Problem Set 12 Solution sp'09

Problem 14.6. (a) By particle balance

$$\gamma_{eff} \cdot (0.8) \cdot \frac{e V_{DC}}{\mathcal{E}_c} = 1$$

For $\mathcal{E}_c = 30$ V and $\gamma_{eff} = 0.05$, $V_{dc} = 750$ V //

(b) $w = 2\sqrt{2 r_e R_c}$ with $R_c = 3$ cm and

$$r_e = \frac{v_e}{\omega_{ce}} = \frac{1}{B_0}\sqrt{\frac{2mV_{DC}}{e}} = \frac{1}{.02}\sqrt{\frac{1500}{1.76\times10^{11}}} = 4.62\times10^{-3} \text{ m}$$

$$w = 2\sqrt{0.462 \cdot 3.2} \text{ cm} = 3.33 \text{ cm} \;//$$

$$J_i = \frac{I_{dc}}{2\pi R w} = \frac{2}{(2\pi)(10)(3.33)} = 0.954\times10^{-2} \frac{A}{cm^2} \;//$$

(c) There are $dN/dt = 2/1.6\times10^{-19} = 1.25\times10^{19}$ atoms/s

$\pi R_a^2 = 706.4$ cm^2, so deposit $\frac{1}{\pi R_a^2}\frac{dN}{dt} = 1.768\times10^{16} \frac{\text{atoms}}{cm^2\text{-s}}$

Al has 6.0×10^{22} atoms/cm^3, so deposition rate is

$$DR = \frac{1.768\times10^{16}}{6.0\times10^{22}} = 2.95\times10^{-7} \frac{cm}{s} \text{ or } 2.95\times10^{-7}\times60\times10^{8} \frac{\text{Å}}{min}$$

$DR = 1768$ Å/min. //

(d) $J_i \simeq 0.6\, e n u_B$. Let $T_e \approx 3$ V so $u_B \approx 2.7\times10^5$ cm/s

Hence $n \approx \frac{0.95\times10^{-2}}{(0.6)(1.6\times10^{-19})(2.7\times10^5)} \simeq 3.7\times10^{11}$ cm^{-3} //

For secondaries, $\frac{dN_{se}}{dt} = \gamma_{eff}(0.8)\frac{dN}{dt} - \frac{n_{se}V_{se}}{\tau_{se}} = 0$.

$\tau_{se} \approx \frac{V_{dc}}{\mathcal{E}_c}\tau_{iz}$ (lifetime) and V_{se} = ring volume

$V_{se} \simeq 2\pi R w r_e \simeq 68.5$ cm^3. $\sigma_{iz} \sim 9\times10^{-17}$ cm^2 and

$v_e = \sqrt{\frac{2eV_{dc}}{m}} \sim 1.63\times10^9$ cm/s. So $\tau_{iz} = \frac{1}{3.5\times10^{14}\cdot 2\times10^{-3}\cdot 9\times10^{-17}\cdot 1.63\times10^9}$

$\tau_{iz} = 9.77\times10^{-8}$ s. $\tau_{se} = 2.44\times10^{-6}$ s. So

$n_{se} \sim (.05)(0.8)(1.25\times10^{19})(2.44\times10^{-6})/68.5 \simeq 1.78\times10^{10}$ cm^{-3} //

Problem 14.7

$$\begin{cases} \dfrac{w}{2R_c} = \sin\theta \\ r_{ce} + R_c\cos\theta = R_c \end{cases}$$

$$\begin{cases} R_c^2\sin^2\theta = \dfrac{w^2}{4} \\ R_c^2\cos^2\theta = (R_c - r_{ce})^2 \end{cases}$$

$$\cancel{R_c^2} = \cancel{R_c^2} - 2r_{ce}R_c + r_{ce}^2 + \frac{w^2}{4}$$

$$w = 2\left(r_{ce}(2R_c - r_{ce})\right)^{1/2}$$

For $r_{ce} = 0.5$ cm $\rightarrow R_c = 4$ cm

$w = 3.87$ cm (compared to 4 cm)