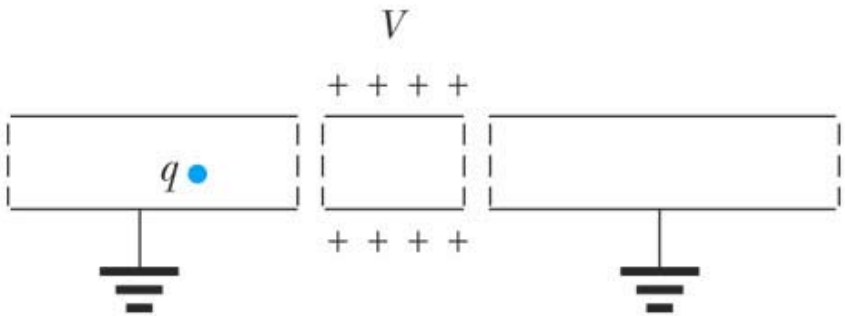
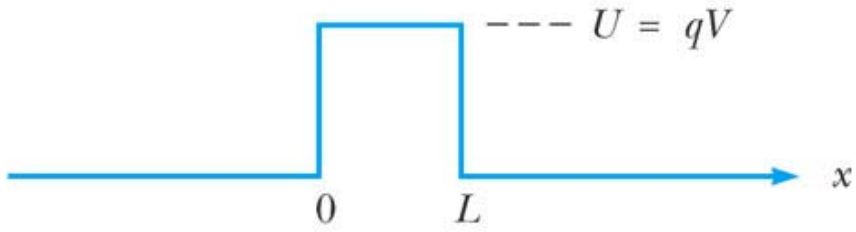
Ch. 7. Tunneling Phenomena

이 병 호
서울대 전기공학부
byoungho@snu.ac.kr

Tunneling



(a)



(b)

Fig. 7-1, p.232

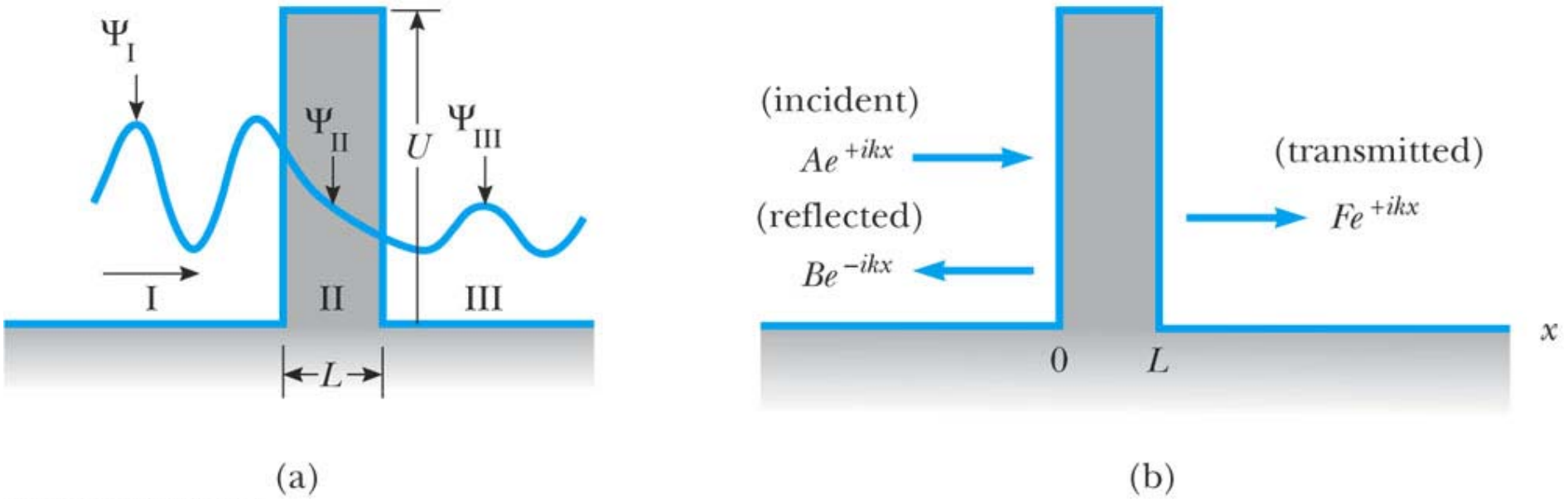


Fig. 7-2, p.233

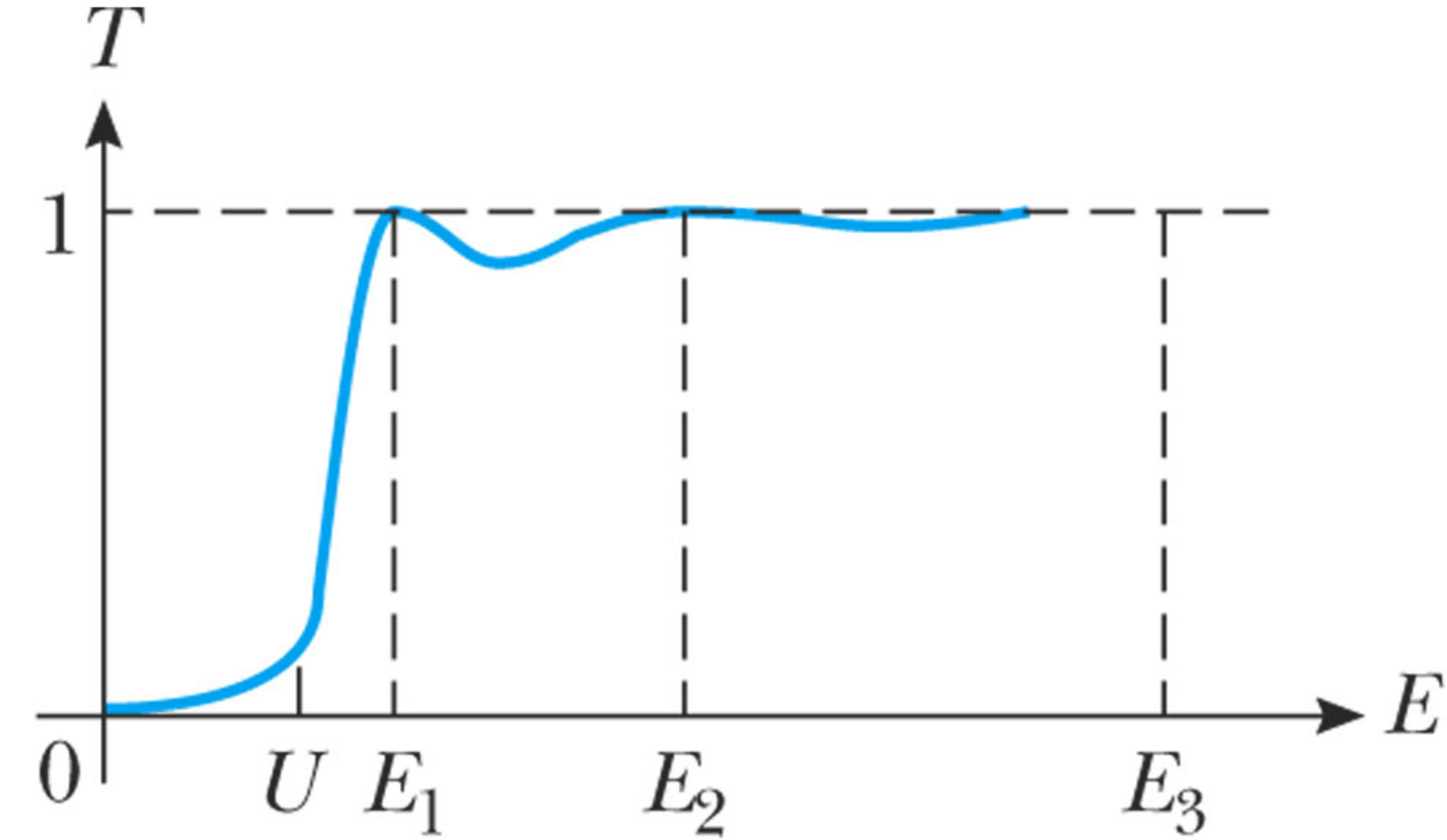
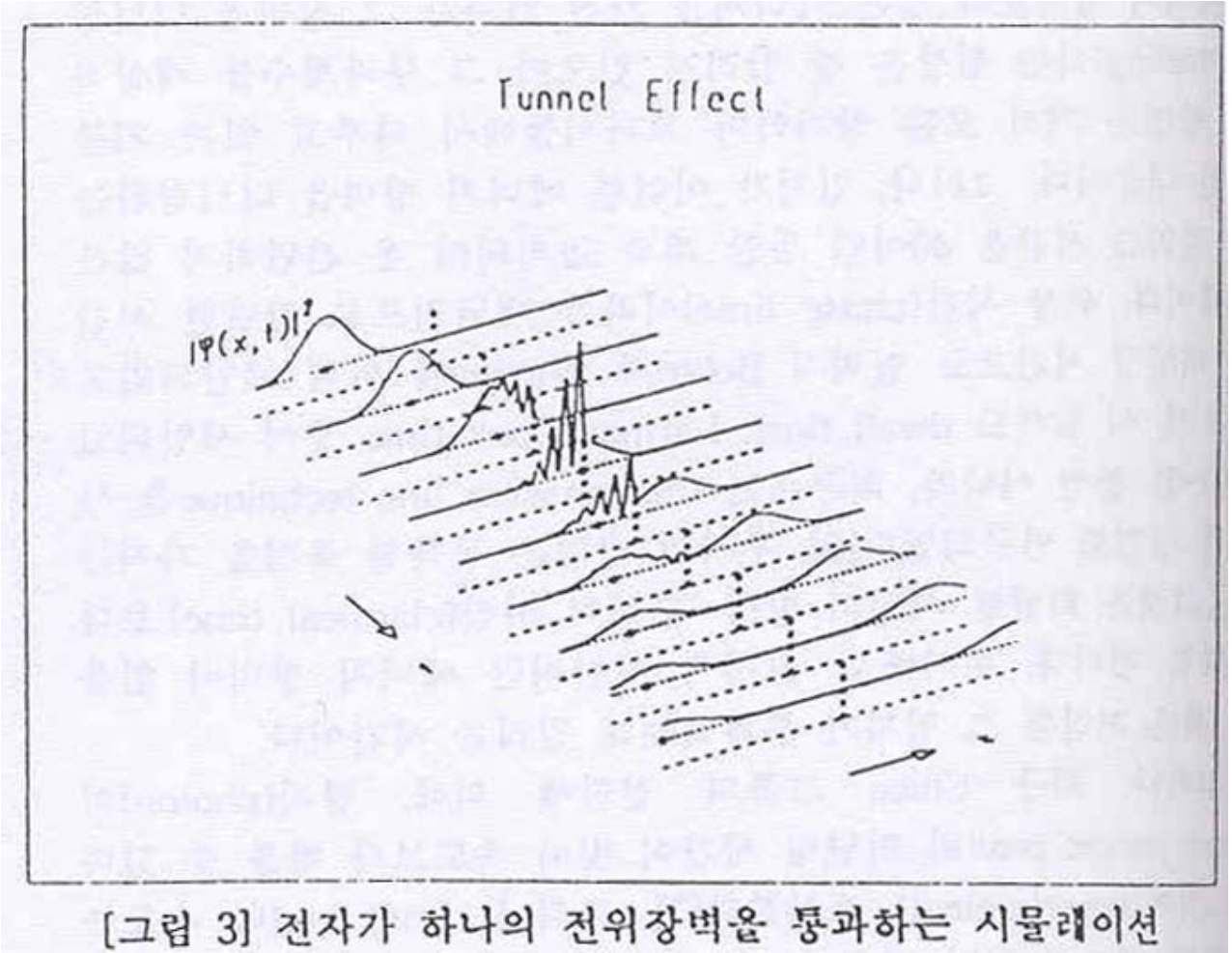
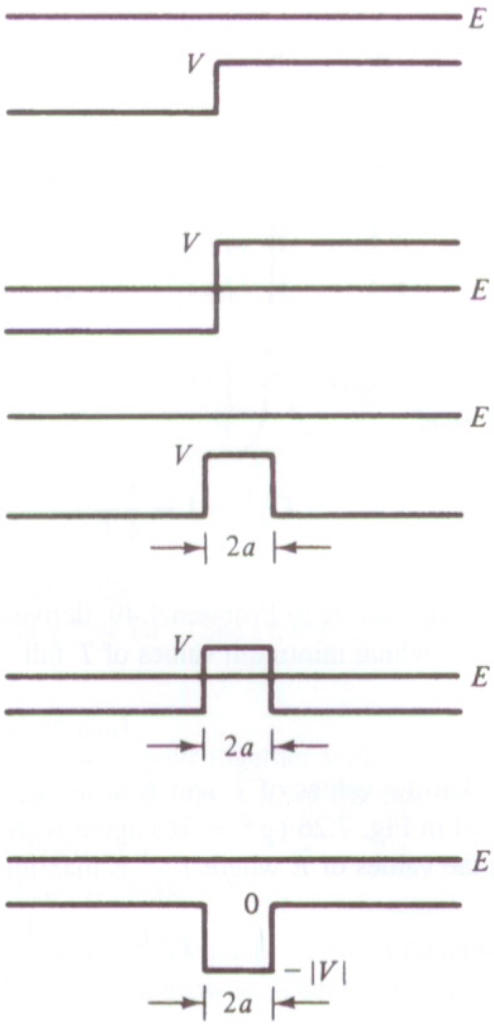


