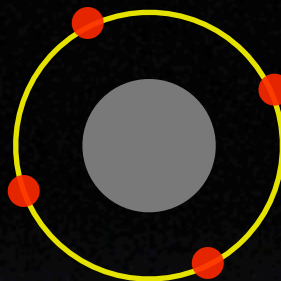


# SEMICONDUCTEURS

Electronique - ENSPG 2005 / 2006

atome

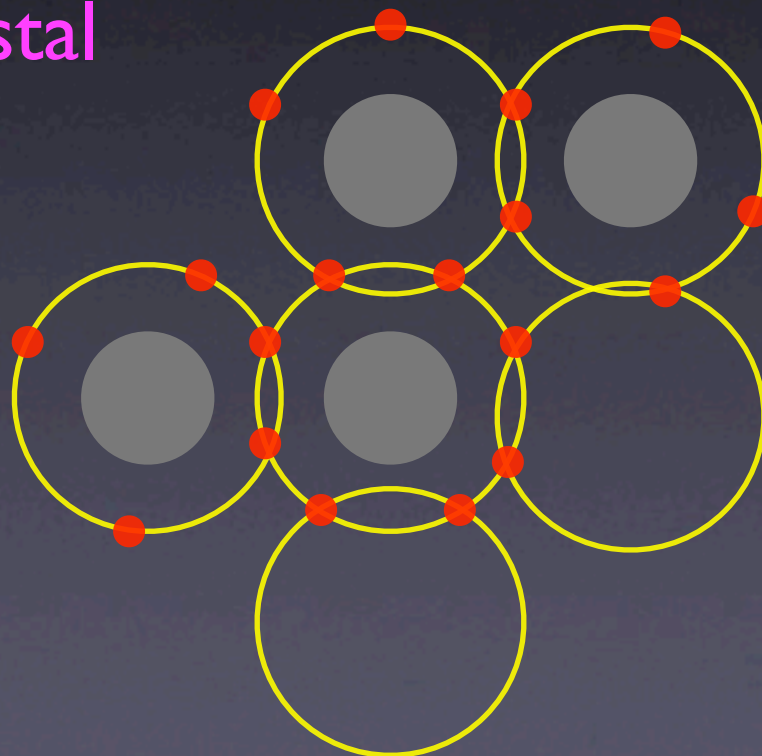


E



Niveaux d'énergie

Cristal



$T > 0K$

E



Bandes d'énergie

$\Delta E$

# CLASSIFICATION PERIODIQUE DES ELEMENTS

- Métaux
- Semi-conducteurs
- Non-métaux
- Gaz nobles
- Lanthanides et actinides

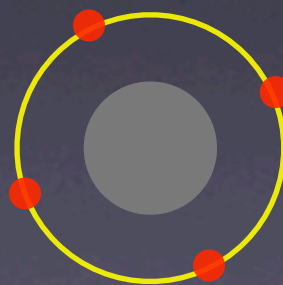
**Li** : Solide à 25°C, sous 1 bar

**He** : Gaz à 25°C, sous 1 bar

**Br** : Liquide à 25°C, sous 1 bar

Tc : Obtenu par synthèse

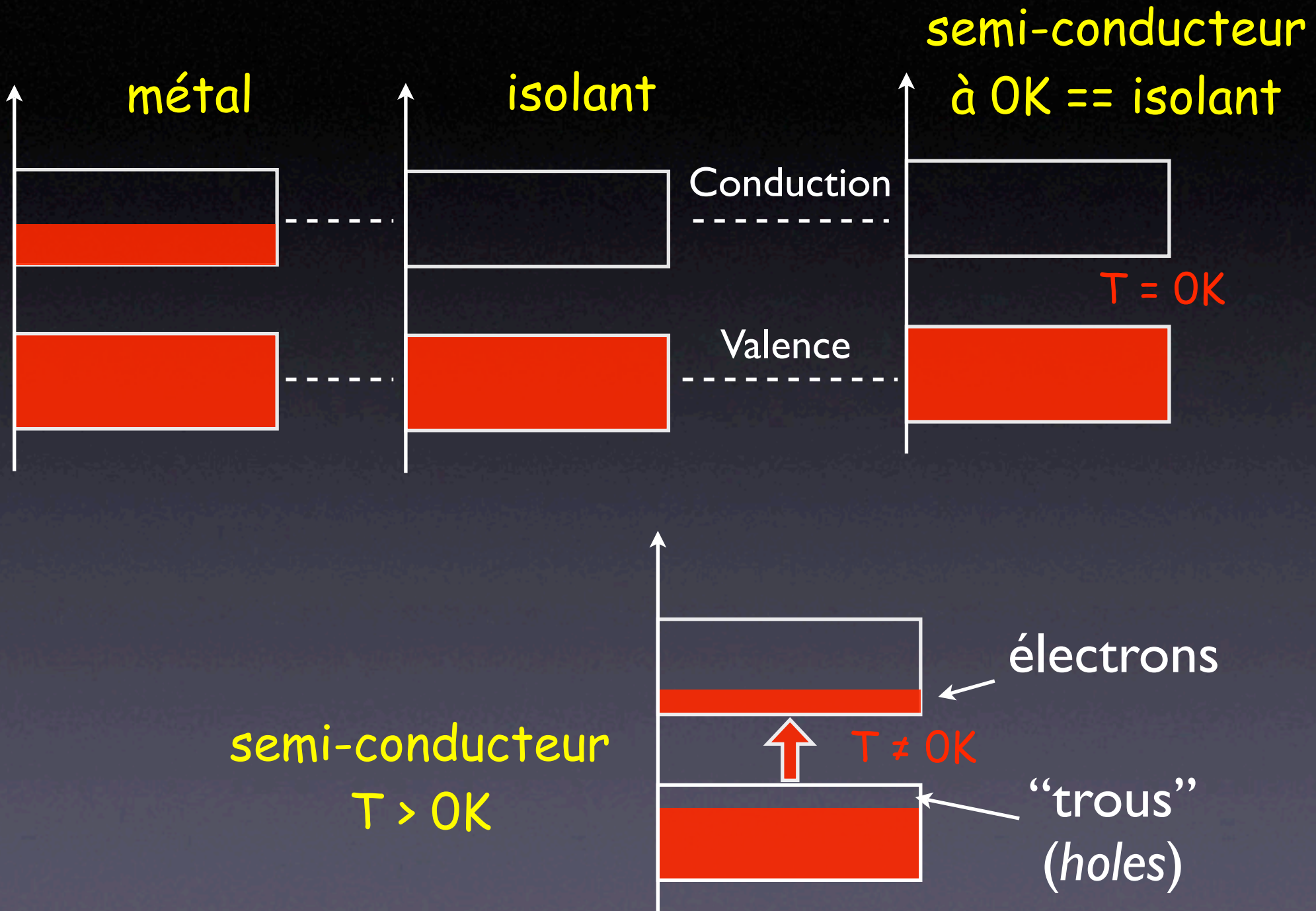
	I												III					IV	V	VI	VII	VIII
1	<b>H</b> 1																					<b>He</b> 2
2	<b>Li</b> 3	<b>Be</b> 4											<b>B</b> 5	<b>C</b> 6	<b>N</b> 7	<b>O</b> 8	<b>F</b> 9	<b>Ne</b> 10				
3	<b>Na</b> 11	<b>Mg</b> 12											<b>Al</b> 13	<b>Si</b> 14	<b>P</b> 15	<b>S</b> 16	<b>Cl</b> 17	<b>Ar</b> 18				
4	<b>K</b> 19	<b>Ca</b> 20	<b>Sc</b> 21	<b>Ti</b> 22	<b>V</b> 23	<b>Cr</b> 24	<b>Mn</b> 25	<b>Fe</b> 26	<b>Co</b> 27	<b>Ni</b> 28	<b>Cu</b> 29	<b>Zn</b> 30	<b>Ga</b> 31	<b>Ge</b> 32	<b>As</b> 33	<b>Se</b> 34	<b>Br</b> 35	<b>Kr</b> 36				



