Solid State Electronics EC210
AAST – Cairo
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Lec. 6: Step Potential and Tunneling

Lecture Notes Prepared by:
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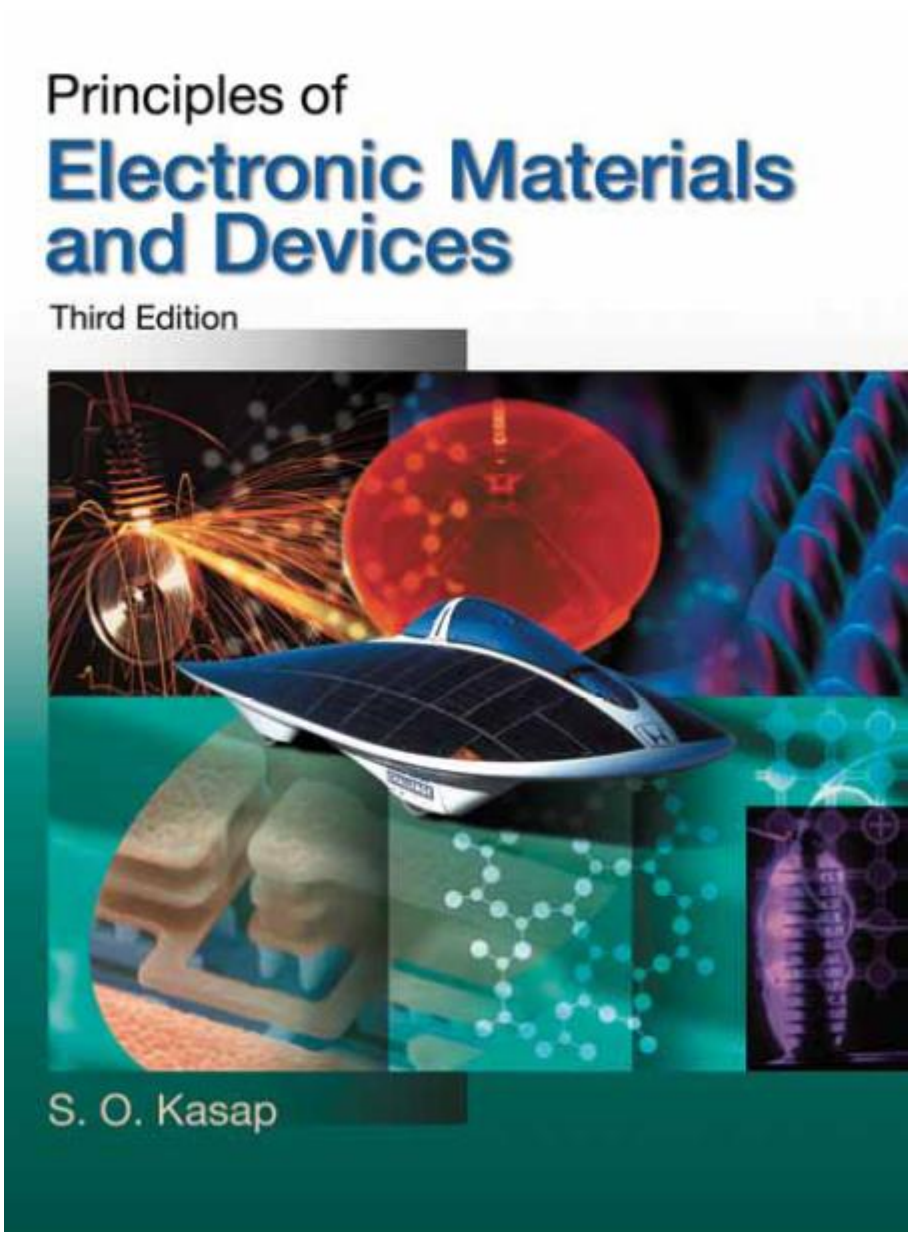

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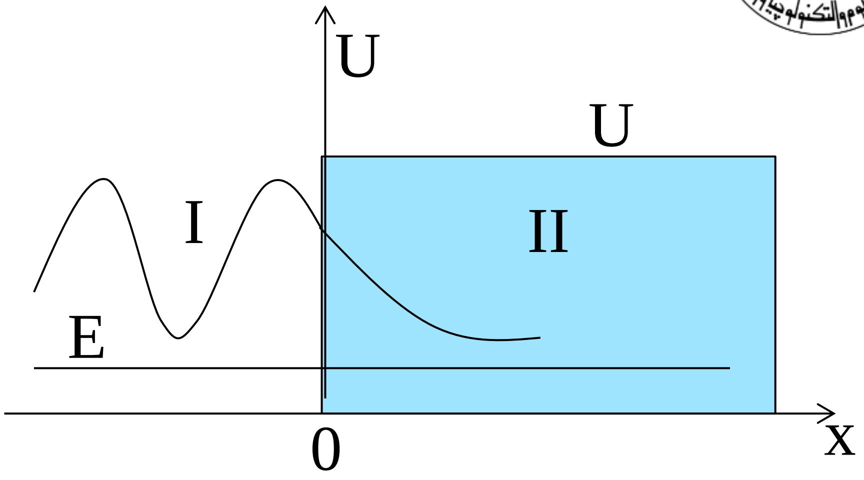
Step Barrier: E<U

Region I:

