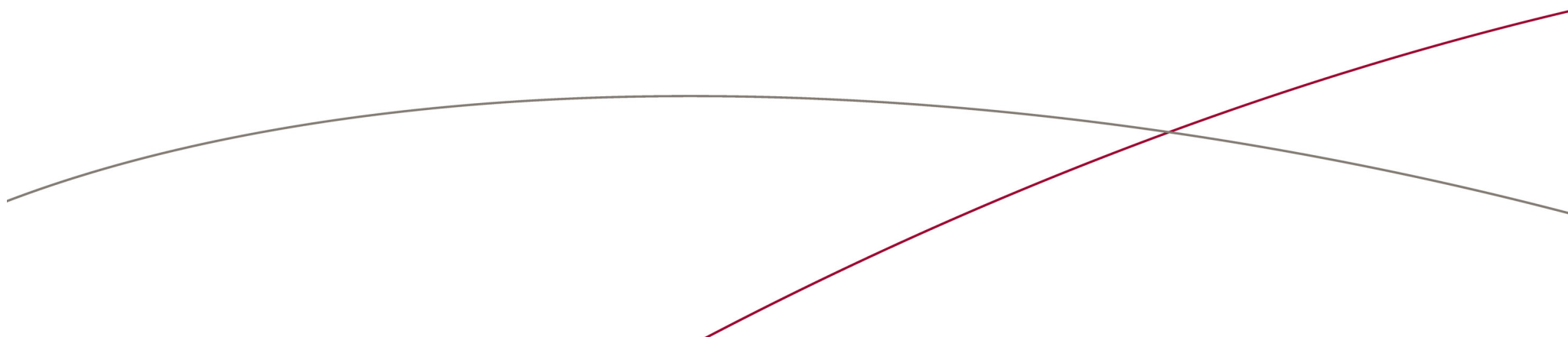




Halvledare

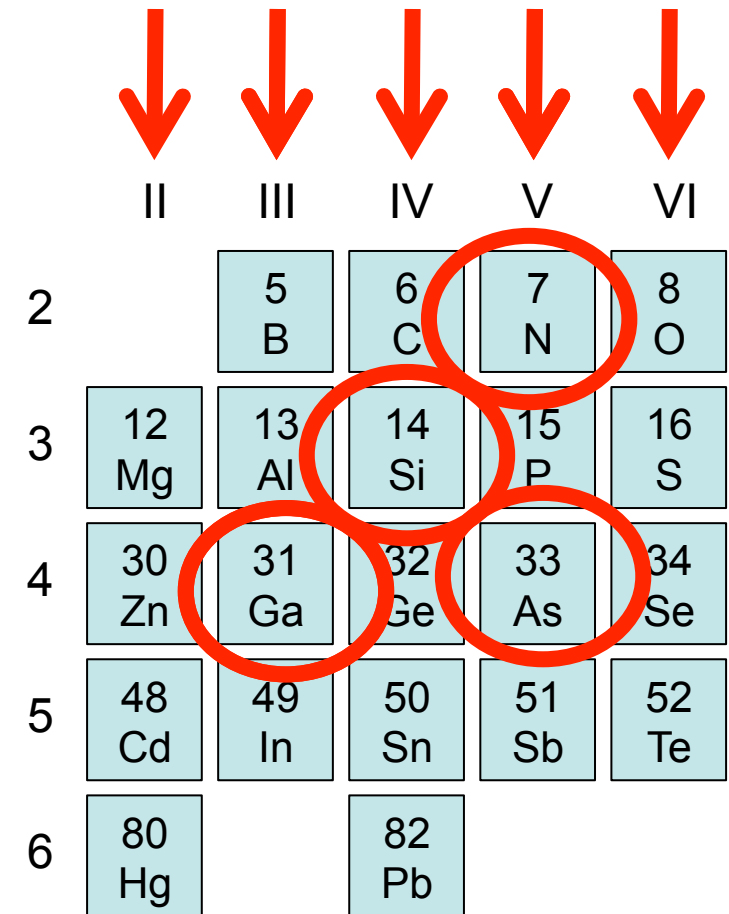


Halvledare

Group→	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
↓Period																		
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	*	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	**	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Uus	118 Uuo
		*	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	
		**	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	

Halvledare

- Grupp IV: Si, Ge
Transistorer, CCD, solceller, indirekt bandgap
- Grupp III-V: GaP, GaAs, InGaAsP...
LED, lasrar, detektorer
- Grupp III-N: GaN, InGaN...
Blå (& vita) LED, UV lasrar
- Grupp II-VI: HgCdTe...
IR-kameror



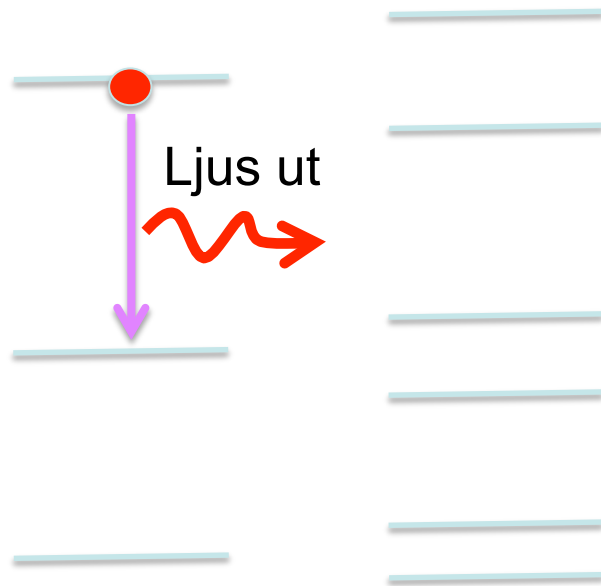
	II	III	IV	V	VI
2		5 B	6 C	7 N	8 O
3	12 Mg	13 Al	14 Si	15 P	16 S
4	30 Zn	31 Ga	32 Ge	33 As	34 Se
5	48 Cd	49 In	50 Sn	51 Sb	52 Te
6	80 Hg		82 Pb		

Periodiska systemet

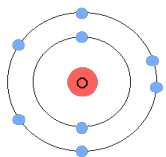
(åtminstone den del som är viktig för en halvledarfysiker)

Introduktion till halvledarfysik

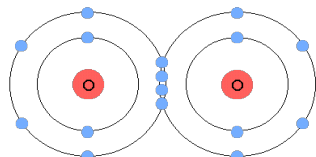
Energಿನivåer



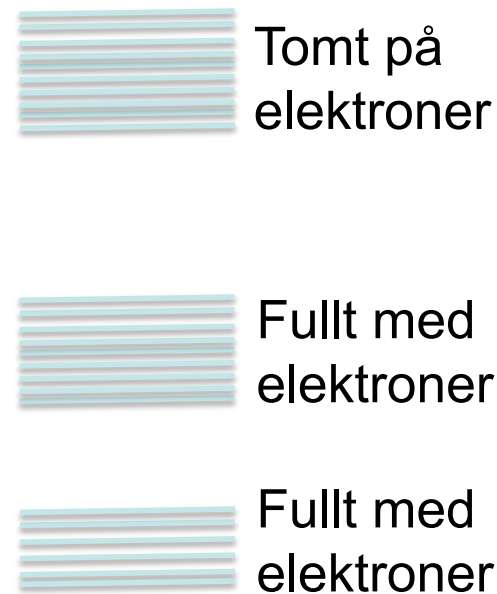
1 atom



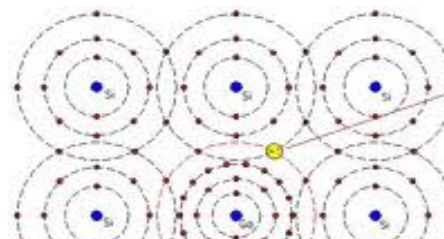
2 atomer



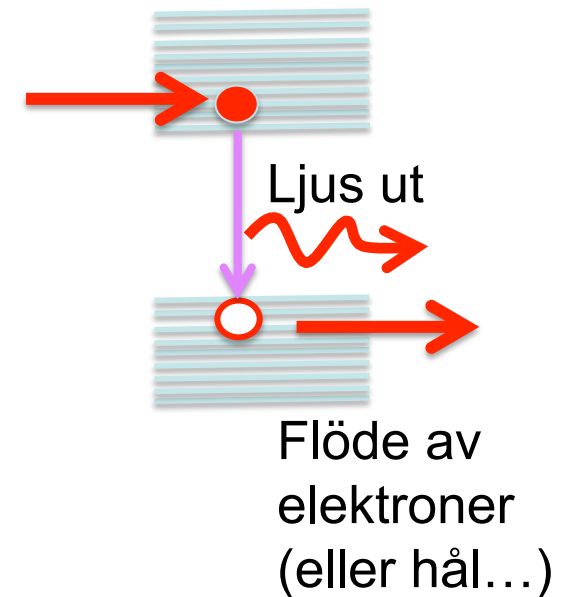
Energiband



Många atomer



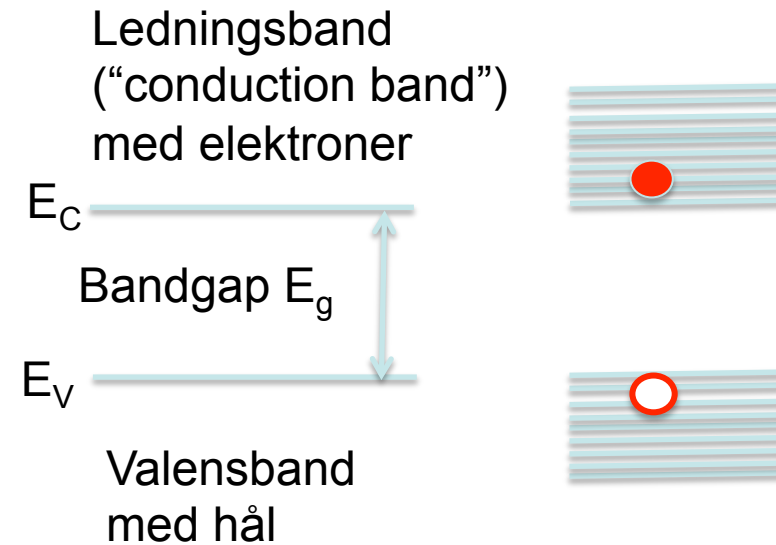
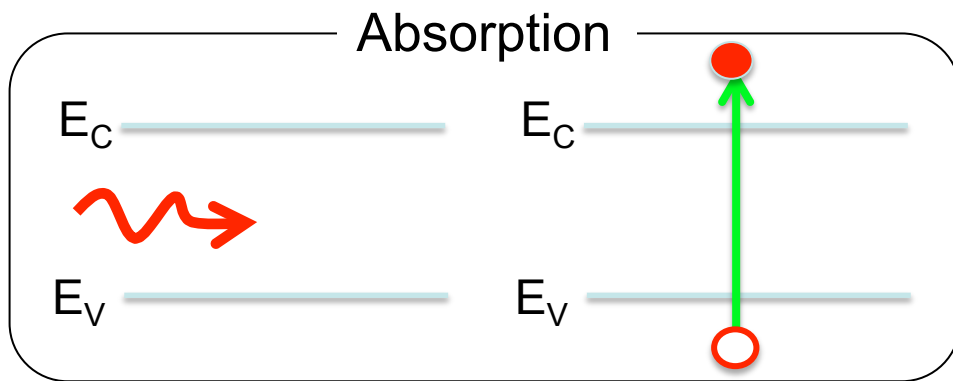
Flöde av elektroner

