Homework 19.0

Carefully review chapter 19 lecture slides and, if time allows, read textbook sections of Askeland 19.1, 19.3-19.4, 19.9-19.10 (some numerical example problems such as 19-2, 19-4, 19-5, 19-7 could be omitted) and give an honor statement confirming the reading

Homework 19.1

Calculate the resistance and resistivity for a conductor wire with cross-section area of 1.25 mm^2 and length of 20 cm subject to voltage of 220 V, if the current density is 1 A/cm^2. Assume the wire is uniform.

Total current:

$$I = ? \times ?? = 0.0125\ \mathrm{A}$$

Total resistance:

$$R = ?? = \mathbf{17,600\ \Omega}$$

Resistivity:

$$\rho = ?? = \ \dots = \mathbf{0.11\ \Omega \cdot m}$$

Homework 19.2

A current of 15 A passes through a 2 mm diameter, 500 m long aluminum wire. Please calculate the power loss. (Aluminum electrical conductivity is 3.77×10^5 S/cm)

Total resistance for the aluminum wire:

$$R = ? = \frac{??}{???} = 4.22\ \Omega$$

Total power loss for the aluminum wire:

$$P = ???? = \mathbf{950\ W}$$

Homework 19.3

A 10 A current flows through a 2.54 mm diameter copper wire. If the power lost should be no more than 200 W, what is the max length of the wire? (Assume copper conductivity of 5.98 x 10^5 S/cm.)

Total power loss must satisfy $P = ?? < 200\ W$

Total resistance for the copper wire: $R < ?? = 2\ \Omega$

On the other hand, $R = ?$

Max length

$$L < ?? = \cdots = 60571\ cm \approx \mathbf{606\ m}$$

Homework 19.4

Calculate the electrical conductivity for Ag and Pt at 600°C. Knowing room temperature resistivity for Ag and Pt is $1.59\times10^{-6}\ \Omega\bullet$cm and $9.85\times10^{-6}\ \Omega\bullet$cm, respectively, while the temperature resistivity coefficient for Ag and Pt is 0.0041/°C and 0.0039/°C, respectively.

Electrical resistivity for Ag at 600°C

$$\rho_{Ag\ 600C} = \cdots = 5.34 \times 10^{-6} \Omega \cdot \mathrm{cm}$$

Electrical resistivity for Pt at 600°C

$$\rho_{Pt\ 600C} = \cdots = 3.19 \times 10^{-5} \Omega \cdot \mathrm{cm}$$

Electrical conductivity for Ag at 600°C $\sigma_{Ag\ 600C} = \cdots = \mathbf{1.87 \times 10^{5}\ S/cm}$

Electrical conductivity for Pt at 600°C $\sigma_{Pt\ 600C} = \cdots = \mathbf{3.13 \times 10^{4}\ S/cm}$

Homework 19.5

If diffusion coefficient for oxygen vacancy at 1000^{o}C is 7.5x10^{-6} cm^2/s (*), and oxygen vacancy concentration is 2.3x10^{21} /cm^3, please estimate the total electrical conductivity for 8YSZ material. Assuming oxygen vacancy is the predominant charge carrier contributing to total electrical conductivity. (* estimated from oxygen diffusion coefficient of 3x10^{-7} cm^2/s & oxygen vacancy fraction X_{OV} = 4% for $Zr_{0.84}Y_{0.16}O_{1.92}$)

Mobility for oxygen vacancy (Vo)

$$\mu_{Vo} = \cdots = 1.37 \times 10^{-4} \frac{\mathrm{cm}^2}{\mathrm{V} \cdot \mathrm{s}}$$

Total electrical conductivity

$$\sigma = \sum_k \ldots \approx \cdots = 0.10 \frac{\mathrm{C}}{\mathrm{V} \cdot \mathrm{s} \cdot \mathrm{cm}} = \cdots = \mathbf{0.10} \frac{\mathbf{S}}{\mathbf{cm}}$$

Homework 19.6

Knowing a $BaTiO_3$ capacitor has active electrode area of 1 cm^2, the distance between two electrodes (dielectric layer thickness) is 10 μm, and $BaTiO_3$ has a relative permittivity of 2000. Please calculate its capacitance and the amount of charge that can be stored in the $BaTiO_3$ capacitor at 2 V.

Capacitance:

$$C = \cdots = \cdots = \mathbf{1.77 \times 10^{-7}\ F}$$

Total charge at 2V

$$Q = \ \ldots = \mathbf{3.54 \times 10^{-7}\ C}$$