**MATERIALS 4Q03**

**Advanced Functional Materials**

**Instructor:** Prof. Nabil Bassim, JHE 258, bassimn@mcmaster.ca, x 24102

**Course Schedule:** Tuesday, Wednesdays, Friday, 12:30-1:20 pm, Hamilton Hall217

**Course Description:**

This course will introduce students to the various concepts of the fundamentals, fabrication and applications of many of the main classes of functional materials. The first half of the course will focus on semiconductor fabrication, including growth, lithography, etching, oxidation and implantation. The second half of the course will focus on an overview of classes of functional materials, including functional oxides, perovskites, magnetic, optical, electronic, energy and bionanomaterials, and 2-Dimensional materials.

**Course Outcomes:**

At the end of the course, students are expected to show the ability to:

- Understand the fundamentals of semiconductor processing, including the many steps for fabrication.
- Understand the fundamentals of several broad classes of advanced functional materials.
- Understand the applications of several broad classes of advanced functional materials.
- Understand the fabrication of several broad classes of advanced functional materials.
- Analyse the literature resources to assess wide range of information related to function, applications and fabrication of nanomaterials.
- Communicate effectively a literature review on functional materials through a presentation to the class, complete with Q&A.

MATLS 4Q03 is an important part of your training as an engineer. In particular the course will allow you to:

**Gain Specialized Engineering Knowledge including:**

(a) How functional materials work.
(b) The main fabrication methods of advanced functional materials.
(c) State-of-the-art applications of these materials
Evaluation:

Exams:

Mid-term (30%): This exam will take place on October 6th, and will cover the topics related semiconductor examination. Most examination questions will focus on clearly explaining key concepts.

Final Examination (35%): 2hr exam: This exam will focus on concepts described and taught during the advanced functional materials, with questions taken from the instructor and student presentations.

Student Presentations (30% plus 5%): Students will be required to deliver a 15 minute presentation based on a topic that will be chosen at the beginning of the term. In each week, after the semiconductor fabrication portion of the lecture (~6 weeks) is completed, the instructor will present a broad overview of a specific class of material. For example, the instructor may start by describing different types of electronic devices. This will last 1 and a half lectures. Then a student will present a 15 minute lecture delving into the details of one aspect of that materials class; e.g. describe a CMOS device, its working principles, fabrication and application. We will have a class-wide 10 minute Q&A session. For the third class in that week, 2 more lectures and Q&A sessions will be presented.

Evaluation hinges on presentation completeness, with an introduction, main content, applications, and fabrication section. Presenters will also be evaluated on presentation style, with a focus on clarity, ease of understanding, and audience engagement.

Depending on the number of student enrolled, we will have teams of two people per presentation or individual presentations delivered. The instructor will share the overview slides with that week’s presenters 2 weeks in advance, and the presenters will share their slides for review one week in advance in order to ensure high quality. Meeting deadlines for preparation leading up to the presentation will be the basis of the 5% mark.

All of the presentation slides will be shared on Avenue after the presentations. These slides will be used as a source of questions for the final examination.

Basic timeline for the course:

1) Semiconductor processing (6 weeks)
   Growth (PVD, CVD, Epi), Oxidation, Etching, Lithography, Implantation, Annealing

2) Functional Oxides
Functional oxides (dielectrics, ferroelectrics, ferroics, electro-optics, piezoelectrics, superconductors) - 2 weeks

3) Optical Materials (mirrors, superlattices, Drude model, Photonic crystals, metamaterials, lasers) – 2 weeks

4) Magnetic Materials – 1 week

5) Batteries and Fuel cells - 2 weeks

6) Electronic devices (beyond PN-junction) - CMOS, CCDs, FETs, diodes, etc - 2 weeks

7) 2-D materials - 1 lecture

8) Bioelectronics (guest lecture – Prof. Leyla Soleymani, Eng. Physics) – 1 lecture

Textbook:

(Optional) Introduction to Microelectronic Fabrication: Volume 5 of Modular Series on Solid State Devices (2nd Edition), Richard C. Jaeger

Literature Sources

MRS Bulletin: Magazine issues with special topics based on current materials of interest with background, and applications. Written at a 4th year or 1st-year graduate student level.

Policy Reminders:
The Faculty of Engineering is concerned with ensuring an environment that is free of all adverse discrimination. If there is a problem that cannot be resolved by discussion among the persons involved, individual are reminded that they should contact the Department Chair, the Sexual Harassment Office or the Human Rights Consultant, as soon as possible. The Senate Resolution on Course Outlines states that: “students should be reminded that they should read and comply with the "Statement on Academic Ethics and the Senate Resolution on Academic Dishonesty" as found in the Senate Policy Statements distributed at registration and available in the Senate Office”.

Academic dishonesty consists of misrepresentation by deception or by other fraudulent means and can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university.

It is your responsibility to understand what constitutes academic dishonesty. For information on the various kinds of academic dishonesty please refer to the Academic Integrity Policy, specifically Appendix 3, located at: http://www.mcmaster.ca/senate/academic/ac_integrity.htm
The following illustrates only three forms of academic dishonesty:
- Plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
- Improper collaboration in group work.
- Copying or using unauthorized aids in tests and examinations.

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- Promoting awareness of the needs and abilities of persons with disabilities;
- Informing the University community about the services available to persons with disabilities and seeking to ensure that such services are delivered in ways that promote equity; and
- Providing support services, subject to certain limitations.

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*For more information, please visit [http://mcmaster.ca/policy/Students-AcademicStudies/](http://mcmaster.ca/policy/Students-AcademicStudies/)*

This is a course under development by the instructor; subject matter and evaluation methods are subject to change at the discretion of the instructor.