

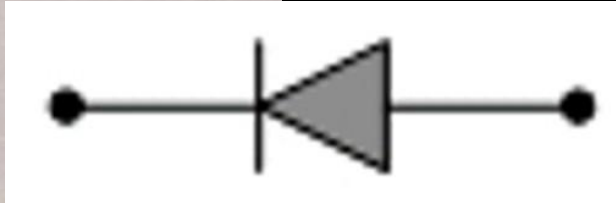
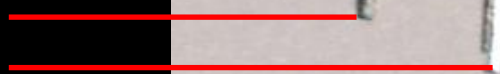
Sveteče diode LED

KSD 2014

Gorazd Planinšič

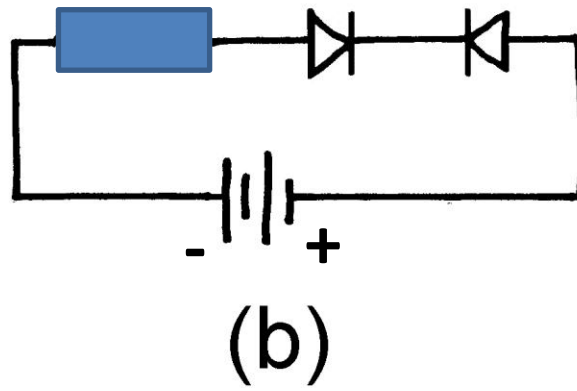
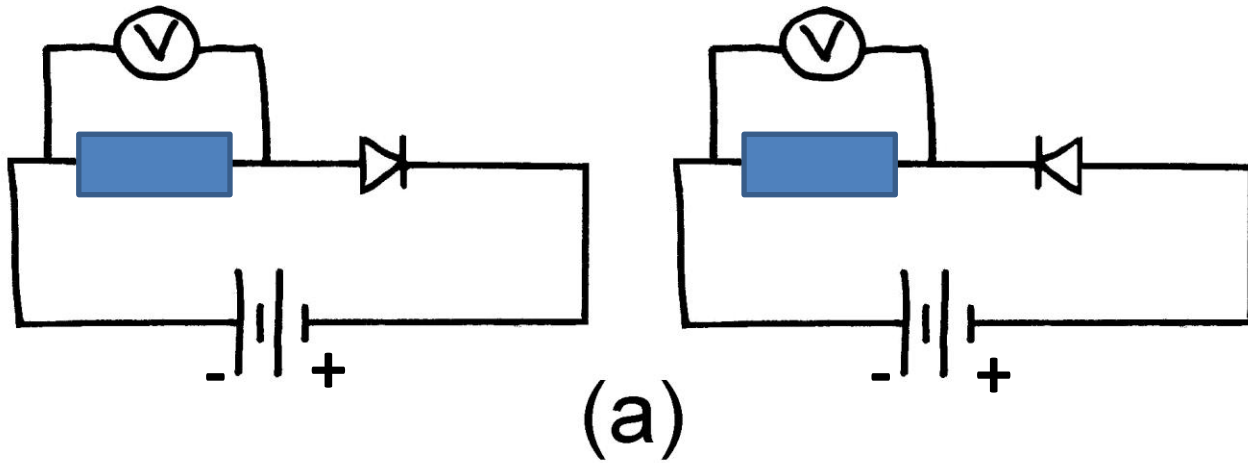


Ena "noga" je krajša kot druga

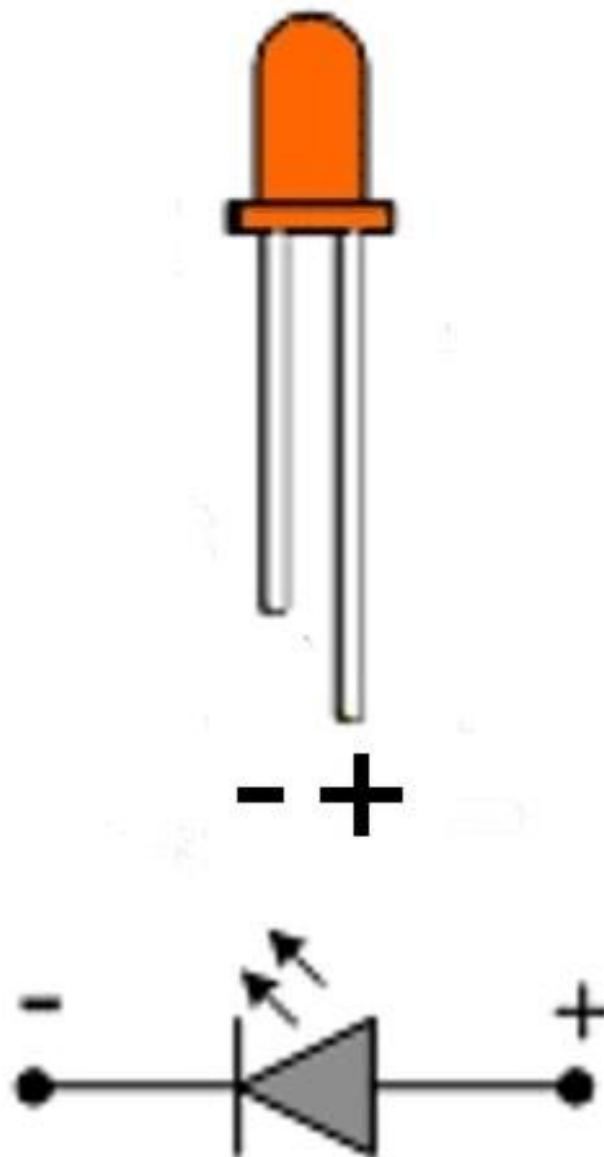


1. Razlaga: LED prevaja tok le v eni smeri. Ko teče tok, LED sveti.
2. Razlaga: LED prevaja tok v obe smeri, toda sveti le, ko tok teče v določeno smer.

Predlagajte testne poskuse, s katerimi bi lahko preverili, katera razlaga ni pravilna.



