ECE 639: Characteristics and Applications of Amorphous Silicon

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Lecture time and place: Thursday at 11:30-2:20 PM, EIT 3141

Course Description

The course will focus on the properties and processing of amorphous silicon thin films. The major areas of thin-film growth, characterization and processing as well as relevant applications for thin-film transistors will be covered. Current research topics will also be used as case studies to illustrate principles and applications of a-Si thin-film technology.

Course Objective

This course will help students with no or limited prior background in the field to:

1. Acquire a general background in the field of disordered materials in terms of basic theory, applications, challenges and limitations, and recent developments.
2. Know and understand relevant fundamental scientific theory (qualitatively), and its relationship to thin-film semiconductor materials and device design concepts.
3. Become familiar with relevant terminology, and be able to read and understand scientific literature in the field, and to conduct a literature review on certain relevant research topics

Topics

1. **Thin-film growth and Structure**
    a. Chemical vapor deposition
    b. Physical vapor deposition
    c. Nucleation and growth
    d. Defects in disordered materials
    e. Role of hydrogen in a-Si:H

2. **Electronic properties**
    a. Density of states
    b. Band tails
    c. Defects and their electronic states
    d. Substitutional doping

e. Electronic transport
f. Recombination

3. **Processing and Characterization**
    a. Interfaces and contacts
    b. Multilayers
    c. Semiconductors, dielectrics and metals
    d. Novel approaches

4. **Thin-film Devices and Applications**
    a. Thin-film transistors
    b. p-i-n diodes and sensors
    c. Solar cells
    d. Displays and sensor arrays
    e. Cost models for a-Si technologies

Tentative Schedule

Week 1: *Course Introduction*
Introduction to Thin-film Technology

Week 2: *Thin-film growth and structure*

Week 3: *Electronic Properties*

Week 4: *Electronic Properties*

Week 5: *Processing and Characterization**

Week 6: *Processing and Characterization*
Novel Processing Approaches

Week 7: *Thin-film Devices*

Week 8: *Thin-film Devices*

Week 9: *Applications*

Week 10: *Applications and Cost Models*

Week 11 and 12: Individual *Presentations*

Textbooks

Hydrogenated Amorphous Silicon (R.A. Street), *REQUIRED*

Technology and Applications of Amorphous Silicon (R.A. Street ed.), *Recommended*

Office Hours: Tues 1-2 PM and W 11-12 PM or by appointment

Grading

Class presentations	15%
Term report	30%
Final	50%
Assignments	5%

Project Presentation and Report

General Scope:

Each student will submit a project presentation and written report. The project will comprise of an in-depth research literature review (no more than 20 pages, double spaced, 12 point font) on a topic of a fundamental scientific nature in the area of amorphous silicon thin-film technology. Some topic suggestions will be provided by the course instructor. Students may suggest their own topics subject to the approval of the instructor. A seminar and written report on the topic will be given by the student providing a general overview on the topic, a scientific focus, recent developments and advances, and current status.

Format for Project Reports

The review can be conducted and presented based on the following elements:

1- *INTRODUCTION:* An introduction to the general field related to its history, advantages, disadvantages, materials/device/technology options, and current state of the art.
2- *SCIENTIFIC/TECHNICAL BACKGROUND:* A scientific/technical treatment of the topic containing the fundamental phenomena, theoretical background, underlying mechanisms, current understanding, and major areas of focus.
3- *CURRENT CHALLENGES (If Applicable):* An overview on current issues/limitations, its root causes, and potential solutions.
4- *RECENT ADVANCES:* A highlight of recent developments in the field related to the topic and the current state-of-the-art results. Provide analysis of the state-of-the-art advances and its impact on the future direction of the technology.
5- *Conclusions: S*ummarize the relevant information and analysis of the project topic.

Oral Presentation

This will be a 20 minute presentation followed by 5 min for questions and answers. The presentations will be delivered during regular lecture time, and will be scheduled (tentatively) for weeks 11-12 of the term. The exact dates (and presentation length) will depend on the final number of students enrolled in the course and therefore will be confirmed later. A copy of presentation slides should be emailed to the instructor by **8:00 AM on the day of your presentation**.

The presentation can be structured using the same elements outlined above in the format section.

The presentation will be evaluated for content (60%) and for demonstrating understanding of the subject from analysis of the delivered material and the Q&A period (40%).

The class will also be evaluated for providing insightful questions and comments during the presentations.

Written Report

A written report presenting the main findings of the literature search on the topic **is due by 3:00 pm on Monday, December 3, 2012.** Email an electronic copy (.pdf) to the instructor, and place a hard copy of the report in the instructor's mail slot (ECE reception area in EIT)

• The report should include: (i) title page, (ii) abstract, (iii) main body, and (iv) references sections.
• The "abstract" should be no longer than 100 words, and should concisely capture the main points of the report.
• The "main body" should typically be 10-15 double-spaced pages (excluding any figures and/or tables), font size 12, and includes sections using the same titles/subtitles as outlined above in the Format section. The report with text and figures should be no more than 20 pages.
• The "references" section should give full citation of all referenced work using American Institute of Physics format (e.g. format used in *Journal of Applied Physics* or *Applied Physics Letters*). A minimum of 5 scientific journal references is required.
• Report Marking Scheme: *INTRODUCTION (15%), SCIENTIFIC/TECHNICAL BACKGROUND (45%), CURRENT CHALLENGES AND RECENT ADVANCES (30%), & CONCLUSIONS (10%).* The grading scheme is a guide and the actual distribution may change slightly due to the nature of the topic presented.

Project Grading

• 15% (of course total grade) Presentation
• 30% (of course total grade) Written Report

Academic Integrity

In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [Check www.uwaterloo.ca/academicintegrity/ for more information.]

Discipline

A student is expected to know what constitutes academic integrity [check www.uwaterloo.ca/academicintegrity/] to avoid committing an academic offence, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about rules for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate Associate Dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline www.adm.uwaterloo.ca/infosec/Policies/policy71.htm. For typical penalties check Guidelines for the Assessment of Penalties, www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm.

Appeals

A decision made or penalty imposed under Policy 70 (Student Petitions and Grievances) (other than a petition) or Policy 71 (Student Discipline) may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72 (Student Appeals) www.adm.uwaterloo.ca/infosec/Policies/policy72.htm.

Note for Students with Disabilities

The Office for Persons with Disabilities (OPD), located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the OPD at the beginning of each academic term.