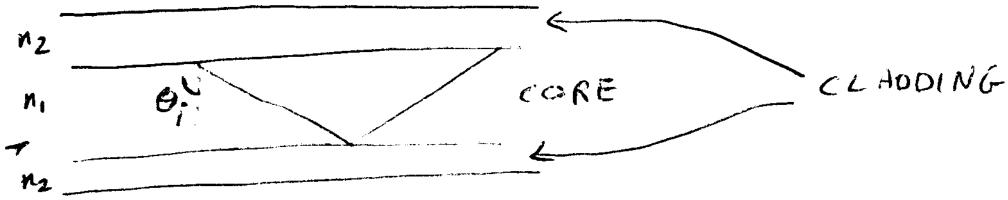
sheet 10

successful coupling

(1)

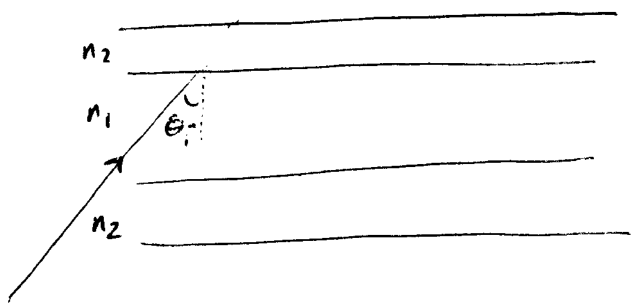
$\theta_i > \theta_c$



incoming light

core has refractive index n_1
cladding has refractive index n_2

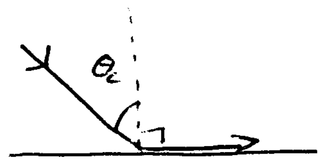
$\theta_i < \theta_c$



unsuccessful coupling

critical angle

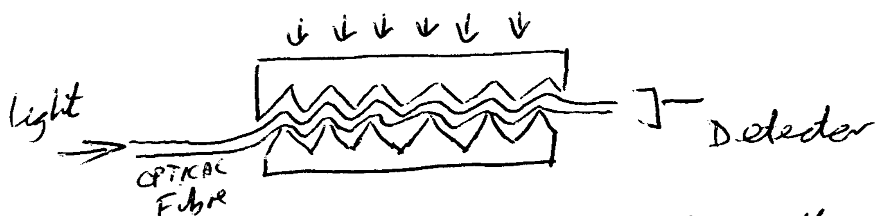
need $\theta_i > \theta_c$ for total internal reflection



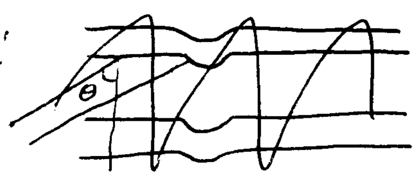
snell's law
$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$
$$n_1 \sin\theta_c = n_2 \sin 90^\circ$$
$$\frac{n_2}{n_1} = \sin\theta_c \quad \Rightarrow \text{need } \theta_i > \arcsin\frac{n_2}{n_1} \text{ for coupling}$$

Pressure from truck

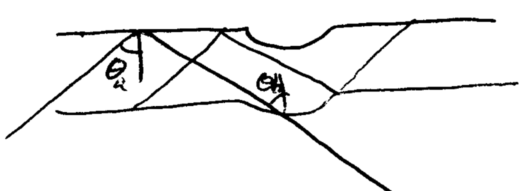
(2) (a) Microbending traffic sensor

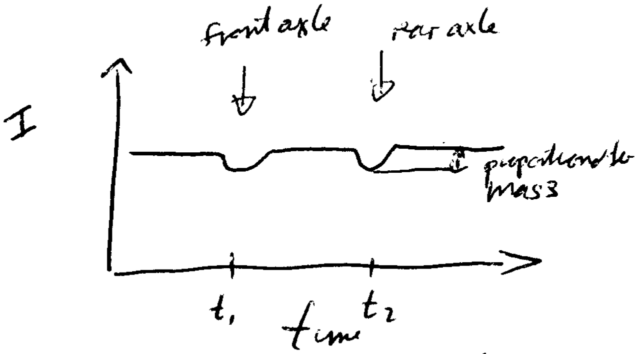


oops!



