COURSE DESCRIPTION AND HANDOUT Date: 02/08/2016

1. Course Information

Course Title:	**Nanoelectronics and Nanophotonics**
Instructor:	Niladri Sarkar
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2. Scope and Objective:

This course provides a blend of photonic and electronic fundamentals and applications to the fast moving technology involved in optical communication systems and devices in terms of nano structures. Electronics and Photonics are becoming increasingly important as limitations of speed, size and bandwidth affect many electronic devices and systems. Moreover, integration of electronics and photonics becomes an important issue related to modern technical aspects like optical interconnects etc. Here the fundamentals of semiconductors, quantum structures and transport properties related to quantum structures will be first discussed. That will be followed by electronic and optical properties and details of strain engineering. Finally all these basic concepts will be applied in understanding modern and photonic and electronic devices useful for engineering applications. Students will also be encouraged to learn hands-on-training in analysis/ simulation of some electronic-photonic devices using MATLAB/ SILVACO TCAD software.

3. Learning Outcomes:

At the end of this course students will have a concept on basic of quantum mechanics and its application to state of the art and emerging semiconductor devices used in computers, communication and networking systems as well as in consumer products.

4. Course Topics:

(a) Semiconductor Fundamentals in Nanotechnology
(b) Introduction to low dimensional nano-structures and Quantum Mechanics
(c) Electronic transport in nano-structures
(d) Optical properties of nano-structures
(e) Strain Engineering
(f) Electro- Optic Effects
(g) Photonic devices based on nano structures
(h) Electronic Devices based on nano structures
(i) Hands-on-Training

5. Text Books:

T1: "Electronic and Optoelectronic Properties of Semiconductor Structures", Jasprit Singh, Cambridge University Press, 2003.
T2: "Physics of Photonic Devices", S. L. Chuang, Wiley Series in Pure and Applied Optics, 2009.

6. Reference Books:

R1: "Solid State Electronic Devices", Streetman and Banerjee, PHI Learning Ltd., 2009.
R2: "Semiconductor Physics and Devices – Basic Principles", D. A. Neamen, Tata McGraw Hill.
R3: "Physics of Semiconductor Devices", S. M. Sze, John Wiley and Sons, JNC.
R4: "Quantum Transport: Atom to Transistor", Supriyo Datta, Cambridge University Press

7. Course Plan in Detail:

Serial No.	Class No.	Main Topic	Detail Areas	Reference
1.	1	Introduction and Overview	What is nanotechnology, Developments in nano-technology	-----
2.	2- 5	Semiconductor Fundamentals in Nanotechnology	Details of Band theory, Energy bands and sub bands, density of states and effective mass, carrier density, degeneracy, Kronig- Penney model, crystal momentum, band alignment, carrier mobility.	R1, T1(Ch 2)
3.	6-8	Introduction to low dimensional nano-structures and Quantum Mechanics	Fundamentals of Quantum mechanics, quantization and low dimensional electron gas, alloying, electrons in nanostructures- Quantum wells, wires and dots, Schrodinger equation and its applications.	T1 (Ch 3), T2 (Ch 3 and 4)
4.	9-12	Electronic transport in nano-structures	Ohms' Law, mobility, Scattering mechanisms, Diffusion, Excess carriers, Transport in 1D and 2 D systems, Resonant tunneling, carrier lifetimes and recombination mechanisms, Statistics of electron transport.	T1 (Ch 4 and 5)
5.	13 - 15	Optical properties of nano-structures	Basics of EM field, Photons, Scattering mechanisms, phonons, absorptions, spontaneous and stimulated emissions, Interband and intraband transitions, excitons.	T1 (Ch 9), T2 (Ch 9)
6.	16 – 18	Strain Engineering	Basics of strain, classifications of strain, effect of strain in various quantum structures	T2, Lecture Class
7.	19 - 26	Physics of the Electronic Devices based on nanoelectronics	Nanoscale MOSFETs., resonant tunneling Devices and circuits, Spintronic devices, single Electron Transistor and Coulomb Blockade	R4(Ch-9-11)

		structures		
8.	27 - 33	Mathematical Methods for Nanoscale Devices	Density Matrix and NEGF Formalism	R4(Ch 7,8)
9.	34 - 36	Numerical Simulations of Nanoscale Devices	Simulation and Analytic modeling of basic photonic and electronic devices using Matlab.	Class Lectures
10.	37-40	Photonic devices based on Nano structures	LEDs, Quantum Well and Multiple QW lasers, QD Lasers, Transistor laser, vertical cavity surface emitting lasers (VCSEL), Contemporary and advanced (Multi junction, intermediate band etc.) solar cells, Photonic crystals, surface plasmons, spintronic devices, photo detectors etc.	R2 (Ch 14), Research papers, R3 (Ch 12- 14)

8. Evaluation Scheme:

EC No.	Evaluation Component	Duration (min)	Marks	Date, Time & Venue	Nature of Component
1.	Mid semester Test	90	90	8/10 4:00 - 5:30 PM	OpenBook+Closed Book
2.	Quiz/ Assignments	-	45	Spread throughout the semester	Closed Book
3.	Simulation based Project Assignments	-----	45	To be announced in the class	Open Book
4.	Comprehensive	180	120	14/12 AN	Open Book + Closed Book
	Total		300		

Niladri Sarkar