, also available electronically

Additional notes and reference materials will be supplied by instructors as required.

Course evaluation:
Assignments: Adrian 10%, Igor 10%

Project: 40%. Project topics to be selected from areas A, B and C below:

Final Exam: 40%

Topics covered:

A. Ferroelectric Materials

(i) Spontaneous polarization, ferroelectric domain structure, phase transitions, physical properties of ferroelectric and antiferroelectric materials at Curie points.
(ii) Fundamental ferroelectric, dielectric, piezoelectric, pyroelectric, and electro-optical properties of ferroelectric materials
(iii) Materials science aspects, advanced ferroelectric compounds and solid solutions, ferroelectric and piezoelectric polymers
(iv) Ferroelectric memory devices
(v) Piezoelectric devices
(vi) Pyroelectric devices
(vii) Advanced materials for capacitors
(viii) Ferroelectric electro-optical devices

B. Magnetic Materials

(i) Magnetic ordering, phase transitions, diamagnetic, paramagnetic, ferromagnetic, ferrimagnetic, antiferromagnetic and superparamagnetic materials
(ii) Fundamental properties and applications of magnetic materials
(iii) Magnetic ordering, anisotropy and domain structure

(iv) Fundamental magnetisation mechanisms
(v) Design of advanced magnetic materials
(vi) Soft and hard magnetic materials, advanced applications
(vii) Magnetic memory materials and devices
(viii) GMR effect, spintronics, fundamental aspects, materials and applications
(ix) Magneto-optical materials and devices

C. **Introduction to semiconductors**

i) Quantum mechanics
ii) Quantum statistics
iii) Uncertainty principle
iv) Group and phase velocities
v) Bloch functions
vi) Kronig Penney and related band models
vii) Effective mass and band transport
viii) Semiconductor densities of states in 1,2 and 3 dimensions
ix) Carrier transport in semiconductors
x) Einstein Relation and it application to semiconductors
xi) Optical properties of inorganic semiconductors
xii) Radiative line widths in direct gap semiconductors
xiii) Applications to semiconductor devices: diodes, transistors, solar cells, light emitting diodes