Colonne **IV** : **Si** ou **Ge**

4 voisins : à 0 K, isolant ; à > 0 K : (mauvais) conducteur **semi**

# Etat des bandes d'énergie dans un cristal



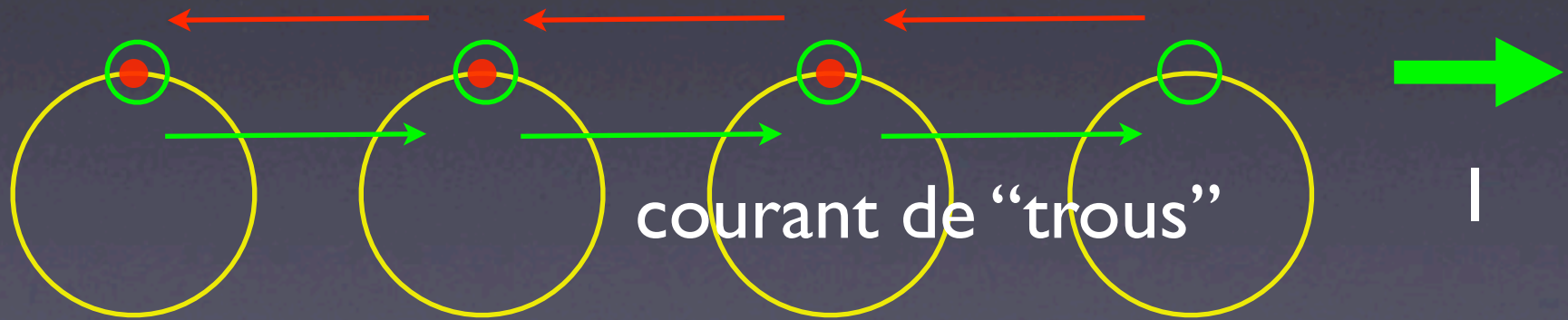
semi-conducteur  
 $T > 0K$



courant d'électrons

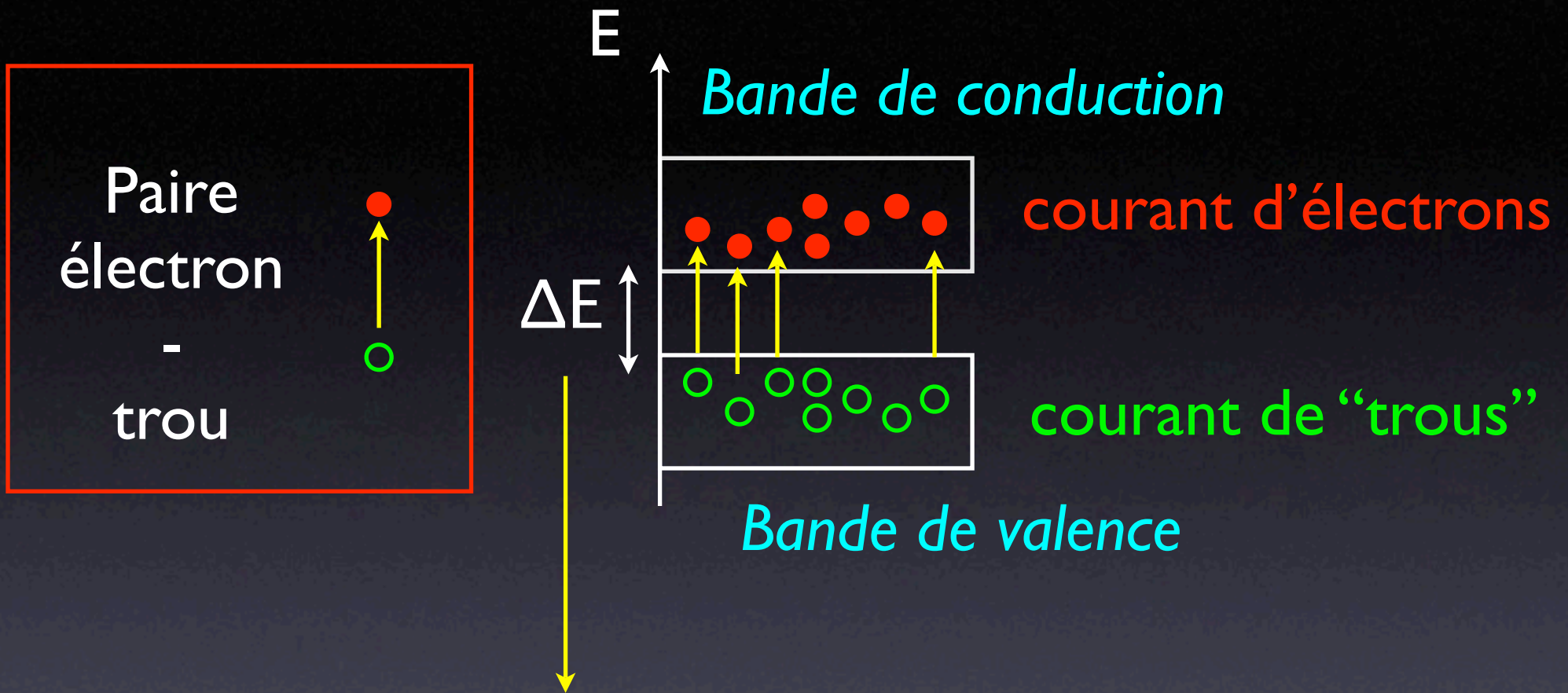
courant de "trous"

courant d'électrons



courant de "trous"