Dogovorjeni
simbol za LED

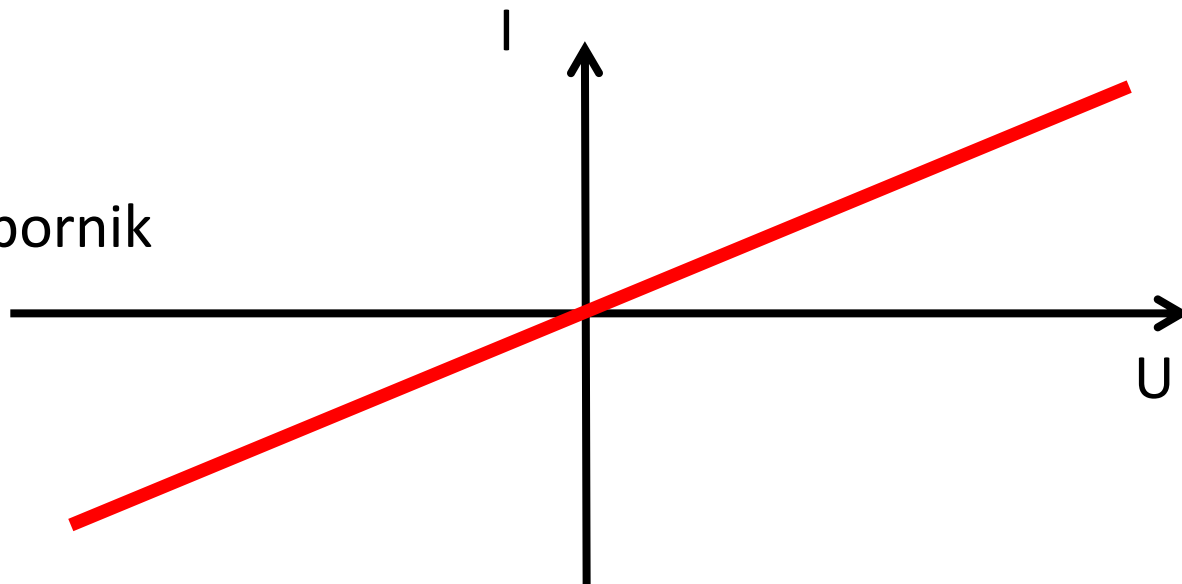


PONOVITEV: Nariši grafa $I(U)$ za

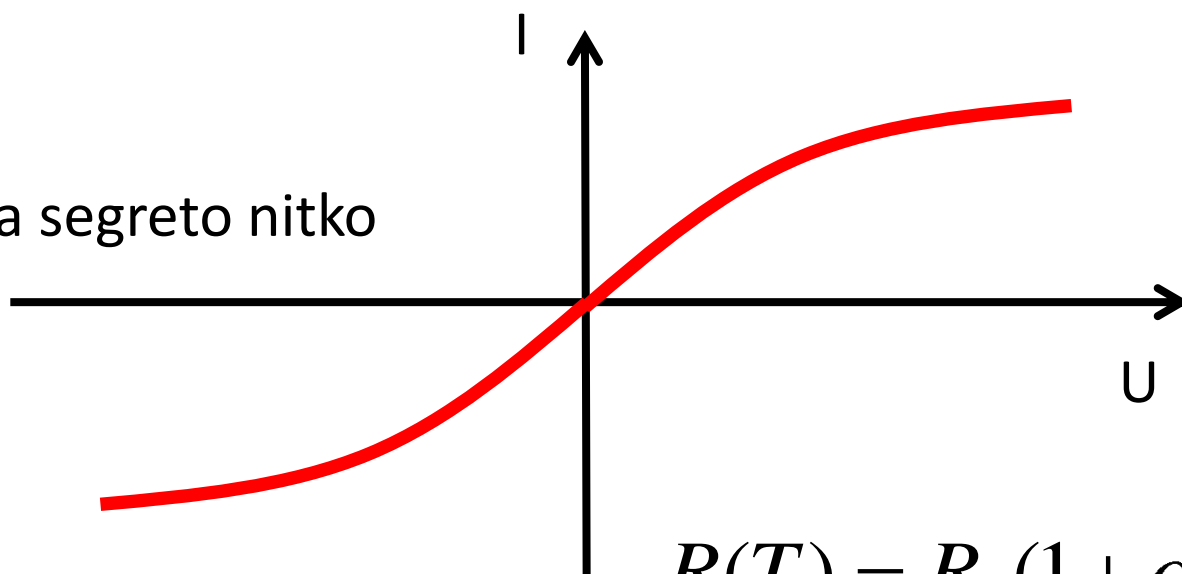
-ohmski upornik

-za žarnico na segreto nitko

Ohmski upornik

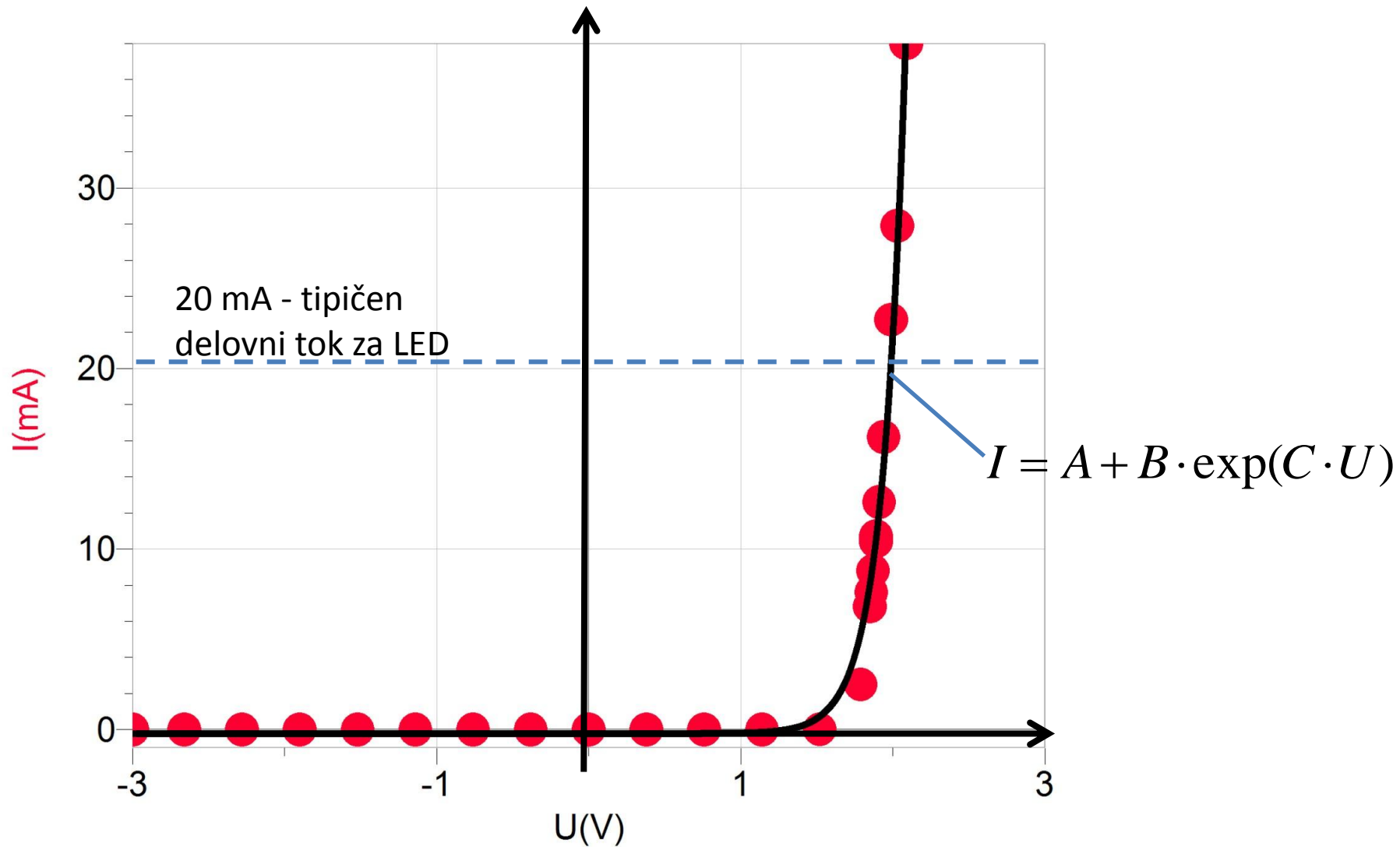


Žarnica na segreto nitko



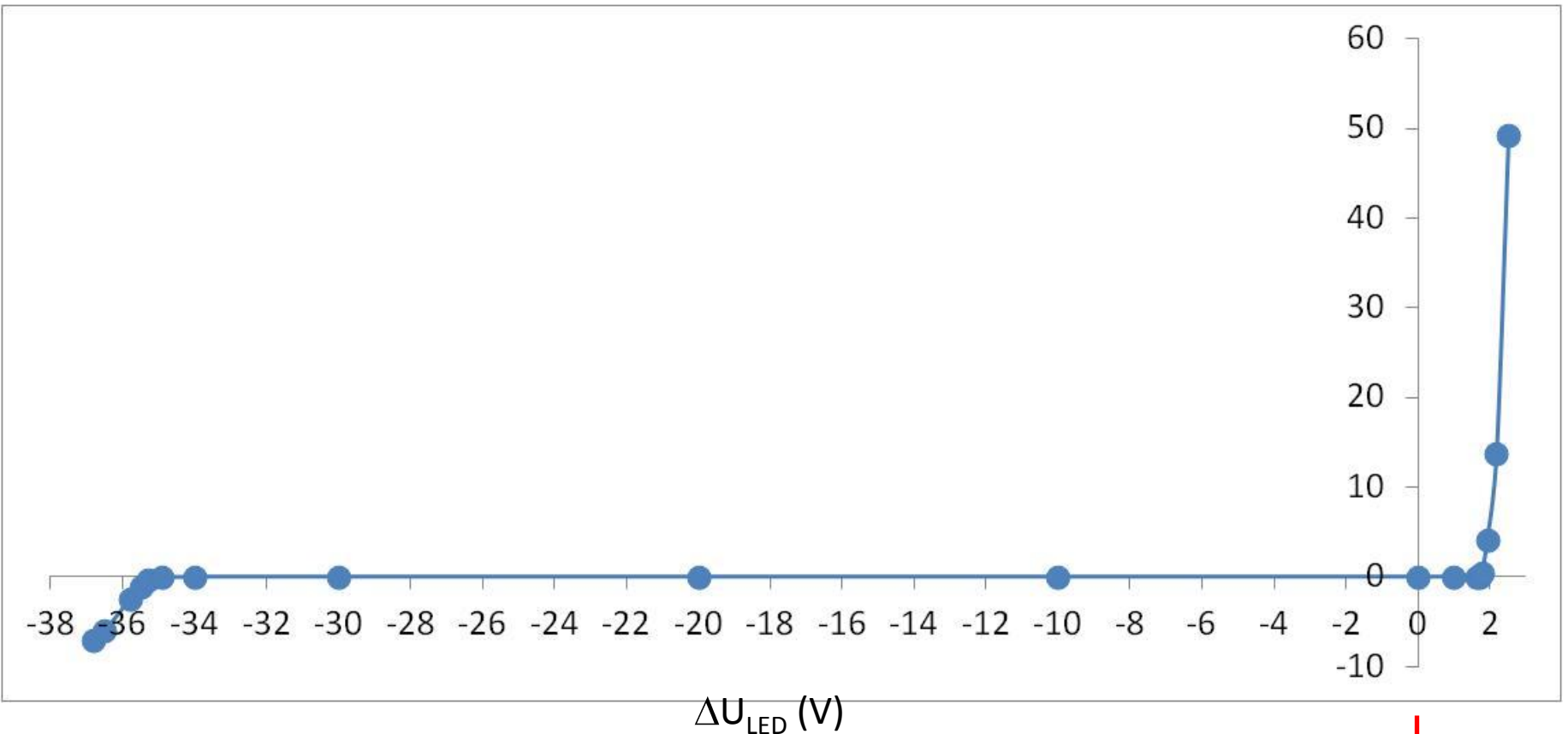
$$R(T) = R_0 (1 + \alpha \cdot (T - T_0))$$

U-I karakteristika rdeče LED



U-I karakteristika rdeče LED

I_{LED} (mA)



