EEE417 OPTICAL COMMUNICATIONS DEVICES & SYSTEMS

Course Description including Aims

1. To study the characteristics of the device components used in optical fibre communication systems and to examine their dependence on design.

2. To study the dependence of the system performance on device design.

The course examines the behaviour of the components in a communications system and the way in which their design and individual performance is determined by that of the system requirements. The course is delivered as a set of 24 one hour lectures in the second semester and includes a visit to the Central Facility. Copies of incomplete OHP transparencies are distributed to students and these are supplemented by additional notes taken during the lecture. Two problems sheets are distributed with guideline answers.

Outline Syllabus

Introduction to optical fibre communications. LEDs; spontaneous emission, surface and edge emitters, linewidth and speed. Semiconductor lasers; gain and feedback, materials, heterostructures, carrier and optical confinement. Threshold gain and Fabry-Pérot mode separation. Parasitic recombination and absorption, dependence of gain on n, λ and T, lasing emission spectrum. DBR and DFB. I_{th}, turn-on delay, dynamic response. Advanced laser structures.
Optical fibres; structure, fabrication, ray and wave optics, attenuation and dispersion. Multimode fibres; NA, sphere lenses, multimode dispersion. Graded index fibres; single mode fibres; mode structure, modal dispersion, cutoff. Fibre amplifiers, solitons. Detectors; pin diodes, absorption in group IV and III-V materials, Si photodiodes. Quantum efficiency, speed, long λ structures. APDs; impact ionisation, field dependence, multiplication, noise and breakdown. APD design; Si, long λ SAM and SAGM devices. System design, speed and power budget.

Time Allocation

24 hours of lectures plus 12 hours of additional support material.

Recommended Previous Courses

EEE207 Semiconductor Electronics and Devices

Assessment

2 hour examination

Recommended books

Senior, J.M.	*'Optical Fibre Communications'*	(Prentice-Hall)
Battacharya, P.	*'Semiconductor Optoelectronic Devices*	(Prentice-Hall)
Gowar, G.	*'Optical Communications Systems'*	(Prentice-Hall)
Singh, J.	*'Semiconductor Optoelectronics'*	(McGraw-Hill)

Objectives

1. To understand the principles of semiconductor lasers, detectors and optical fibres.

2. To appreciate the dependence of device performance on design.

3. To understand how device design and performance feeds through into system performance.

Syllabus

1. Introduction, plan of course, applications of fibre optics, course books. Introduction to semiconductor lasers; gain and feedback, absorption and gain, stimulated emission, Fresnel reflection at facets.

2. Materials for lasers; GaAs/AlGaAs, InGaAsP/InP, heterostructures, carrier and optical confinement, waveguiding, optical confinement factor, Γ.

3. LEDs; spontaneous emission, surface and edge emitters, linewidth and speed.

4. Conditions for lasing; formulae for threshold gain and Fabry-Pérot mode separation.

5. Parasitic recombination (e.g. Auger) and absorption (e.g. IVBA) processes, dependence of gain on carrier concentration, wavelength and temperature, Fabry-Pérot lasing spectrum.

6. Alternative feedback mechanisms; distributed Bragg reflection and distributed feedback, narrow linewidth lasers.

7. Threshold current, turn-on delay at threshold, dynamic response above threshold.

8. Quantum mechanics, advanced laser structures, quantum wells, wires and dots, effects of strain, VCSELs.

9. Introduction to optical fibres; structure, fabrication, ray and wave optics, principles of loss and dispersion.

10. Multimode, step index fibres; Numerical Aperture, sphere lenses, multimode dispersion.

11. Graded index fibre; reduced dispersion by speed compensation. Single mode fibres; mode structure, Bessel functions, LP modes, modal (waveguide dispersion), cutoff.

12. Fibre performance summary. Fibre amplifiers, solitons.

13. Introduction to detectors; pin diodes, structure and principles.

14. Wavelength dependence of absorption coefficient in Si, Ge and III-Vs. Si photodiodes.

15. Quantum efficiency, speed, tradeoffs, long wavelength photodiode structures.

16. Introduction to avalanche photodiodes; impact ionisation, coefficients, high field carrier transport and dependence of coefficients on field, multiplication, noise.

17. Calculating multiplication; $\beta = 0$, $\alpha = \beta$, feedback effects, breakdown.

18. APD design; Si APDs, long wavelength SAM and SAGM APDs.

19. System design, attenuation and power budget.

20. Emitter linewidth, dispersion and system speed.