Fig. 7-3, p.235



[그림 3] 전자가 하나의 전위장벽을 통과하는 시뮬레이션

TABLE 7.2 Transmission coefficients for three elementary potential barriers



$$T = \frac{4k_2/k_1}{[1 + (k_2/k_1)]^2}$$

$$\left(\frac{k_2}{k_1}\right)^2 = 1 - \frac{V}{E}$$

$$T = 0, \quad R = 1$$

$$\frac{1}{T} = 1 + \frac{1}{4}\frac{V^2}{E(E-V)}\sin^2(2k_2a)$$

$$\frac{\hbar^2 k_2{}^2}{2m} = E - V$$

$$\frac{1}{T} = 1 + \frac{1}{4}\frac{V^2}{E(V-E)}\sinh^2(2\kappa a)$$

$$\frac{\hbar^2 \kappa^2}{2m} = V - E$$

$$\frac{1}{T} = 1 + \frac{1}{4}\frac{V^2}{E(E+|V|)}\sin^2(2k_2a)$$

$$\frac{\hbar^2 k_2{}^2}{2m} = E - V = E + |V|$$

Photon Tunneling

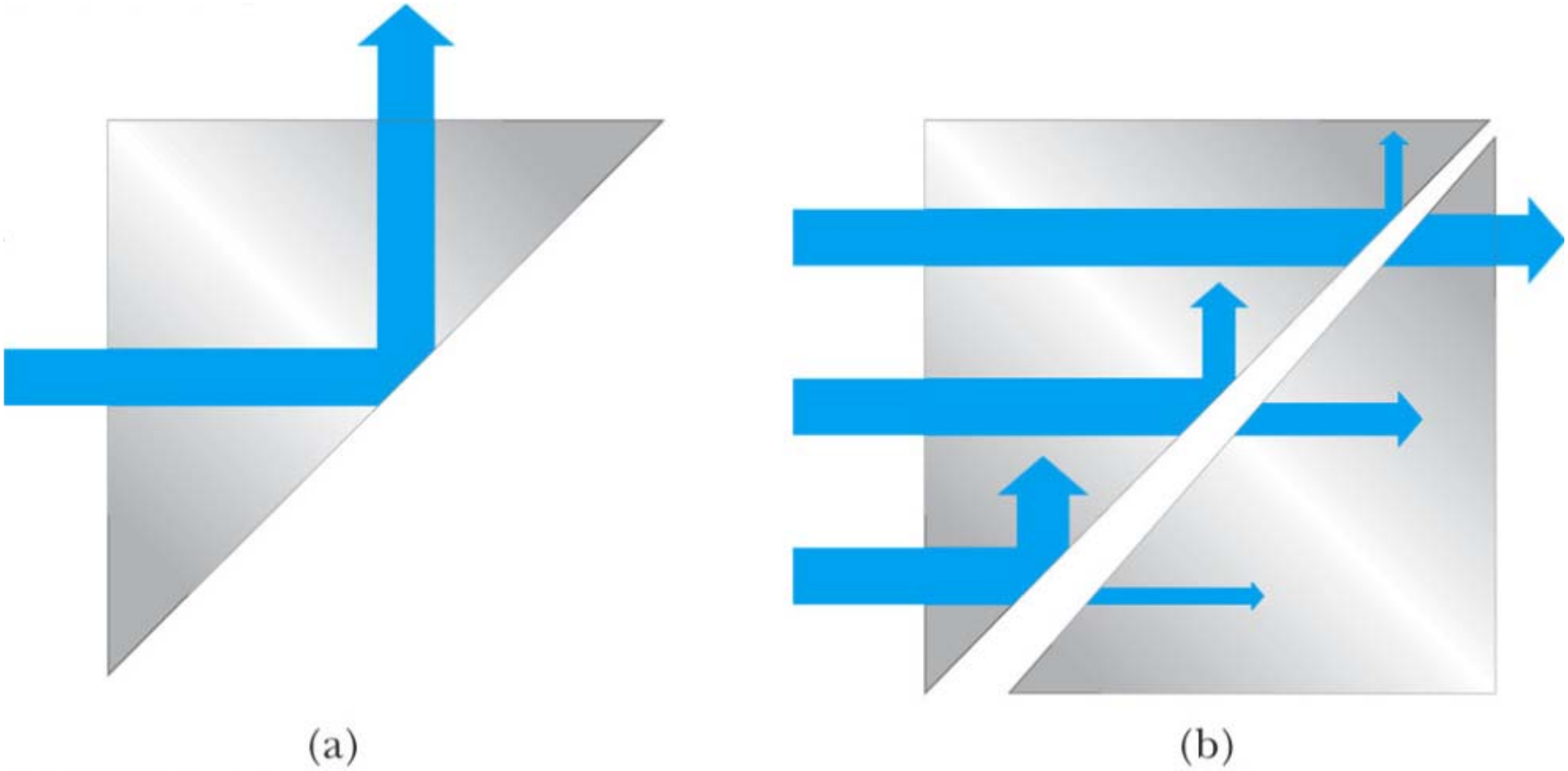


Fig. 7-5, p.238

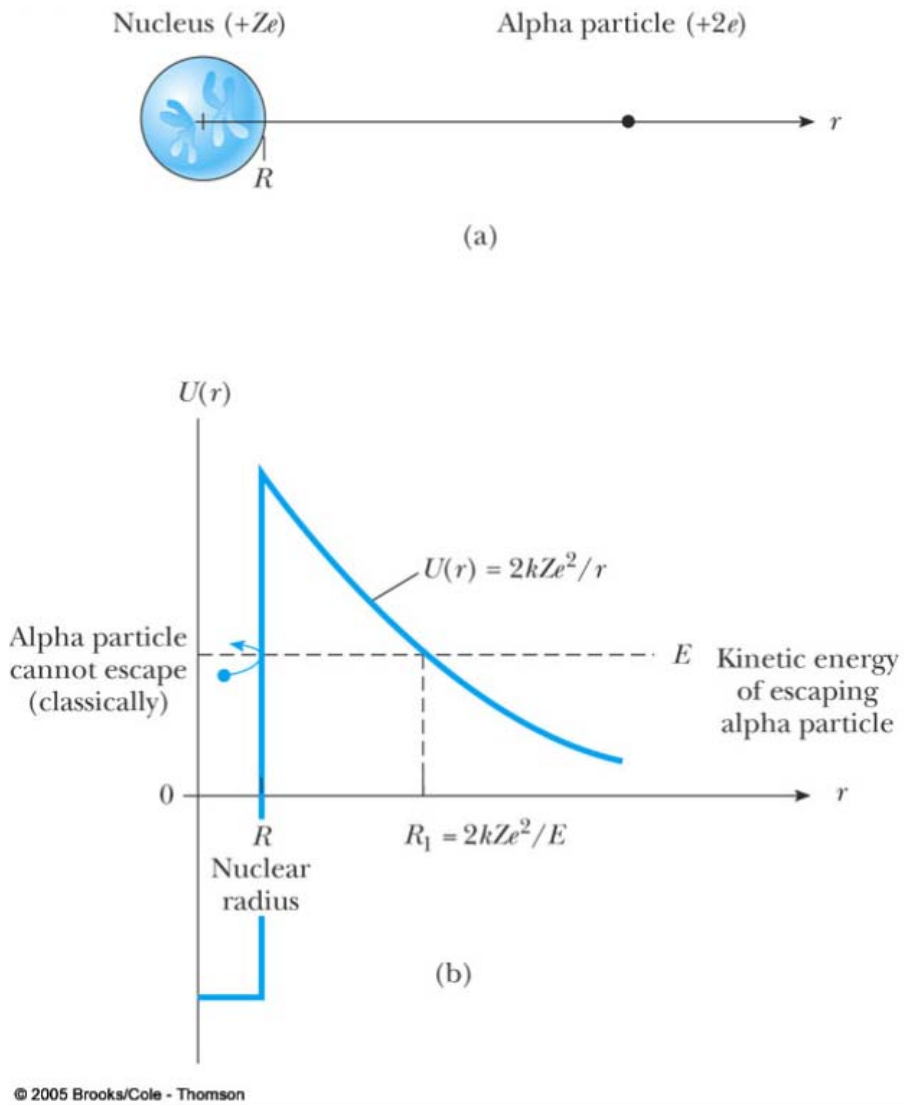

Nucleus (+Ze)
Alpha particle (+2e)
r
R
(a)
U(r)
U(r) = 2kZe²/r
Alpha particle
cannot escape
(classically)
E
Kinetic energy
of escaping
alpha particle
0
r
R
Nuclear
radius
R₁ = 2kZe²/E
(b)
© 2005 Brooks/Cole - Thomson