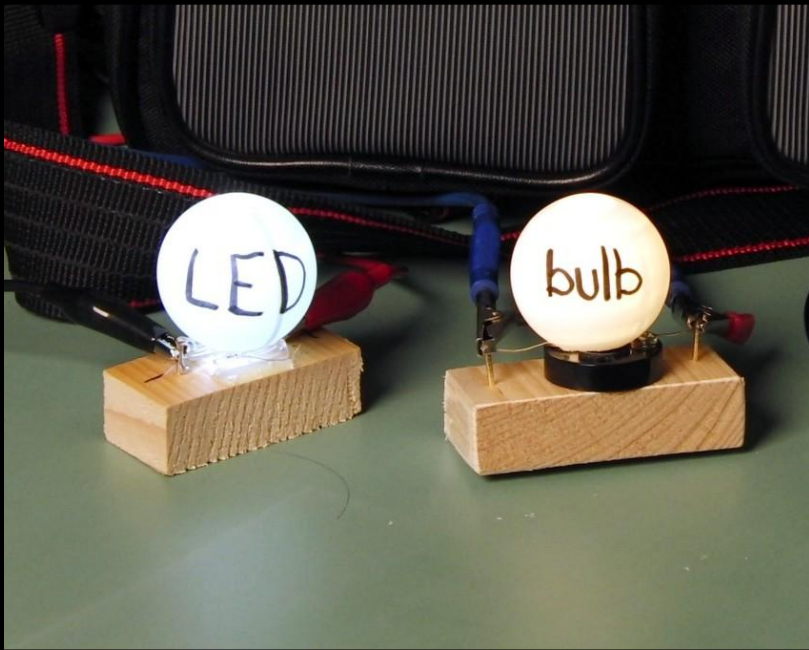
ZAPORNA SMER

PREVODNA
SMER

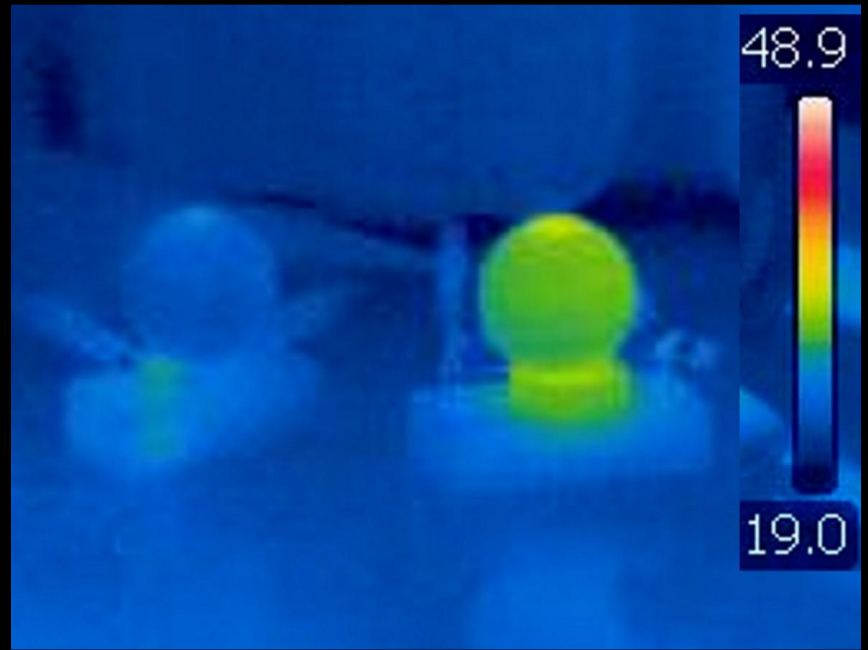
LED priključimo na izmenično napetost.
Razložite izid poskusa. Kaj lahko na podlagi
poskusa poveste o napetosti vira?

KAKO (NE) NASTANE SVETLOBA V LED?

(primerjaj s svetilkami,
ki jih že poznaš)



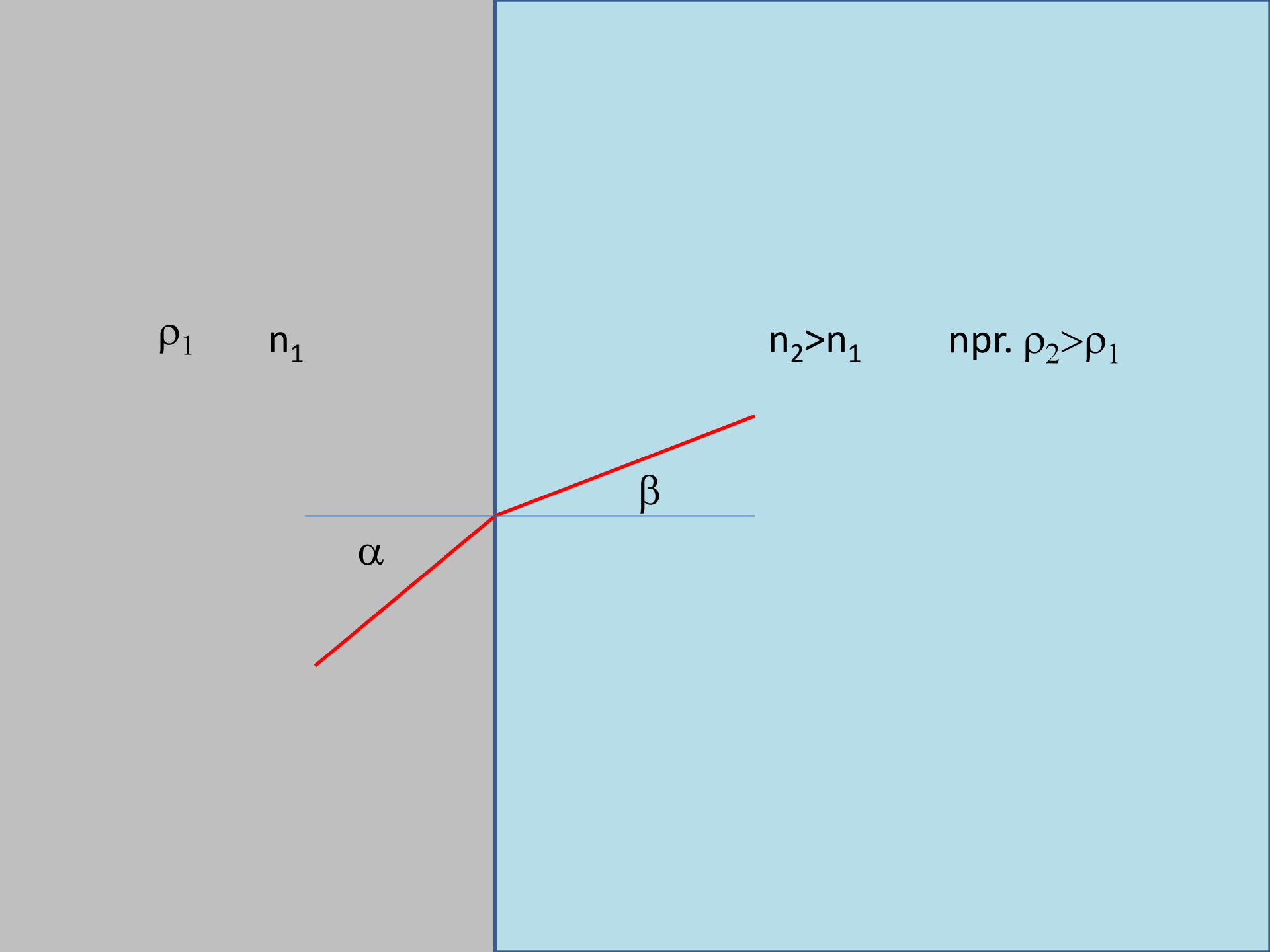
Digitalni fotoaparati
(vidna svetloba)



Toplotna kamera
(IR svetloba)

KAKO JE ZGRAJENA LED?

Kaj lahko naredimo, da bomo bolje videli zgradbo LED?



ρ_1

n_1

$n_2 > n_1$

npr. $\rho_2 > \rho_1$

α

β

ρ_1

n_1

$n_2 = n_1$

npr. $\rho_2 > \rho_1$



α

β

“Index matching”

