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Sol. ~~Immobilization~~ :- in

The first step is functionalisation. This step is mainly used to make the biomems sensors more receptive and ~~af~~ after functionalisation immobalisation happens so the sensor's limit of detection ~~of~~ substrate increases.

- One process to perform immobilisation on.

i.) Polymeric Substrate :-

So, the surface with active amino groups by following the wet silanization this is the method of immobilisation.

Eg.:- SU8, as its the most usable substrate.

ii.) Gold :-

Gold has a inert nature & good electrical properties.

So, formations of layers of thiols, biotin ~~&~~, protien, etc ~~and to~~ from this the high affinity ~~to~~ of sulphur to gold is exploited and from this method the immobilization happens.

iii.) Silicon Oxide / nitride :-

By silanization with various head groups. like NH_2, COOH, CHO, etc.

This is the method of immobilization.

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Sol 2.(a) $F = 1mN$

Cross sectional area = 5 cm by 4 cm.

$E = 120GPa$.

fracture strain = 0.3%

% relative elongation of the beam

we know that,

$$\sigma = \frac{F}{A}$$

$$\sigma = \frac{1\times10^{-3}}{5\times10^{-6}\times4\times10^{-6}}$$

$$\sigma = \frac{1}{20}\times10^{9}$$

$$\boxed{\sigma = 5\times10^{7}\ N/m^2} \quad -(i)$$

Now, $\sigma = E.\delta$

$$5\times10^{7} = 120\times10^{9}\times\delta \quad - \text{ from (i)}$$

$$\cancel{\delta = \frac{5\times10^{7}}{1.2\times10^{7}}}$$

$$\delta = \frac{5\times10^{7}}{120\times10^{9}}$$

$$\delta = 0.041\times10^{-2}.$$

Now,

$$\delta = \frac{\Delta l}{l}.$$

$$0.041\times10^{-2} = \frac{\Delta l}{5\times10^{-6}}.$$

$$0.205\times10^{-8} = \Delta l.$$

So, $\frac{\Delta l}{l}\times100 = \frac{0.205\times10^{-8}}{5\times10^{-6}}\times100$

relative elongation = 0.041 %

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Sol 2 (b) $l = 100\mu m = 100 \times 10^{-4} cm$

$b = 2\mu m = 2 \times 10^{-4} cm$

$t = 0.5\mu m = 0.5 \times 10^{-4} cm$

Doping Conc. $= 10^{17}$ atoms/cm^3

$\mu n = 1350\ cm^2/Vs$

$\mu p = 480\ cm^2/Vs$

$ni = 1.5 \times 10^{10}$ atoms/cm^3

So, we know that at room temp $Nd = Nd^+$

By mass action law,

$$ni^2 = p_o n_o$$

$$(1.5 \times 10^{10})^2 = p_o (10^{17})$$

$$p_o = \frac{2.25 \times 10^{20}}{10^{17}}$$

$$\boxed{p_o = 2.25 \times 10^3}$$

So, total resistance $= \rho = \frac{1}{\sigma} = \frac{1}{q(n\mu n + p\mu p)}$

$$= \frac{1}{1.6 \times 10^{-19}(10^{17} \times 1350 + 2.25 \times 10^3 \times 480)}$$

$$= \frac{1}{1.6 \times 10^{-19}(10^{17} \times 1350)}$$ because $p\mu p$ term is so small.

$$= \frac{1}{1350 \times 1.6 \times 10^{-2}}$$

$$= \frac{100}{2160}$$

$= 0.0462$ ~~resistance~~ Ω/cm^3

$= 4.62 \times 10^{-2}$

for resistance = So,

$= 100 \times 10^{-4} \times 2 \times 0.5 \times 10^{-8} \times 4.62 \times 10^{-2}$

$= 100 \times 10^{-12} \times 4.62 \times 10^{-2} = 462 \times 10^{-14} \Omega$

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Sol 3.) Given

$$C_{Si}\langle 100\rangle = \begin{bmatrix} 1.66 & 0.64 & 0.64 & 0 & 0 & 0 \\ 0.64 & 1.66 & 0.64 & 0 & 0 & 0 \\ 0.64 & 0.64 & 1.66 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.8 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.8 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.8 \end{bmatrix} \times 10^{11}$$

for young's modulus of [100]

$$\begin{bmatrix} T_1 \\ T_2 \\ T_3 \\ T_4 \\ T_5 \\ T_6 \end{bmatrix} = C_{Si}\langle 100\rangle \begin{bmatrix} S_1 \\ S_2 \\ S_3 \\ S_4 \\ S_5 \\ S_6 \end{bmatrix}.$$

$$T_1 = [1.66\times S_1 + 0.64\times S_2 + 0.64\times S_3]\times 10^{11} \quad -(i)$$
$$0 = [0.64\times S_1 + 1.66\times S_2 + 0.64\times S_3]\times 10^{11} \quad -(ii)$$
$$0 = [0.64\times S_1 + 0.64\times S_2 + 1.66\times S_3]\times 10^{11} - (iii)$$

from subtracting ii & iii

$$0 = 1.02\times S_2 - 1.02\,S_3.$$
$$S_2 = S_3. \quad -(iv).$$

Putting iv in ii & iii.