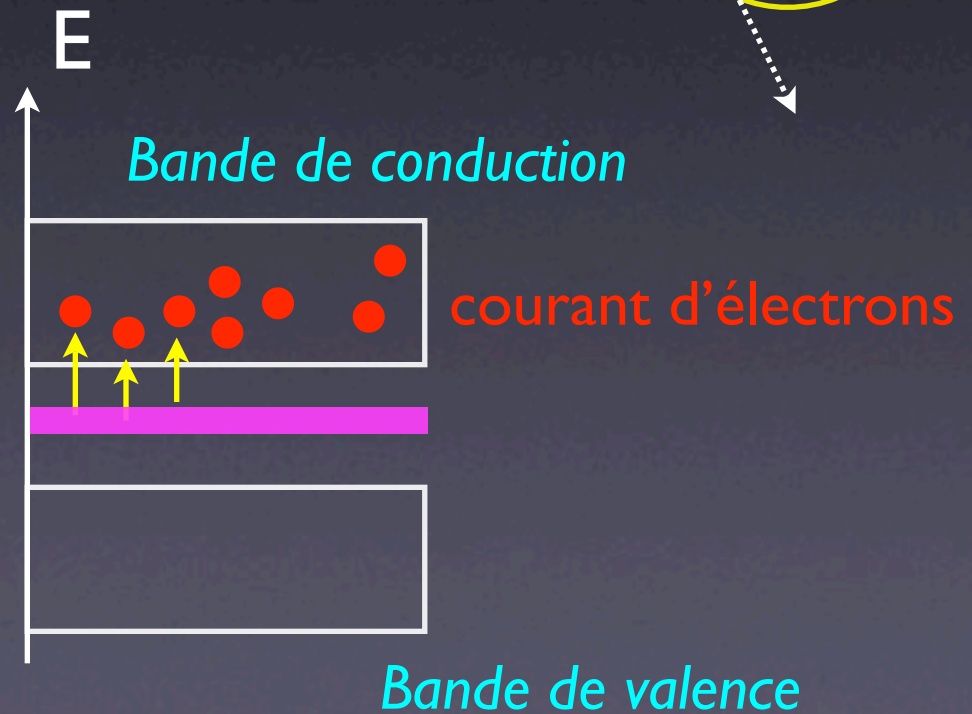
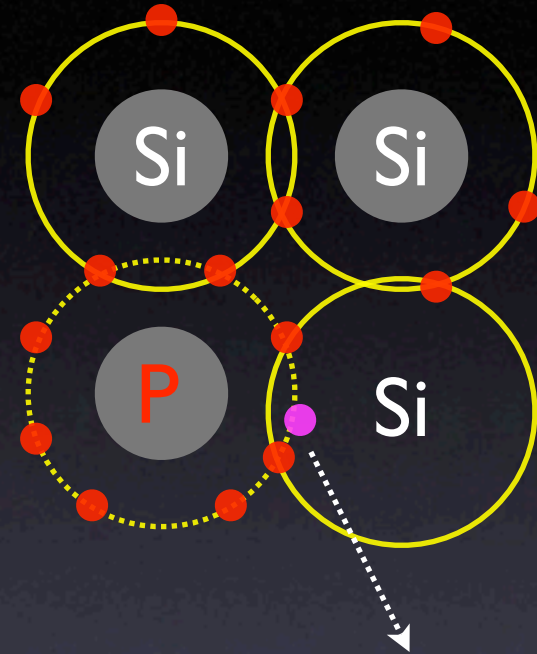
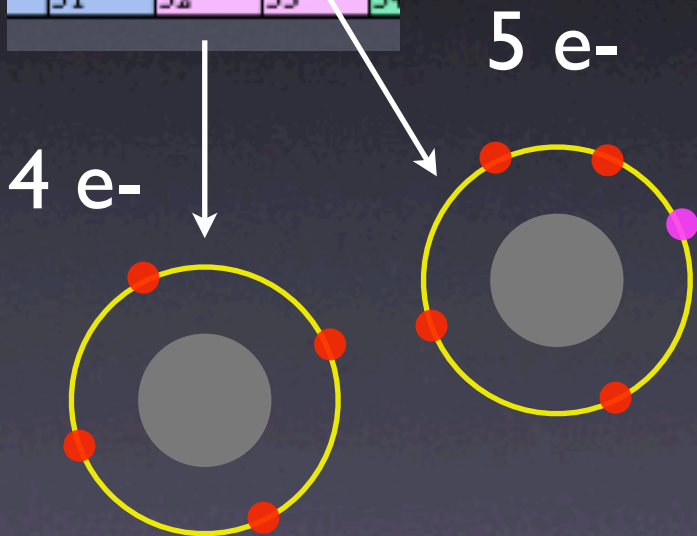
I



Si :  $\Delta E \approx 1 \text{ eV} (10^{-19} \text{ J})$

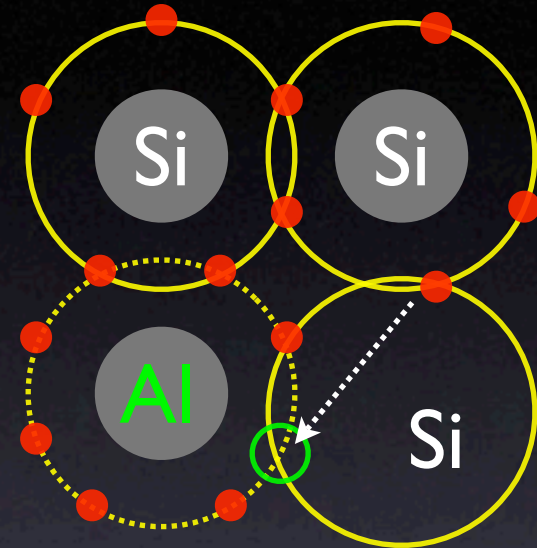
# Semiconducteur dopé N ("de type N")

	III	IV	V	
	B	C	N	
5		6	7	8
	Al	Si	P	
13		14	15	16
	Ga	Ge	As	
31		32	33	34

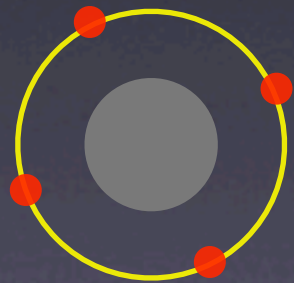
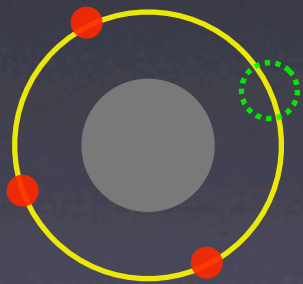


# Semiconducteur dopé P ("de type P")

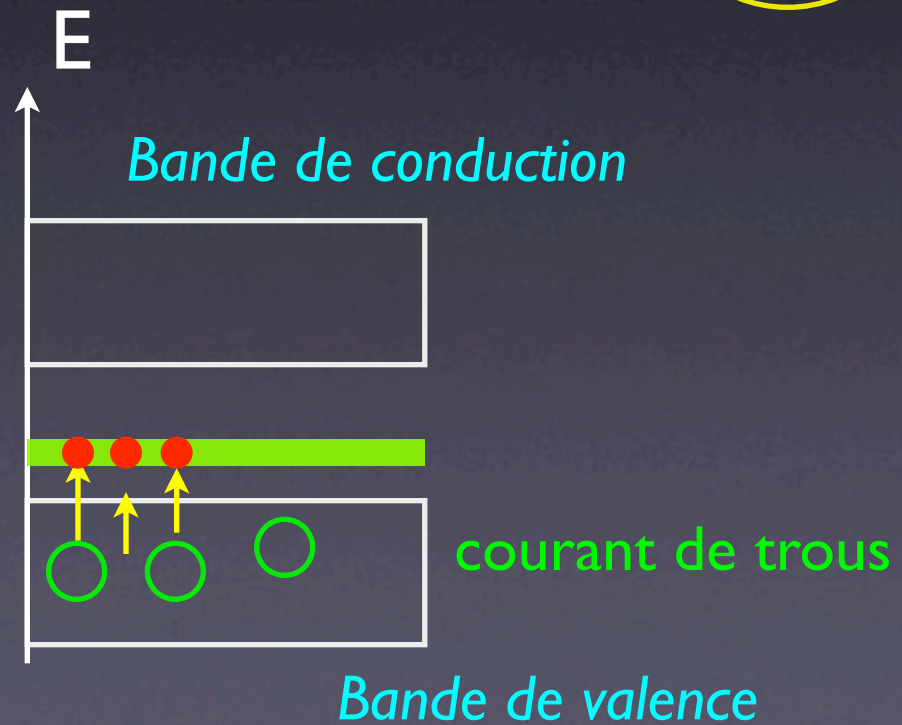
	III	IV	V	
	B	C	N	
5		6	7	8
	Al	Si	P	
13		14	15	16
	Ga	Ge	As	
31		32	33	34



