Silicon Crystal Structure
**Boltzmann Equation**

\[ n_e^0 = \text{Electron Density (No Potentials)} \]
\[ n_h^0 = \text{Hole Density (No Potentials)} \]
\[ e = |\text{Electron Charge}| = +1.6 \times 10^{-19} \text{ C} \]
\[ \Phi(x) = \text{Local Potential} \]

\[ n_e(x) = n_e^0 \exp\left(\frac{e\Phi(x)}{kT}\right) \]
\[ n_h(x) = n_h^0 \exp\left(-\frac{e\Phi(x)}{kT}\right) \]
PN Junction: Bias Applied
PN Junction: Reverse Bias
$I_0 = \text{Reverse Conduction Current}$

$$I = I_0 (\exp(eV/kT) - 1)$$
Original Transistor, 1947
Bipolar Junction Transistor

- p Type Silicon
- n Type Silicon
- SiO$_2$
- Aluminum

Diagram showing the components of a bipolar junction transistor with labels for Emitter, Base, and Collector.