Q1. Snells Law $\Rightarrow n_1 \sin\theta = n_2 \sin\theta$

- $\theta_2 < 90°$ $\Rightarrow$ light coupled into cladding & lost
- if $\theta_2 > 90°$ $\Rightarrow$ Total internal reflection, hence light stays in core $\Rightarrow$ fibre acts as waveguide.
- Critical angle for total internal reflection, θ_c occours for $\theta_2 = 90°$

$$\Rightarrow n_1 \sin\theta_c = n_2 \sin(90°) = n_2$$

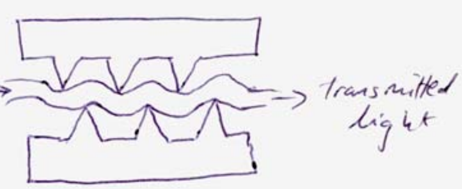
$$\Rightarrow \sin\theta_c = \frac{n_2}{n_1}$$

$$\text{OR} \quad \theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)$$

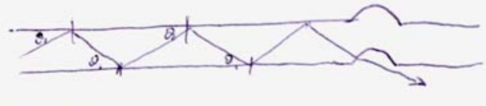
Q2. Intensity based optical fibre

Eg. Microbending

Principle of Operation.



→ Microbends change θ_a locally.



→ At microbend light coupled into fibre cladding which reduces transmitted intensity.

→ Increasing the bending of the fibre will further reduce the transmitted intensity

→ Can be used for monitoring strain/pressure.

Q 2. (Continued)

Optical fibre sensor based on phase change

- Bragg Grating.

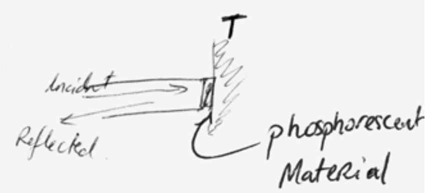
- Permanent grating structure imprinted in to core of fibre
- This structure causes local modifications of R.I.
- The structure causes certain wavelengths to be reflected as determined by $\lambda_B = 2n\Lambda$.
- ~~Modi~~ Changes to n or Λ will cause λ_B to be changed

$\Rightarrow$ Monitoring reflected wavelength, λ_B, can be used to detect changes in n (Temperature) or Λ (strain).

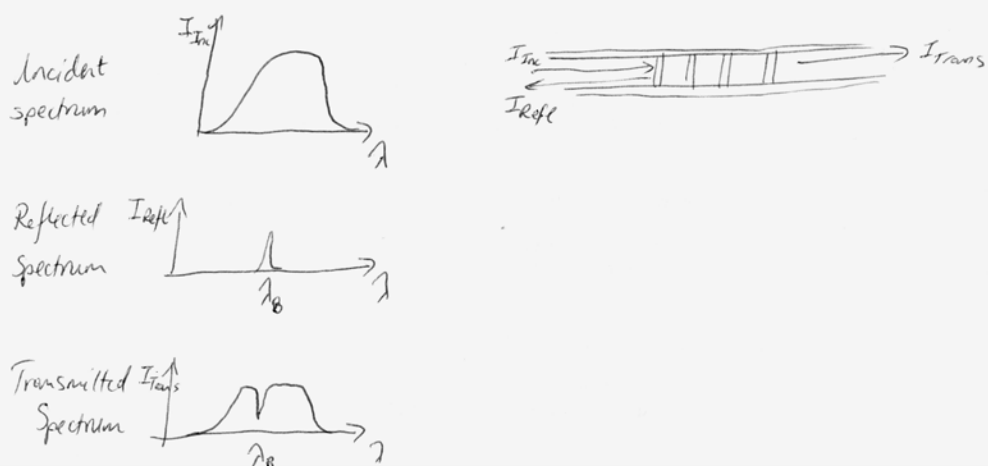
Q3. $\rightarrow$ Bragg grating $\rightarrow$ n changes with T

$\Rightarrow$ λ_B will change with T

$\rightarrow$ Reflected λ from phosphorescent material $\rightarrow$ wavelength of phosphorescence dependant upon temperature.



Q4 (a) Assume broadband source used as incident beam

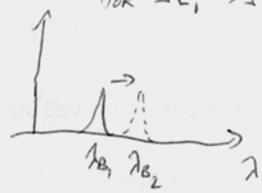


Q4(a) (contd)

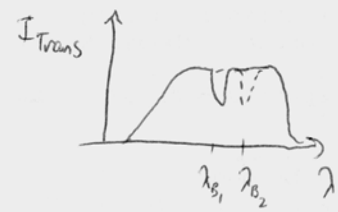
$\lambda_B = 2n\Lambda$ Λ is spacing of grating

if Λ increases $\Rightarrow$ λ_B increases

$\Rightarrow$ Reflected for $\Lambda_1 \rightarrow \Lambda_2$



Transmitted



(b)

$\lambda_B = 2n\Lambda$

$\lambda_B = 2(1.4)(330\,nm) = 924\,nm$

Q(5) (a) $\frac{1}{\lambda_B}\frac{\Delta\lambda_B}{\Delta T} = 6.667\times10^{-3}$

if $\Delta T = 10°C$ & $\lambda_B = 924\,nm$

$\Rightarrow \Delta\lambda_B = \lambda_B(6.667\times10^{-3})\Delta T$

$= (924\,nm)(6.667\times10^{-3})(10)$

$= 61.6\,nm$

(b) $\Delta T = 0.1$ $\Rightarrow \Delta\lambda_B = 0.616\,nm$

$\Rightarrow \frac{\Delta\lambda_B}{\lambda_B} = \frac{(0.616\times10^{-9})}{(924\times10^{-9})} = 66\times10^{-3}$

Q6. - In a conventional microscope the resolution is limited by the wavelength of light

- In NSOM an aperature of width, d ($d < \lambda$) is used to confine the lateral extension of the light
- Thus the illuminated portion of the sample is considerably less than the wavelength of the incident light.
- The sample is maintained in close proximity to probe tip ⇒ coupling of evanescent waves from probe to surface enhances transmitted intensity
- The intensity of the coupled evanescent wave decreases dramatically as the probe surface distance increases - hence small change in surface contours will modify coupled light & therefore the image contrast

Q7.

(a) $$\delta = \frac{\lambda_1}{2\pi n_1 \sqrt{\sin^2(\theta_1) - \left(\frac{n_2}{n_1}\right)^2}} = \frac{600nm}{2\pi(1.5)\sqrt{\sin^2(45) - \left(\frac{1}{1.5}\right)^2}}$$

$$\Rightarrow \delta = 270nm.$$

(b)

$$I_{x=\delta} = I_0 e^{-x/\delta}$$

if $I(x=\delta) = 0.95 I_0$ $\quad e^{-a} = 0.95 \Rightarrow a = 0.05$

$$\Rightarrow 0.95 I_0 = I_0 e^{-x/\delta} \Rightarrow 0.95 = e^{-x/\delta}$$

$$\Rightarrow \frac{x}{\delta} = -\ln(0.95) \Rightarrow x = -\delta(-0.0513) = (270nm)(0.0513)$$

$$\Rightarrow x = 13.85nm.$$