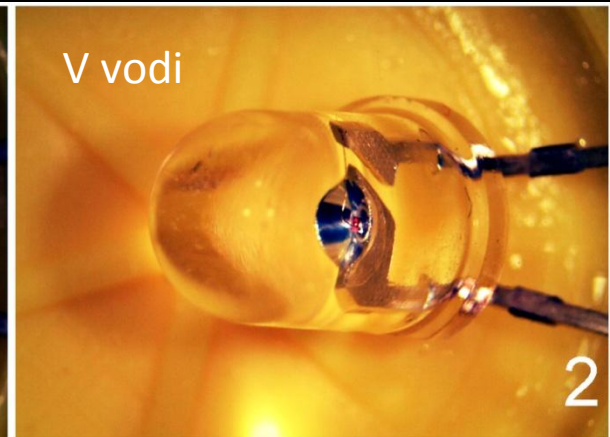


V zraku



1

V vodi



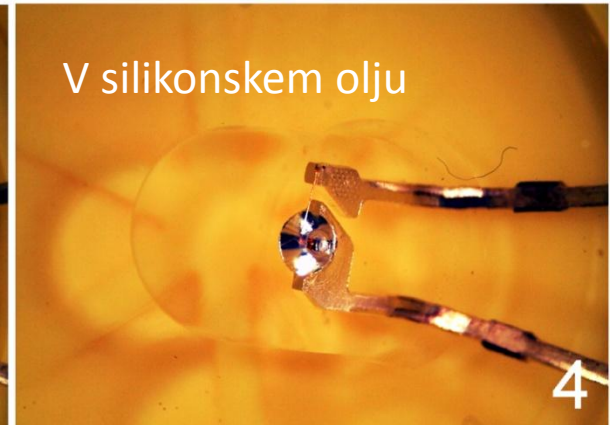
2

V glicerinu

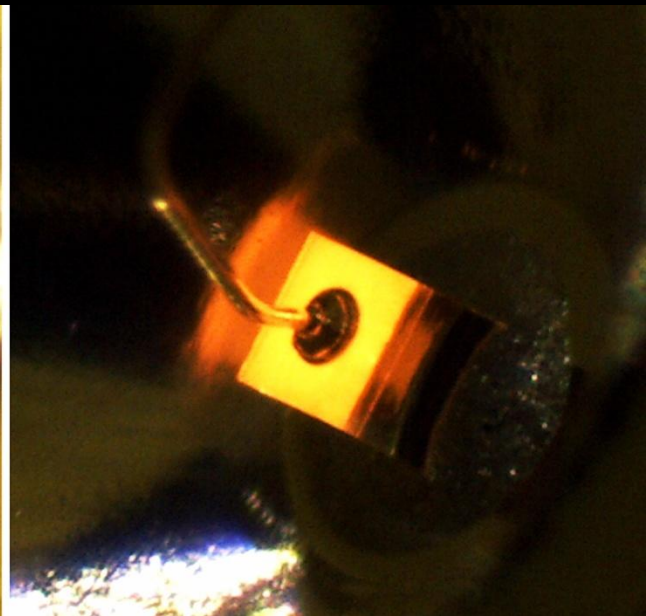
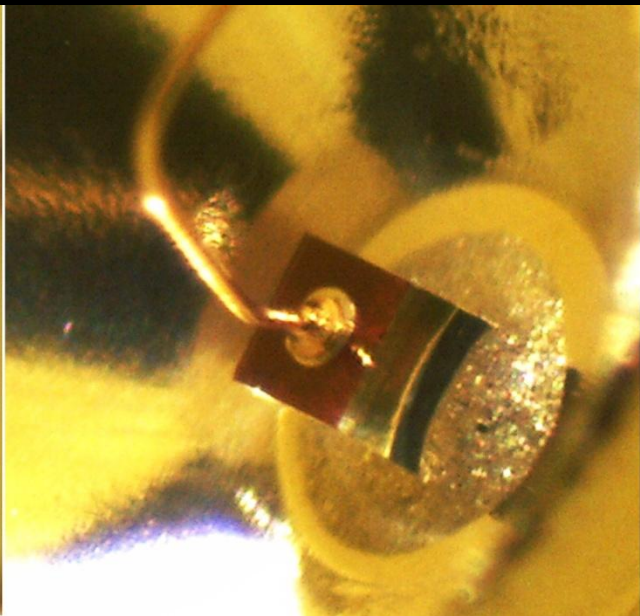
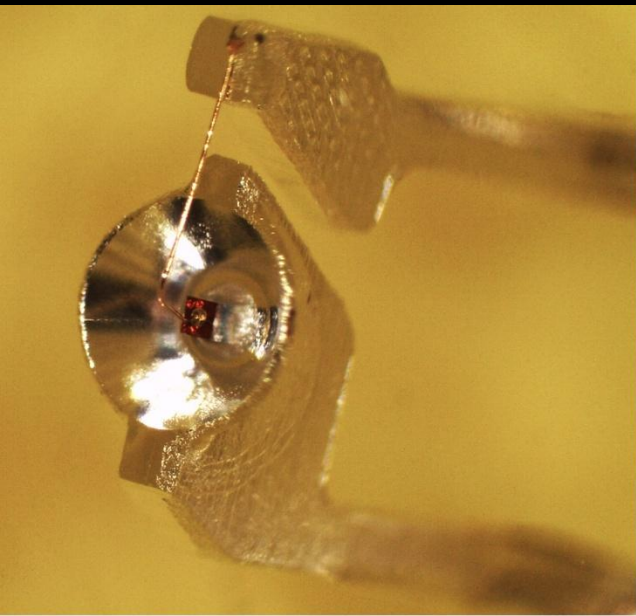


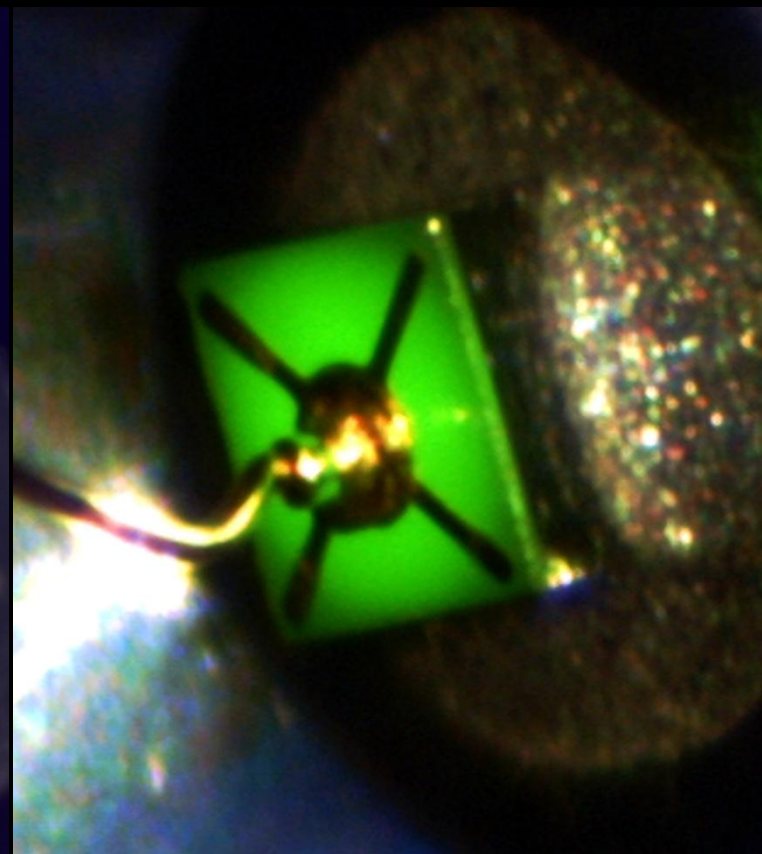
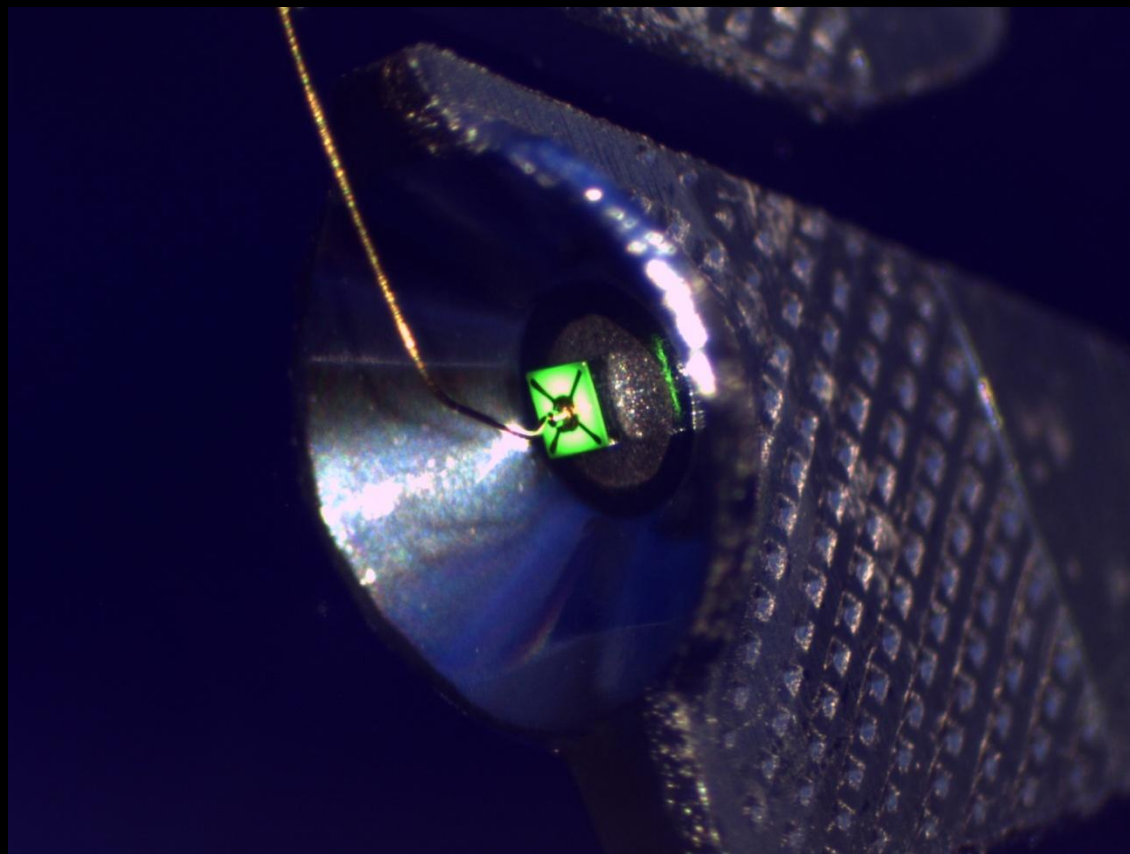
3