3 e-



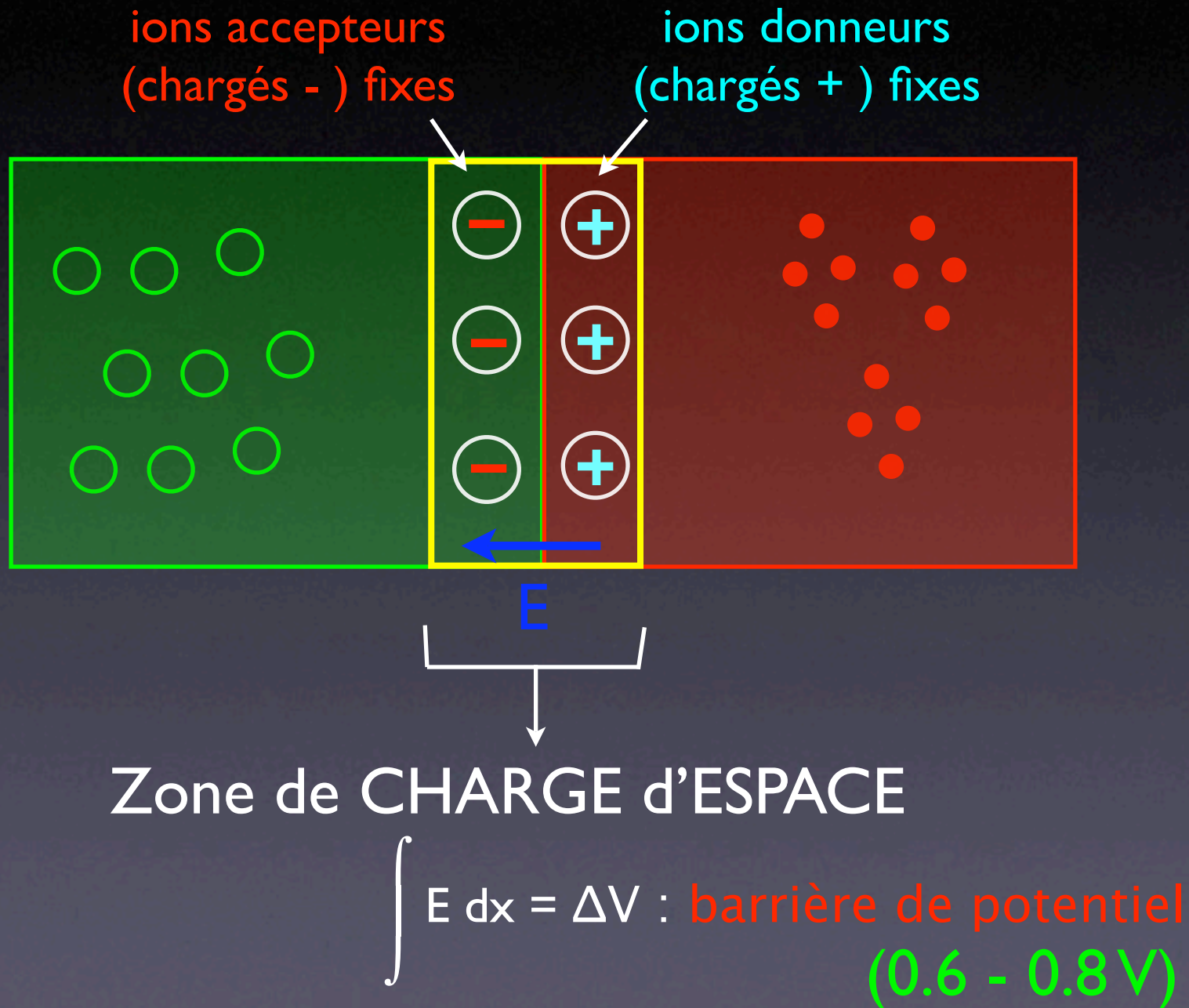
4 e-



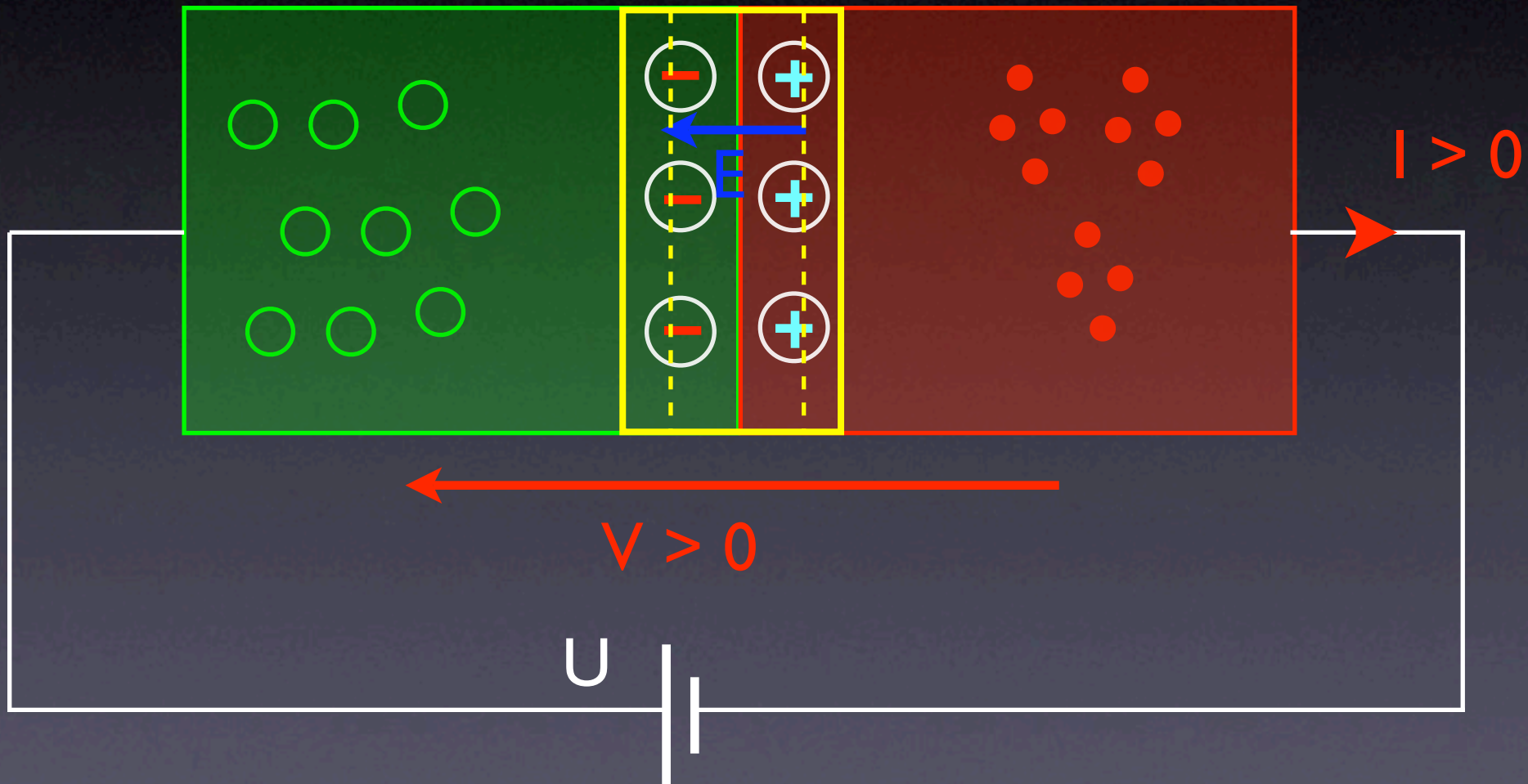
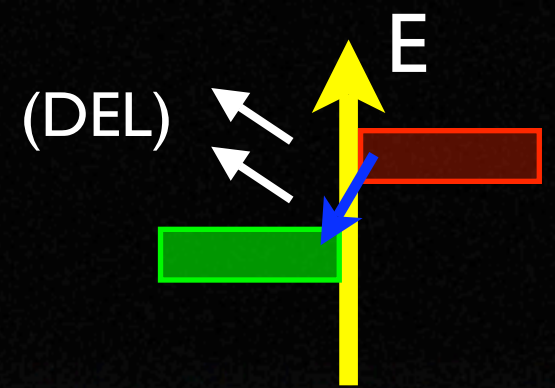
Bande de valence