Bends change θ locally

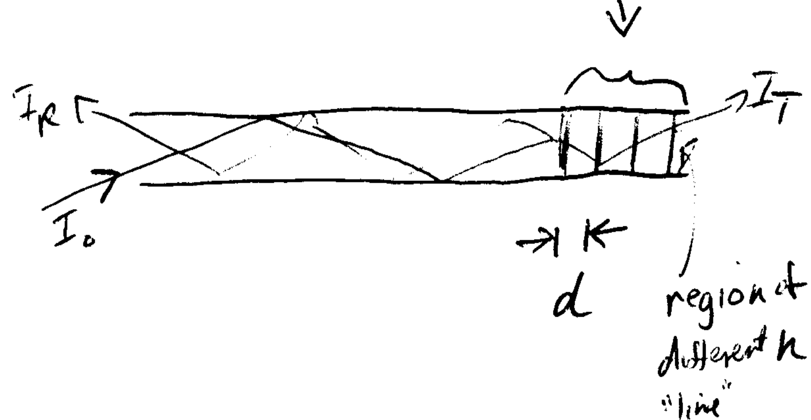




$(t_2 - t_1)$ proportional to speed.

$\theta_b < \theta_c$ so light escapes fibre (decoupling) and transmitted intensity drops. The greater the pressure, the more extreme the bending and the greater the drop in intensity

② (b)



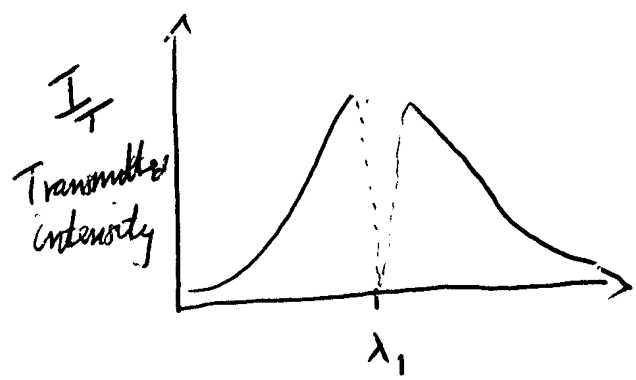
condition for maximum reflection

$$2d\sin\theta = n\lambda_1 \leftarrow \sim 300\,nm$$

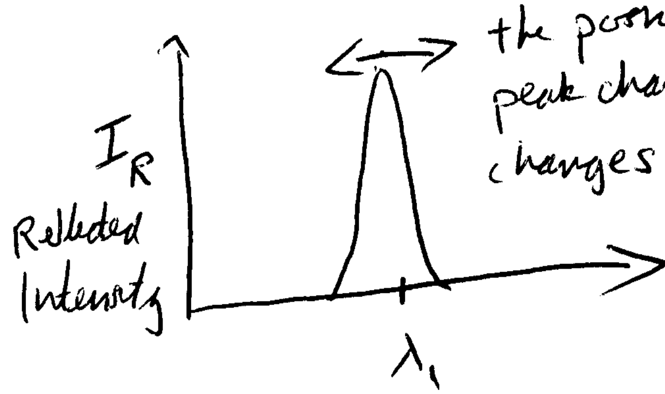
assume $n=1$

can sometimes assume $\theta \simeq \frac{\pi}{2}$

$d \simeq \frac{\lambda_1}{2}$ defines wavelength of reflected light λ_1



Assume broad spectrum source (note that this means that there will be a slightly different θ for each wavelength)



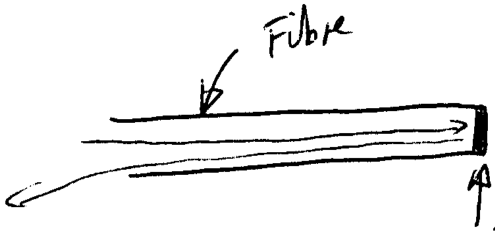
the posn of this peak changes as d changes (and n)

The spacing between the lines in the grating changes with temperature and pressure. So does n.

~~Also~~ (choose material so that the change is biggest in the property that we want to monitor) ~~eg~~

(3) could use Bragg grating from 2b

OR

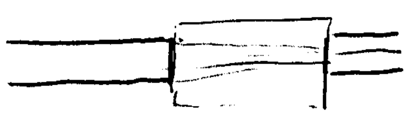


Phosphorescent material atoms
Incoming light excites ~~atoms~~ which then relax, emitting photons. Energy levels include vibrational & rotational levels which change with temp, so λ of ~~an~~ emitted photon changes $\bar{w}$ temp.

nb- uses Raman-type mechanism to access vibrational & Rot energy levels using visible light (E_v & E_r usually in IR, not vis).

OR

Fabry-Perot etalon: spacing between mirrors changes $\bar{w}$ temp & λ of transmitted light changes (ring spacing changes). ∴ temperature!



(Q4) (a) see Q2

(b) $2d\sin\theta = n\lambda$

$n\lambda_1 \simeq 660\,nm$

$\lambda_1 \simeq \frac{660\,nm}{1.4} = 470\,nm$

(5)

$$\frac{1}{\lambda_B}\frac{\Delta \lambda_B}{\Delta T} = \frac{20}{3} \times 10^{-3} \quad /^\circ C$$

(a) $\Delta T = 30 - 20 = 10^\circ C$

$\lambda_B(20) = ?$ call it λ_B^{20}

$\lambda_B(30) = \lambda_B^{30}$

$$\Delta \lambda_B = \frac{20}{3} \times 10^{-3} \times 10^\circ C \times \lambda_B^{20}$$

$$= \frac{.2}{3} \lambda_B^{20}$$

what the psheet doesn't tell us is that $\lambda_B^{20} = 924\,nm$!