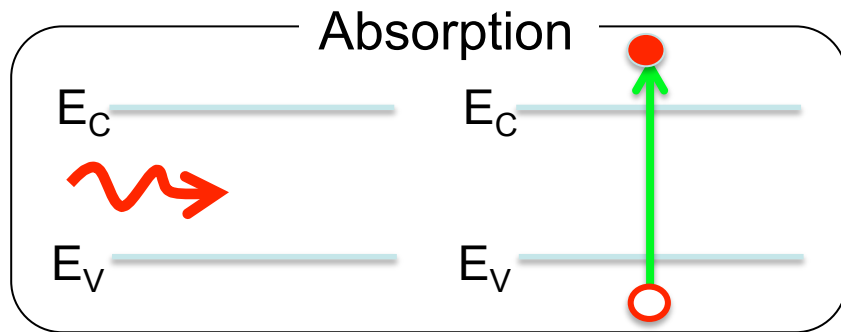


LED

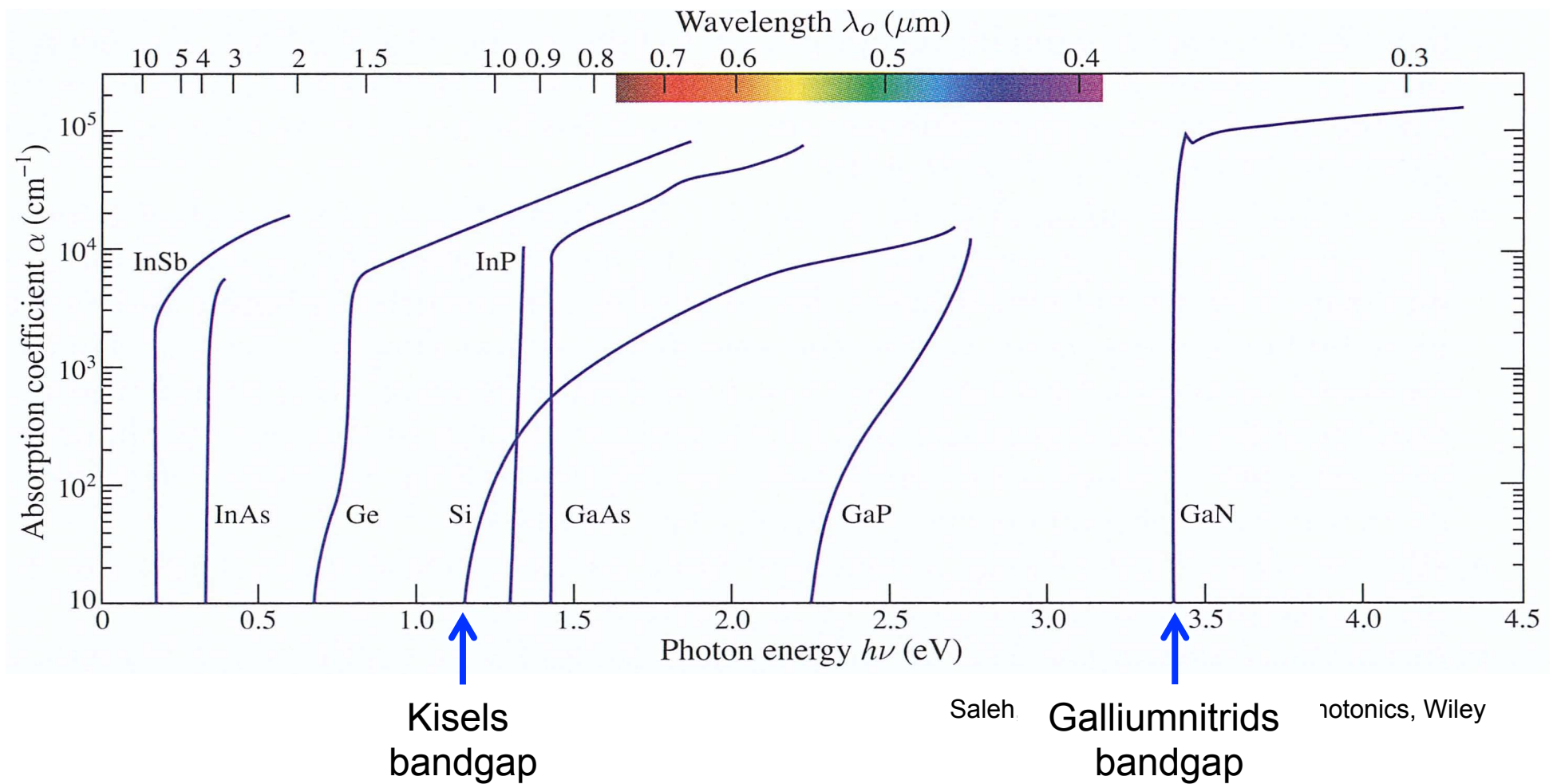


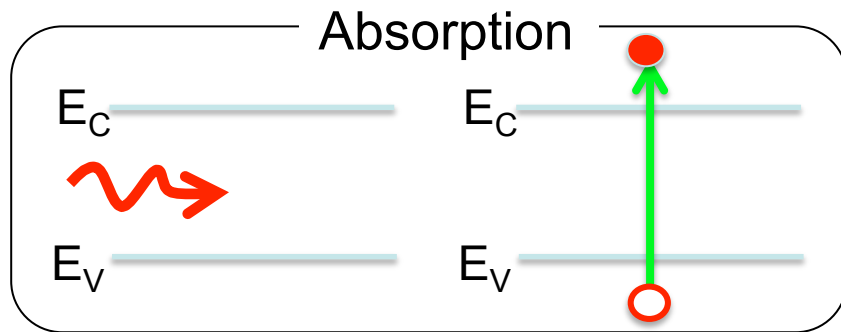
Introduktion till halvledarfysik





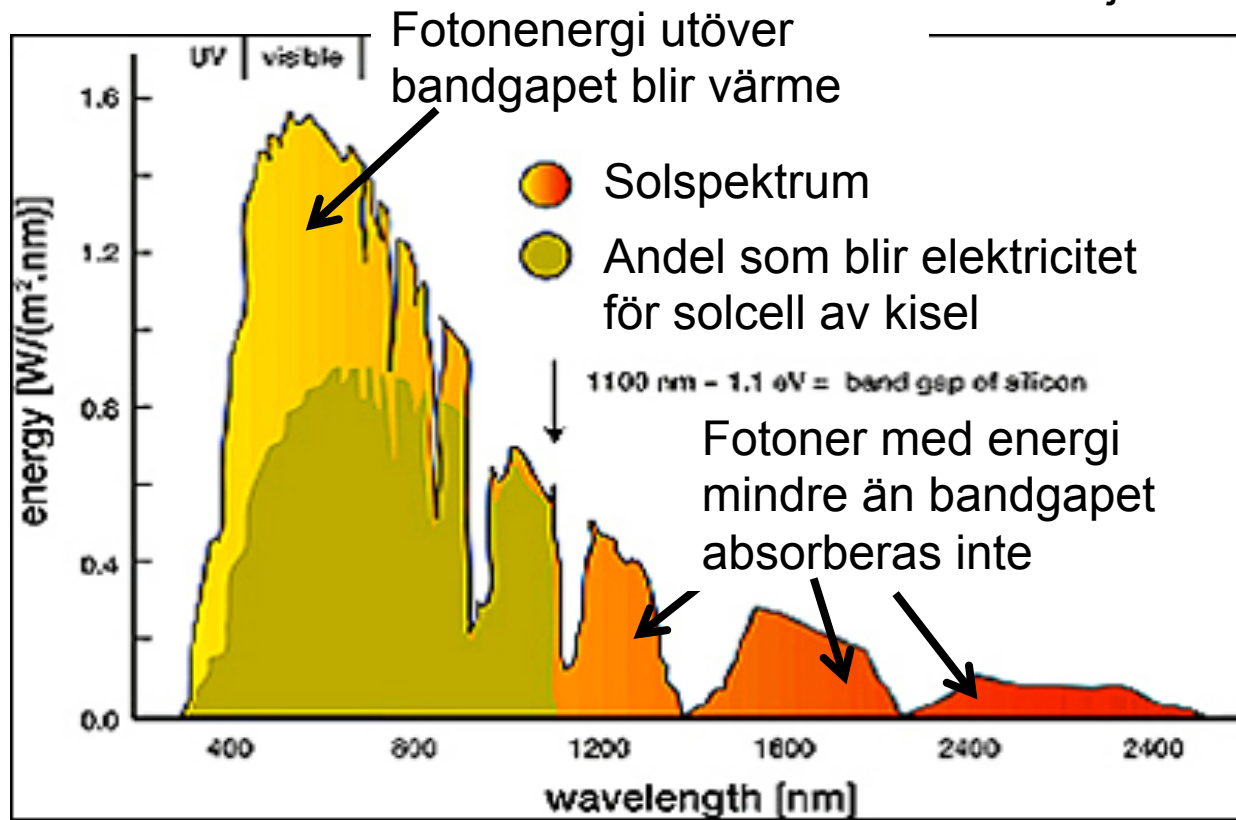
Ljusabsorption



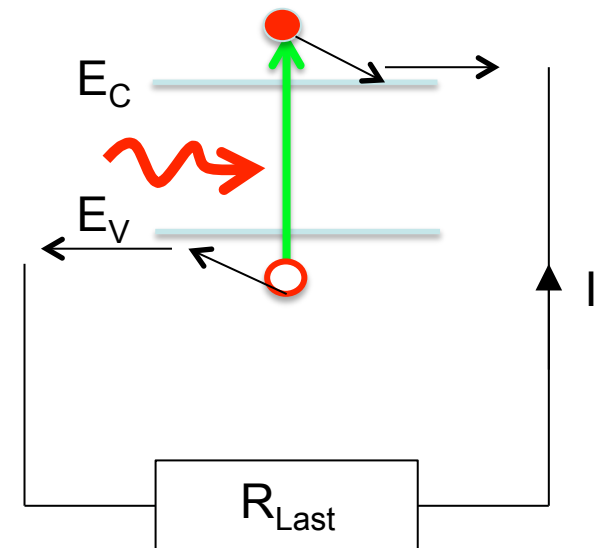


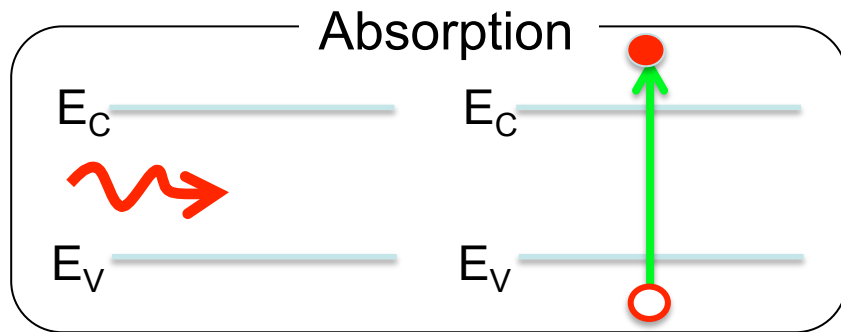
Solcell

Kostnad
Livslängd
Miljö



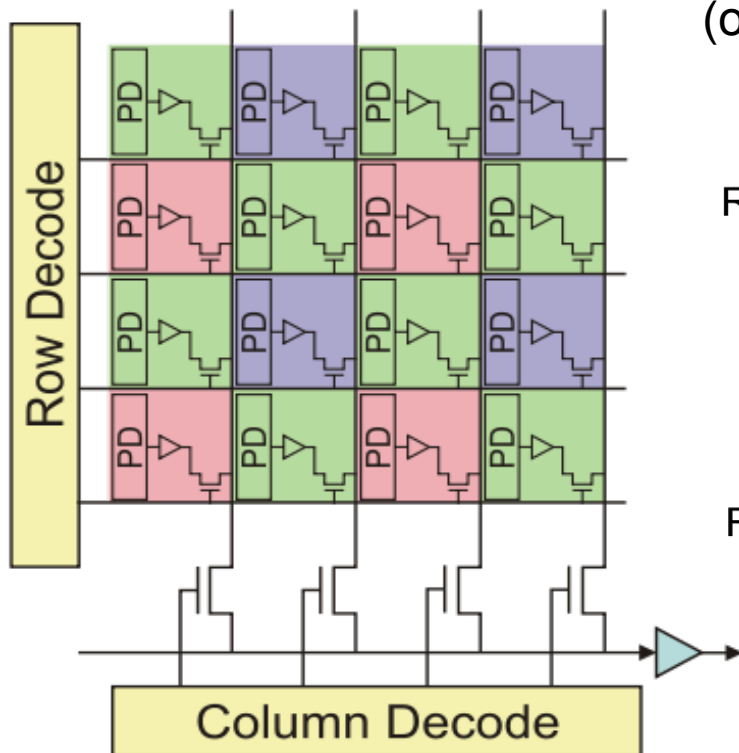