# Jonction PN

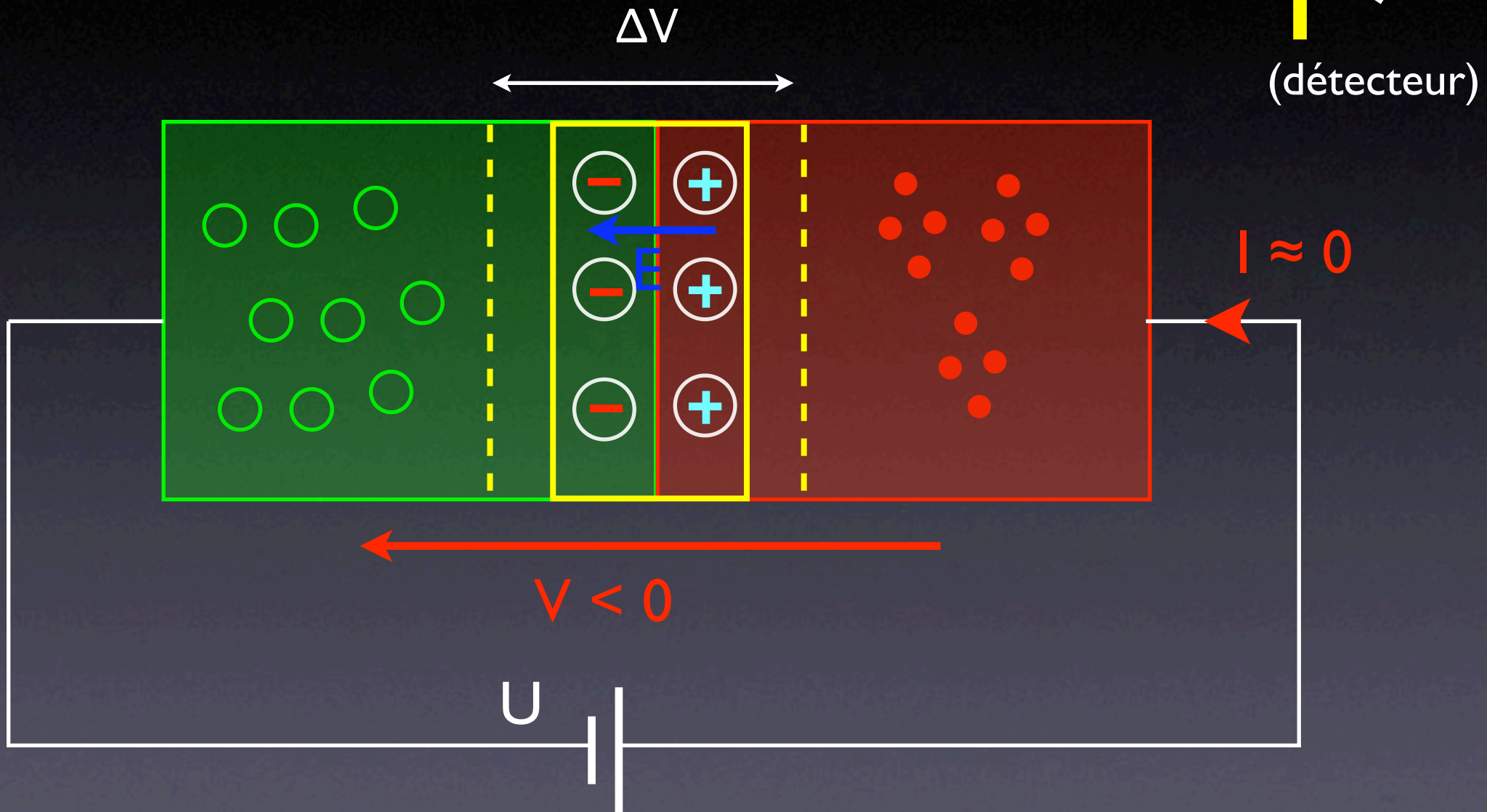


# Jonction PN polarisée en direct



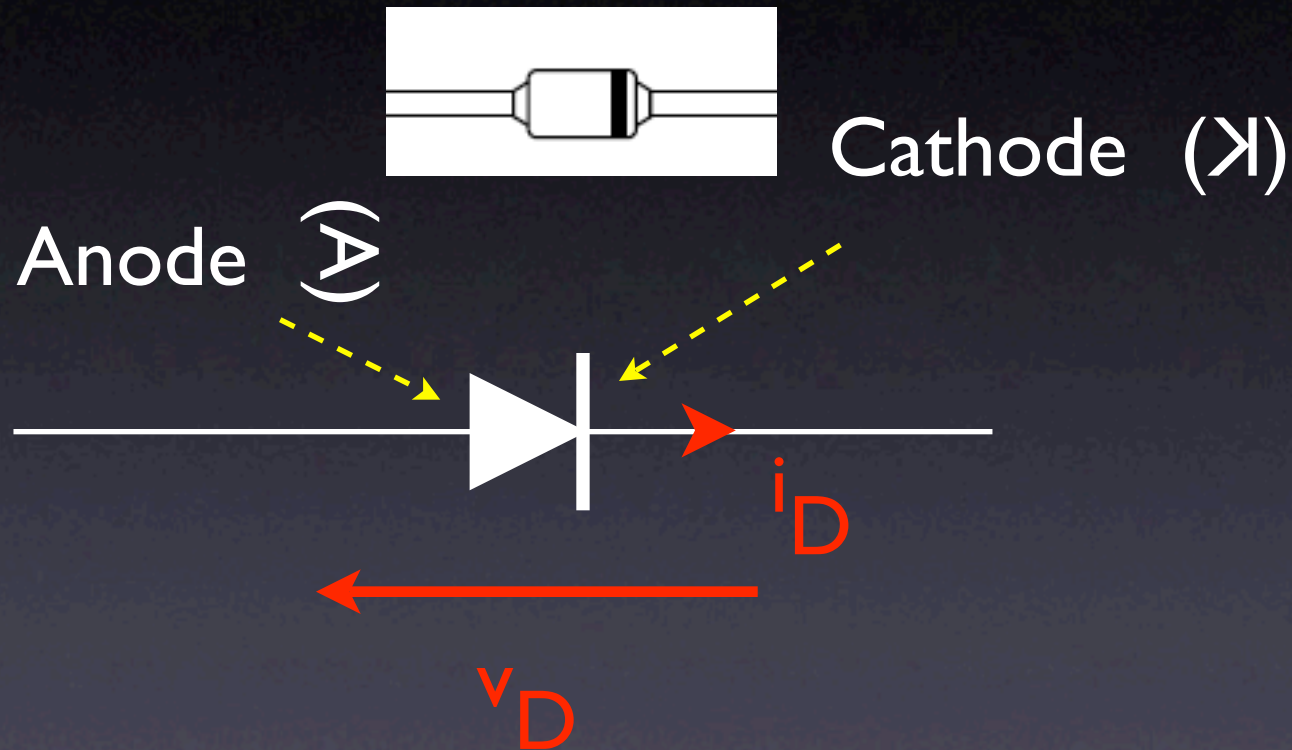
dès que  $U > \Delta V$ ,  $I$  est important