Fig. 7-9, p.245

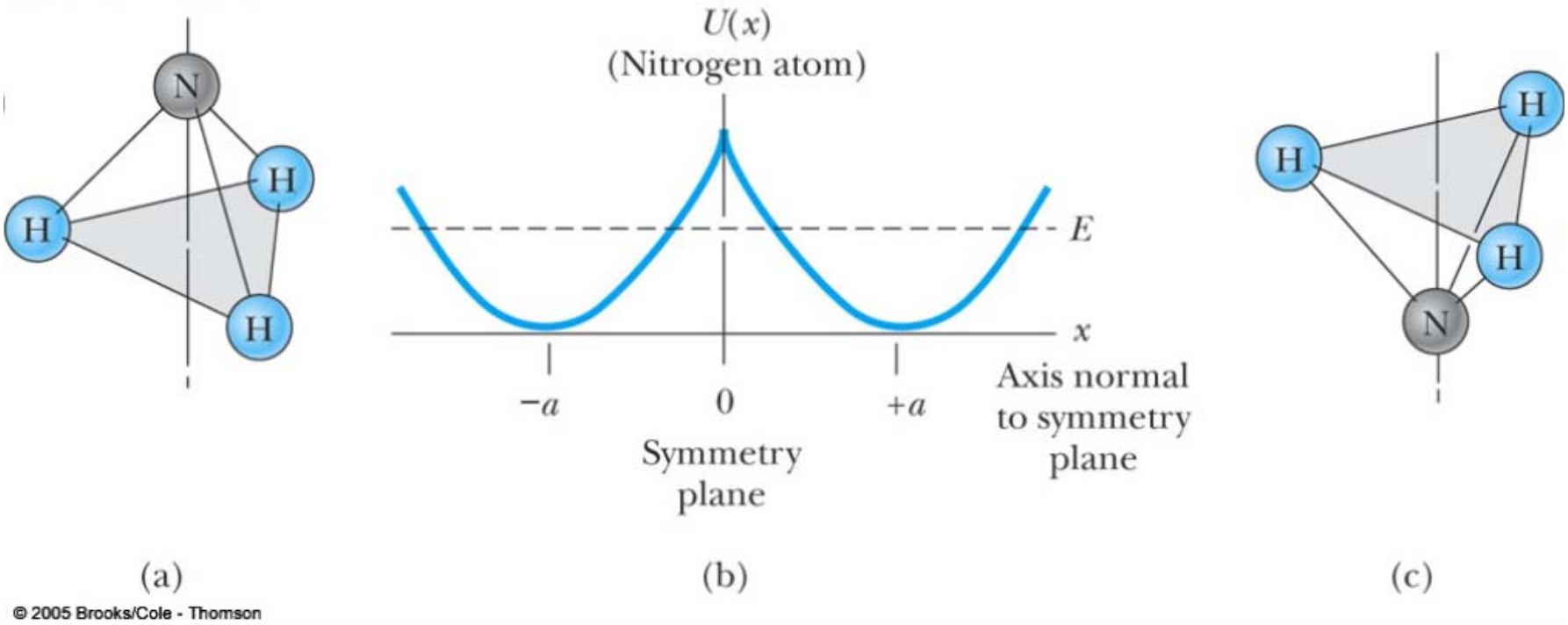


Fig. 7-10, p.245

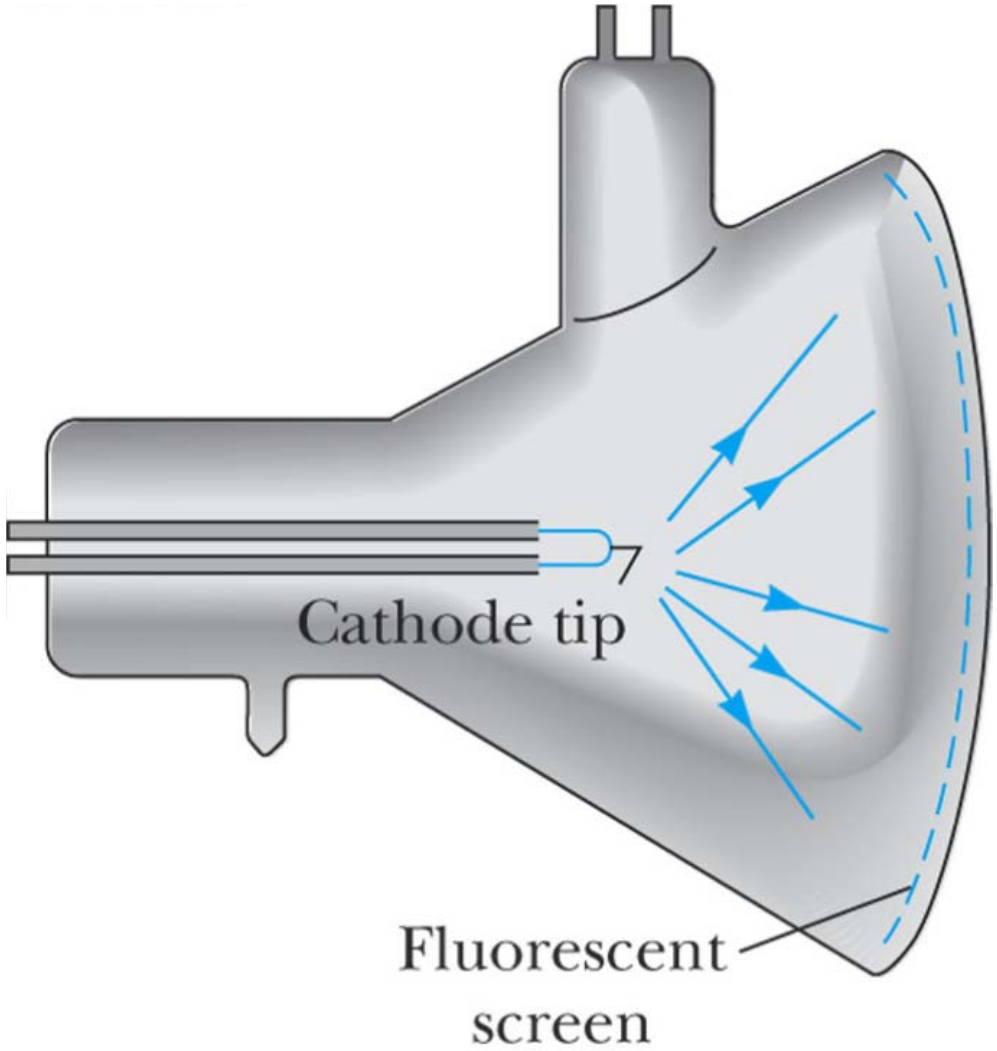


Fig. 7-6, p.239