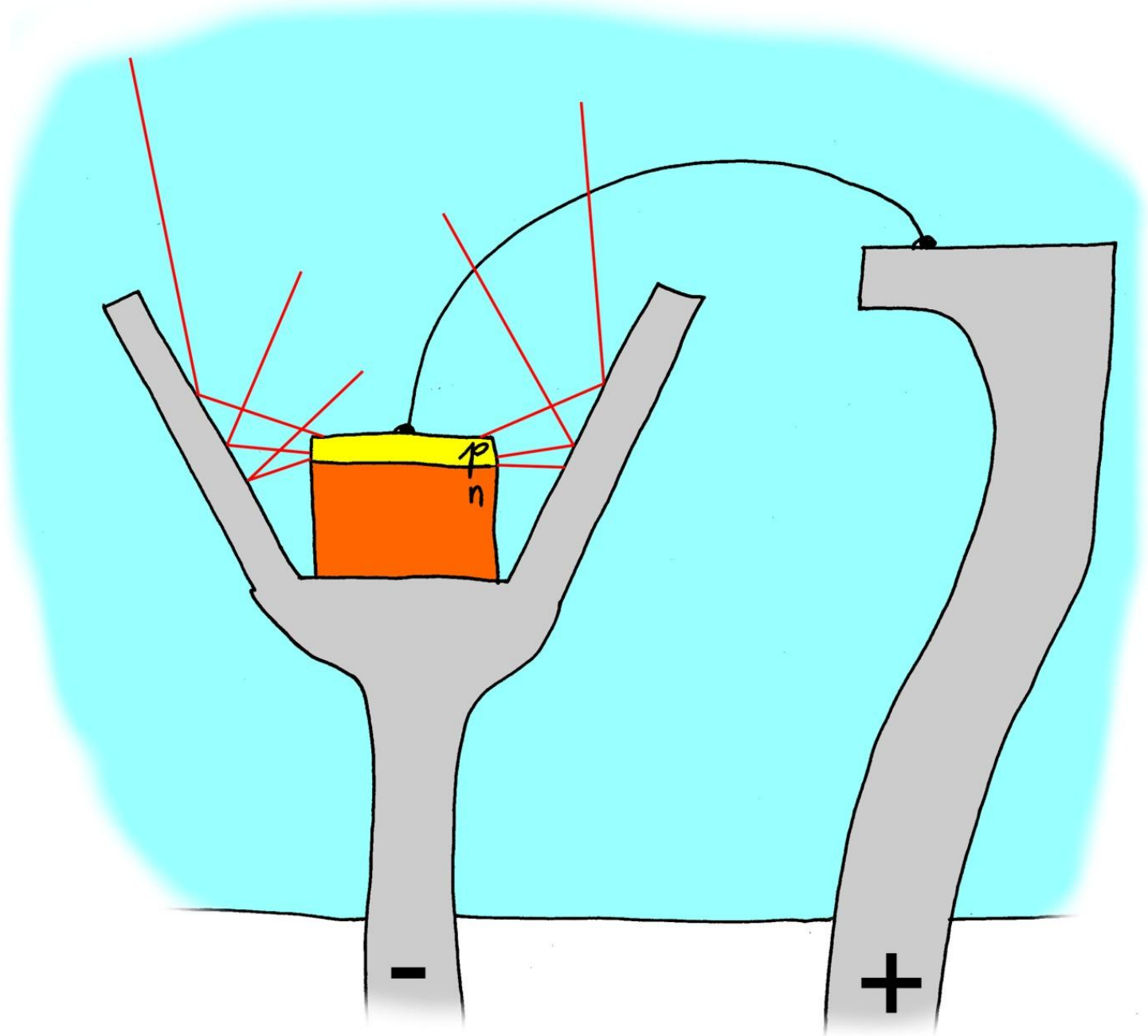
V silikonskem olju



4





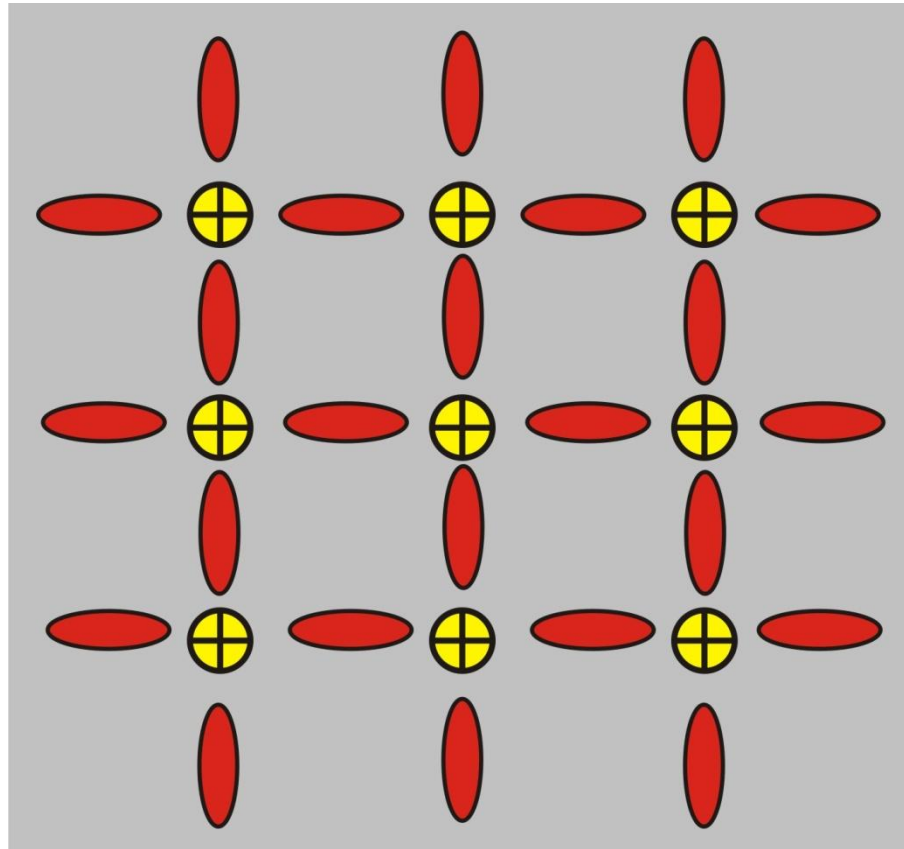


LED je polprevodniški
element

(zelo poenostavljena teorija LED)