<http://solarcellcentral.com>



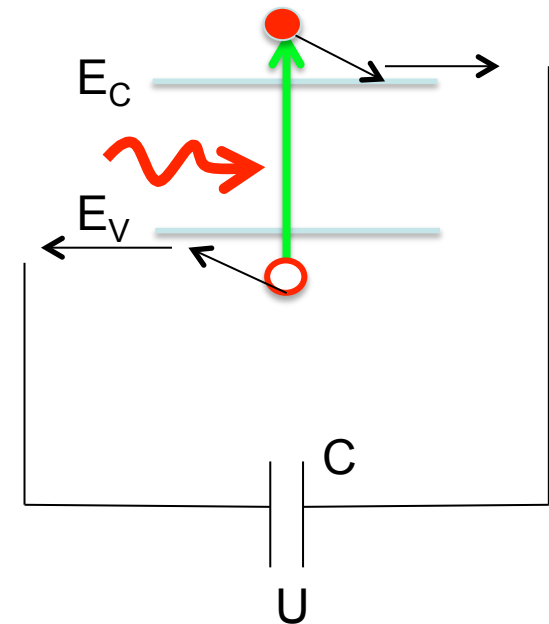
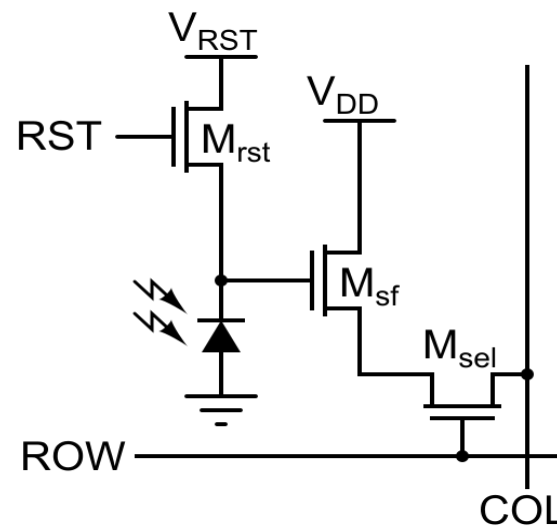


Kamerasensor

Miljontals pixlar med filter
för rött, grönt eller blått

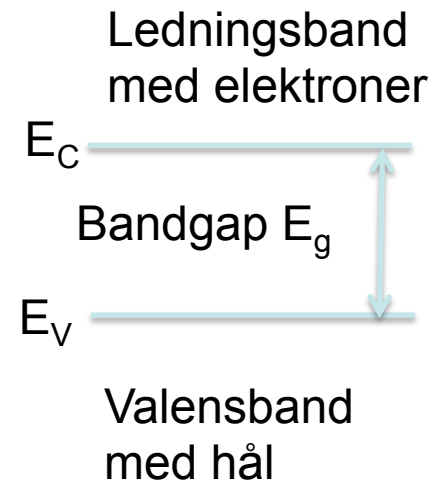
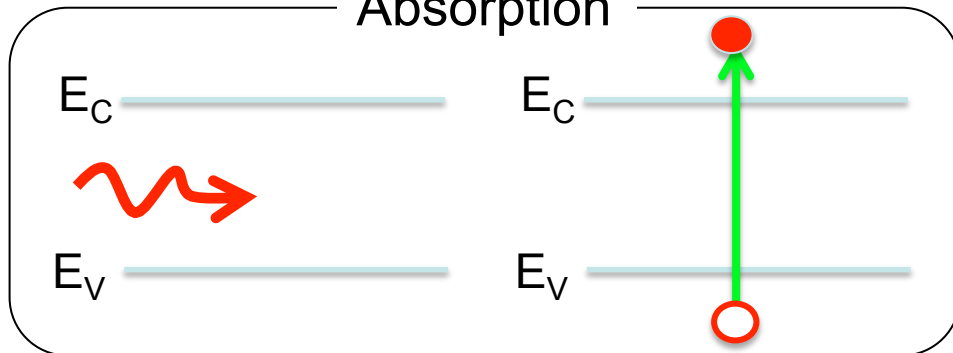


Varje pixel har en fotodiod
som detekterar ljuset
(och ett antal transistorer)

