

ESE/MEAM 529: RF MEMS

Course Description

Introduction to RF MEMS and NEMS technologies: need for RF MEMS/NEMS components in wireless communications. Review of micromachining techniques and MEMS/NEMS fabrication approaches. Actuation methods in MEMS and NEMS, RF MEMS/NEMS design and modeling. Examples of RF MEMS/NEMS components from industry and academia. Case studies: micro and nano switches, tunable capacitors, inductors, micro and nano resonators, filters, oscillators and sensors.

Textbooks: (Recommended Only)

1. "RF MEMS and Their Applications", Vijay Varadan, K. J. Vinoy, K. A. Jose, Wiley, 2002.
2. "RF MEMS: Theory, Design, and Technology", Gabriel M. Rebeiz, Wiley, 2003.
3. "Introduction to Microelectromechanical Microwave Systems, Second Edition", Hector J. De Los Santos, Artech House, 2004.
4. "RF MEMS Circuit Design for Wireless Applications", Hector J. De Los Santos, Artech House, 2002.

Additional Materials: Journal papers, Matlab, Abaqus, Ansoft Designer, MEMS ConvectorWare (if available).

Syllabus

Topics:

1. Introduction to RF MEMS/NEMS: application in wireless communications, space and defense applications. RF MEMS in industry and academia
2. Overview of RF MEMS fabrication, design and testing.
3. Introduction to Microfabrication Techniques:
 - a. Materials properties
 - b. Bulk and surface micromachining
 - c. Wet and dry etching
 - d. Thin-film depositions (LPCVD, Sputtering, Evaporation)
 - e. Other techniques (LIGA, Electroplating)
4. Actuation Mechanisms in MEMS:
 - a. Piezoelectric
 - b. Electrostatic
 - c. Thermal
 - d. Magnetic
5. MEMS Design Process:
 - a. Basic review of constituent equations, static and dynamics
 - b. Fundamental equations for simple beams
 - c. FEM analysis
 - d. Basic review of lumped electrical parameters and simple LCR circuits
 - e. Parametric analysis of simple electrical circuits

6. Case Study 1: MEMS Switch
 - a. Example of RF MEMS switches and applications
 - b. Mechanical design (Analytical and FEM)
 - c. Electromagnetic modeling (Capacitance, Loss, Isolation)
 - d. Current research in MEMS and NEMS
7. Case Study 2: MEMS Resonators
 - a. Example of RF MEMS resonators and their applications
 - b. Comparison of electrostatic and piezoelectric resonators
 - c. Mechanical design of resonators
 - d. Electromechanical parameter derivation
 - e. Application in oscillators: pierce oscillator overview
 - f. Application in filters: design and simulation of band pass electrically and mechanically coupled filters
8. Case Study 3: Tunable Capacitors and Inductors
 - a. Example of tunable capacitors and inductors and their applications in circuits
 - b. Mechanical Design (Analytical and FEM)
 - c. Electromagnetic modeling
 - d. Integration issues
9. Case Study 4: NEMS Resonators and Switches
 - a. NEMS resonator/switch overview
 - b. Key challenges: fabrication, transduction, surface to volume ratio
 - c. State of the art research and applications

Evaluation Criteria:

1. Class Attendance and Participation (5 %)
2. Homework (20 %)
3. Midterm (35 %)
4. Final Project (40 %)