ECE5332– Spintronic Devices and Applications

Spring 2023

Department of Electrical and Computer Engineering, Texas Tech University

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Class Meeting Time: M, W, F 9:00 am – 9:50 am
Classroom: TBD
Office Hours: TBD
Class Website: Blackboard
Grader: TBD

Required Textbooks:
"Modern Magnetic Materials: Principles and Applications" Robert C. O'Handley
"Introduction to Magnetic Materials" (2nd Edition) B.D. Cullity and C.D. Graham
Lectures slides will be distributed on Blackboard.

Course Overview:
Basic concepts and physical principles underlying spintronic devices; engineering designs and basic features of matured spintronic devices: giant magnetoresistance (GMR), magnetic tunnel junction (MTJ) sensor, magnetoresistive random-access memory (MRAM), etc; new opportunities and engineering designs and challenges of spintronic devices: STT-RAM, spin toque oscillator (STO) and all spin logic, etc.

Course Outcomes:
Students successfully completing this course are expected to understand the fundamentals of analysis and engineering design of spintronic devices as well as underlying physical principles. Students will be able to use micromagnetic simulation tool OOMMF for modeling some spintronic devices.

Methods of Assessment of Learning Outcomes
The learning outcome will be evaluated based on students' performance in homework and exams (fundamental knowledge) and design projects (practical skills).

Grading:
Homework: 30%
Mid-term test: 20%

Mid-term project: 20%
Final test: 30%
Homework assignments will be on a weekly basis.

In-Class Exam Policy:

One in-class mid-term exams (80 minutes) will be offered.

Preliminary Course Outline (26 lectures):

1. Overview of spintronic devices (1 lecture)
2. Basics of magnetic materials and magnetism (3 lectures)
   Crystal lattices; Magnetic anisotropy; Stoner-Wolfarth model; Thermal stability; Magnetic domains; Nanomagnetic structures; Multilayer and ultra-thin film deposition; Micro and nano patterning process
3. Basics of quantum mechanics (2 lectures)
   Wave functions and probability; Bra-ket notation; Electron spin; Spin orbit coupling
4. Basic concepts of spintronics (4 lectures)
   Magneto-resistance effects; Two channel model; Spin accumulation, Spin diffusion, Spin scattering, Spin relaxation, Spin injection; Spin Hall effect
5. GMR and MTJ: structures and devices (2 lectures)
6. Micromagnetic Simulation (2 lectures)
7. Spin transfer torque physics and devices (2 lectures)
8. Spin Hall physics and devices (2 lectures)
9. Half metal and highly spin polarized materials (1 lecture)
10. Spin current generation structures and devices (1 lecture)
11. Spin torque oscillators and spin torque oscillation (2 lectures)
12. Magnetic biosensors: GMR, MTJ, NMR, MPS, STO, etc. (2 lectures)
13. Advanced Topics (2 lectures)
    Covering most recent papers on magnetic and spintronic nanodevices such as magnetoelectric switching devices; magnetic domain devices; magnetic skyrmions, etc.