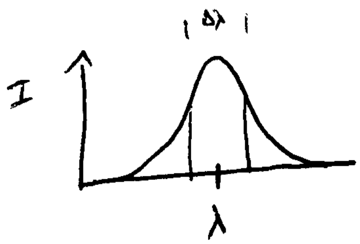
$\Delta \lambda_B = 61.6\,nm$

$\lambda_B^{30} = 924 - 61.6 = 862.4$

(b) need to resolve $.1^\circ C$ changes ie $\Delta T = .1^\circ C$

$$\frac{\Delta \lambda_B}{\lambda_B} = \frac{20}{3} \times 10^{-4}$$

minimum resolution req'd to detect change

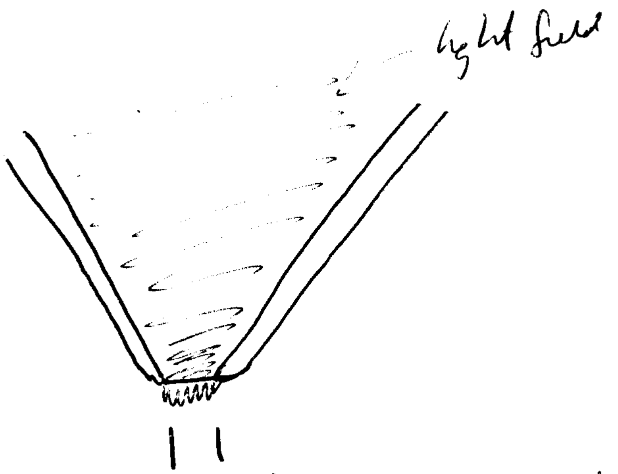


note that this is a standard defn of spectral resolution

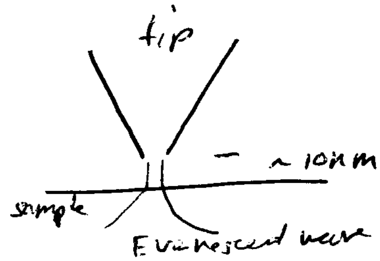
$$R = \frac{\Delta \lambda}{\lambda}$$

(6)

Resolution is in general λ limited, ie the smallest resolvable feature is about λ big (maybe $\frac{\lambda}{2}$ if you push it). This is because of diffraction effects. Get around the diffraction limit by NSOM



$d < \lambda$ ie $\lesssim 100\,nm$

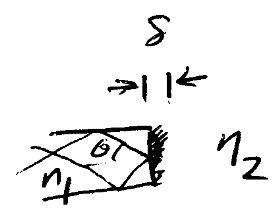


Evanescent wave drops off vv sharply with dist. If the tip is close enough to the sample for the evanescent wave to touch the surface, then some light will be transmitted and this can be detected in the tip. Thus as the topography of the surface changes, so does the transmitted intensity. $\Rightarrow$ get topographic maps.

(7)

light wavelength

$$\delta = \frac{\lambda_1}{2\pi n_1 \sqrt{\sin^2\theta_1 - \left(\frac{n_2}{n_1}\right)^2}}$$



(a)
$$\delta = \frac{600\,nm}{2\pi 1.5 \sqrt{\left(\sin\frac{\pi}{4}\right)^2 - \left(\frac{1.5}{1}\right)^2}}$$

$$= \frac{600\,nm}{3\pi \sqrt{\frac{1}{2} - \left(\frac{2}{3}\right)^2}}$$

$$= 270\,nm$$

$\cdot d \quad 0 \qquad\qquad \delta$

$d = 0 \quad I = I_0$

$d = \delta \quad I = \dfrac{I_0}{e}$

$d = \varepsilon \quad I = \dfrac{I_0}{1.05}$

$I(\delta) = \dfrac{I_0}{e}$

$I(\varepsilon) = \dfrac{I_0}{1.05}$

need to know that

$$I(x) = I_0 e^{-x/\delta}$$

$$I(\varepsilon) = I_0 e^{-\varepsilon/\delta}$$

$$\frac{I(\varepsilon)}{I_0} = 0.95 = e^{-\varepsilon/\delta}$$

$$-\log_e(0.95) = \cancel{\frac{\varepsilon}{\delta}} \qquad \frac{\varepsilon}{\delta}$$

$$\varepsilon = -\delta \log_e(0.95)$$

$$= 13.85 \text{ nm}$$