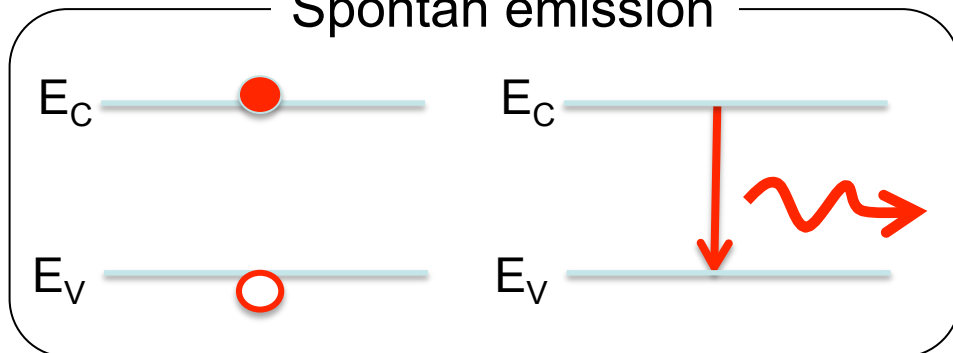


Introduktion till halvledarfysik

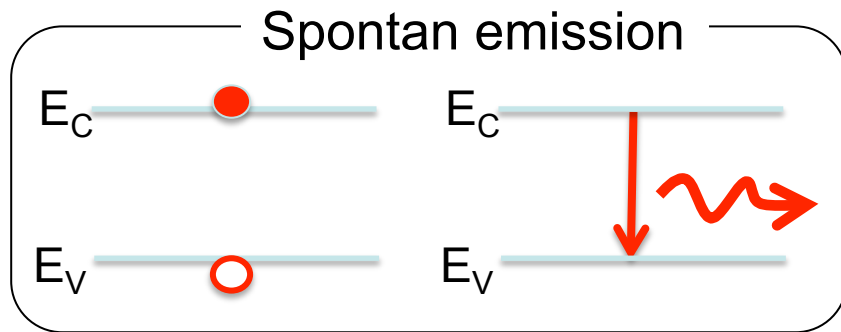
Absorption



Spontan emission

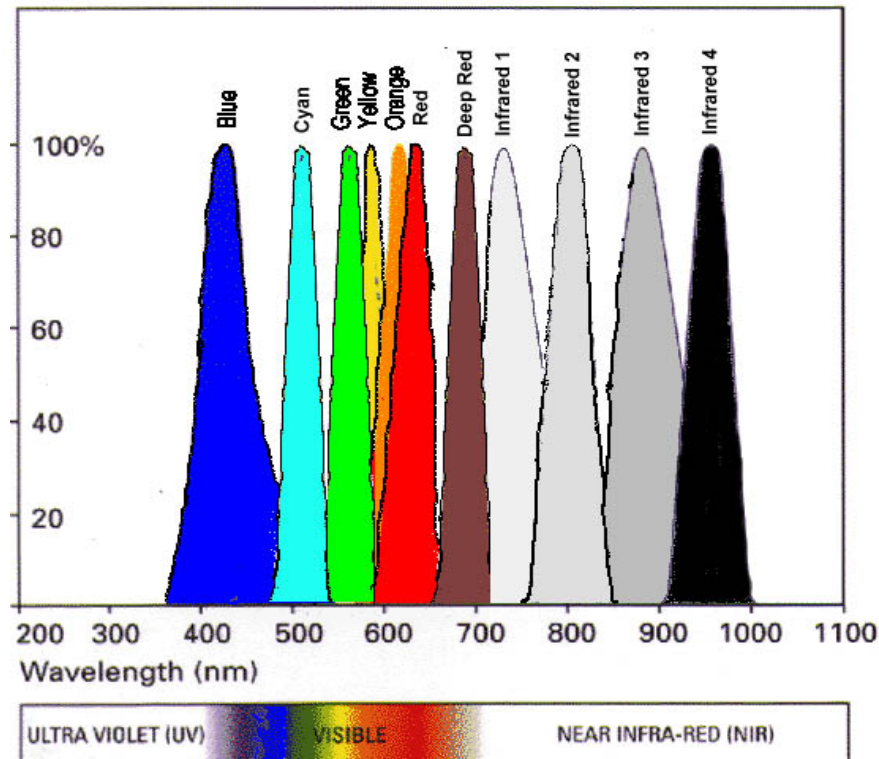


Lysdiod, LED, light emitting diode

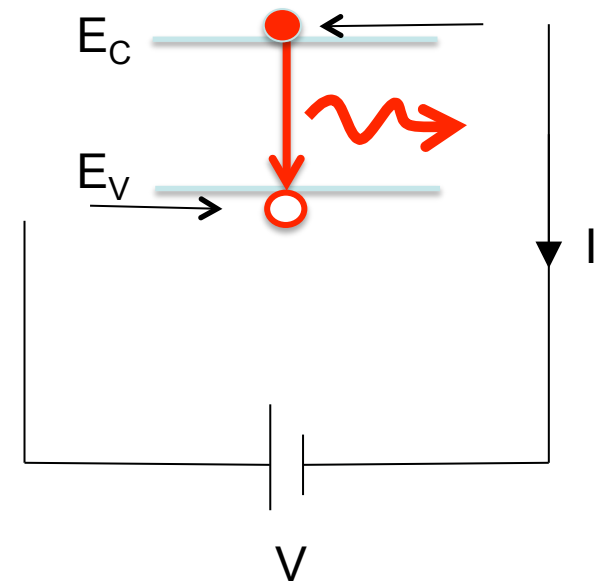


Olika halvledare har olika bandgap och därmed olika färg

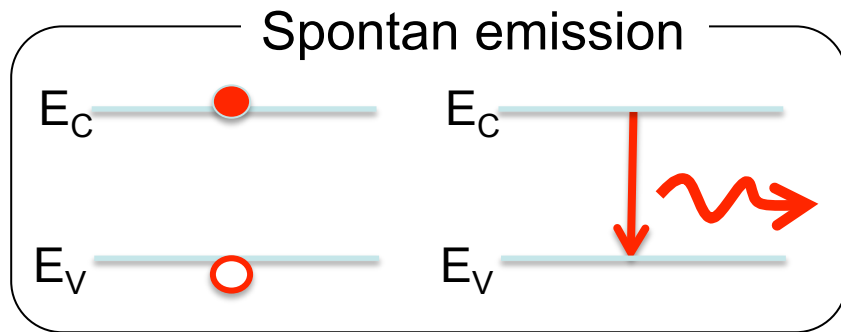
Figure 1. LED Emission Spectra



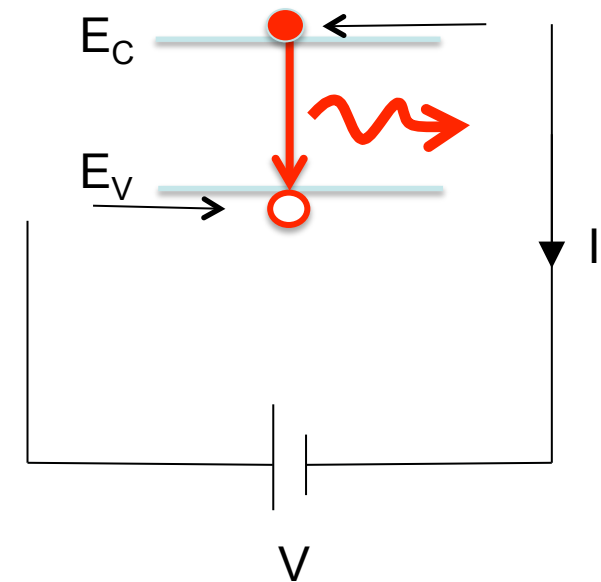
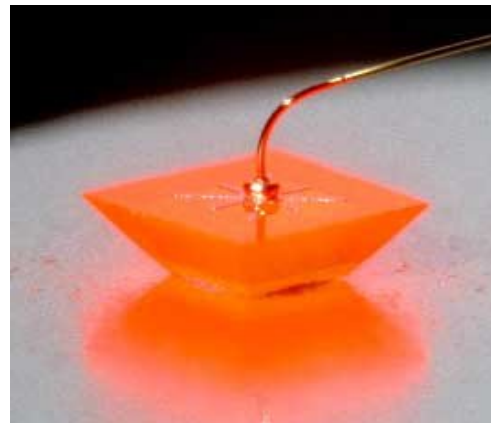
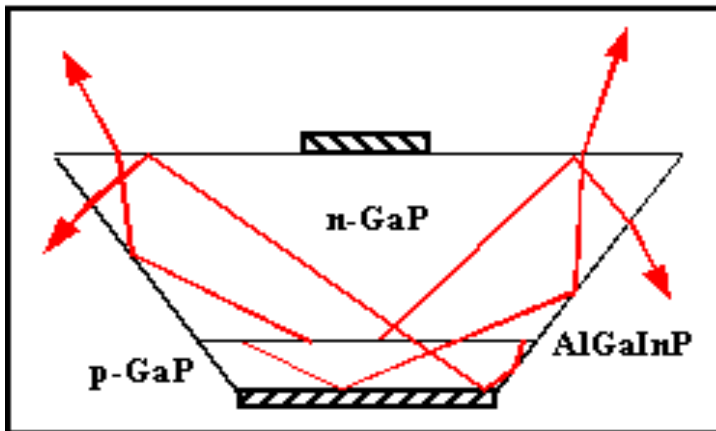
<http://www.lpi.usra.edu/education/products/spectrometer/>



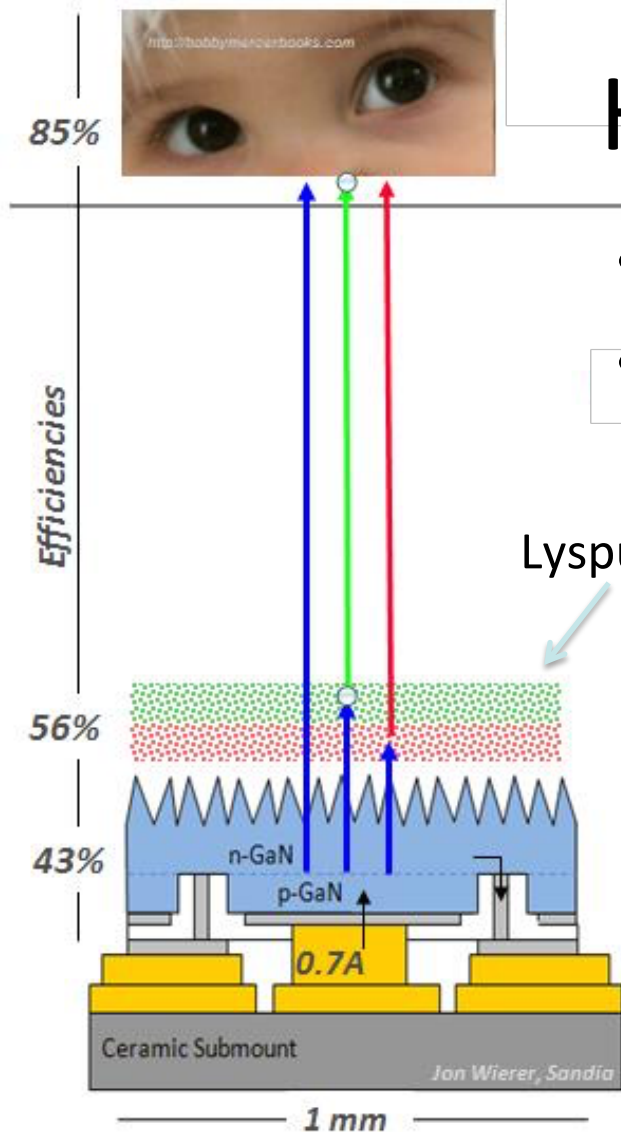
Lysdiod, LED, light emitting diode



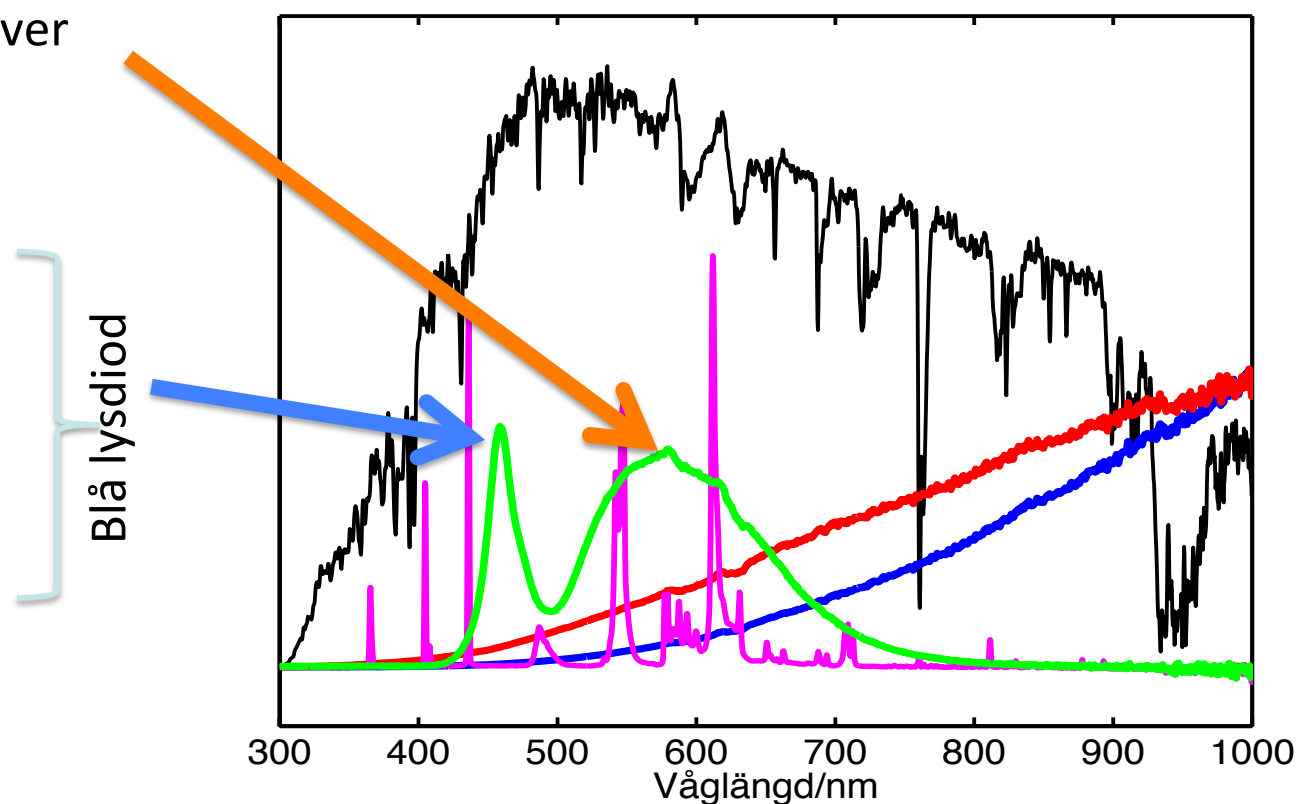
Halvledare har stort brytningsindex n .
Hög reflektivitet mot luft samt total internreflektion gör
det svårt att få ut ljuset.



