The University Of Sheffield.

Data Provided: None

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Autumn Semester 2009-2010 (2 hours)

Optical Communication Devices and Systems 6

Answer **THREE** questions. **No marks will be awarded for solutions to a fourth question.** Solutions will be considered in the order that they are presented in the answer book. Trial answers will be ignored if they are clearly crossed out. **The numbers given after each section of a question indicate the relative weighting of that section.**

1. **a.** Sketch the spectral dependence of attenuation as a function of wavelength for a silica fibre. Label all regions of the graph and provide an explanation as to the origin of these features. **(4)**

b. Describe the effects of attenuation and chromatic dispersion on a pulse amplitude modulated optical signal. Explain how these effects affect the distance over which such a signal can be successfully transmitted. **(4)**

c. A fibre optic link is to be created to operate at a data rate of 10 GBit/second using amplitude modulated pulses with 1:1 mark:space ratio. A fabry-perot (F-P) laser and a p-i-n photodiode are to be used as the transmitter and receiver, respectively.

The Fabry-Perot laser has spectral linewidth of 2nm and launch power of 5dBm. A p-i-n diode, which requires a signal power at the receiver of -15 dBm at this bit-rate to achieve the required bit-error-rate, is the receiver. A power budget margin of 15dB is required for the system. The system will operate in the 1310nm region giving a dispersion coefficient of 0.8 ps/(nm/km). The attenuation of the signal in the fibre at this wavelength is 0.4 dB/km.

Calculate the maximum link length possible stating all assumptions made. **(8)**

Explain how you would modify the transmitter and receiver to increase the link length. **(4)**

2. **a.** Describe the operating principles of a WDM link, using schematic diagrams if necessary. **(8)**

   b. Identify what components are required in a WDM network, the requirements placed upon them and sources of noise. **(6)**

   c. Explain the effects of chromatic dispersion on a WDM link. Explain how this manifests itself in system performance. **(6)**

3. **a.** Figure 3 below shows a schematic of a photodiode operated in reverse bias to be used as a receiver in an optical communications system. If the intended operating wavelength is 1550nm describe suitable materials for layers A, B, and C. **(3)**

   b. Describe design considerations for the thickness, L, of the intrinsic region for both high responsivity, and high speed operation of the device.

   By equating time constants, derive an equation which relates the thickness L to other device parameters for a device optimised for high speed operation. State all assumptions and define all parameters. **(8)**

   c. Describe the effect of elevated temperature on a photodiode, and the impact this has on the operation of an optical communications link. **(2)**

   d. Describe how a photodiode can be engineered to have electrical gain, describing the physical processes utilised, and utilising schematic diagrams where necessary.

   Describe the effects of elevated temperature on this type of device. **(7)**

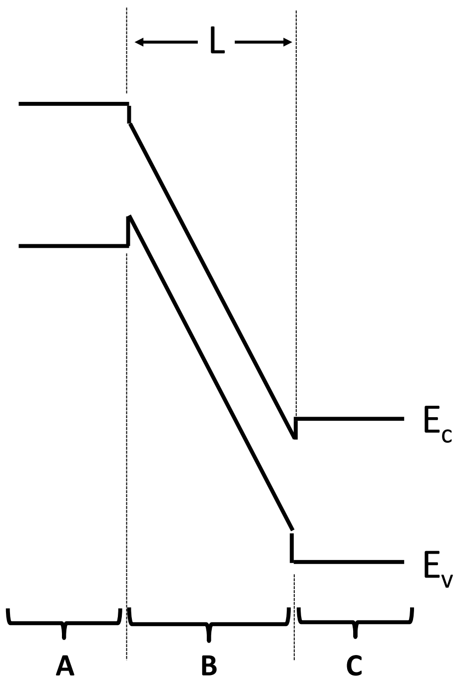

Figure 3.

4. **a.** Describe light absorption and emission processes in a semiconductor, using diagrams if necessary. **(3)**

b. Figure 4 shows the relationship between current density and modal gain for a semiconductor laser gain material.

Describe the relative probabilities of the optical transitions described in part (a) at points X, Y, and Z on the graph. **(3)**

c. By writing an expression which relates modal gain and current density, and the threshold gain condition, derive expressions which relate threshold current density to the internal loss α_i, length L of the cavity, reflectivities of the facets R1 and R2. **(3)**

Comment upon the minimization of threshold current density, J_{th}. **(1)**

Assuming a waveguide width W, derive an expression for the threshold current I_{th}. **(1)**

Comment upon the minimization of threshold current and discuss which parameters may be altered to reduce both Ith and Jth. **(3)**

d. If two lasers were made from the laser material of part 4b, one operating with a threshold current of 700Acm^{-2}, and the other with threshold current of 800Acm^{-2}, write a brief reasoned argument that identifies which of these two would operate with the highest direct modulation rate. **(6)**

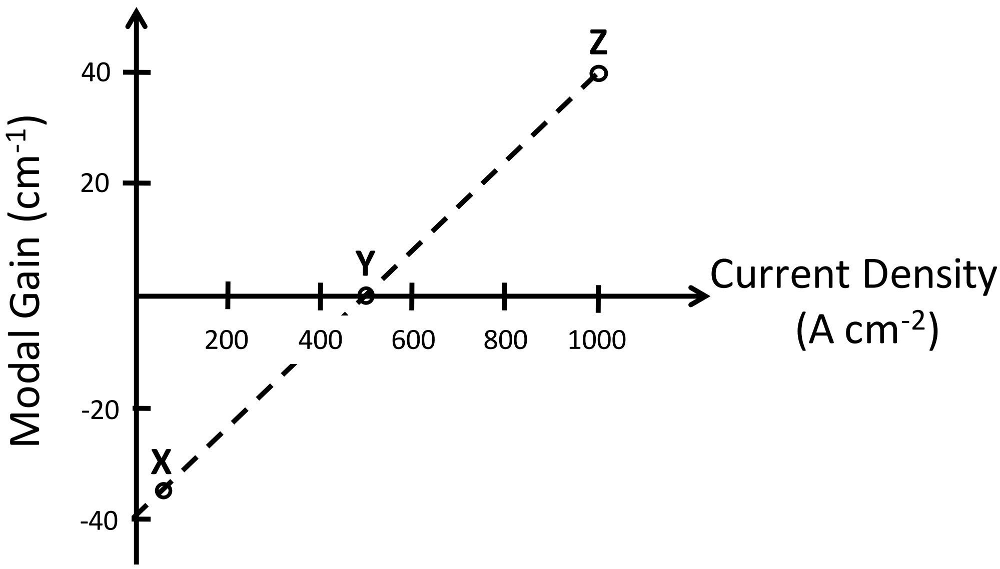

Figure 4.

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