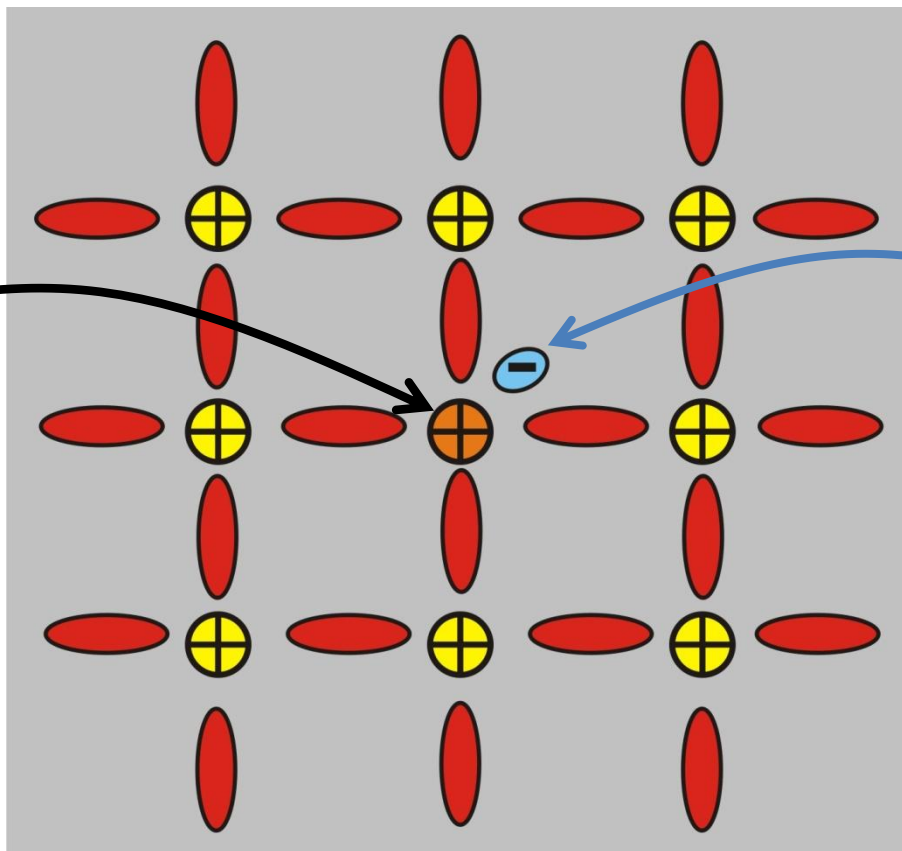
Čisti polprevodnik

4-valentni
atomi



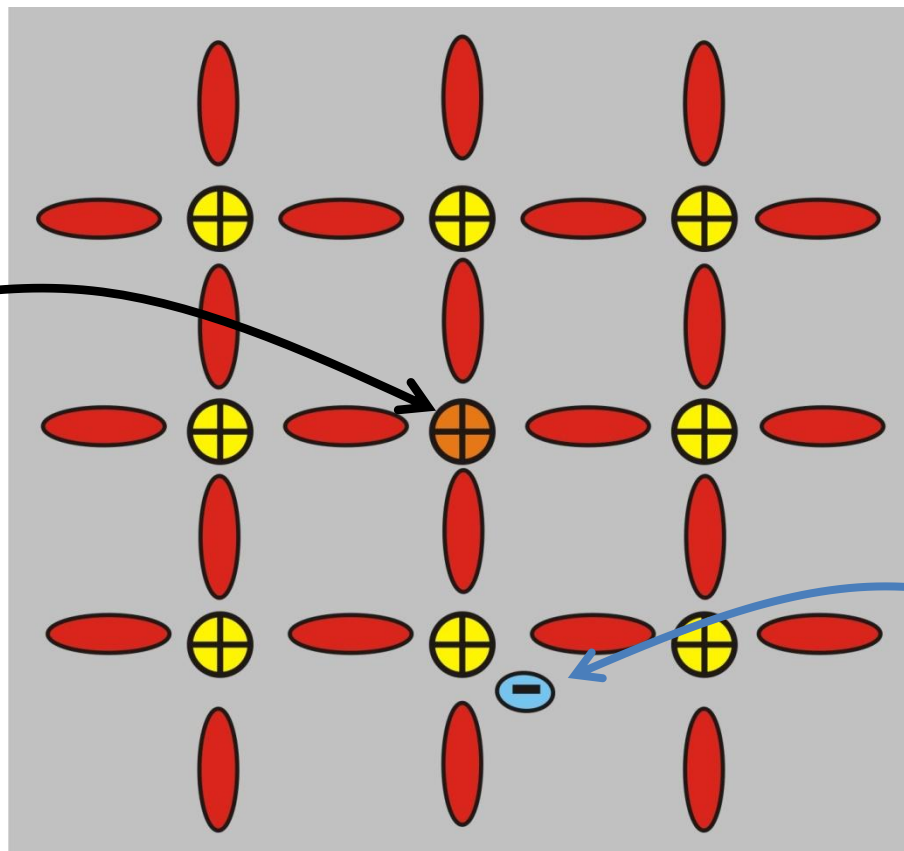
N-dopirani polprevodnik

5-valentni atom



elektron

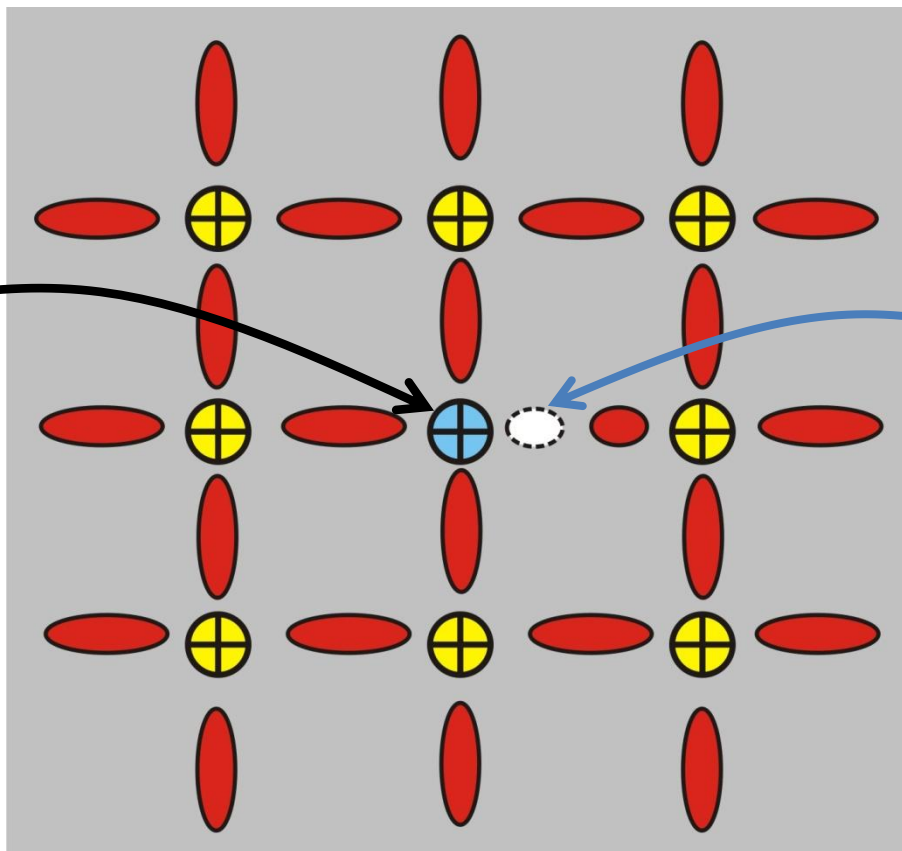
Pozitivni ion



potujoči
elektron
(-)

P-dopirani polprevodnik

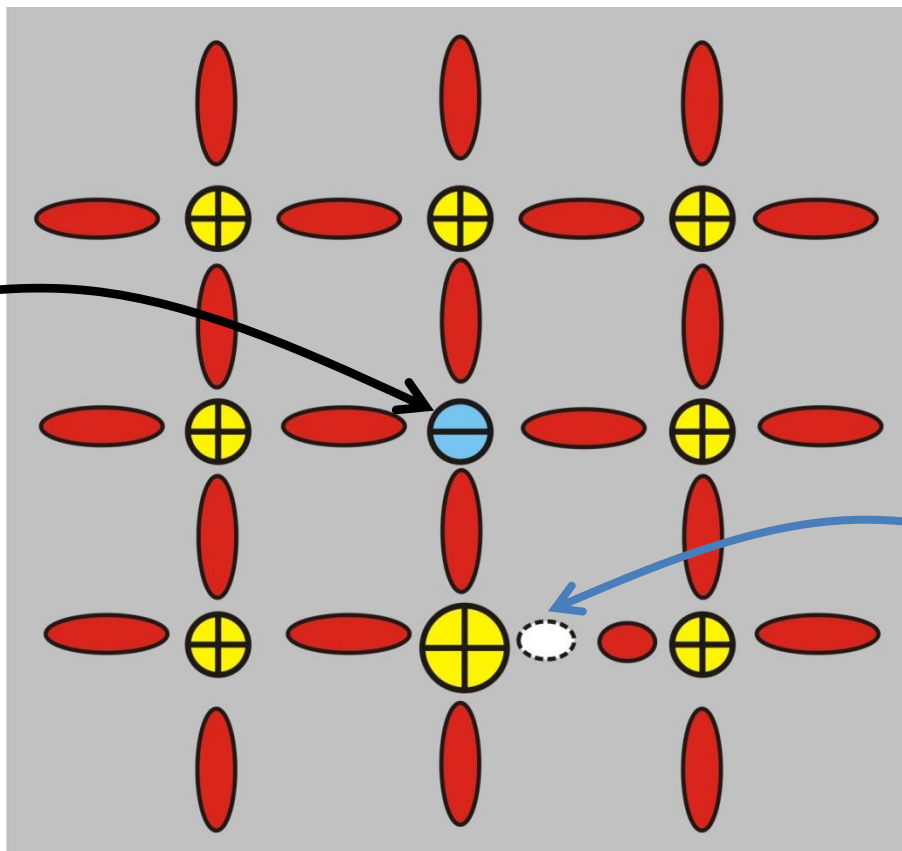
3-valentni atom



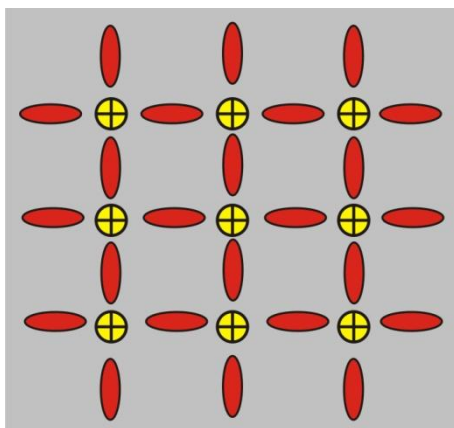
vrzel

P-dopirani polprevodnik

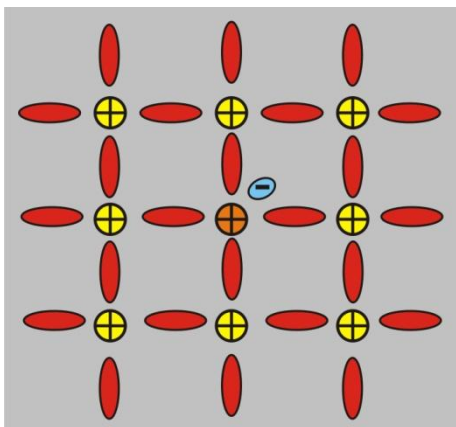
Negativni ion



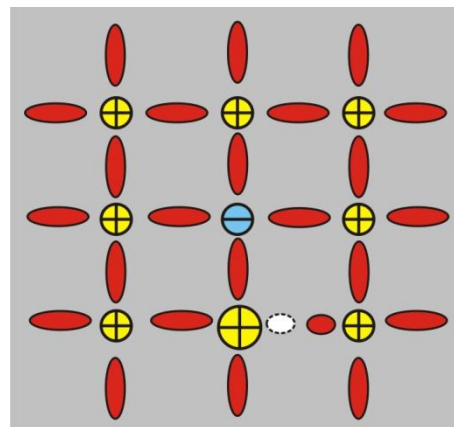
“potujoča”
vrzel (+)