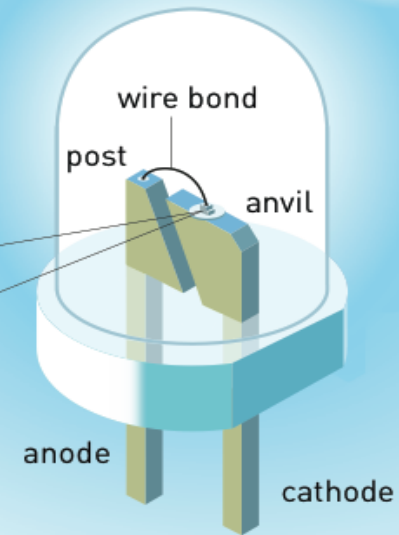
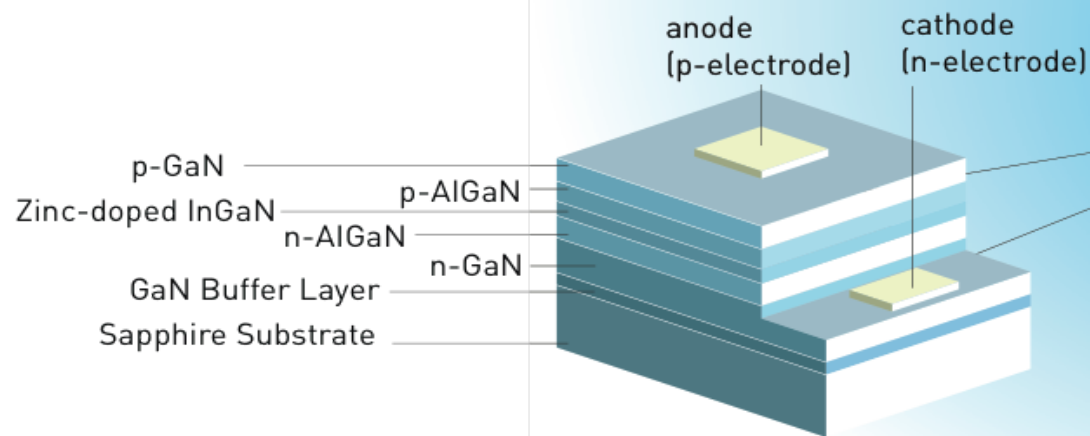
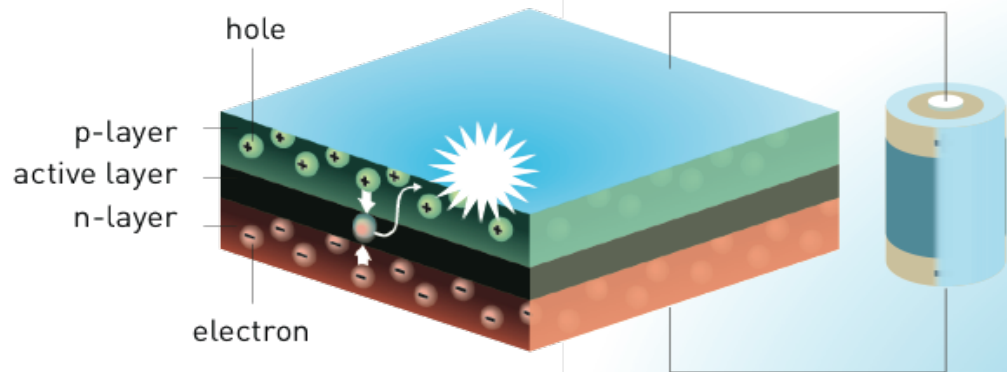
Hur fungerar vita lysdioder?



- Blå lysdiod gör blått ljus mha elektricitet
- Lyspulver gör om en del blått ljus till grönt, gult och rött

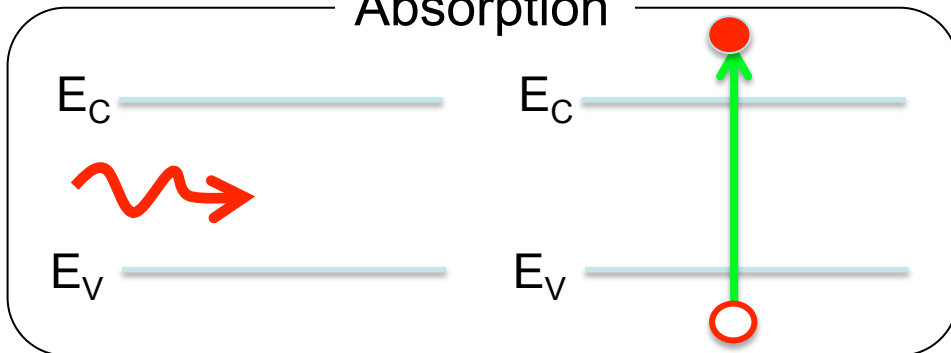


Nobelpriset i fysik 2014

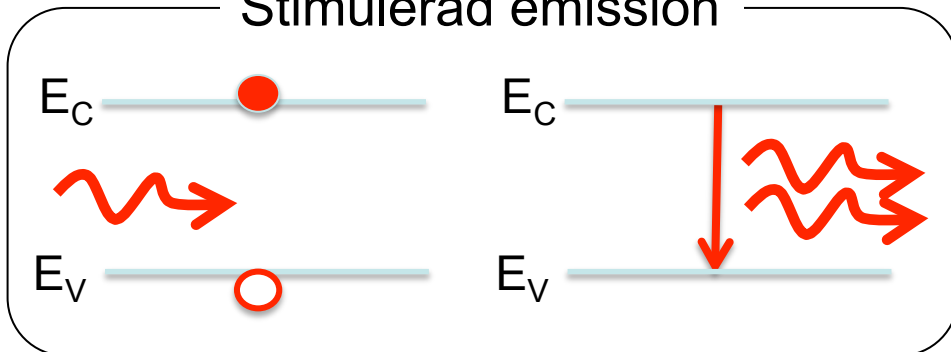


Introduktion till halvledarfysik

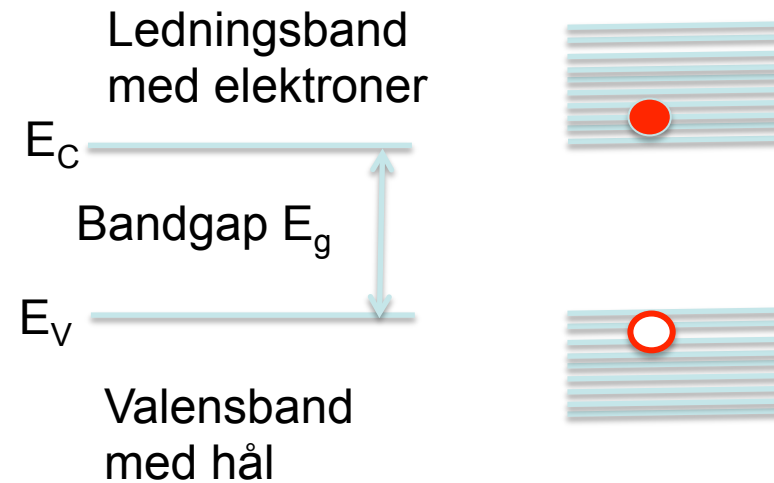
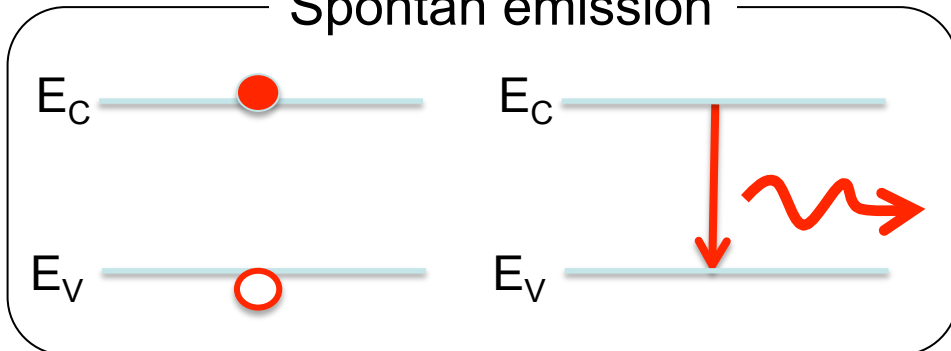
Absorption



