ELEC9703

Microsystems Design & Technology

COURSE INTRODUCTION—Session 2, 2008

Course Staff
Course conveners: Prof. Chee Yee KWOK, room EE242;
cy.kwok@unsw.edu.au

Consultations: Students are encouraged to use the open consultation hour rather than contact by email; students may seek consultation with the course convener at other times by appointment. Consultations: Monday 4pm–5pm, room EE242

Course details

Credits: The course is a 6 UoC course; expected workload is 10–12 hours per week throughout the 12 week session.

Contact hours: The course consist of 3 hours of lectures per week. Some of the time during the lecture could be devoted to addressing some assignment questions.

Lectures: Wednesday, 6-9pm, in G3 of the EE&T Building

COURSE INFORMATION

Context and aims
The whole field of microsensors and microactuators has evolved at an exceedingly rapid pace over the past 25 years. It is often referred to as MEMS (Micro Electro Mechanical Systems) or Microsystems Technology. Signals from the physical world around us is always in analog form. Yet, much of the signal processing is done in digital form by microelectronic circuits. Microsensors and microactuators are the interfaces between the digital electronic domain and the physical world. Sensors and actuators in various forms have been around for centuries but significant miniturisation was not possible until the last couple of decades due to the significant technological advances in microfabrication techniques. In many cases, these new devices bring along new advantages over the traditional components like several orders of magnitude in size reduction, new functionality, and possibly integration of on-chip signal processing circuit (smart sensors/actuators). Many of the microfabrication techniques originate from the wealth of processes developed for the fabrication of integrated circuits. Yet, the MEMS business cannot be simply compared to the IC business. ICs deal with electrical signals whereas MEMS devices are interfaces to the physical world from the electrical domain. As such, one would expect a more diverse, a more complicated overall environment, interacting effectively and accurately between the electronic domain and the outside world. The natural outcome of this is the vast and diverse range of MEMS devices. In fact, if one word were to be used to characterise the field of MEMS or Microsystems, it would be its multidisciplinary nature. The most important disciplines needed for Microsystems work are electrical engineering, mechanical engineering, microelectronic engineering, material science, chemistry, fluidic engineering, photonics, biomedical engineering, biosciences etc. MEMS is truly an enabling technology which has penetrated into and begun to change the the way major discipline do things, including biotechnology, storage technology, instrumentation, telecommunications, optical communications, MEMS device packaging, etc. etc. MEMS research and engineering development and manufacture must require close interation of experts from many disciplines. On the other hand MEMS researchers and engineers must be willing to cross interdisciplinary boundaries and acquire knowledge outside their discipline of expertise. Examples of MEMS devices produced on large volumes include, pressure sensors, accelerometers, microvalves, projection display chips, biosensors, injector nozzle arrays, optical crossswitches etc. etc.

This course will cover a wide range of MEMS issues from microfabrication to design and case studies. It is intended to stimulate students to understand other disciplines and interacting productively to bring about new outcomes and new solutions to engineering problems.

**Aims:** The course aims to exposed students to Microsystems technology (or MEMS technology as is also known) and appreciate the many advances in technology that has become the ‘enabling technology’ for many other disciplines.

**Relation to other courses**
The course is a postgraduate course offered to students in the Faculty of Engineering Postgraduate Coursework program (5338,8538,8539). This course is
one of 5 courses offered to those interested in specialising in the Microsystems and Microelectronics area.

**Pre-requisites:** This course is multidisciplinary in nature. Whilst not specific perquisites are required, a previous knowledge in VLIS technology would be useful.

**Assumed knowledge:** It is further assumed that the students are prepared to approach this course with a multidisciplinary frame of mind.

**Following courses:** This course complements the VLSI Technology course ELEC9704.

**Old courses:** The course replaces previous course ELEC9505: Microsystems Technology and Design.

**Learning outcomes**

After the successful completion of the course, the student will be able to:

1. Understand a range of technologies used for microfabrication.
2. Exposed to a range of this enabling technologies across several disciplines.
3. Analysis of microsensors and microactuators.
4. Appreciate the multi-disciplinary nature of Microsystems.

The course delivery methods and course content address a number of core UNSW *graduate attributes*; these include:

1. The capacity for analytical and critical thinking and for creative problem-solving, which is addressed by the design task and tutorial exercises.
2. The ability to engage in independent and reflective learning, which is addressed by the design task.
3. The skills of effective communication, which are addressed by the reports.
4. Information literacy, which is addressed by the homework.

Please refer to [http://www.ltu.unsw.edu.au/content/userDocs/GradAttrEng.pdf](http://www.ltu.unsw.edu.au/content/userDocs/GradAttrEng.pdf) for more information about graduate attributes.

**Teaching strategies**

The course consists of the following elements: lectures and assignments (2-3). Each lecture will be recorded and burned on CD for distribution in the following week.