Free particle: $k^2 = \frac{2mE}{\hbar^2}$

$$\Psi_{\mathrm{I}}(x) = Ae^{jkx} + Be^{-jkx}$$



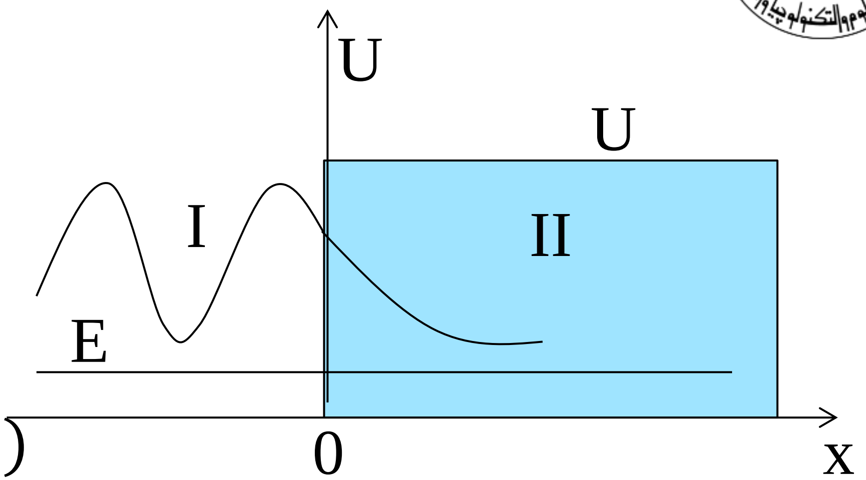
Region II:

$$\alpha^2 = 2m(U - E)/\hbar^2$$

$$\Psi_{\mathrm{II}}(x) = Ce^{-\alpha x} + 0$$

Stationary ψ(x) for Step Barrier: E<U

Boundary Conditions at x=0:



$$\psi_I(0) = \psi_{II}(0) \rightarrow A + B = C$$

$$\frac{d\Psi_{\mathrm{I}}(x=0)}{dx} = \frac{d\Psi_{\mathrm{II}}(x=0)}{dx}$$

$$\rightarrow jk(A-B) = -\alpha C = -\alpha(A+B)$$

$$\rightarrow A(\alpha + jk) = -B(\alpha - jk)$$

$$\frac{B}{A} = \frac{-\alpha - jk}{\alpha - jk} = \frac{1 - j\frac{\alpha}{k}}{1 + j\frac{\alpha}{k}},$$ and $$\frac{C}{A} = \frac{2}{1 - j\frac{\alpha}{k}}$$

$$\mathrm{R = Reflection\ Coefficient} = \left|\frac{B^*B}{A^*A}\right| = 1$$

$\rightarrow \mathrm{T = Trasnmission\ Coeff.} = 0$ *(Since this is a potential which has no end, i.e. extends to +∞ -> electrons will never exit from other side)*

Tunneling: Solution of Schrodinger's Eqn.

$$\psi_{II}(x) = B_1 e^{\alpha x} + B_2 e^{-\alpha x}$$

$$\alpha^2 = \frac{2m}{\hbar^2}(V_o - E)$$

$$\psi_I(x) = A_1 e^{jkx} + A_2 e^{-jkx}$$

$$\psi_{III}(x) = C_1 e^{jkx} + C_2 e^{-jkx}$$

Transmission Coeff. ≠0

There is a finite probability at x=a

$$k^2 = \frac{2mE}{\hbar^2}$$

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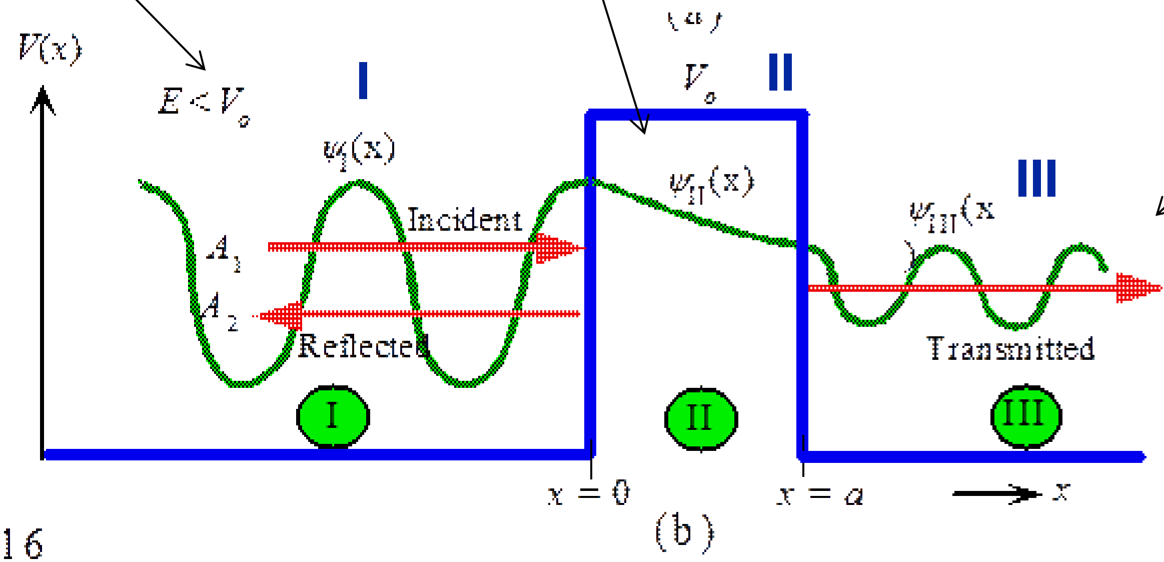

Fig. 3.16

From Principles of Electronic Materials and Devices, Third Edition, S.O. Kasap (© McGraw-Hill, 2005)