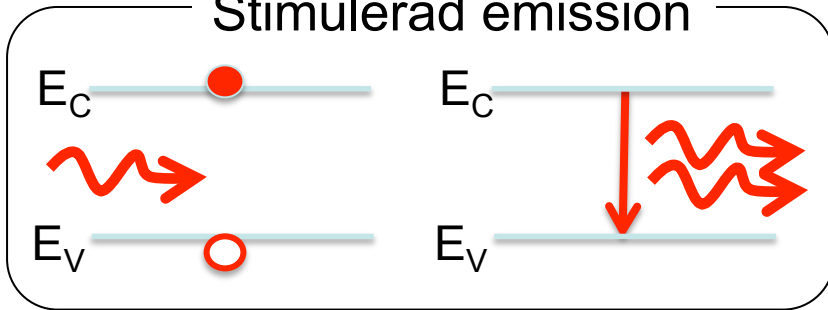
Stimulerad emission



Spontan emission



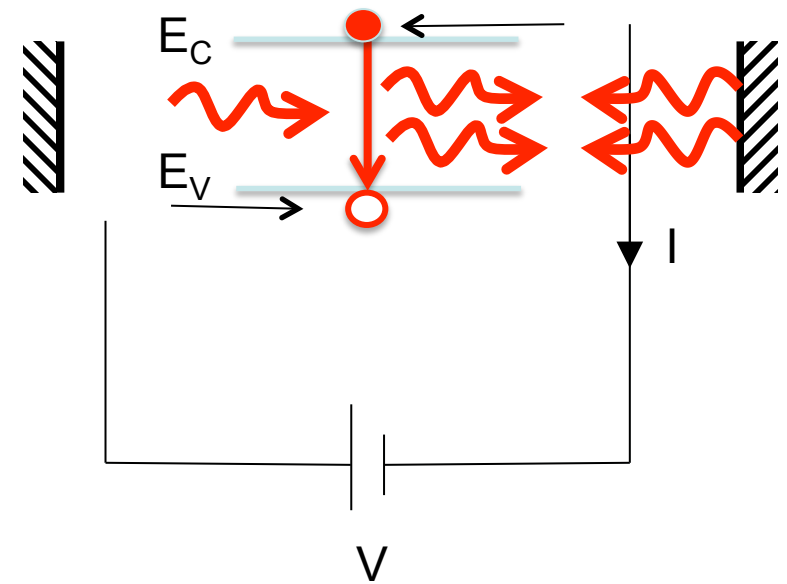
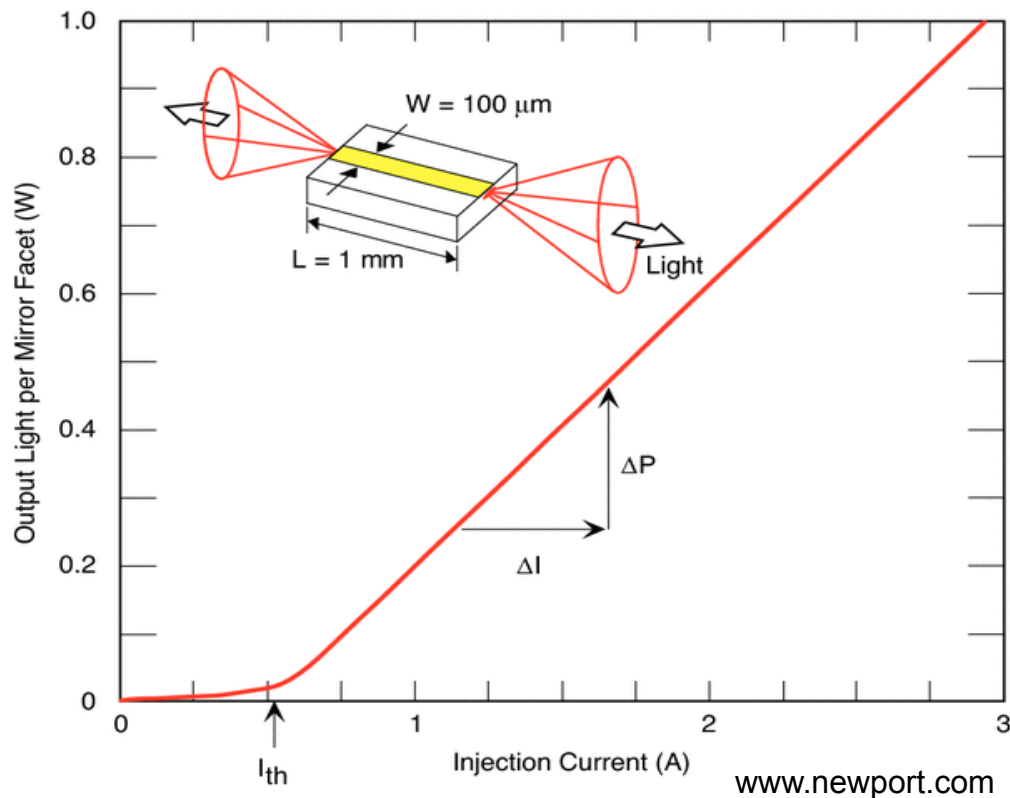
Stimulerad emission



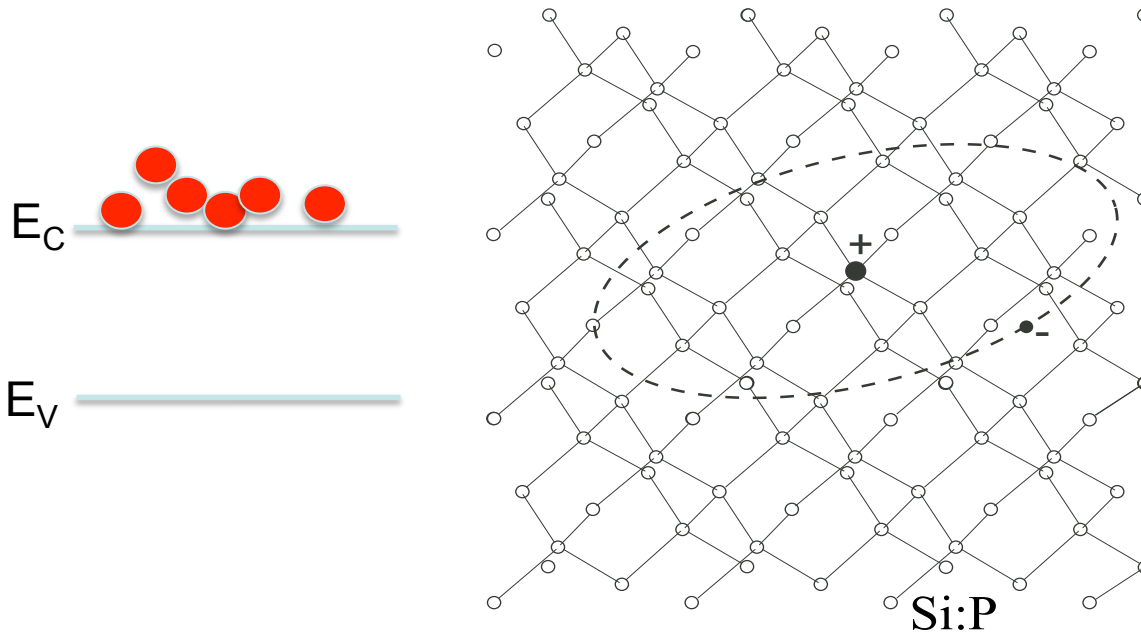
Diodlaser

Stimulerad emission (laser) kräver:

- Många elektroner och hål => stor ström
- Mycket ljus => speglar (men klyvd yta räcker ofta)



Dopning



Fosfor i kisel => extra elektron (och proton!); **n-typ**

Gallium i kisel => brist på elektron (och proton!); **p-typ**

E_C _____

E_V _____

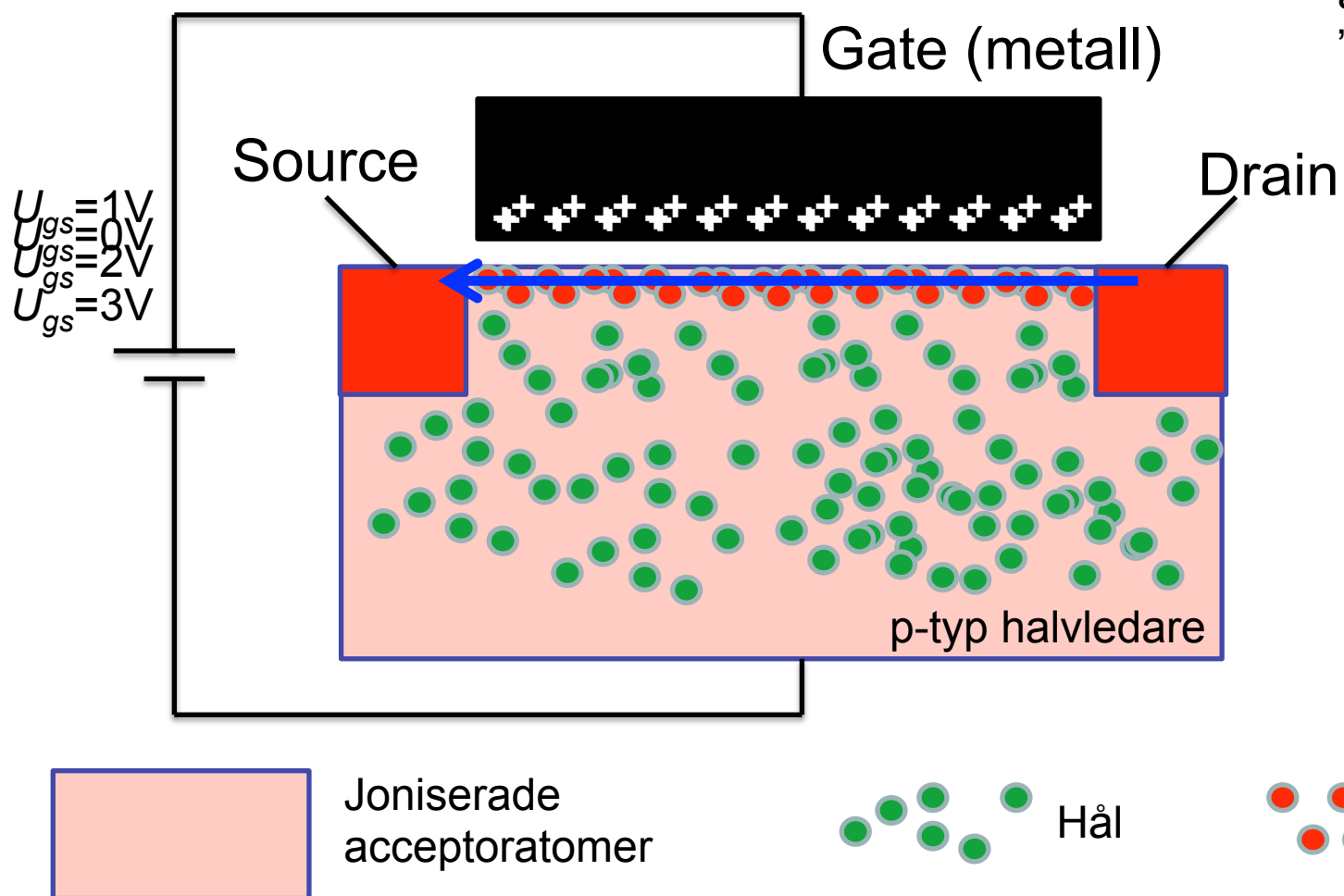
	II	III	IV	V	VI
2		5 B	6 C	7 N	8 O
3	12 Mg	13 Al	14 Si	15 P	16 S
4	30 Zn	31 Ga	32 Ge	33 As	34 Se
5	48 Cd	49 In	50 Sn	51 Sb	52 Te
6	80 Hg		82 Pb		

