MAT E 201: Solution to Assignment #8

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Q1 Co wire 2/3 of the valence electrons serve as charge carriers.

Valence of Co is 2 $\quad v = ?$

$J = 2000\ A/cm^2$, Co (HCP structure) $\Rightarrow$ 2at/u.c.

$V = a_0^2 c_0 \cos 30°$, $a_0 = 2.5071 \cdot 10^{-8}\ cm$, $c_0 = 4.0686 \cdot 10^{-8}\ cm$

Total number of valence electrons:

$$n_T = \frac{2\,at/u.c. \cdot 2\,elec./at}{(2.5071 \cdot 10^{-8})^2 (4.0686 \cdot 10^{-8}) \cos 30°} = 1.8061 \cdot 10^{23} \frac{el}{cm}$$

Number of charge carriers;

$$n = \frac{2}{3} \cdot n_T = 1.204 \cdot 10^{23} \frac{electr.}{cm^3}$$

$\bar{v} = ?$ $\quad \bar{v} = \frac{J}{nq}$

$\bar{v} = 0.104\ cm/s$

Q2 Refer to book.

Q3 Conductivity of copper in $-100°C$ and $500°C$

$\rho_{RT} = 1,67 \times 10^{-6}\ \Omega cm$; $\alpha = 0,0043\ 1/C$

@ $-100°C$

$\Delta T = -100 - 25 = -125°C$

$\rho = \rho_{RT}(1 + \alpha_R \Delta T)$

$\rho_{-100°C} = 1,67 \times 10^{-6}\ \Omega cm (1 + 0,0043(-125))$

$\rho_{-100°C} = 7,723 \times 10^{-7}\ \Omega cm$

$\sigma_{-100°C} = \frac{1}{\rho_{-100°C}} = \underline{1,295 \times 10^{6}\ cm^{-1}\Omega^{-1}}$

@ $500°C$

$\Delta T = 500 - 25 = 475°C$

$\rho_{500} = 1,67 \times 10^{-6}\ \Omega cm (1 + 0,0043(475))$

$\rho_{500} = 5,081 \times 10^{-6}\ \Omega cm$

$\sigma_{500°C} = \frac{1}{\rho_{500°C}} = \underline{1,968 \times 10^{5}\ cm^{-1}\Omega^{-1}}$

~500

Q4. $\rho_{Al} = 2.65 \cdot 10^{-6}\ \Omega cm$ $\alpha = 0.0043\ 1/°C$

Resistivity at $0°C$, $\Delta T = -25°C$

$\rho_0 = 2.65 \cdot 10^{-6}(1 + 0.0043(-25)) = 2.365 \cdot 10^{-6}\ \Omega cm$

$\sigma_0 = \frac{1}{\rho_0} = 4.228 \cdot 10^{5}\ \Omega^{-1} cm^{-1}$

$\sigma_1 = 2\sigma_0 = 8.456 \cdot 10^{5}\ \Omega^{-1} cm^{-1}$, $\rho_1 = \frac{1}{\sigma_1} = 1.182 \cdot 10^{-6}\ \Omega^{-1} cm^{-1}$

$\rho_1 = \rho_{RT}(1 + \alpha_R \Delta T)$ $\Delta T = \frac{\rho_1 - \rho_{RT}}{\rho_{RT}\,\alpha_R}$

$\Delta T = \frac{1.182 \cdot 10^{-6} - 2.65 \cdot 10^{-6}}{2.65 \cdot 10^{-6} \cdot 0.0043} = -128.83$ $\Delta T = T - 25$

$T = \Delta T + 25 = -128.83 + 25 = -103.83°C$

Q5 @ 450°C , 7% alloying element.

$\rho_{450°C} = 70 \times 10^{-6}\ \Omega cm$ $\qquad \alpha_R = 0{,}025\ 1/°C$

Pure Be $\quad \rho_{RT} = 4.0 \times 10^{-6}\ \Omega cm$.

@ 450°C with $x = 0{,}07$.

$\rho_T = \rho_{450} = \rho_{RT}(1 + \alpha_R \Delta T)$

$\Delta T = 450 - 25 = 425\ °C$

$\rho_T = 4.0 \times 10^{-6}\ \Omega cm(1 + 0{,}025(425))$

$\rho_T = 4{,}65 \times 10^{-5}\ \Omega cm$.

if $\rho = \rho_T + \rho_d \implies \rho_d = \rho - \rho_T$.

$\rho_d = 70 \times 10^{-6}\ \Omega cm - 4{,}65 \times 10^{-5}\ \Omega cm = 2{,}35 \times 10^{-5}\ \Omega cm$

$\rho_d = bx(1-x) \qquad x = 0{,}07 \qquad (7\ at\%)$.

$$b = \frac{\rho_d}{x(1-x)} = \frac{2{,}35 \times 10^{-5}\ \Omega cm}{0{,}07\ (1 - 0{,}07)} = 3{,}61 \times 10^{-4}\ \Omega cm$$

@ 250°C with $x = 0{,}15$

$\rho_{250°C} = 4.0 \times 10^{-6}\ \Omega cm\ (1 + 0{,}025(250 - 25))$

$\rho_{250°C} = 2{,}65 \times 10^{-5}\ \Omega cm$.

$\rho_d = bx(1-x) = 3{,}61 \times 10^{-4}\ \Omega cm(0{,}15)(1 - 0{,}15)$

$\rho_d = 4{,}603 \times 10^{-5}\ \Omega cm$

$\rho = \rho_T + \rho_d = 2{,}65 \times 10^{-5}\ \Omega cm + 4{,}603 \times 10^{-5}\ cm\Omega$

$\rho = 7{,}25 \times 10^{-5}\ \Omega cm$.