# Jonction PN polarisée en Inverse

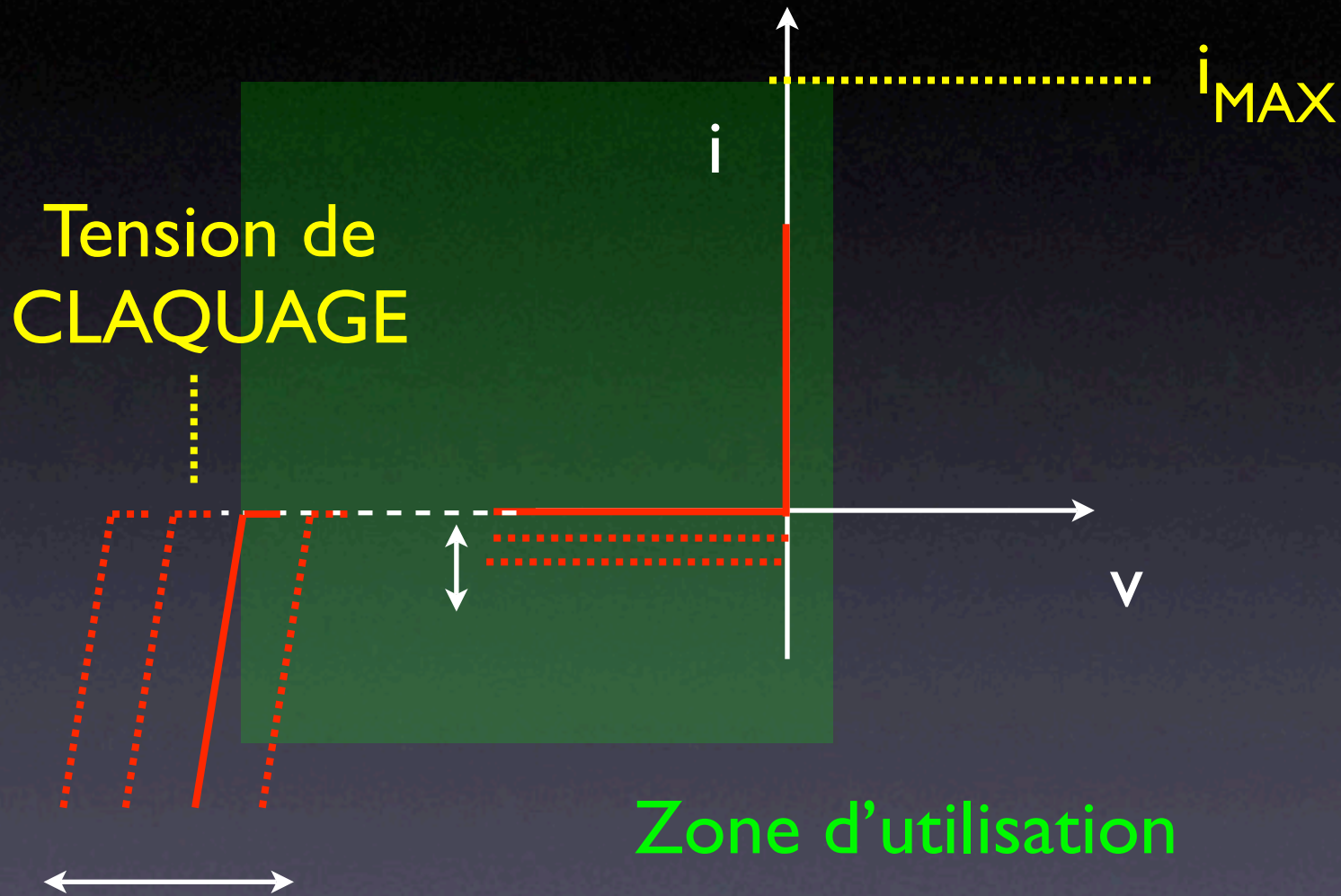


$\Delta V$  augmente et  $I$  reste très faible

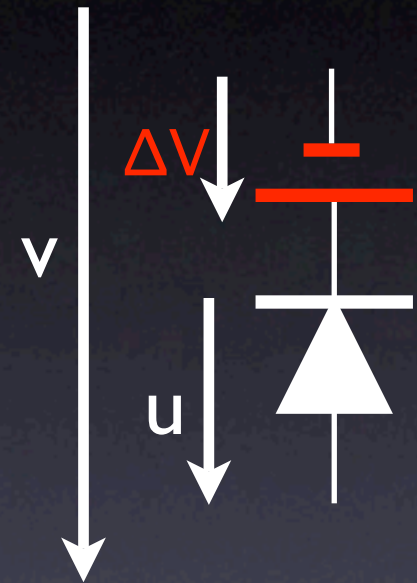
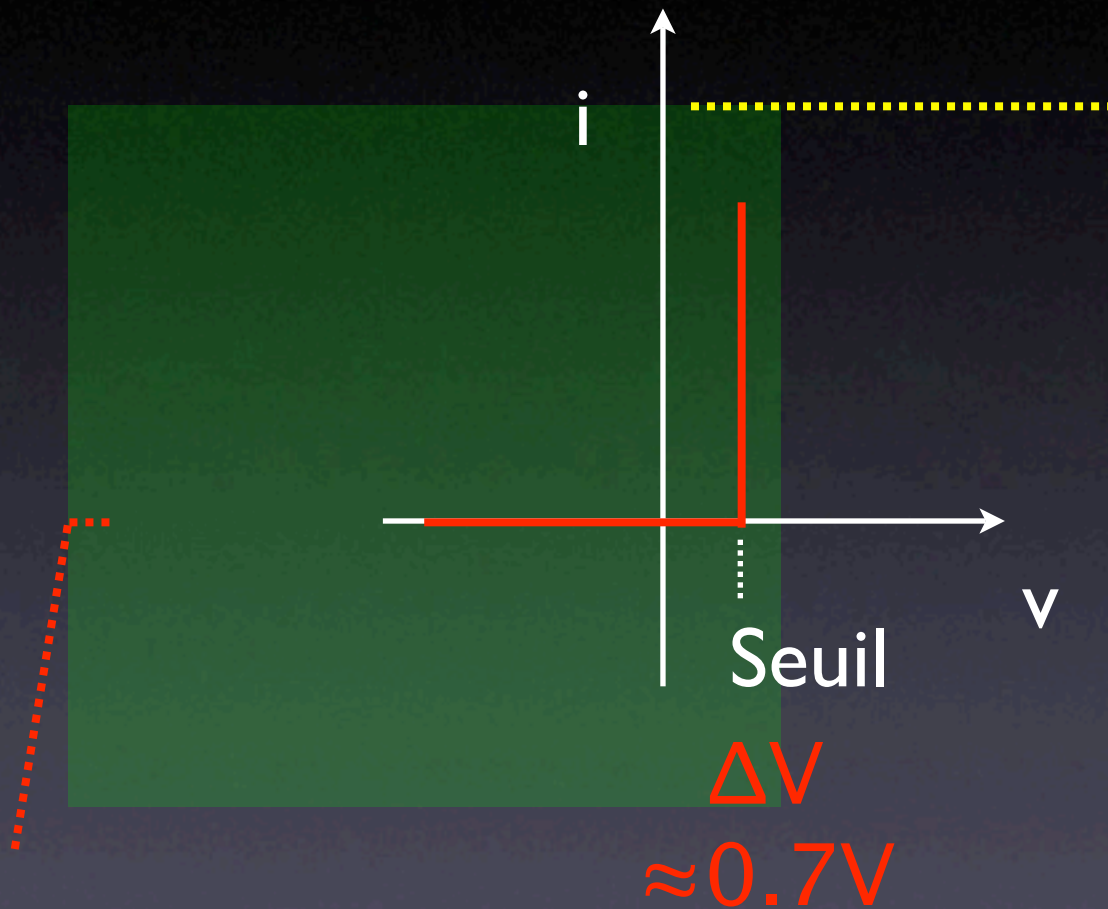
DIODE = dispositif “dysymétrique”  
unidirectionnel en courant