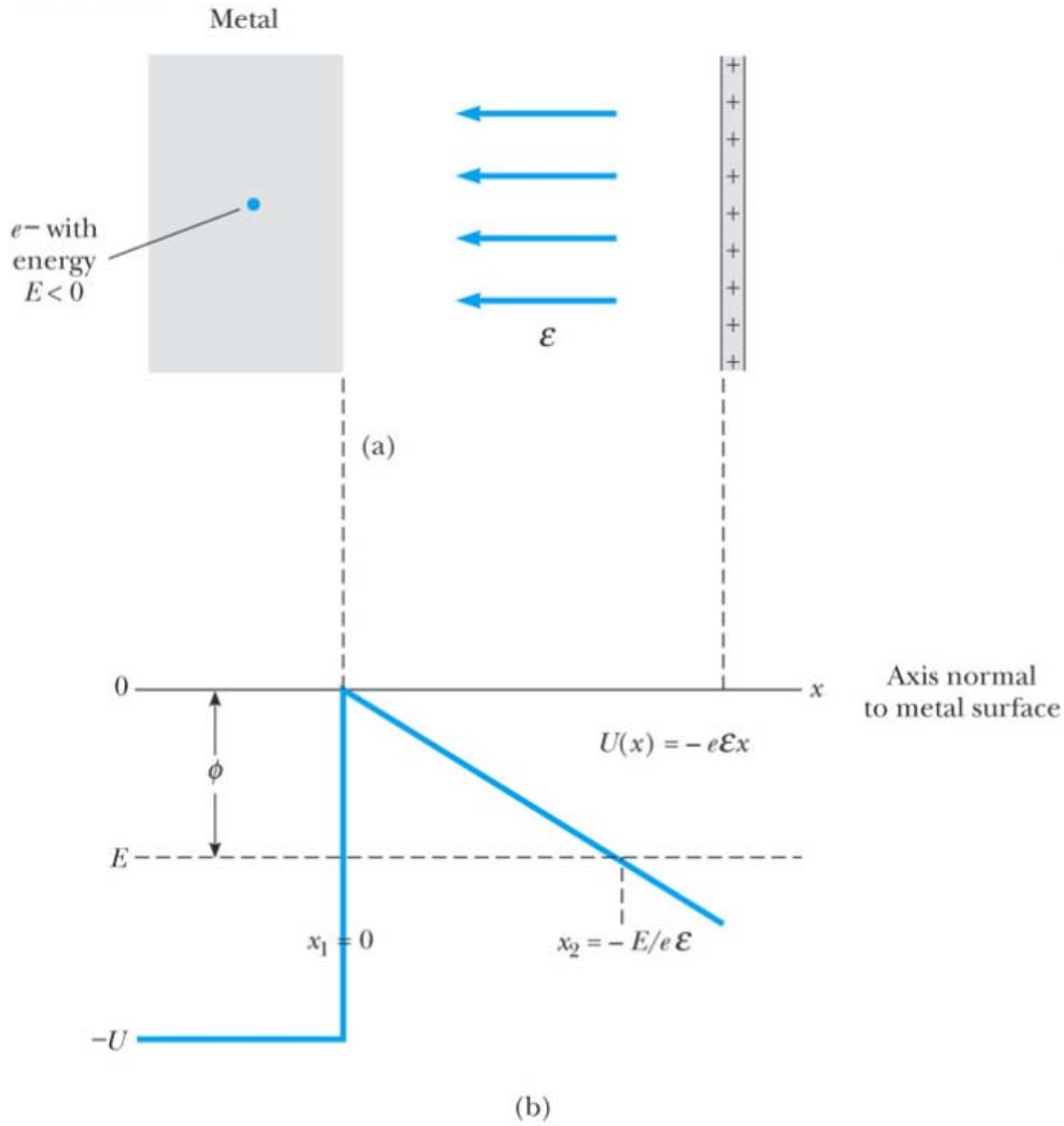


Fig. 7-7, p.240

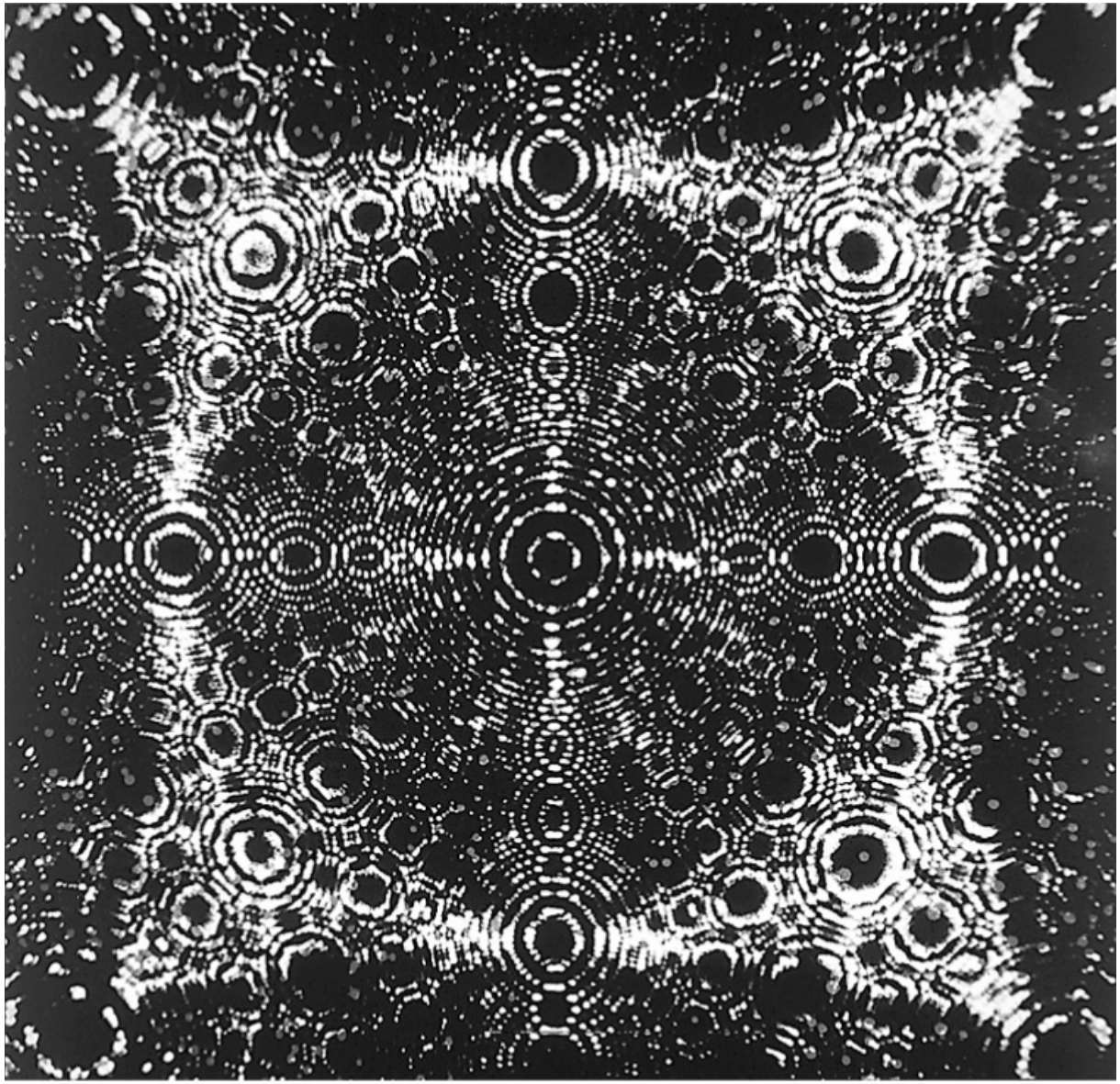
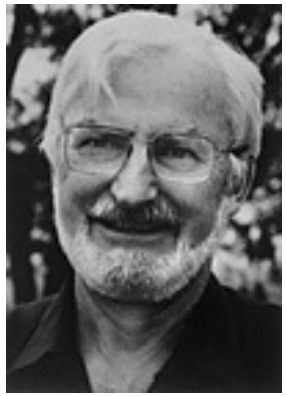