Čisti polprevodnik

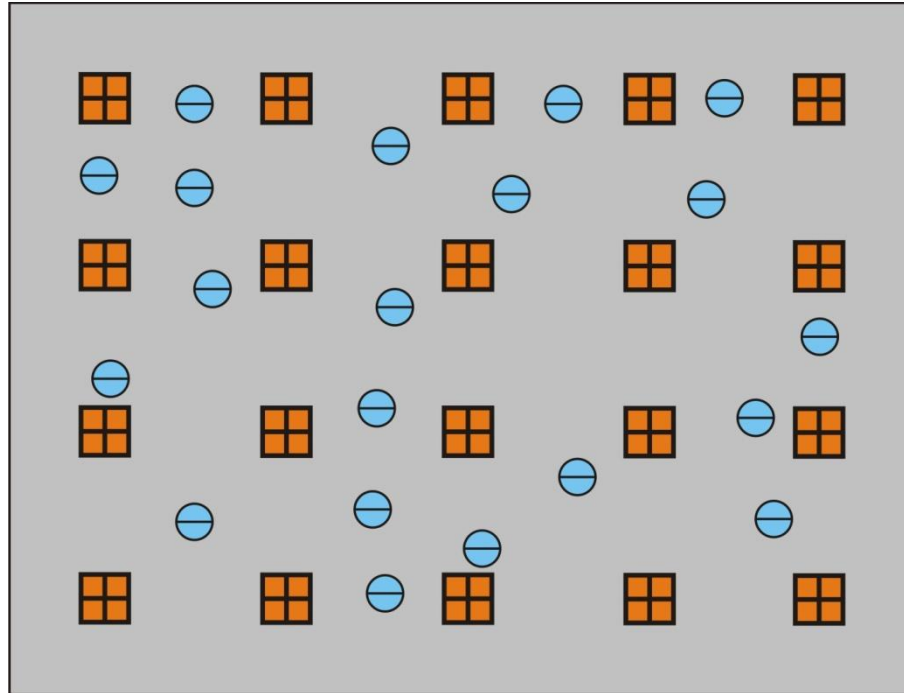


N-tip

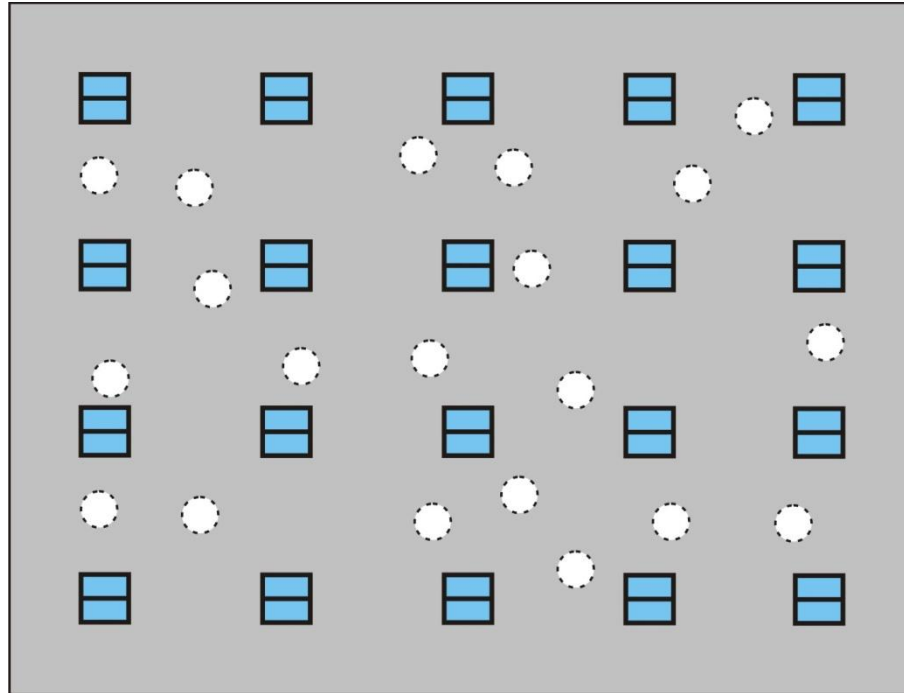


P-tip

N-tip

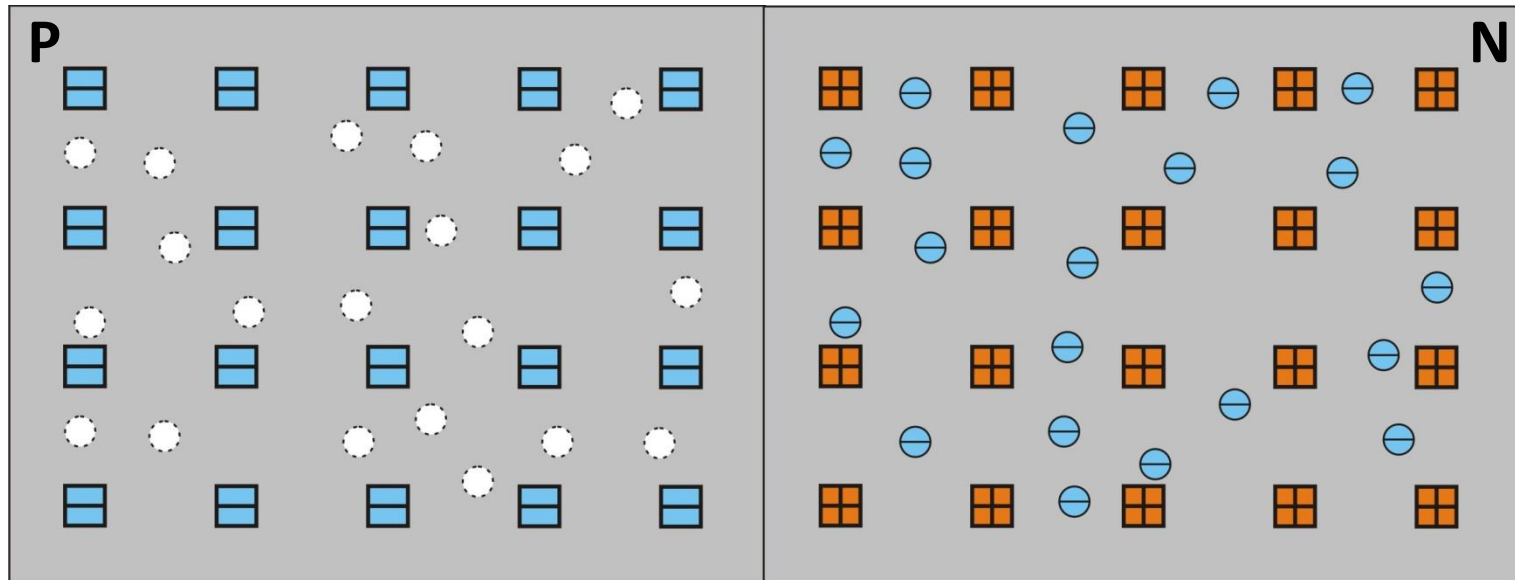


P-tip



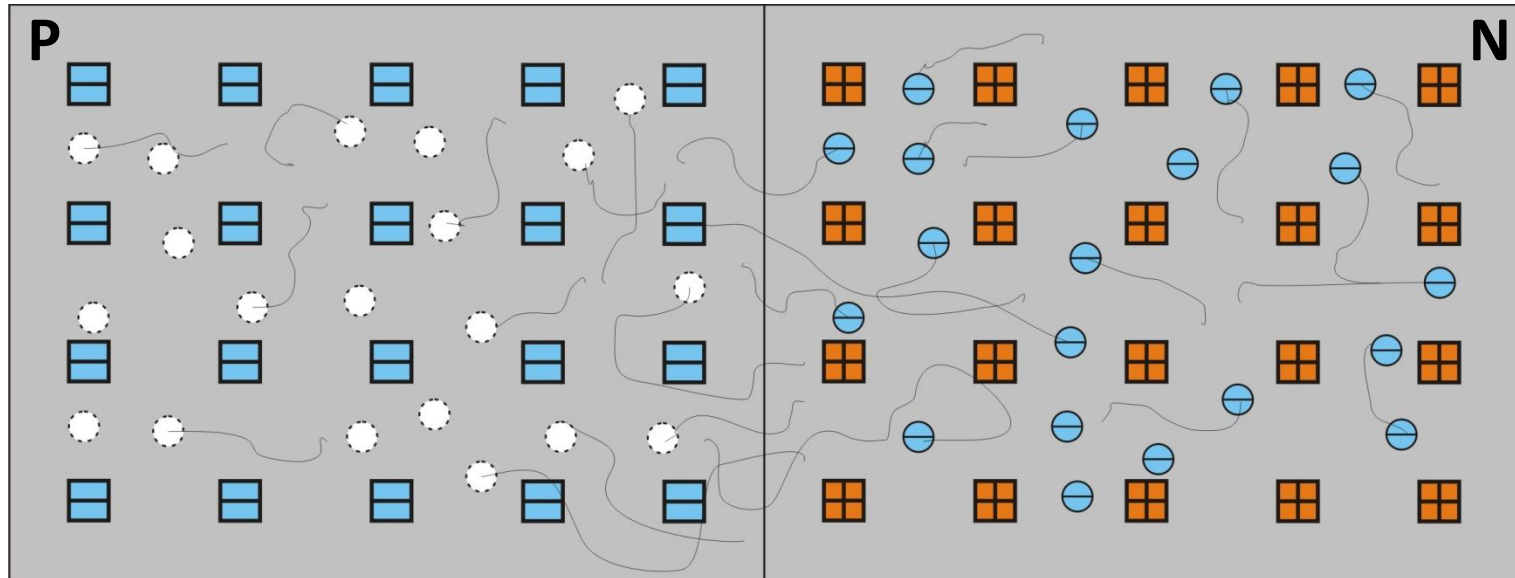
PN-stik

(takoј po tem, ko združimo P in N...)



PN-stik

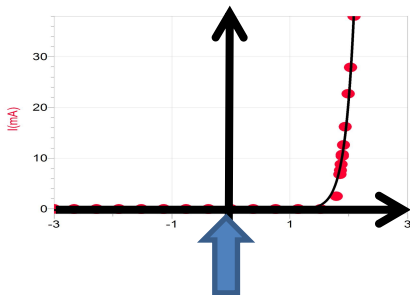
