Semiconductor Optical Communication Components and Devices - Web course

COURSE OUTLINE

This course is intended as an introductory course for Postgraduate Students in the areas of Photonics and Optoelectronic Devices.

Students in their final year undergraduate degree in ECE, who would like to specialize in this area, will also find this course revealing.

The treatment would look at semiconductor devices that are commonly used in optical fiber communications.

COURSE DETAIL

Sl. No.	Topic/s	No.of Lectures
1	**Introduction**. • Historical development of Optical Communications. • Modulation and Bandwidth in Optical Communications. • Optical Communication Capacity - DWDM and CWDM. • Present Technology and future trends.	1
2	**Semiconductor Optical Waveguides.** • Refractive Index in semiconductor materials. • Review of electromagnetic theory. • Laws of reflection and refraction - Critical Angle, Brewster's angle, and power flow. • Electromagnetic approach to Symmetric and Asymmetric Slab-waveguides - transverse modes and propagation. • Two Dimensional waveguides. Effective Index and other techniques for the design and analysis of single mode Rib-, Ridge-, Buried-, etc. waveguides.	4
3	**Review of Semiconductors**. • Band structure. • Direct and Indirect Transitions. • Density of States. • Spontaneous and Stimulated Recombination.	6

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http://nptel.iitm.ac.in

Electronics & Communication Engineering

Pre-requisites:

1. An undergraduate course in solid state devices.
2. An undergraduate course in Electromagnetic Fields and Waves.

Additional Reading:

1. Properties of Semiconductor Alloys: S. Adachi, Wiley publishers.
2. Handbook of semiconductor lasers and photonic integrated circuits: Ed. Y. Suematsu & A. R. Adams, Chapman & Hall publishers.
3. Analysis and design of Vertical Cavity Surface Emitting Lasers: S. F. Yu, Wiley publishers.
4. Laser diode modulation and noise: K. Petermann, Kulwer Academic publishers.

Hyperlinks:

Will be provided in the lectures.

Coordinators:

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	• Probability and rates of optical transitions. • P-N junctions. • Heterojunctions. • Carrier injection and Quasi Fermi Eenergy. • Carrier mobility and velocity saturation.	
4	**Epitaxial Growth of Semiconductors.** • LPE, MBE, and MOCVD growth systems. • Growth of DH structures. • Growth of Quantum Wells. • Strained Layers and Strained Quantum Wells. • Quantum Dots and Dashes.	2
5	**LED**. • Spontaneous emission spectrum - Gaussian approximation. • Current - Output Power dependence and Peak Emission wavelength. • Surface and Edge emitting LEDs. • Efficiency Calculation of LEDs. • Emission Intensity Pattern of LEDs. • Superluminescent LEDs. • Modulation Bandwidth and Temperature dependence of LED power and wavelength.	4
6	**Diode Lasers.** • Gain. • Fabry-Perrot Cavity. • Longitudinal modes of a semiconductor Laser. • Calculation of Threshold Current and Linewidth. • Output power dependence on Current. • Near and Far-field pattern. • Types of semiconductor diode lasers. • Fabrication of Laser Diodes. • Photon lifetime. Power conversion efficiency and Differential Gain. • Modulation Bandwidth of FP-Lasers - Lasing Spectrum and dynamic Broadening. • Characteristic temperature of lasers. • Tunability of Semiconductor lasers. • Quantum Well and Quantum Dot lasers.	6

	• Noise in semiconductor lasers.	
7	**Single mode Laser diodes**. • C-cube laser. • Distributed Bragg reflector. • DBR Lasers. • DFB Lasers - Fabrication and analysis. • Tuning of DFB lasers. • Vertical Cavity Lasers - Fabrication and analysis. • Tuning of VCSELs. • External cavity Lasers. • Injection Locking. • Saturable absorber.	5
8	**Detectors.** • Photon Absorption and Excess carrier generation-choice of semiconductor. • Photoconductors and MSM detectors. • PIN Photodiodes. • Heterostructure and Quantum Well photodiodes. • Efficiency and Responsivity calculation of Photodiodes. • Temporal response of PIN photodiodes. • Noise and NEP. • Carrier Multiplication and Avalanche Photodiodes (APDs) and its NEP. • Gain-Bandwidth product. • SAM APD. • Resonant Photodiodes. • Waveguide Photodiodes. • Gated Photon counting.	6
9	**Packaging**. • Packaging and driving of LEDs. • Different packages of Diode lasers. • Fiber coupled Laser Diodes and Photodiodes.	1
10	**Photonic Integrated Circuits.** • Optical Amplifiers. • Electro-optic effect and phase shifters - bulk and quantized structures.	5

	• Machzehnder Modulator. • External modulation of semiconductor lasers. • Coplanar and Vertical couplers. • Grating assisted couplers. • Ring cavity couplers for add-drop. • Photodiode-Amplifier Integration.	
	Total	40

References:

1. Guided Wave Photonics: A. B. Buckman, HBJ Saunders publisher.
2. Guided Wave Optoelectronics: Ed. T. Tamir, Springer v26.
3. Semiconductor Optoelectronic Devices: P. K. Bhattacharya, Prentice Hall publishers.
4. Optical Fiber Communications: J. M. Senior, Prentice Hall publishers.