**Lectures**

The lectures, delivered in class, will cover a range of Microsystems topics. It will begin with a revision of the scope and definition of Microsystems (MEMS). It will then proceed to explain a wide range of microfabrication techniques (surface/bulk micromachining, bonding processes, advanced etching process etc.) that are available at our disposal nowadays. Basic modelling (electrical equivalent) of transducers that convert energy from one domain to another. Design and analysis of various transducers: physical, optical, fluidic, chemical etc.

**Laboratory work**
The is no laboratory component in this course apart from a lab tour.

**Home work**

The lectures can only cover the course material to a certain depth; students must read the textbook and reflect on its content as preparation for the lectures to fully appreciate the course material. Students are encouraged to read the textbook and reference materials. Home preparation for laboratory exercises provides the student with quantitative understanding of the experiment.

**Self-guided tutorials**

The some tutorials questions will be provided to students for self study and help them to consolidate their knowledge.

**Assignments:**

Two-three assignments will be set for this course. Assignments will allow the student to explore the subject in great depth and would consume more effort and time than the normal tutorial questions. Deadline for the submission of assignment are in the course schedule. UNSW plagiarism rules apply.

**Assessment**

There are 2 components of the assessment in this course:

- Assignments: 30% overall weight
- Final examination: 70% overall weight
- Assessment task due dates Week 7 and Week 12

**Final examination:** The examination in this course is in the form of an open-book 3 hours written examination. University approved calculators are allowed. The examination test analytical and critical thinking and general understanding of the course material in a controlled fashion. Assessment is a graded mark according the correct fraction of the answers to the exam questions.
<table>
<thead>
<tr>
<th>WEEK</th>
<th>TOPIC</th>
<th>LECTURER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(28/7)</td>
<td>Introduction to Microsystems: an overview and trends</td>
<td>CYK</td>
</tr>
<tr>
<td>2(4/8)</td>
<td>Lithography &amp; Thin Film processes</td>
<td>CYK</td>
</tr>
<tr>
<td>3(11/8)</td>
<td>Bulk Silicon micromachining</td>
<td>CYK</td>
</tr>
<tr>
<td>4(18/8)</td>
<td>Surface micromachining</td>
<td>CYK</td>
</tr>
<tr>
<td>5(25/8)</td>
<td>Bonding processes</td>
<td>CYK</td>
</tr>
<tr>
<td>6(1/9)</td>
<td>High aspect ratio micromachining (HARM)</td>
<td>CYK</td>
</tr>
<tr>
<td>7(8/9)</td>
<td>Electroplating techniques &amp; miscellaneous processes</td>
<td>CYK</td>
</tr>
<tr>
<td>8(15/9)</td>
<td>Mechanics: properties of materials, structures, energy methods</td>
<td>CYK</td>
</tr>
<tr>
<td>9(22/9)</td>
<td>Electrostatic, electromagnetic, thermal actuation</td>
<td>CYK</td>
</tr>
<tr>
<td>Break</td>
<td></td>
<td>CYK</td>
</tr>
<tr>
<td>10(6/10)</td>
<td>Lumped modelling with circuit elements and system dynamics</td>
<td>CYK</td>
</tr>
<tr>
<td>11(13/10)</td>
<td>Inertial sensors: accelerometer, gyroscope</td>
<td>CYK</td>
</tr>
<tr>
<td>12(20/10)</td>
<td>Pressure transducers, Optical transducers Microfluidics basics, Microfluidic devices, BioMEMS</td>
<td>CYK</td>
</tr>
</tbody>
</table>

**RESOURCES FOR STUDENTS**

**Textbooks:** Prescribed textbook

In view of the wide range of disciplines in this course, there is not one textbook that adequately covers the course. Hence, there is no prescribed text but a preferred reference book is recommended below.
Reference books
The following books are a good resource for topics on Microsystems.

2. MJ Madou: Fundamentals of Microfabrication, CRCPress. *(good text to buy)*
7. SA Campbell: The Science and Engineering of Microelectronics Fabrication
15. Sensors and Actuators A
16. Journal of Micromechanics and Microengineering
17. Proceedings of Transducer conferences
18. Proceedings of MEMS conferences
19. Proceedings of EUROSENSOR conferences

On-line resources
Some additional on-line resources relevant to the course:
Resource: course webct http://vista.elearning.unsw.edu.au
library resources http://info.library.unsw.edu.au/web/services/teaching.html

CAD resources

OTHER MATTERS

Academic Honesty and Plagiarism
Plagiarism is the unacknowledged use of other peoples work, including the copying of assignment works and laboratory results from other students. Plagiarism is considered a serious offence by the University and severe penalties may apply. For more information about plagiarism, please refer to http://www.lc.unsw.edu.au/plagiarism

Continual Course Improvement
Students are advised that the course is under constant revision in order to improve the learning outcomes of its students. Please forward any feedback (positive or negative) on the course to the course convener or via the Course and Teaching Evaluation and Improvement Process.

**Administrative Matters**

On issues and procedures regarding such matters as special needs, equity and diversity, occupational health and safety, enrolment, rights, and general expectations of students, please refer to the School policies, see http://scoff.ee.unsw.edu.au/.