Integrated Photonic Device

Homework 2
2007, Fall

4.1 We wish to fabricate a planar waveguide for light of wavelength $\lambda_0 = 1.15\,\mu m$ that will operate in the single (fundamental) mode. If we use the proton-bombardment, carrier-concentration-reduction method to form a $3\,\mu m$ thick waveguide in GaAs, what are the minimum and maximum allowable carrier concentrations in the substrate? (Calculate for the two cases of p-type or n-type substrate material if that will result in different answers.)

4.4 We wish to fabricate a planar waveguide for light of $\lambda_0 = 0.9\,\mu m$ in $Ga_{(1-x)}Al_xAs$. It will be a double layer structure on a GaAs substrate. The top (waveguiding) layer will be $3.0\,\mu m$ thick with the composition $Ga_{0.9}Al_{0.1}As$. The lower (confining) layer will be $10\,\mu m$ thick and have the composition $Ga_{0.17}Al_{0.83}As$. How many modes will this structure be capable of waveguiding?

6.3 In the optical integrated circuit shown above, all of the waveguides have the same cross sectional dimensions and loss per unit length due to scattering and absorption. However, the curved waveguides have an additional loss per unit length due to radiation.

If the total loss between the following elements is:

Between D and E $\quad L_T = 1.01\,dB$
Between C and D $\quad L_T = 1.22\,dB$
Between B and C $\quad L_T = 1.00\,dB.$

What is the total loss L_T between elements A and B? (Neglect coupling losses – consider only waveguide loss as above.)

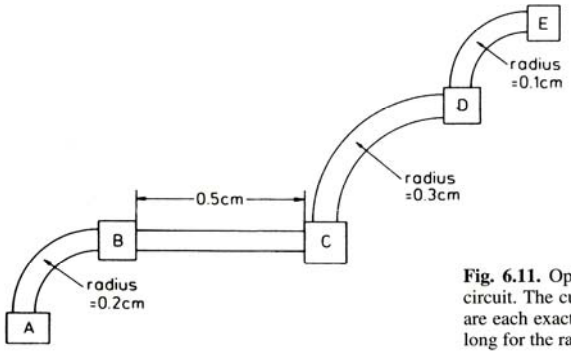

Fig. 6.11. Optical integrated circuit. The curved waveguides are each exactly 1/4 of a circle long for the radii given

6.5 A certain ribbed channel waveguide, 1-μm deep, is used in an OIC for guiding light of vacuum wavelength $\lambda_0 = 6328$ Å. Loss measurements made on test sections of the guide have shown that the loss coefficient in a straight sample is $\alpha = 0.3\,\text{cm}^{-1}$, while in a curved section with radius of curvature $R = 0.5$ mm it is $\alpha = 1.4\,\text{cm}^{-1}$, and in a curved section with $R = 0.3$ mm it is a $\alpha = 26.3\,\text{cm}^{-1}$.

What is the minimum radius of curvature that can be used if α must be less than $3\,\text{cm}^{-1}$ at all points in the circuit?