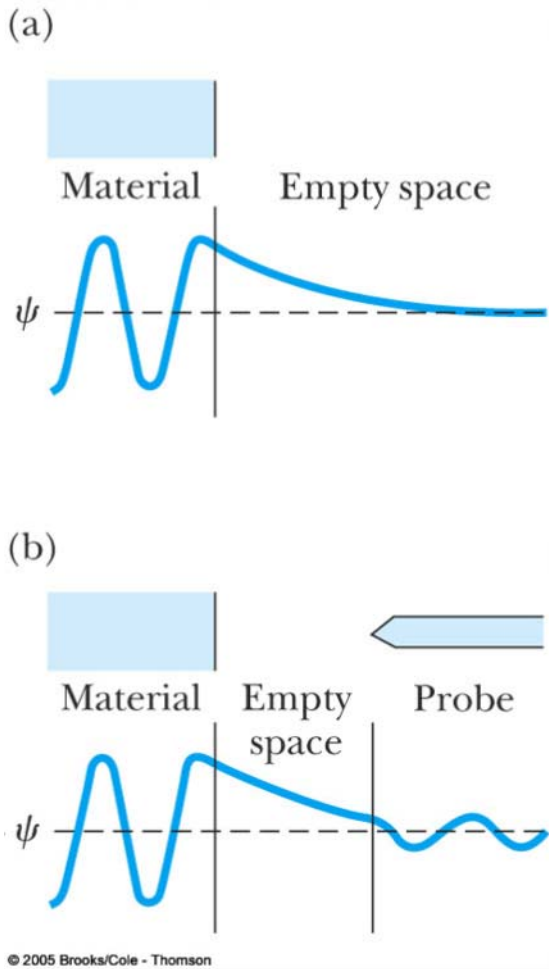
Fig. 7-8, p.241

Scanning Tunneling Microscope (STM)

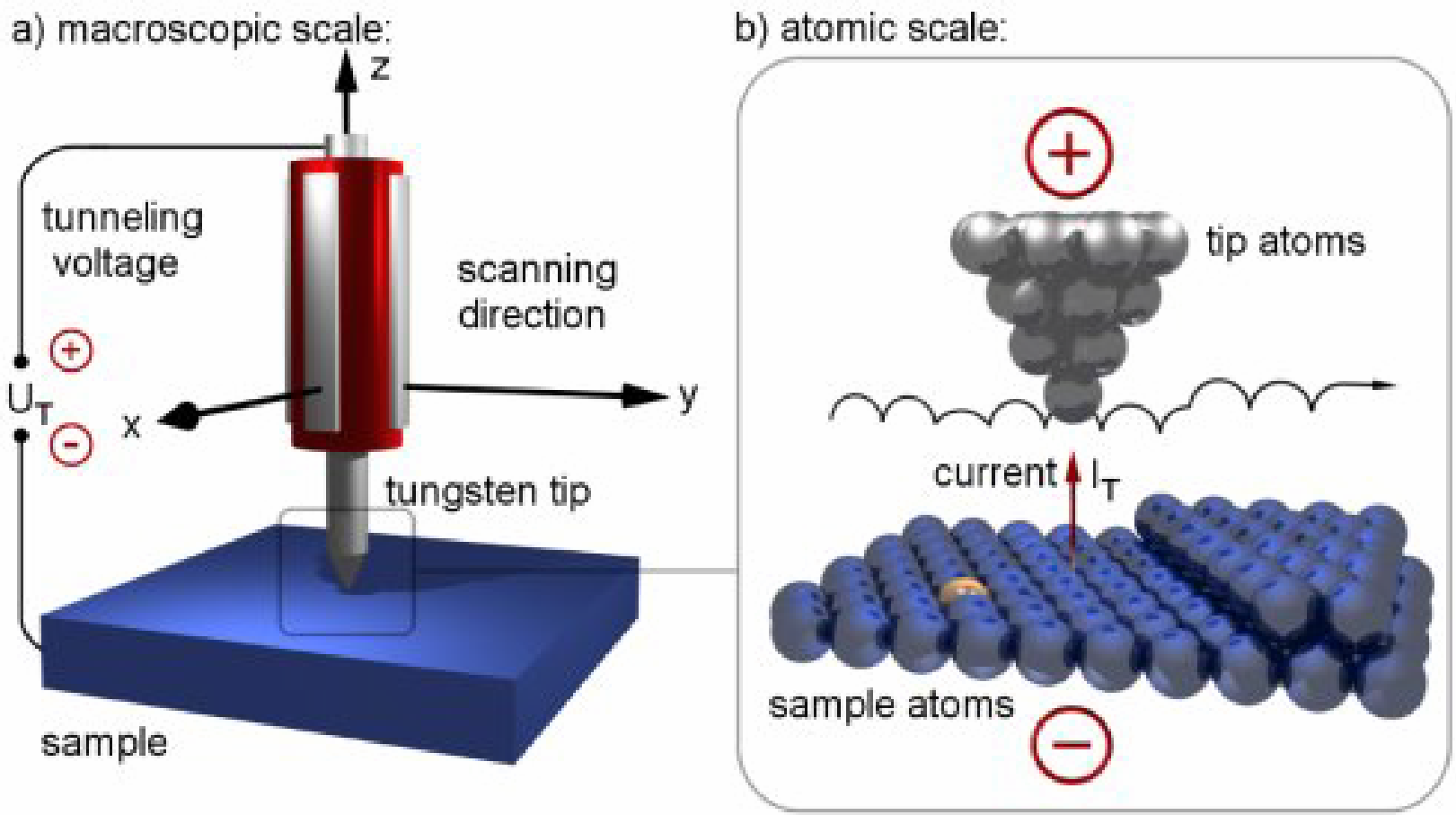
Gerd Binnig
(1947-)

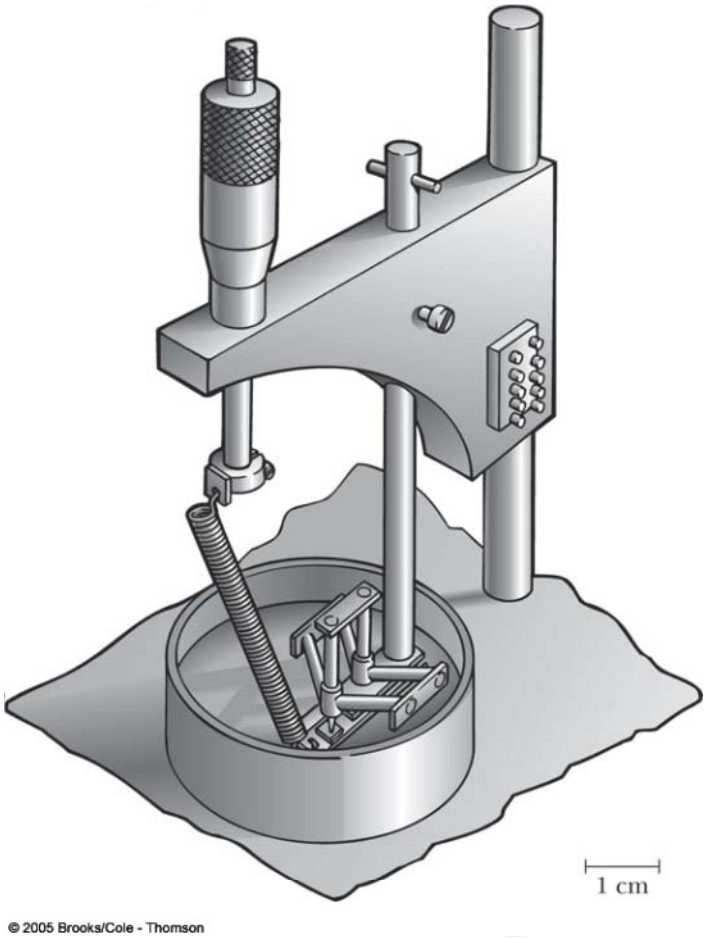


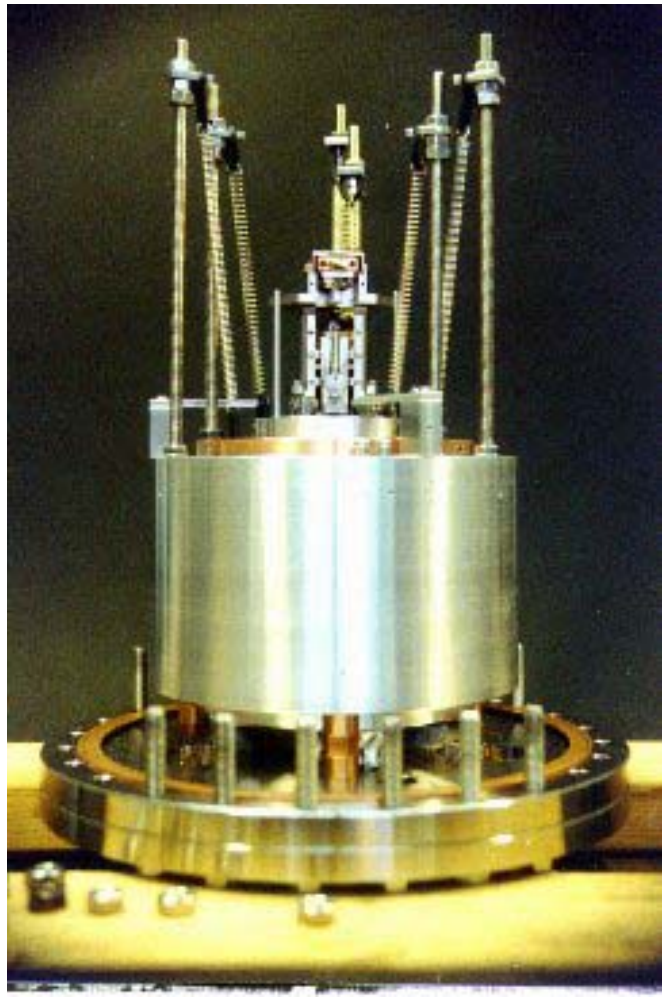
Heinrich Rohrer
(1933-)



