SEL EXHIBIT NO. 2029

INNOLUX CORP. v. PATENT OF SEMICONDUCTOR ENERGY LABORATORY CO., LTD.

IPR2013-00066

Syllabus

492/592-003 – Soft Electronics: Organic Devices & Liquid Crystal Displays

NC State University – Spring Semester 2010

Class Meeting Times / Location

Lecture / Lab Time: Monday and Wednesday, 3:50pm – 5:05pm
Lecture Location: EB1 Bldg rm 2015
Lab Location: EB2 Bldg rm 1034

Instructor Contact Information

Professor: Dr. Michael Escuti, mjescuti@ncsu.edu
Office / Phone: MRC Bldg, room 322A (Centennial Campus), 513-7363

Office Hours

Day(s)/Time(s): by appointment (arrange via email)
No office hours will be held during University holidays, during the first week, or during finals week.

Educational Resources (Textbook & Online)

Since active student participation is essential to the impact (and fun!) of this course, we strongly encourage students to take advantage of office hours, online resources, library resources, and office hours. We welcome all questions (at least those nominally course or career related) during lecture, labs, or by contacting us directly.

Required Coursepack: A PDF copy of most reading materials is provided online for free download.

Main Website (Moodle): http://moodle.wolfware.ncsu.edu/course/view.php?id=4043
MessageBoard: http://moodle.wolfware.ncsu.edu/mod/forum/view.php?id=113409
Extra Resources: http://courses.ncsu.edu/ece592/lec/003/ (old course website)

Course Description, Structure, & Attendance

This course focuses on the foundational principles of organic electronic and photonic devices, whose operation is fundamentally based on "soft" condensed-matter principles and materials. We will focus on current research efforts in a variety of organic devices, including flat-panel-displays (LCDs and Organic LEDs), transistor-based electronics, and solar cells. We will build from the traditional foundation of EE students in semiconductor materials and address the differences in physical properties, fabrication processes, and device limitations/advantages. Topics will include electronic transport and light emission, self-assembly and partial-order, lightwave propagation, and fabrication. A modest set of *laboratory experiments* will be included where students will fabricate the following devices:

1. a single-pixel liquid crystal display,
2. a polymer light-emitting-diode,
3. an organic photovoltaic solar cell,
4. and a polymer field-effect-transistor.

Important Administrative Dates

First Lecture:	*Course Add or Drop Deadline:*	*Last Lecture:*	*Final Project/Exam:*
11 Jan	25 Jan	28 Apr	10 May

(Labs will start several weeks into the semester.)

Laboratory Experiments

The following four laboratory experiments will be conducted predominantly in the lab room (1034 EB2). A prelab worksheet must be completed before starting all labs, and the lab experiment manuals can be downloaded from the course website. Each lab experiment will consume at least one full lecture period.

1. Single-Pixel Liquid Crystal Display: A single pixel TN-LCD will be fabricated from scratch.
2. Polymer Light-Emitting-Diode: An electrically-driven polymer-LED will be fabricated from scratch.
3. Organic Photovoltaic Solar Cell: An organic photovoltaic device will be fabricated and characterized.
4. Polymer Field-Effect-Transistor: A polymer-FET will be fabricated and characterized.

Evaluation and Grading Policy

A weighted average grade will be calculated as shown below. As a laboratory course, all labs must be completed for a passing grade. Two in-class tests will be given during the semester, and the individually written final project. The test dates above are tentative and may change.

	ECE-**592**-003	ECE-**492**-003
Laboratory Experiments	40%	40%
Prelecture Quizes	10%	10%
Test 1 (due # Mar, take-home)	14%	14%
Test 2 (due # Apr, take-home)	14%	14%
Final Project (due 10 May, 5 pm) (**)	22%	22%

(**) The final project assignment will be slightly different for ECE-492 (undergraduate) and ECE-592 (graduate) students. See next section.

It is important to note that the Professor *will not be curving grades in this course.* The good news is that it is theoretically possible for everyone in the class to get an A (or an F). Your performance depends entirely on how you do, and not on how everyone else in the class does. It is therefore in your best interest to help your classmates in every legal way possible.

The conversion system below will be used to convert numerical scores to letter grading. Note that a passing grade is ≥ 70 (C-) and that grades below 60 receive F.

Score	*Letter Grade*	*Score*	*Letter Grade*	*Score*	*Letter Grade*	*Score*	*Letter Grade*
$97 \leq X$	=> A+	$87 \leq X < 90$	=> B+	$77 \leq X < 80$	=> C+	$67 \leq X < 70$	=> D+
$93 \leq X < 97$	=> A	$83 \leq X < 87$	=> B	$73 \leq X < 77$	=> C	$63 \leq X < 67$	=> D
$90 \leq X < 93$	=> A-	$80 \leq X < 83$	=> B-	$70 \leq X < 73$	=> C-	$60 \leq X < 63$	=> D-

There will be a *gray area* of several points below each of the numerical cutoffs at left (except for A to A+). A student within this gray area may receive the higher grade (e.g. a B+ instead of a B) at the discretion of the Professor. This discretion may depend on several things: your test/homework grades improved steadily over the semester, strong in-class and lab participation, attendance in lecture, etc.

Final Project

The final project will consist of a written proposal-style document based on knowledge gained in the course as well as in the lab. The assignment will be posted about 5 weeks before semester end. Graduate students will have the additional responsibility of delivering an oral presentation to the instructor, and possibly, their peers. Topics must be approved by the instructor at a date to be determined.

Homework Policy

Homework assignments will be posted on the course website, and are generally due at the *beginning* of the TBA lecture the following week after being assigned. If you are late, your homework is late. Our intention is to post homework solutions online within two days of the due-date.

