Answer on Question #46854 – Physics – Solid State Physics

Two metallic wires of the same material and same length but different cross rational areas are joined together (in series) and (in parallel) ,to a source of amf. in which of the two wires will the drift velocity of electron be more in each of the two cases and why?

Solution:

The formula for evaluating the drift velocity of electrons in a material of constant cross-sectional area is given by ($\mathrm{A}-$ area of cross $-$ section of the material, $\mathrm{I}-$ current flowing through the material, $\mathrm{q}-$the charge of the electron, n is the charge-carrier density):

$$\mathrm{v}=\frac{\mathrm{I}}{\mathrm{nAq}}$$

First case: series connection

In a series circuit, the current through each of the components is the same $(\mathrm{I}_1=\mathrm{I}_2)$, thus drift velocity is more in wire with smaller area of cross-section:

$$\mathrm{v}_1=\frac{\mathrm{I}}{\mathrm{nA}_1\mathrm{q}}$$

$$\mathrm{v}_2=\frac{\mathrm{I}}{\mathrm{nA}_2\mathrm{q}}$$

$$\mathrm{A}_2>\mathrm{A}_1 \Longrightarrow \frac{\mathrm{I}}{\mathrm{nA}_2\mathrm{q}}<\frac{\mathrm{I}}{\mathrm{nA}_1\mathrm{q}}$$

$$\mathrm{v}_2<\mathrm{v}_1$$

First case: parallel connection

In a parallel circuit, the voltage across each of the components is the same, and the total current is the sum of the currents through each component ($\mathrm{L}-$length of the wire, $\rho-$ electrical resistivity).

$$\mathrm{I}_1=\frac{\mathrm{U}}{\mathrm{R}}=\frac{\mathrm{U}}{\frac{\rho\mathrm{L}}{\mathrm{A}_1}}=\frac{\mathrm{UA}_1}{\rho\mathrm{L}}$$

$$\mathrm{I}_2=\frac{\mathrm{U}}{\mathrm{R}}=\frac{\mathrm{U}}{\frac{\rho\mathrm{L}}{\mathrm{A}_2}}=\frac{\mathrm{UA}_2}{\rho\mathrm{L}}$$

$$\mathrm{v}_1=\frac{\mathrm{I}_1}{\mathrm{nA}_1\mathrm{q}}=\frac{1}{\mathrm{nA}_1\mathrm{q}}\frac{\mathrm{UA}_1}{\rho\mathrm{L}}=\frac{\mathrm{U}}{\mathrm{nqL}}$$

$$\mathrm{v}_2=\frac{\mathrm{I}}{\mathrm{nA}_2\mathrm{q}}=\frac{1}{\mathrm{nA}_2\mathrm{q}}\frac{\mathrm{UA}_2}{\rho\mathrm{L}}=\frac{\mathrm{U}}{\mathrm{nqL}}$$

According to initial condition of the task, $\mathrm{L}_1=\mathrm{L}_2=\mathrm{L}$, $\rho_1=\rho_2=\rho$ (wires of the same material and same length), thus, drift velocities will be th same in both wires.

$$v_1=v_2=\frac{\mathrm{U}}{\mathrm{nqL}}$$