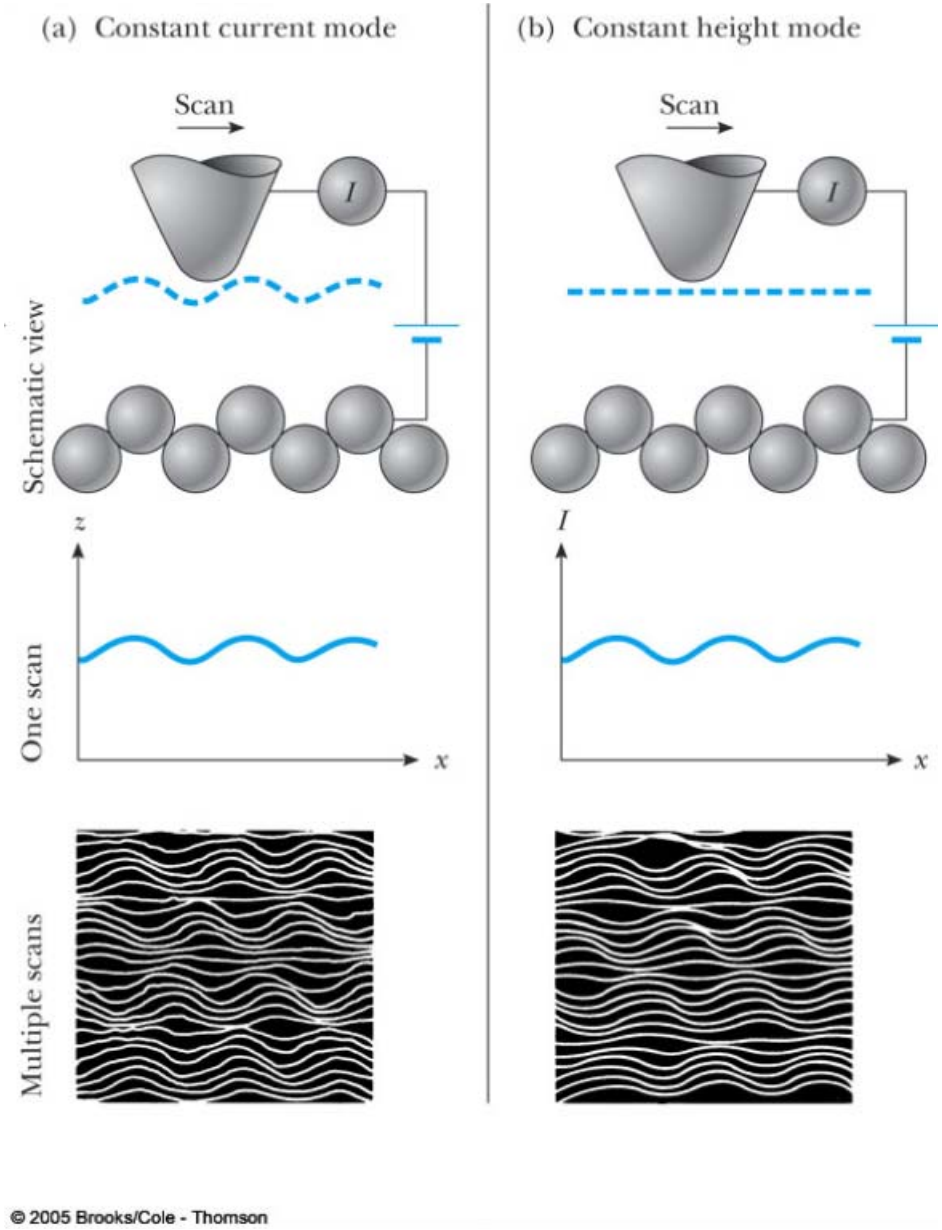
p.255

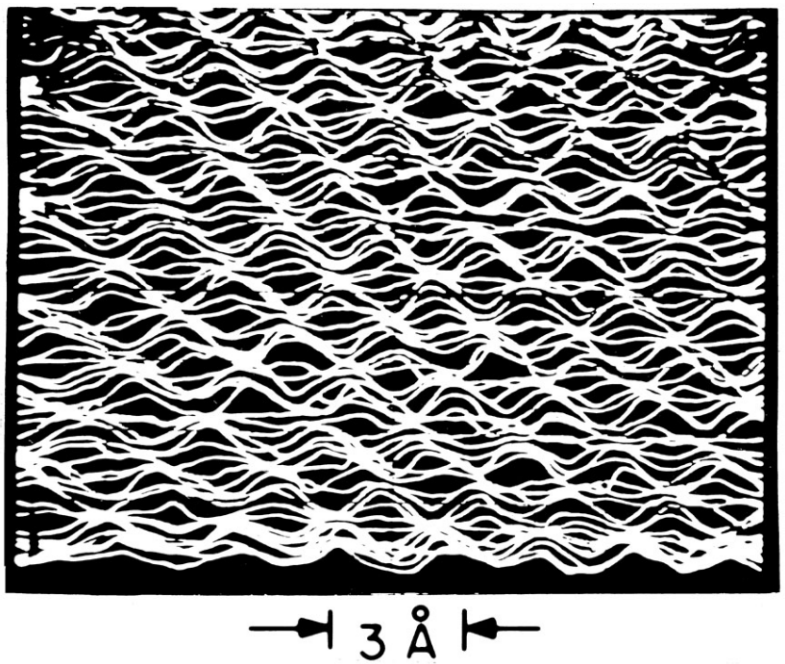

a) macroscopic scale:
z
tunneling
voltage
scanning
direction
U_T
x
y
tungsten tip
sample
b) atomic scale:
tip atoms
current I_T
sample atoms