Late Homework Policy

Any homework handed in after the due date/time described above will be considered late (unless there you make previous arrangements with the Professor, or can demonstrate an emergency situation after the due date/time). Late homework will be penalized –10% and accepted until 10:00am the day after it was originally due. In this circumstance, you may hand in the assignment in several ways: (a) hardcopy to my office in MRC; (b) email scanned images; or (c) fax to 515-3027 (to Dr. Escuti's attention).

Laboratory Experiment Policy

Since there will not be some weeks without a lab experiment, check the course laboratory webpage to be sure of the schedule.

Students will perform the experiments within three-person teams, but hand in individual pre-lab assignments and lab write-ups. Pre-lab assignments will be posted on the course website, and must be handed to the TA at the *beginning* of the lab section. Without the hardcopy of the Pre-Lab, you will not be permitted to perform the lab experiment — it is your ticket in the door. Note that the Pre-Lab assignment is meant to introduce you to the lab, and will therefore not generally demand a lot of time.

The lab write-up will be based on properly keeping a laboratory "notebook". While this will be different than what most students have done in previous courses, we hope that it will provide a very useful real-world skill that many students may not otherwise learn: how to keep a technical lab notebook.

Each lab experiment generally involves three "stations", each focusing on a different part of the lab. The student-groups will rotate through each station within the three-hour lab time. The TA and/or Professor will provide a brief introduction to the experiment and assist students as needed to promote timely progress. If a group requires more time for a particular experiment, they will generally need to visit one of the other lab sections on another day (with an open station).

Lab and Test Make-up Policy

If a student has a non-emergency reason to miss a test or lab, then they MUST contact the Professor. Any emergency absence will require some sort of documentation. A make-up opportunity for each lab experiment will generally be offered the following week, and will be scheduled as closely to the original test-date for a test. Only in extreme circumstances will exceptions to this be allowed.

Instructors' Commitment

You can expect your instructors to be courteous, respectful, and punctual; to be well organized and prepared for lectures/labs; to answer questions clearly and in a non-negative fashion; to be available during office hours or notify you beforehand if we are unable to kept them; to grade uniformly and consistently according to posted guidelines. We aim to provide you with the best course materials and to go out of our way to assist you in learning the material.

For Students with Disabilities

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with Disability Services for Students at the Student Health Center. For more information on NC State's policies on working with students with disabilities, see this link. You instructor and TAs have been and will continue to be as flexible as possible.

Academic Integrity

University policy will be followed. Note that teamwork is strongly encouraged (as it is an important part of being a successful engineer), but plagiarism/cheating is not be tolerated at all. You are expected to fully understand and author any assignments (homework, lab write-ups, exams, reports) even though you may work on them with your classmates on out-of-class assignments. If you do not meet this standard, it is far better to discuss the situation with the professor than to dig yourself into a hole (i.e. cheating) that will have significant long-term consequences.

Policy on Auditing and Satisfactory/Unsatisfactory

University policy will be followed for those taking the course with the satisfactory/unsatisfactory or the audit classifications. In simple terms, satisfactory or audit credit will only be given to those students who have a C- or higher final grade and who have followed the regulations in the "Evaluation and Grading Policy" section above.

Instructional Objectives

We aim to produce students with a foundation and working knowledge of modern photonics concepts/terminology, major opto-electronic devices/components, optical communication systems, and device measurement/handling. As most electrical engineering students have minimal exposure to optics and photonics, we will provide the necessary background and invoke a series of laboratory experiments to explore and demonstrate the most fundamental concepts and devices. In order to do well in this course, students must demonstrate the ability to:

1. **Equip** students with basic knowledge of organic electronic and photonic materials increasingly present in consumer devices;
2. **Reinforce** common principles of electronic devices and fundamentals of optics;
3. **Inspire** students toward graduate-level research in these multidisciplinary research areas;
4. **Train** students via hands-on instruction of essential fabrication skills relevant to the creation and integration of organic devices.

Preliminary Course Outline (dates are tentative!)

Week 1
- Introduction, Course Overview, Expectations
- Overview of Display Technology
- Basic Operation and Components of Liquid Crystal Displays (LCDs)
- Review of Light Emission, Propagation, and Polarization

Week 2
- Radiometry, Color, Light Measurement
- Active Matrix and Passive Matrix Addressing
- Review of Inorganic Semiconductor Principles and Electron Behavior
- TFT Operation 1

Week 3
- Quantum Optics, Fresnel Optics, Photonics
- Charge Transport in Soft Materials
- Materials with Partial Order
- Exam 1

Week 4
- TFT Operation 2
- Operation of Popular LCD Modes
- Photon-Electron Interactions

Week 5
- Fabrication Processes of LCD Electronics, and Films

Week 6
- Single-Pixel LCD *Laboratory*

Week 7
- Organic Light Emitting Diode (OLED) Fabrication, Operation, Application, Characterization
- Student Oral Presentations

Week 8
- Organic Light Emitting Diode Fabrication, Operation, Application, Characterization

Week 9
- Organic Light Emitting Diode *Laboratory*

Week 10
- Organic Photovoltaic Solar Cell Fabrication, Operation, Application, Characterization

Week 11
- Organic Photovoltaic Solar Cell *Laboratory*

Week 12
- Polymer Field Effect Transistor Fabrication, Operation, Application, Characterization

Week 13
- Polymer Field Effect Transistor Fabrication, Operation, Application, Characterization
- Exam 2

Week 14
- Polymer Field Effect Transistor *Laboratory*