# Caractéristique (v,i) de diode Approximation '0'



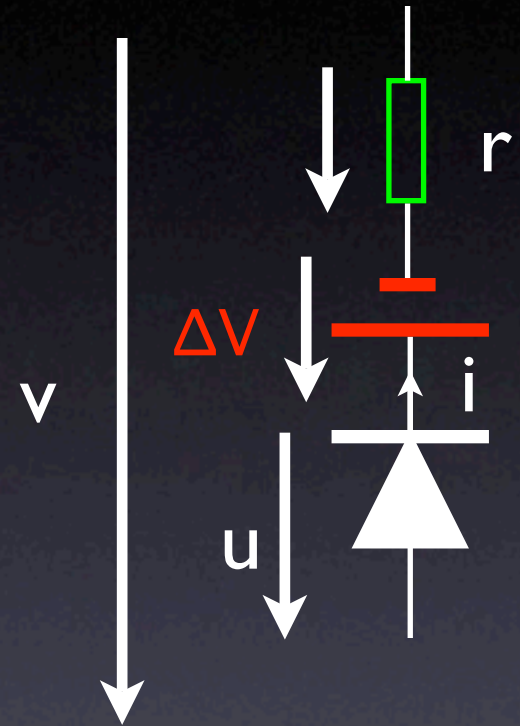
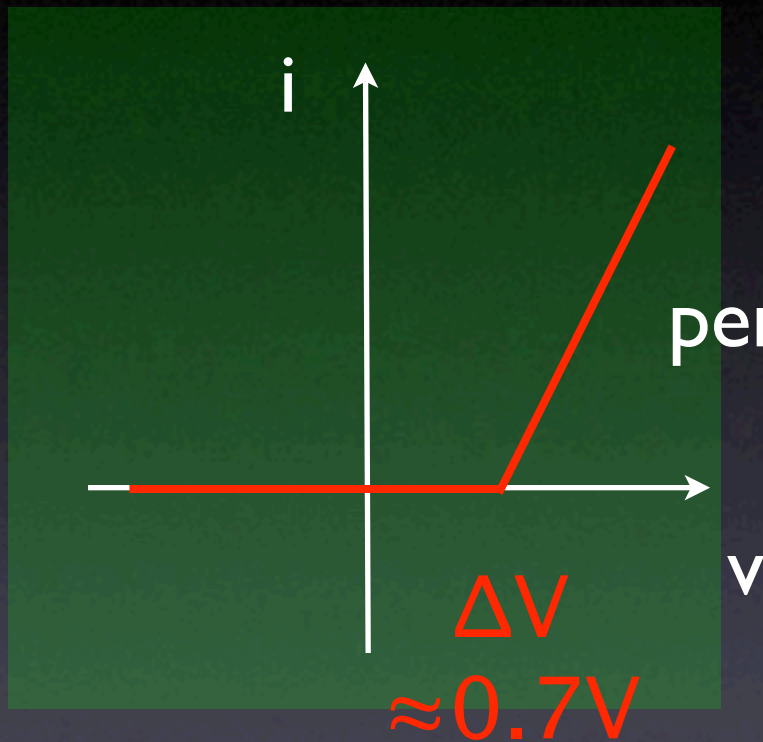
# Caractéristique (v,i) de diode Approximation 'I'



$$v = u + \Delta V$$

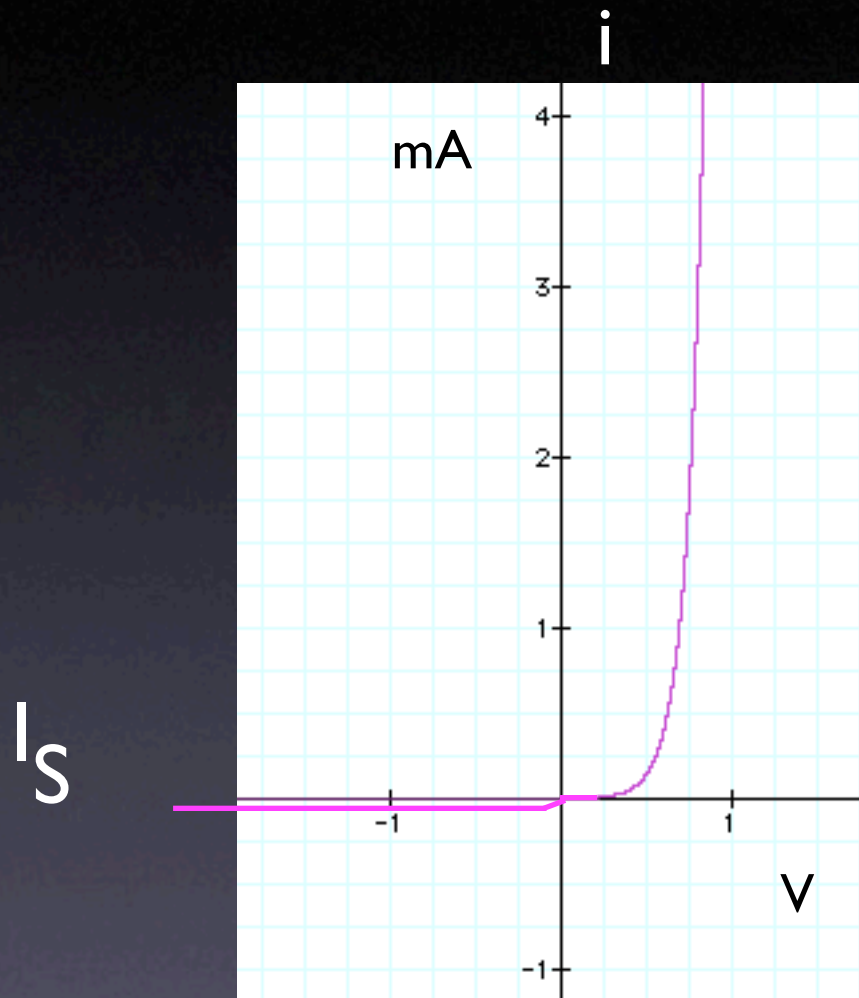
$v > \Delta V \rightarrow u > 0$   
diode passante