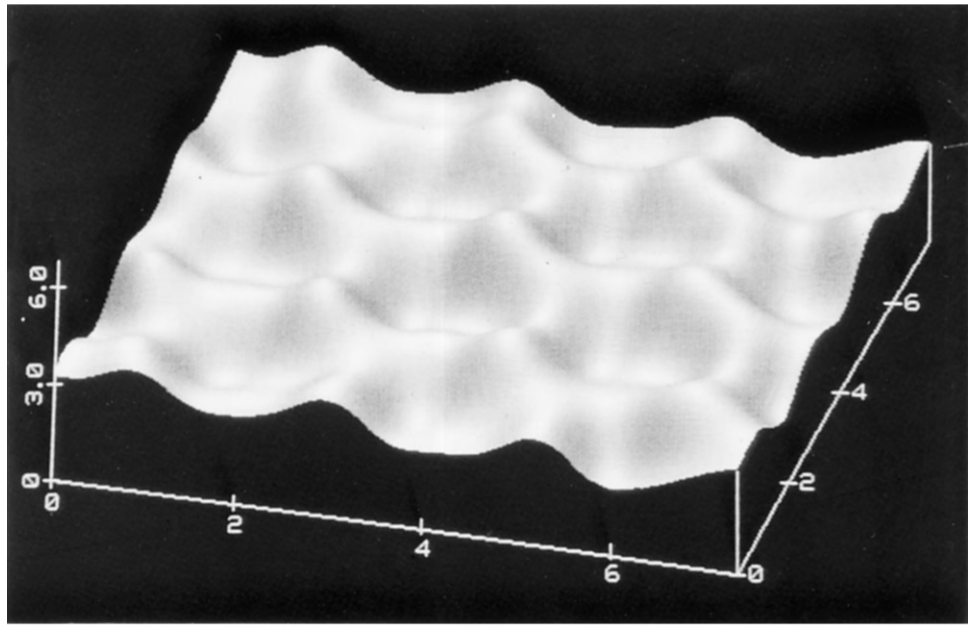




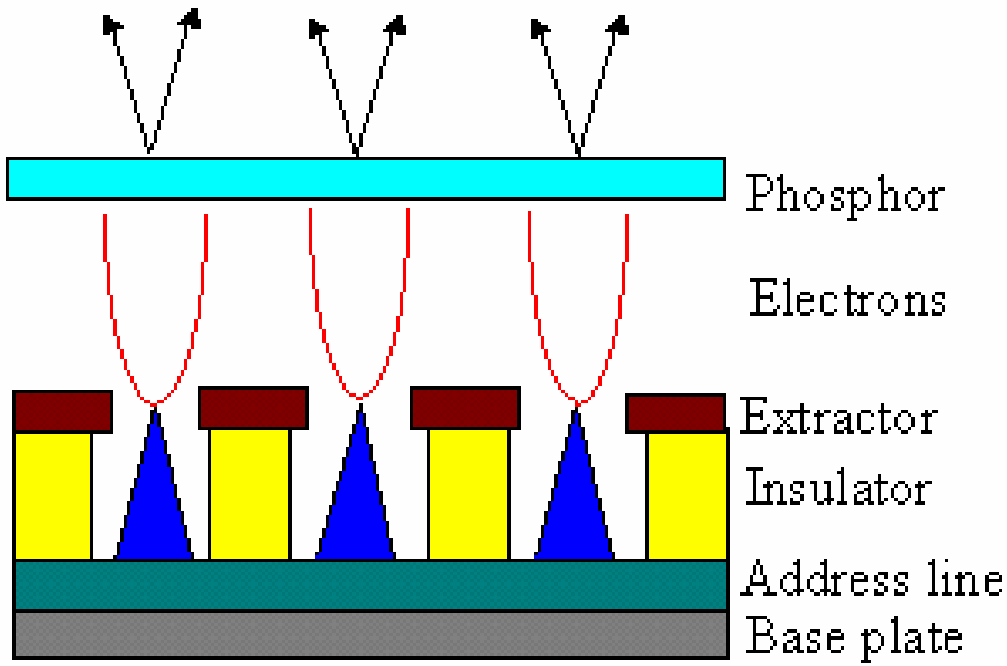
p.254

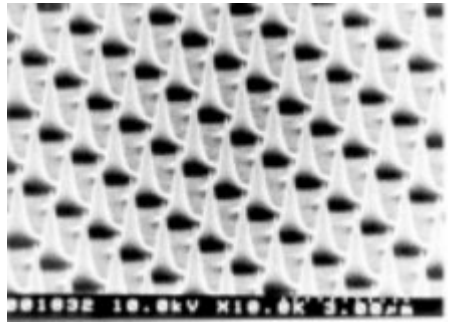


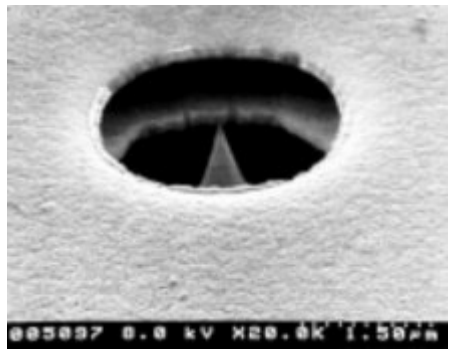


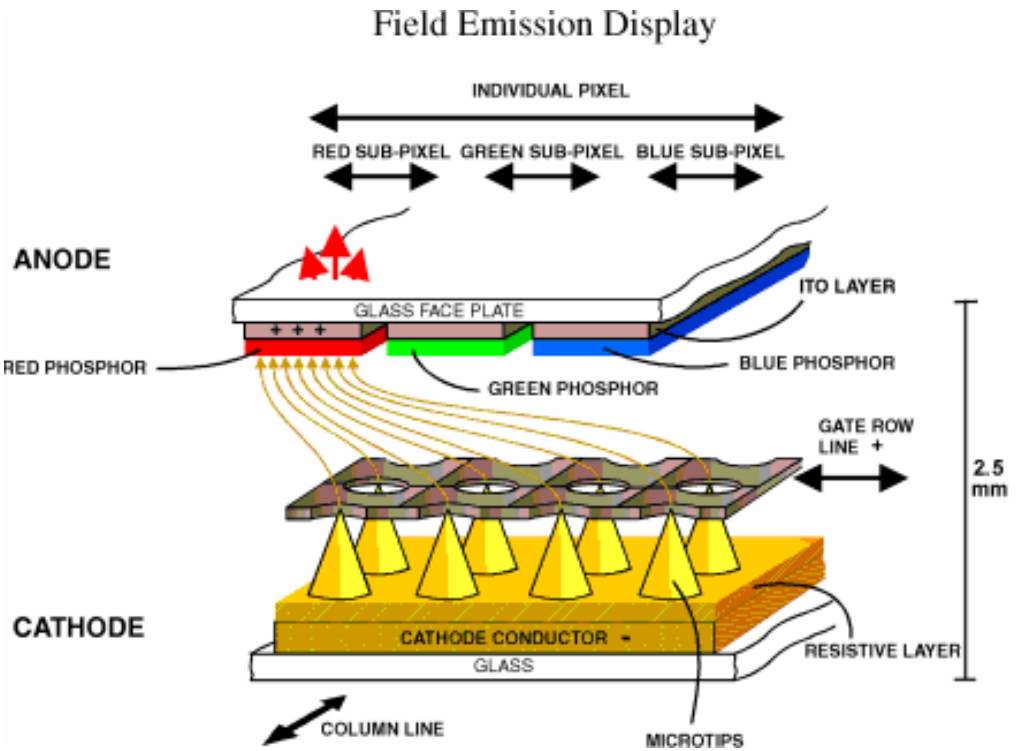


Field Emission Display (FED)



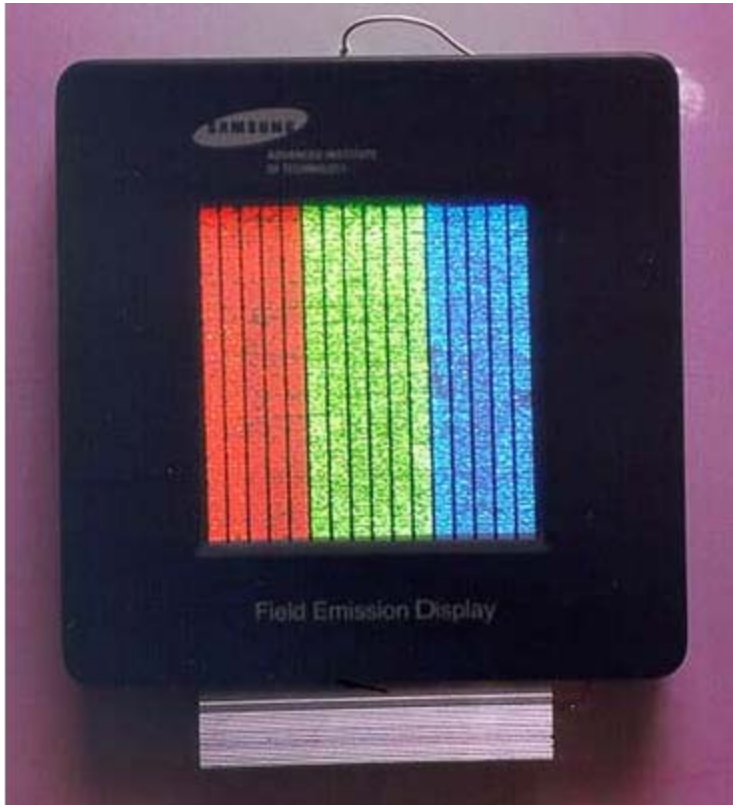


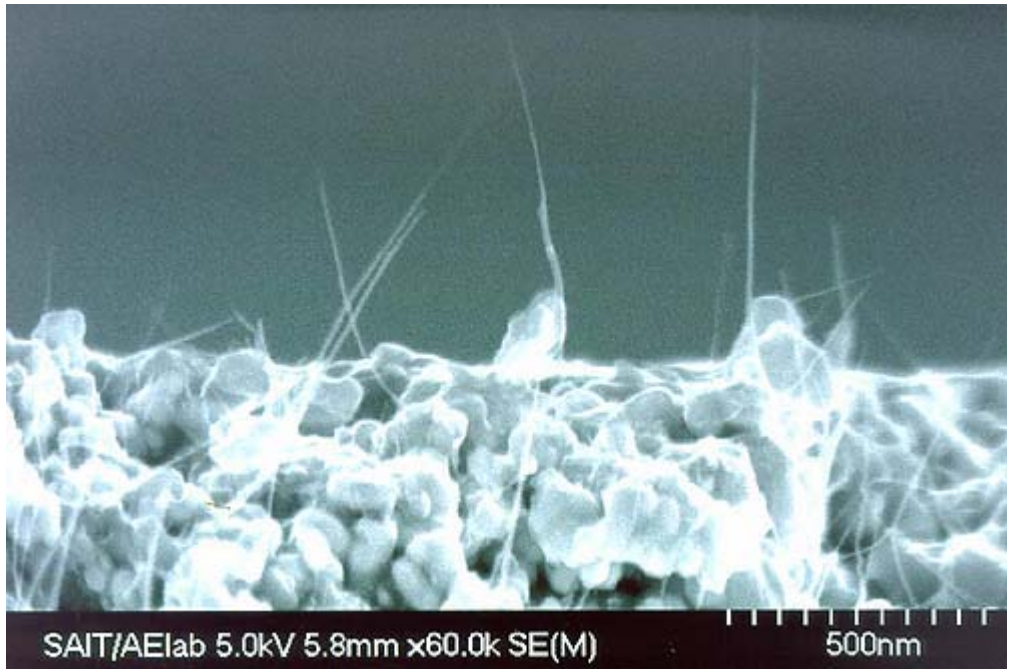



Field Emission Display
INDIVIDUAL PIXEL
RED SUB-PIXEL
GREEN SUB-PIXEL
BLUE SUB-PIXEL
ANODE
GLASS FACE PLATE
ITO LAYER
RED PHOSPHOR
GREEN PHOSPHOR
BLUE PHOSPHOR
GATE ROW LINE +
2.5 mm
CATHODE
CATHODE CONDUCTOR -
GLASS
RESISTIVE LAYER
COLUMN LINE
MICROTIPS