$$0 = [0.64\times S_1 + 1.66\times S_2 + 0.64\times S_2] - (ii)$$
$$0 = [0.64\times S_1 + 0.64\times S_3 + 1.66\times S_3] - (iii)$$

from ii & iii.

$$S_2 = -\frac{0.64\times S_1}{2.3},\quad S_3 = -\frac{0.64\,S_1}{2.3}$$

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Now putting.

$$T_1 = \left[S_1 \times 1.66 - \frac{2 \times 0.64 \times 0.64 \times S_1}{2.3} \right] \times 10^{11}\,Pa$$

$$\frac{T_1}{S_1} = \left[1.66 - \frac{2 \times 0.64 \times 0.64}{2.3} \right] \times 10^{11}\,Pa$$

$$\frac{T_1}{S_1} = \left[1.66 - 0.356 \right] \times 10^{11}\,Pa$$

$$E_{[100]} = 1.304 \times 10^{11}\,Pa$$

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Similarly, for E_2 [010] direction.

$$\cancel{T}0 = (1.66 \times S_1 + 0.64 \times S_2 + 0.64 \times S_3) \times 10^{11} \quad -(i)$$
$$T_2 = [0.64 \times S_1 + 1.66 \times S_2 + 0.64 \times S_3] \times 10^{11} \quad -(ii)$$
$$0 \, \cancel{T_3} = [0.64 \times S_1 + 0.64 \times S_2 + 1.66 \times S_3] \times 10^{11} \quad -(iii)$$

from subs. i & iii

$$0 = 1.02 S_1 - 1.02 S_3$$
$$S_1 = S_3 \quad - iv.$$

So, putting iv in i & iii.

$$0 = 1.66 \times S_1 + 0.64 \times S_2 + 0.64 \times S_1 \quad - (i)$$
$$0 = 0.64 \times S_3 + 0.64 \times S_2 + 1.66 \times S_3 \quad - (ii).$$

$$\cancel{S_2 = -\frac{2.3}{} S_1}$$

$$S_1 = -\frac{0.64}{2.3} S_2 \qquad S_3 = \frac{0.64}{2.3} S_2$$

Now putting

$$T_2 = \left[-\frac{0.64 \times 0.64}{2.3} S_2 + 1.66 \times S_2 - \frac{0.64 \times 0.64 S_2}{2.3}\right] \times 10^{11} Pa.$$

$$\frac{T_2}{S_2} = \left[1.66 - \frac{2 \times 0.64 \times 0.64}{2.3}\right] 10^{11} Pa.$$

$$E_2 [010] = 1.304 \times 10^{11} Pa$$

$$E_1 [100] = E_2 [010].$$

Both offers same resistance

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Sol 4. b) $C = 3\times10^{-14}$ F

$V = 0.5V$

We know that $V = \frac{Q}{C}$

where Q = no. of electron × charge of electron.

$\Downarrow$

n.

Given = $0.5 = \frac{n \times 1.6\times10^{-19}}{3\times10^{-14}}$

$\frac{1.5\times10^{-14}}{1.6\times10^{-19}} = n$.

$0.9375\times10^{5} = n$.

No. of electron = $\underline{\underline{93750}}$

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Sol:- Q.1 Area of plates = 400 x 400 cm^2

$x_0 = 100 cm$

Voltage = 5V

Calc. Capacitance, attractive force, Capacitance sensitivity.

Given, $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m

So, Capacitance $= \frac{\varepsilon A}{d}$

$$= \frac{8.85 \times 10^{-12} \times 400 \times 400 \times 10^{-12}}{100 \times 10^{-6}}$$

$$= 8.85 \times 400 \times 4 \times 10^{-18}$$

$$= 14160 \times 10^{-18}$$

$$= 1.4 \times 10^{-14} F.$$

So, we know that

$$F = \frac{dU}{dx}$$

$$F = \frac{d}{dx}\left(\frac{1}{2}CV^2\right) \quad \text{assum. } d = x$$

$$F = \frac{1}{2}\varepsilon A V^2 \left(\frac{d}{dx}\left[\frac{1}{x}\right]\right)$$

$$F = \frac{1}{2}\frac{\varepsilon A}{x}\frac{V^2}{x} \rightarrow \text{ignoring - sign}$$

$$F = \frac{1}{2}\frac{CV^2}{d} \quad x = d.$$

$$F = \frac{1}{2} \times \frac{\overset{0.7}{\cancel{1.4}} \times 10^{-14} \times (5)^2}{100 \times 10^{-4}}$$

$$= 0.7 \times 25 \times 10^{-10}$$

$$= 1.75 \times 10^{-9} N.$$

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for, calc. capacitance sensitivity.

$$\frac{dC}{dx} = \frac{d}{dx}\left(\frac{\varepsilon A}{d}\right)$$

$$= \frac{-\varepsilon A}{d^2}$$

$$= \frac{8.85 \times 10^{-12} \times 400 \times 400 \times \cancel{10^{-12}}}{100 \times 100 \times \cancel{10^{-12}}}$$

$$= 8.85 \times 16 \times 10^{-12}$$

$$= 1.416 \times 10^{-10} \, F/m$$