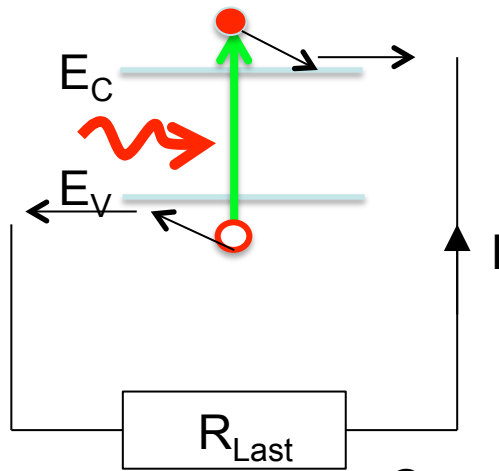
Periodiska systemet

(åtminstone den del som är viktig för en halvledarfysiker)

Plattkondensator - Fälteffekt-transistor (MOSFET)

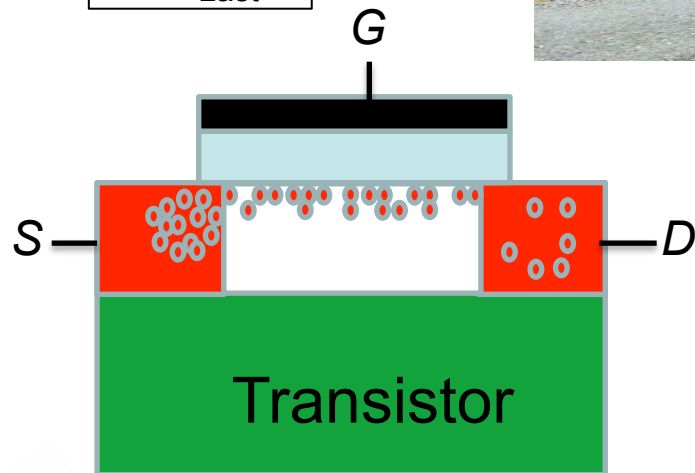
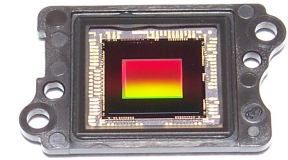
Transistorn
används ofta som
"strömbrytare"



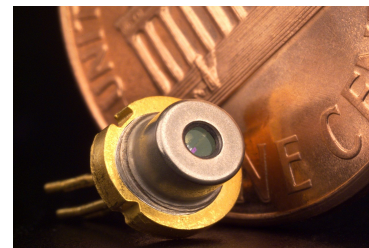
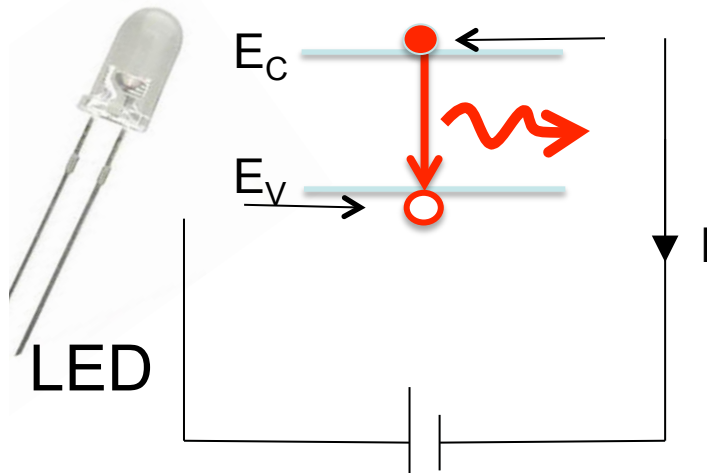


Solceller

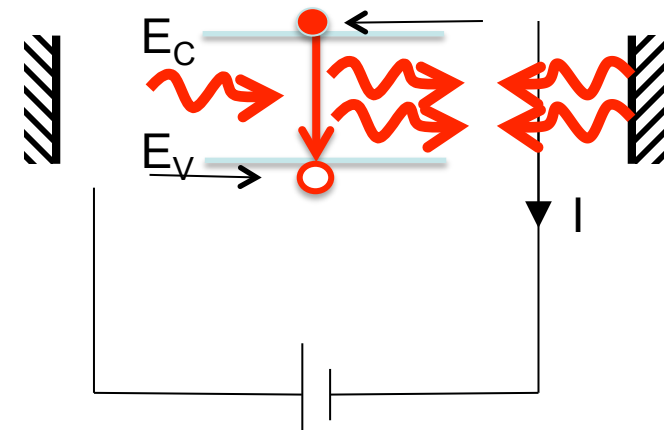
Kamerasensor



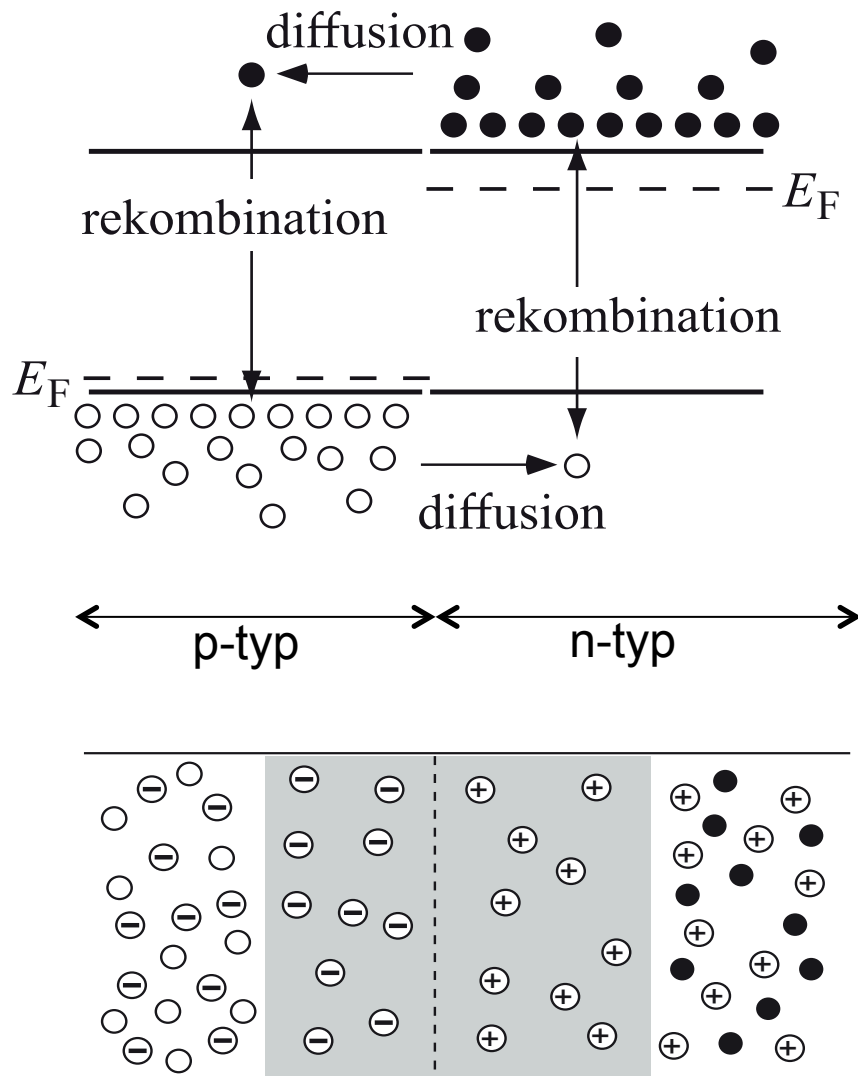
Halvledare



Diodlaser



Diod = pn-övergång

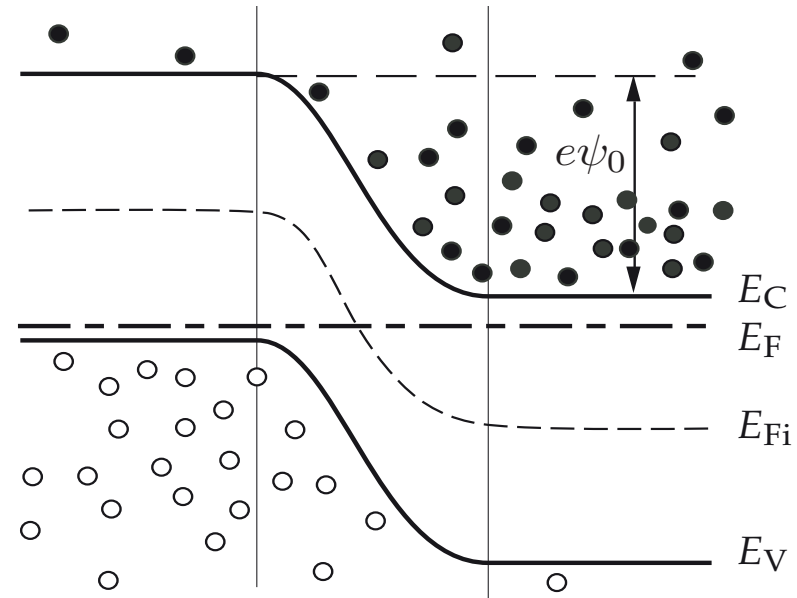
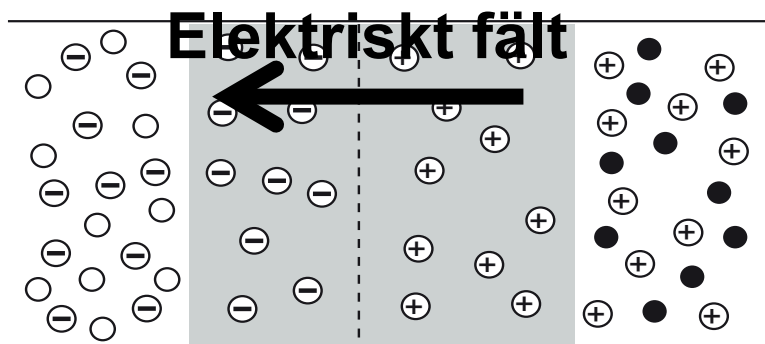
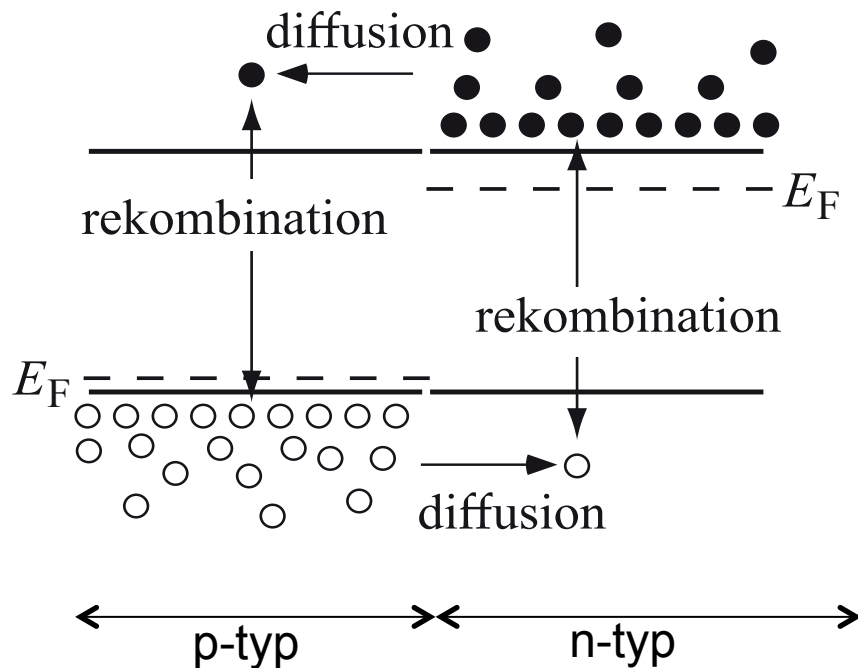