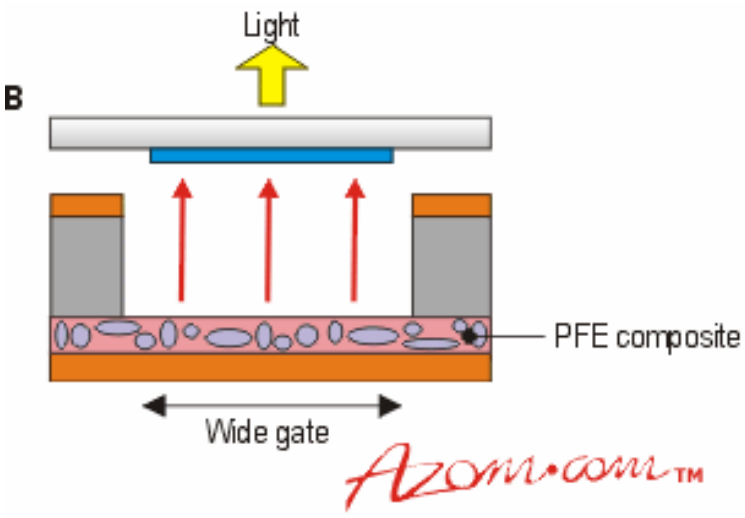

PixTech

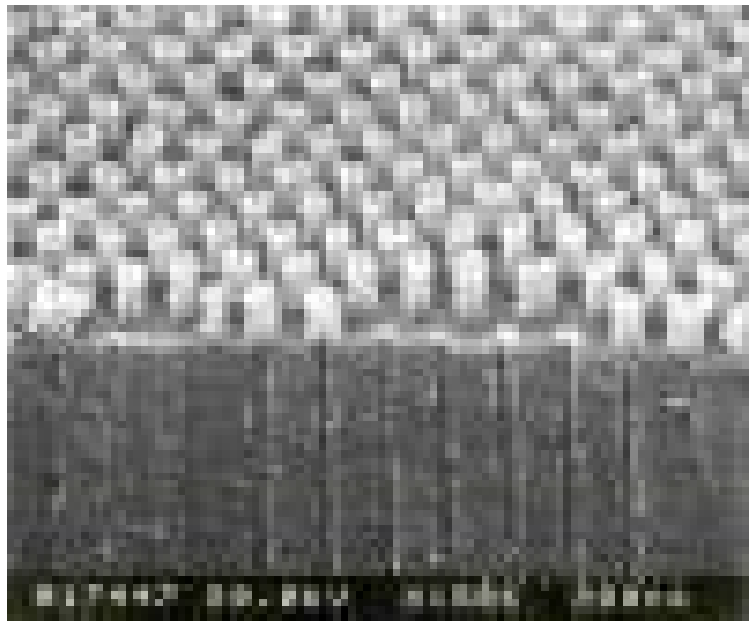
Carbon Nanotube FED





Field Emission Backlight

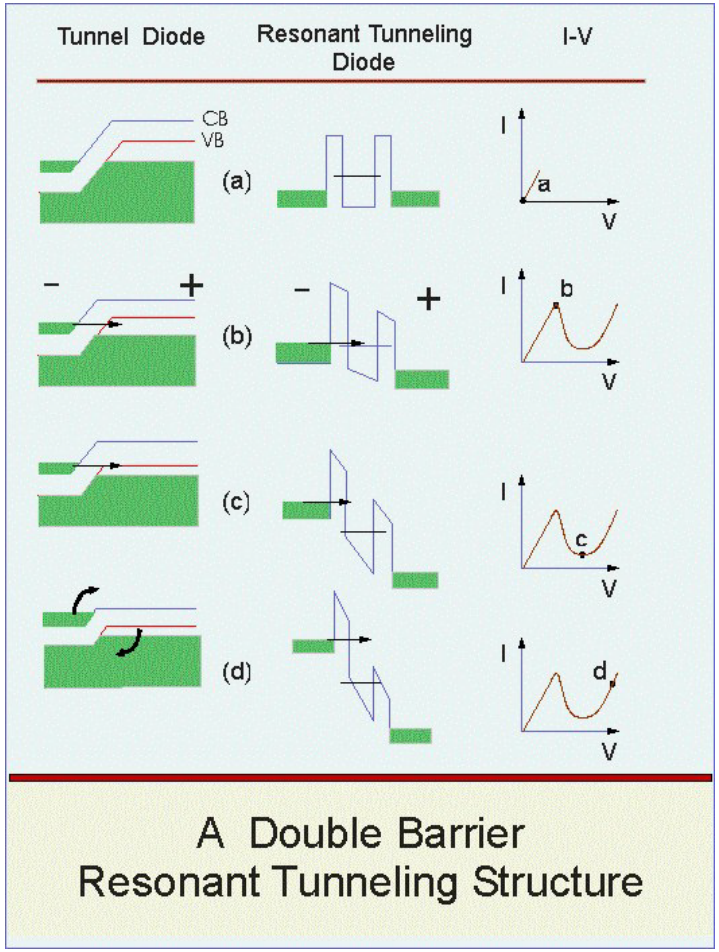




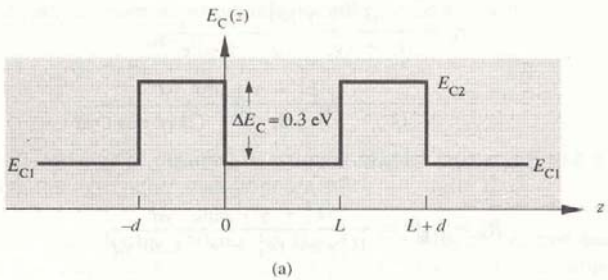
Esaki

Leo Esaki
(1925-)

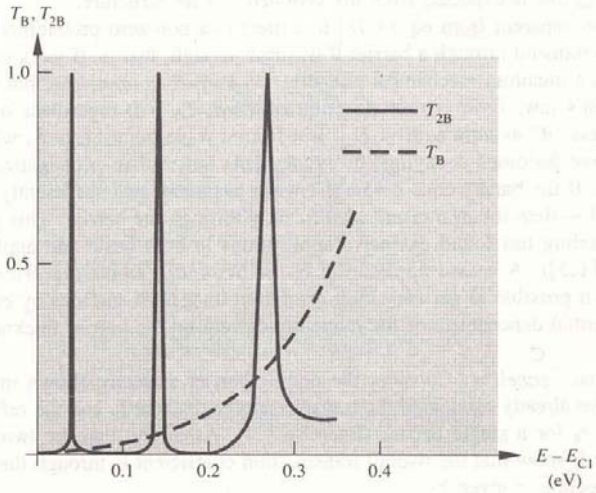
Tunneling Diode and Resonant Tunneling Diode



Resonant Tunneling



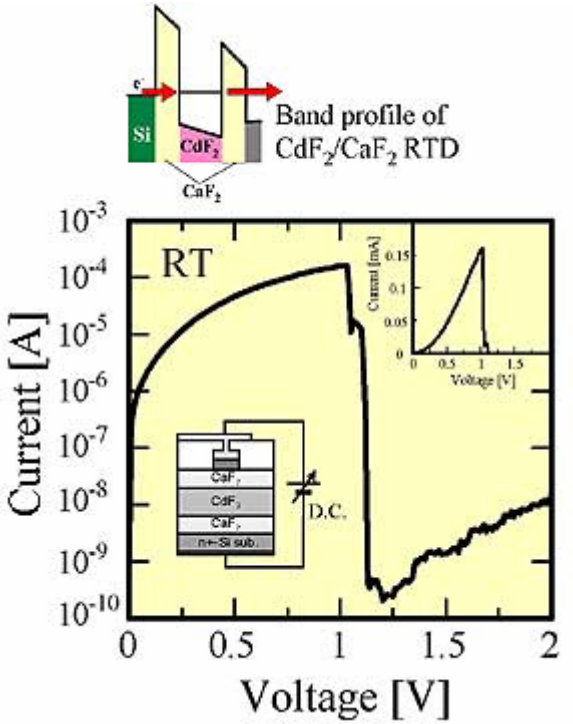
(a)

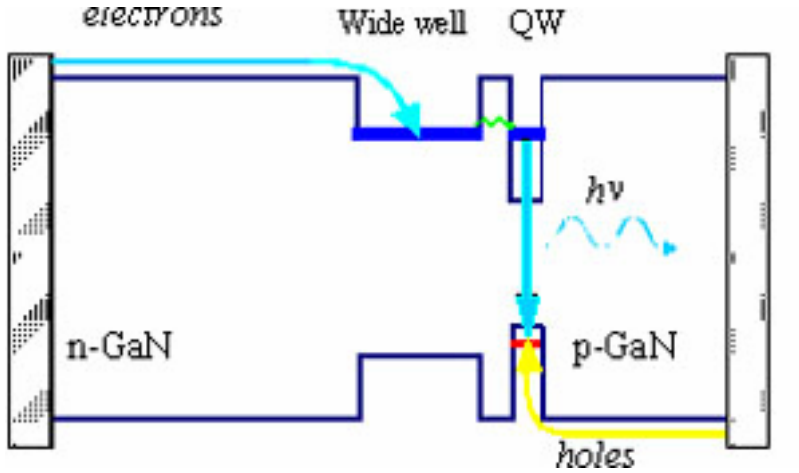


(b)

Fig. 1.11 The resonant tunneling device (d = 40 Å, L = 100 Å). (a) $E_C(z)$ vs. z; (b) $T_B(E)$, $T_{2B}(E)$.

Tunneling and Resonant Tunneling





Superlattices