MATLS 3Q03: MATERIALS FOR ELECTRONIC APPLICATIONS

Instructor

Oleg Rubel
Room: JHE 359
Tel: +1-905-525-9140, ext. 24094
E-Mail: rubelo(a)mcmaster.ca
URL: http://olegrubel.mcmaster.ca

Please see Avenue for office hours

Course description

This course focuses on modern electronic materials, their processing and device applications. The emphasis is placed on materials properties and underlying physical principles from a nano-scale perspective, which is taught in a context of technological applications. Topics covered include: materials for photovoltaics, light-emitting, thermoelectric, and piezoelectric devices.

Course structure

12 weeks, lectures 3 hrs/week

Module 1 (week 1–3): Fundamentals of electron theory [1, chap. 1–6], [3, chap. 2, 5, 7]

- wave-particle duality, elements of quantum mechanics, solution of the Schrödinger equation for specific problems;
- nature of chemical bonds;
- electrons in a crystal, energy bands, metals and insulators;
- *ab initio* modelling.

Module 2 (week 4–10): Electronic properties of materials

- mobility and electrical conductivity (p-n junction, diodes, transistors, field-effect transistors) [1, chap. 7–9];
- bandgap in semiconductors, direct and indirect semiconductors, optical absorption and emission, heterostructures, low-dimensional structures (LED's, solar cells, lasers) [2, chap. 1–5];
- dielectric properties, piezoelectricity and ferroelectricity (capacitors and actuators) [3, chap. 10];
- thermal conductivity, heat capacity, thermal expansion (thermoelectric devices) [1, chap. 18–22].

Module 3 (week 11–12): Processing and characterization of electronic materials [4, chap. 12–13]

- growth of semiconductor materials and nanostructures, chemical and physical vapour processes;
- structural, optical, and electrical characterization techniques.

Objectives and learning outcomes

Provide an introduction into the operating principles of electronic and optical devices, the principles of semiconductor processing. Present the relevant materials science issues in semiconductor processing. Prepare students a) for work in semiconductor processing facilities and b) for graduate studies related to semiconductor processing and materials science topics.

- understand the physics of materials used for electronic devices;
- identify resources providing information on electronic material development;
- understand the fundamental properties at the basis of the choice of electronic materials;
- understand selected fabrication techniques and differences in fabrication methods.

Prerequisites and relevance to other courses

The material covered is largely self-contained, but an earlier exposure to quantum mechanics and solid state physics is desirable.

Evaluation

Activities	Contribution to the final grade
Participation (lectures)[a]	20%
In class assignment/quizzes[a]	20%
Final exam	60%
Total	100%

[a]MSAF is required for missing academic work

For SAS students: Occasional absence from class due to disability is defined as one per 4 weeks.

Recommended texts

[1] Rolf E. Hummel, *Electronic Properties of Materials* 4th ed. (Springer, 2012). ISBN: 978-1-4419-8163-9 (main text)

[2] Adrian Kitai, *Principles of Solar Cells, LEDs and Diodes: The role of the PN junction* (Wiley-Blackwell, 2011). ISBN: 978-1-4443-1834-0

[3] Laszlo Solymar, Donald Walsh, and Richard R. A. Syms, *Electrical Properties of Materials* (Cambridge University Press, 2014). ISBN: 978-0-19-870278-8

[4] Manijeh Razeghi, *Fundamentals of Solid State Engineering* (Springer, 2006). ISBN: 978-0-387-28152-0

Dated: January 4, 2017