Course No.: 104NEMS5800

RF MEMS Components and Applications

Fall 2015

Instructor:
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Course Description:

Radio **F**requency **M**icro **E**lectro **M**echanical **S**ystems (RF MEMS) are miniaturized devices that are created using micromachining technologies similar to those used to manufacture integrated circuits, and are capable of performing many tasks and functions, such as frequency selection, frequency generation, and frequency translation, that involve mechanical, electrical, and other types of signals. RF MEMS and related Integrated Microsystems are increasingly finding applications in many areas, especially in signal processing and telecommunications. RF MEMS industry is also ready to penetrate into wireless communication products (filters, timing reference devices, switches, etc.).

This is an introductory and design course of RF MEMS components with class lectures and hands-on design labs based on ANSYS/Comsol Multiphysics/CoventorWare. This course introduces students to this rapidly emerging multi-disciplinary and exciting field. It will teach fundamentals of micromachining and microfabrication techniques that are crucial to RF MEMS fabrication. A designer of RF MEMS requires knowledge and expertise across several different disciplines. Therefore, this course will pay attention to teaching fundamentals necessary for the design and analysis of RF MEMS devices and systems in mechanical and electrical domains, and will teach basic techniques for multi-domain analysis (e.g., electromechanical). Fundamentals of transduction mechanism (i.e., conversion between mechanical signals and electrical signals), including capacitive and piezoelectric techniques, and design and analysis of micromachined miniature devices using these techniques will be covered. Many examples of exciting devices and their applications will be reviewed. Students with electronic background and non-electronics are all welcome to study such interdisciplinary subject. Successful project designs will have opportunities to be made via foundry MEMS process.

Tentative Outline:

Week	Lecture Date	Lecture
1	**9/17**	**Introduction to RF MEMS Technologies**
2	**9/24**	**Applications in Wireless Communications**
3	**10/1**	**Microfabrication Technologies**
4	**10/8**	**Structure Analysis I**
5	**10/15**	**Structure Analysis II**
6	**10/22**	**Resonant Transducers**
7	**10/29**	**Vibration Theory and Resonator Modeling**
8	**11/5**	**Capacitive Transduction I**
9	**11/12**	**Capacitive Transduction II**
10	**11/19**	**Micromechanical Resonator**
11	**11/26**	**Midterm**
12	**12/3**	**Micromechanical Oscillator**
13	**12/10**	**No Class due to IEDM**
14	**12/17**	**Micromechanical Filter**
15	**12/24**	**CMOS-MEMS Technologies**
16	**12/31**	**SAW and FBAR**
17	**1/7**	**Piezo-MEMS Resonators and RF-MEMS Switches**
18	**1/14**	**Project Presentation**

Textbook:

Class Notes.

References – Books:

1) Stephen D. Senturia, *Microsystem Design*, Kluwer Academic Publishers, 2000
2) Gregory T. A. Kovacs, *Micromachined Transducers Sourcebook*, McGraw Hill, 1998
3) R. S. Muller, R. T. Howe, S. D. Senturia, R. L. Smith, and R. M. White, *Microsensors*, New York: IEEE Press, 1991
4) M. Madou, *Fundamental of Microfabrication*, New York: CRC Press, 1997
5) M. Elwenspoek, H. Jansen, *Silicon Micromachining*, Kluwer Academic Publishers, 2001
6) J. W. Gardner, "Microsensors – Principles and Applications," John Wiley & Sons, 1994

References – Journals:

IEEE/ASME Journal of Microelectromechanical Systems (JMEMS)

IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control (JUFFC)

IOP Journal of Micromechanics and Microengineering (JM&M)

Sensors and Actuators

Sensors and Materials

IEEE Sensors
IEEE Transactions on Electron Devices

References – Conference Proceedings:

IEEE Micro Electro Mechanical Systems Workshop (MEMS'XX, every year)
International Conference on Solid-State Sensors and Actuators (Transducers'XX, odd years)
Solid-State Sensor and Actuator Workshop (Hilton Head Island, even years)
IEEE International Electron Devices Meeting (IEDM'XX, every year)
IEEE International Solid-State Circuits Conference (ISSCC'XX, every year)
IEEE Ultrasonics Symposium (Ultrasonics'XX, every year)
IEEE Frequency Control Symposium (IFCS'XX, every year)

Prerequisite:

This course is intended for undergraduate seniors and graduate students. It is a half-introductory-and-half-advanced course designed for those students who are not familiar with RF MEMS, microfabrication technologies, integrated circuits, or non-electrical devices and systems. Therefore, the course prerequisites are selected to allow students from MANY engineering and science disciplines, including mechanical, electrical, chemical, aerospace, biomedical, and material engineering to take the course. The course is organized into lectures and computation labs. The lectures present material that ALL students need to learn and the labs are intended to teach students how to use simulators to facilitate the RF MEMS design procedure. The following academic background is required for this course: (a) college math, calculus, and differential equations; (b) basic college-level physics and chemistry.

Grading Policy: (subject to revision)

Homework 20%, Midterm 20%, Final Project 50%, Class Participation 10%