n-typ: innehåller donatorer, dvs atomer med en extra elektron och en extra proton. Elektronerna diffunderar iväg och lämnar efter sig ett överskott av protoner.

p-typ: innehåller acceptorer, dvs atomer som saknar en elektron och en proton. Hål diffunderar iväg och lämnar efter sig ett underskott av protoner.

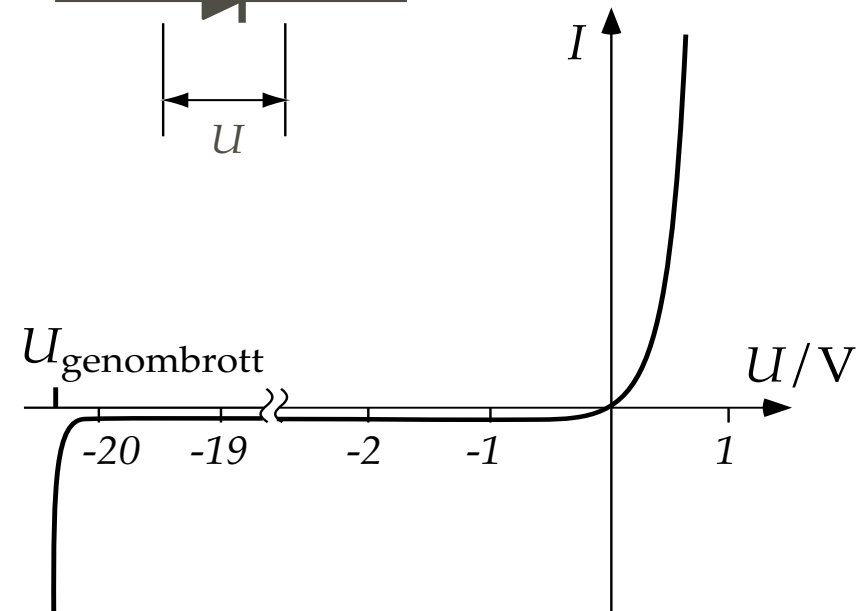
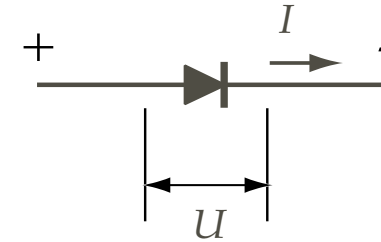
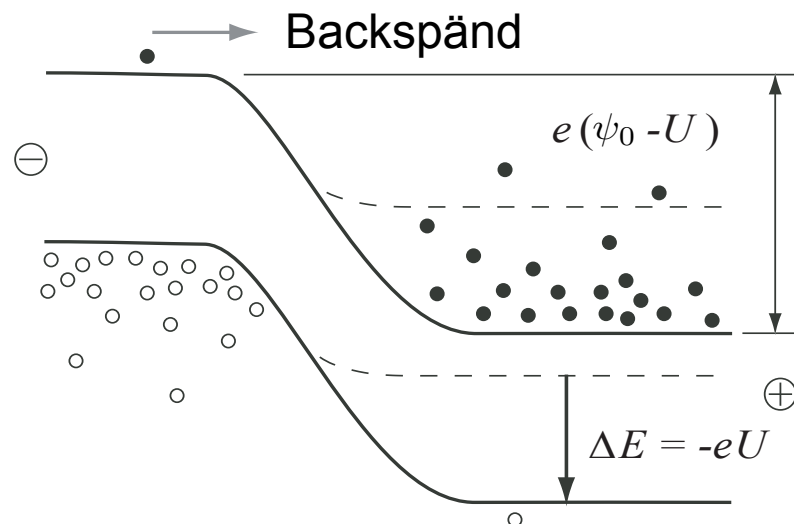
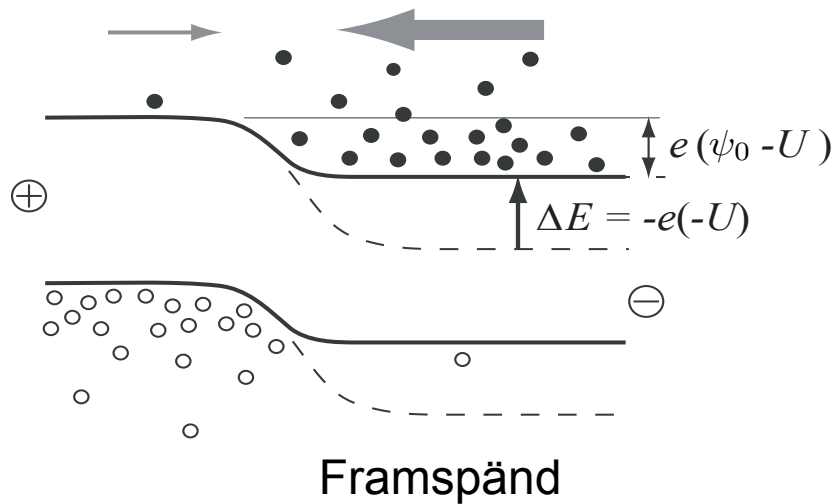
Därmed uppkommer ett elektriskt fält som hindrar fler elektroner och hål från att diffundera över till andra sidan. De upplever ett potentialsteg

Diod = pn-övergång



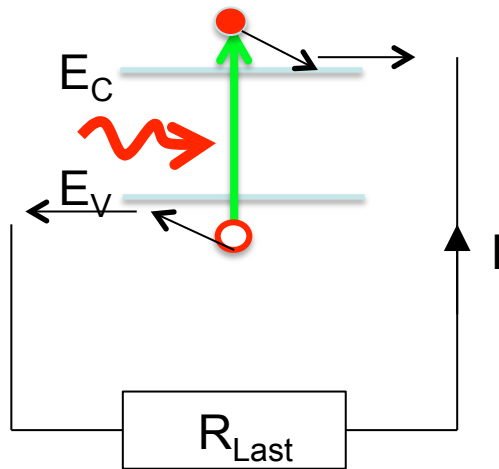
Därmed uppkommer ett elektriskt fält som hindrar fler elektroner och hål från att diffundera över till andra sidan. De upplever ett potentialsteg

Diod = pn-övergång

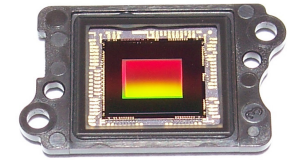


Vid framspänning minskar potentialsteget, vid backspänning ökar det. Därmed börjar det flyta en ström:

$$I = I_0 \left(e^{eU/\eta kT} - 1 \right), \quad (1 \leq \eta \leq 2)$$

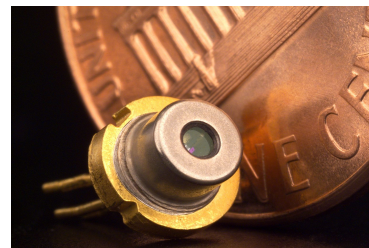
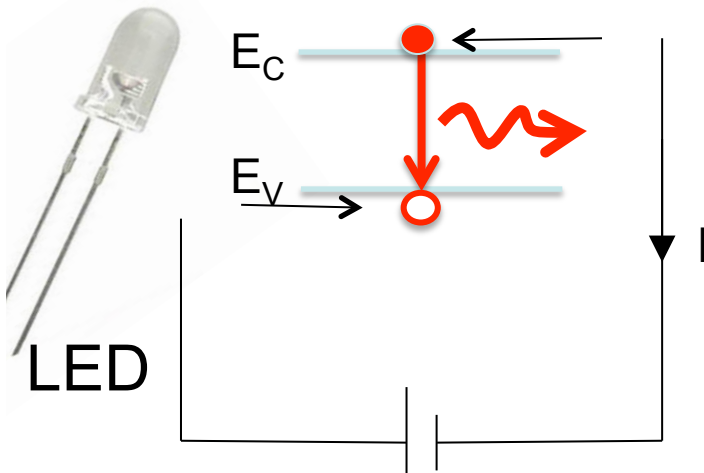
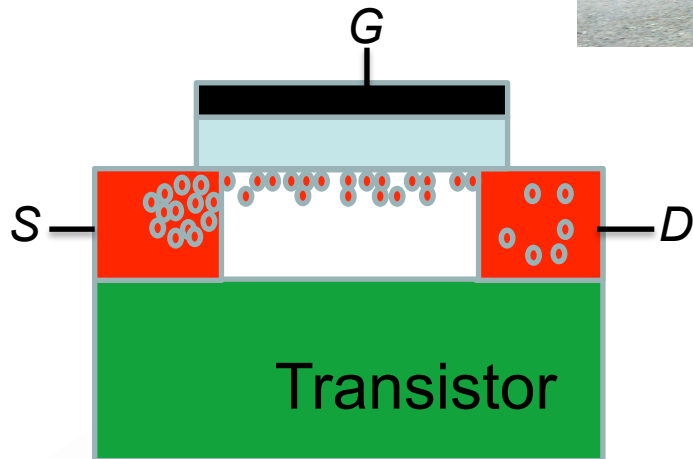


Kamerasensor



Solceller Halvledare

- Band av möjliga energier separerade av bandgapet
- Elektronerna delas av alla atomer
=> kan leda ström
- Dopning ger två typer av kontakter



Diodlaser

