Spintronics: Physics and Technology - Web course

COURSE OUTLINE

The course in physics and technology of spintronics introduces the fundamental concepts on spin electronics, Classes of magnetic materials, quantum mechanics of spins, spin-orbit interaction, and exchange interactions.

In addition, the spin relaxation mechanisms, spin relaxation in quantum dots, spin galvanic effect, spin-dependent transport in single-electron devices and magnetic nanostructures would be discussed.

This course covers a deeper insight in theories and practical knowledge of Spin dependent transport, Andreev Reflections at ferromagnet and superconductor interfaces, measurement of spin polarization, spin-transfer torques and domain wall magnetoresistance in nanostructures, Spin injection in hybrid nanostructures.

Also, this book brings out the basics and advanced practical knowledge in Spintronic Materials, Technology and Spin Devices for futuristic applications.

The topics covered in this course include introduction to spin and spin electronics, spin relaxation behavior, Spin dependent transport, Spin-transfer torque, Spin injections and spin devices, and Advances in spintronic materials, technology.

As the motivation of the course is to provide an understanding of fundamentals of spinelectronics, spin relaxation, spin transport in metal and semiconductors, and advances in spin electronic technology and futuristic materials with high spin polarization.

This will be very much useful to the students studying in any B.Tech. engineering branches, Master of Science and M.Tech. with the background knowledge on Solid State Physics and for teachers and practitioners.

Contents:

History and overview of spin electronics; Classes of magnetic materials; The early history of spin; Quantum Mechanics of spin; The Bloch sphere; Spin-orbit interaction;

Exchange interaction; Spin relaxation mechanisms; spin relaxation in a quantum dots; The spin Galvanic effect; Basic electron transport; Spin-dependent transport; Spin dependent tunneling; Andreev Reflection at ferromagnet and Superconductor interfaces; Spintransfer torques;

Spin-transfer drive magnetic dynamics; Current-driven switching of magnetization and domain wall motion; Domain wall scattering and Current-Induced switching in ferromagnetic wires;

Spin injection, spin accumulation, and spin current, Spin hall effect, Silicon based spin electronic devices,

Spin LEDs: Fundamental and applications, Spin photoelectronic devices based on Heusler alloy, Electron spin filtering, Materials for spin electronics, Nanostructures for spin electronics, Deposition techniques, micro and nanofabrication techniques.

Spin-Valve and spin-tunneling devices: Read Heads, MRAMS, Field Sensors, Spintronic Biosensors, Spin transistors, Quantum Computing with spins.

COURSE DETAIL

NPTEL

http://nptel.iitm.ac.in

Physics

Pre-requisites:

Solid State Physics and/or magnetic materials.

Additional Reading:

Literature on Magnetic recording.

Coordinators:

Dr. A. Perumal
Department of PhysicsIIT Guwahati

Sl.No.	Module/ Lecture Topics	No. of Hours
	1. Introduction:	
1.	History and overview of spin electronics, Classes of magnetic materials,	01
2.	The early history of spin, Quantum Mechanics of spin, The Bloch sphere,	02
3.	Spin-orbit interaction, exchange interaction	02
	2. Spin relaxation:	
4.	Spin relaxation mechanisms,	01
5.	Spin relaxation in a quantum dots,	01
6.	The spin Galvanic effect.	01
	3. Spin dependent transport:	
7.	Basic electron transport	01
8.	Spin-dependent transport	01
9.	Spin dependent tunneling	01
	4. Andreev Reflection at ferromagnet and Superconductor Interfaces:	
10.	Basic theory of Andreev reflections.	01
11.	Point-Contact Andreev Reflection,	01
12.	Ferromagnet/Superconductors/Ferromagnet double junctions, crossed Andreev reflections.	02
	5. Spintransfer torques:	
13.	Intuitive picture of spin-transfer torques, spin-transfer drive magnetic dynamics,	03

14.	Current-driven switching of magnetization and domain wall motion,	02
15.	Domain wall scattering and Current-Induced switching in ferromagnetic wires.	02
	6. Spin injection:	
16.	Spin injection, spin accumulation, and spin current.	02
17.	Spin hall effect, Silicon based spin electronic devices: Toward a spin transistor,	02
18.	Spin LEDs: Fundamental and applications,	02
19.	Spin photoelectronic devices based on Heusler alloy,	02
20.	Electron spin filtering, Monolithic and Hybrid Spintronics,	02
	7. Advances in Spintronic Materials, Technology and Devices	
21.	Materials for spin electronics, Nanostructures for spin electronics	02
22.	Deposition techniques, micro and nanofabrication techniques.	03
23.	Spin-Valve and spin-tunneling devices:	02
24.	Read Heads, MRAMS, Field Sensors, Spintronic Biosensors,	02
25.	Quantum Computing with spins.	01
	Total	42

References:

1. S. Bandyopadhyay, M. Cahay, Introduction to Spintronics, CRC Press, 2008.
2. M. Johnson, Magnetoelectronics, Academic Press 2004.
3. D. J. Sellmyer, R. Skomski, Advanced Magnetic Nanostructures, Springer, 2006.

4. S. Maekawa, Concepts in Spin Electronics, Oxford University Press, 2006.

5. D.D. Awschalom, R.A. Buhrman, J.M. Daughton, S.V. Molnar, and M.L. Roukes, Spin Electronics, Kluwer Academic Publishers, 2004.

6. Y.B. Xu and S.M.Thompson, Spintronic Materials and Technology, Taylor & Francis, 2006.