# Caractéristique (v,i) de diode Approximation 'II'



$$v = u + \Delta V + ri$$

# Caractéristique (v,i) de diode Approximation 'III'

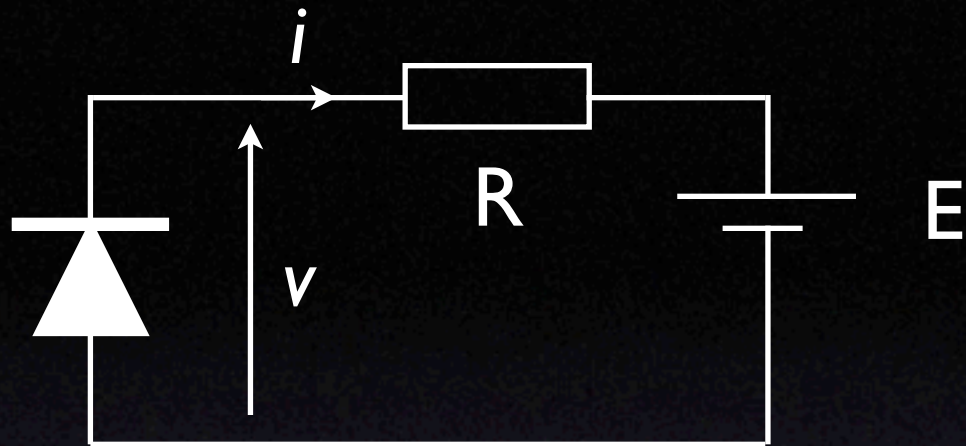


$$i = I_S \left[ \exp\left(\frac{v}{kT/e}\right) - 1 \right]$$

v

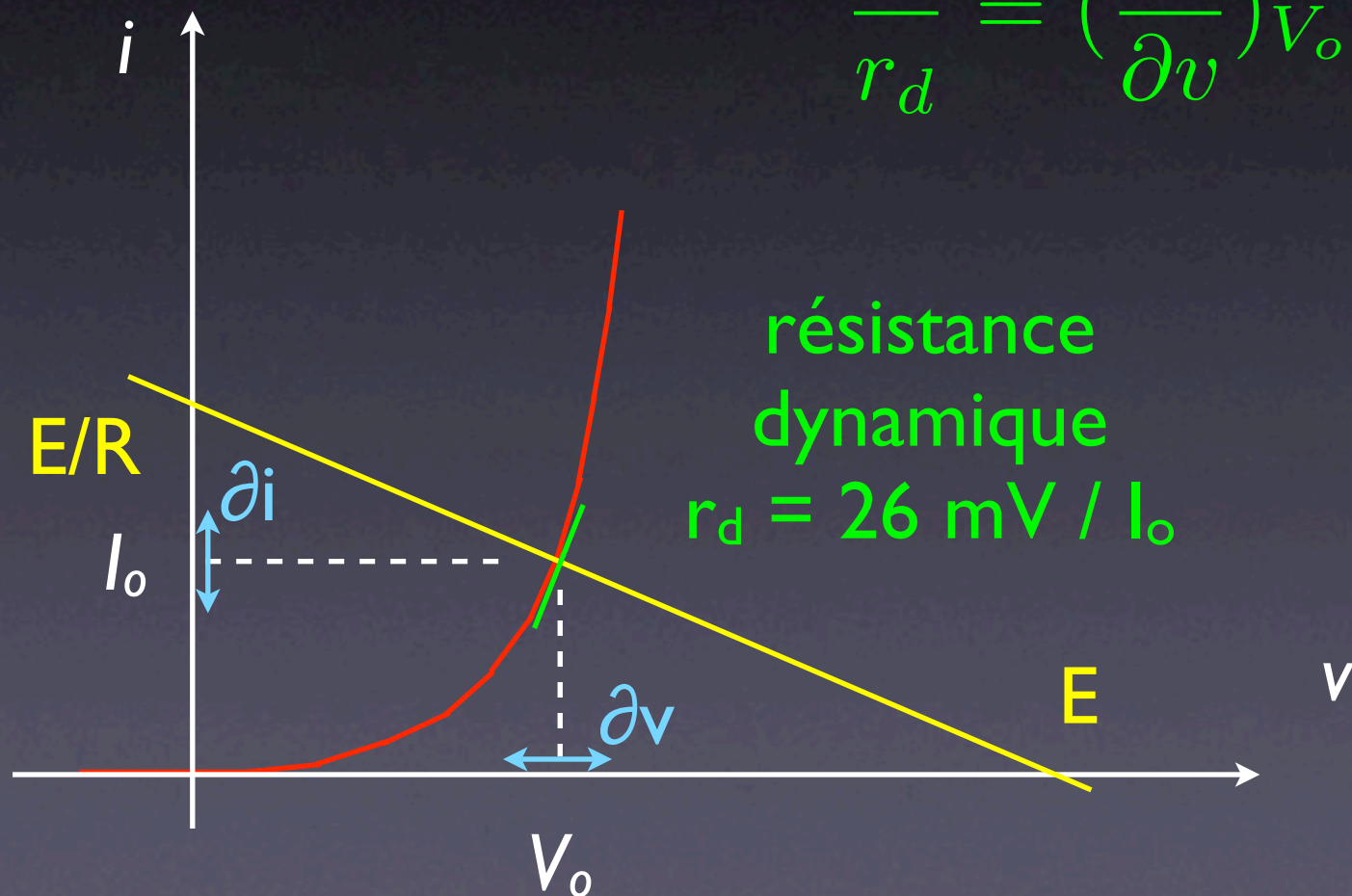
$$kT/e \approx 26 \text{ mV (@ 300K)}$$





$$i = I_S \left[ \exp\left(\frac{v}{kT/e}\right) - 1 \right]$$

$$\frac{1}{r_d} = \left( \frac{\partial i}{\partial v} \right)_{V_o} = \frac{I_o}{26 \text{ mV}}$$



résistance  
dynamique  
 $r_d = 26 \text{ mV} / I_o$