MICROSCOPIC MODEL OF CURRENT CONTINUED

• ON THE ROAD TO OHM'S LAW

- $\Sigma F = ma \rightarrow \Sigma F = m\frac{\Delta V}{\Delta t} \rightarrow \Delta V = \frac{\Sigma F \Delta t}{m} = \frac{eE\Delta t}{m}$ (TIME BETWEEN COLLISIONS)

- AVERAGES...

$$\Delta \bar{V} \rightarrow \bar{V}_d = \frac{eE}{m}\bar{\Delta t}$$ ← AVERAGE TIME BETWEEN COLLISIONS

COMBINE WITH MICRO MODEL OF CURRENT $I = enAV_d$

- RESULT...

$$\frac{I}{A} = \frac{ne^2\bar{\Delta t}}{m} E$$

$\frac{I}{A}$: CURRENT DENSITY "J"

$\frac{ne^2\bar{\Delta t}}{m}$: CONDUCTIVITY "$\sigma$" MATERIAL PROPERTY OF CONDUCTORS

E: ELECTRIC FIELD INSIDE CONDUCTOR

$$J = \sigma E$$ // ALMOST OHM'S LAW

• CONDUCTIVITY $\frac{[A]^2[T]^3}{[M][L]^3} \equiv \sigma = \frac{ne^2\bar{\Delta t}}{m}$ (FUNDAMENTAL DIMENSION "AMP")

- FOR A GIVEN CONDUCTOR n = CONSTANT
- HOW CAN WE AFFECT $\bar{\Delta t}$? ...TEMP AND IMPURITIES

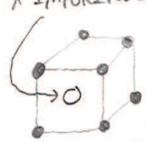
* AS TEMP ↑, σ ↓ BECAUSE $\bar{\Delta t}$ ↓ ← e^- COLLIDES MORE OFTEN

LOW TEMP

HIGH TEMP

← LATTICE VIBRATES MORE, THUS $\bar{\Delta t}$ ↓

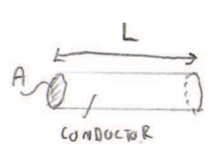
* IMPURITIES: IMPERFECTIONS IN LATTICE



CAN CAUSE $\bar{\Delta t}$↓ THUS σ↓

• RESISTIVITY $\frac{[M][L]^3}{[A]^2[T]^3} \equiv \rho = \frac{1}{\sigma}$

• RESISTANCE $\frac{[M][L]^2}{[A]^2[T]^3} \equiv R = \frac{\rho L}{A}$



• FINALLY.... OHM'S LAW

MICRO MODEL & ELECTRIC FIELD

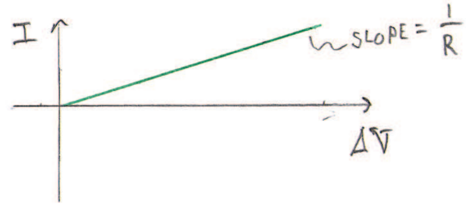
$$J = \sigma E \quad + \quad |\vec{E}| = \frac{|\Delta V|}{L}$$

OHM'S LAW (APPLY A VOLTAGE DIFFERENCE ACROSS A WIRE WITH RESISTANCE AND CURRENT WILL FLOW)

$$\frac{I}{A} = \frac{L}{RA}\frac{\Delta V}{L} \longrightarrow \boxed{I = \frac{\Delta V}{R}} \text{ OR } \Delta V = IR$$

*LIMITED APPLICATION: MOST MATERIALS DO NOT OBEY OHM'S LAW (i.e. NON-OHMIC) HOWEVER CERTAIN CIRCUIT ELEMENTS LIKE RESISTORS AND LIGHT BULBS CAN BE MODLED WITH OHM'S LAW MOST OF THE TIME.

OHMIC MATERIALS (e.g.) RESISTOR



NON-OHMIC MATERIAL EXAMPLE ... SEMICONDUCTOR (TRANSISTOR)