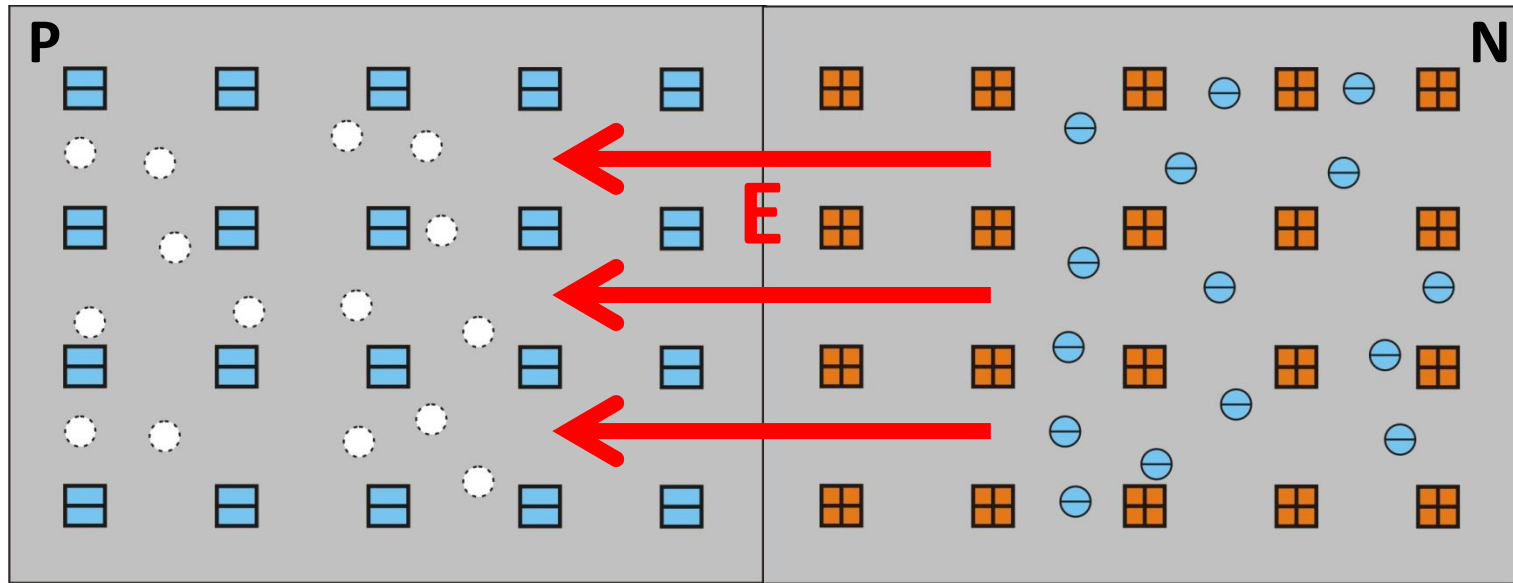
...nosilci naboja potujejo /difuzija/...



...ko se srečata vrzel in elektron, se rekombinirata (izgineta, nastane foton)

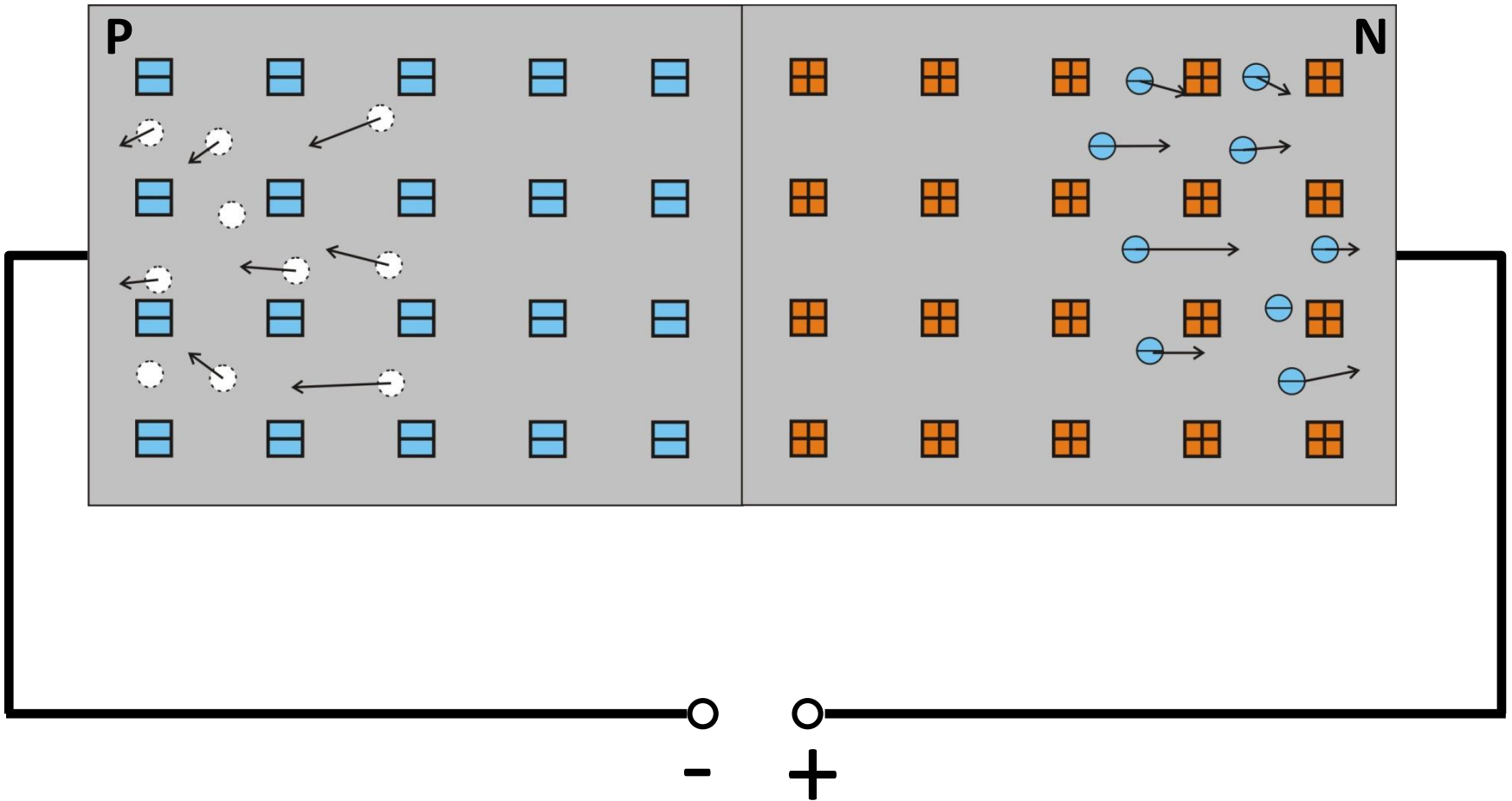
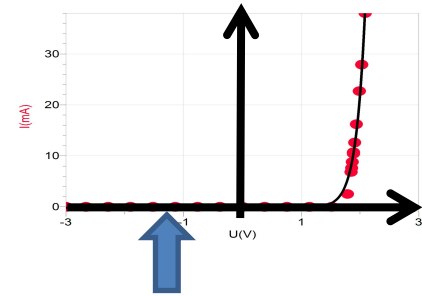
PN-stik

...in kmalu se vzpostavi ravnovesje

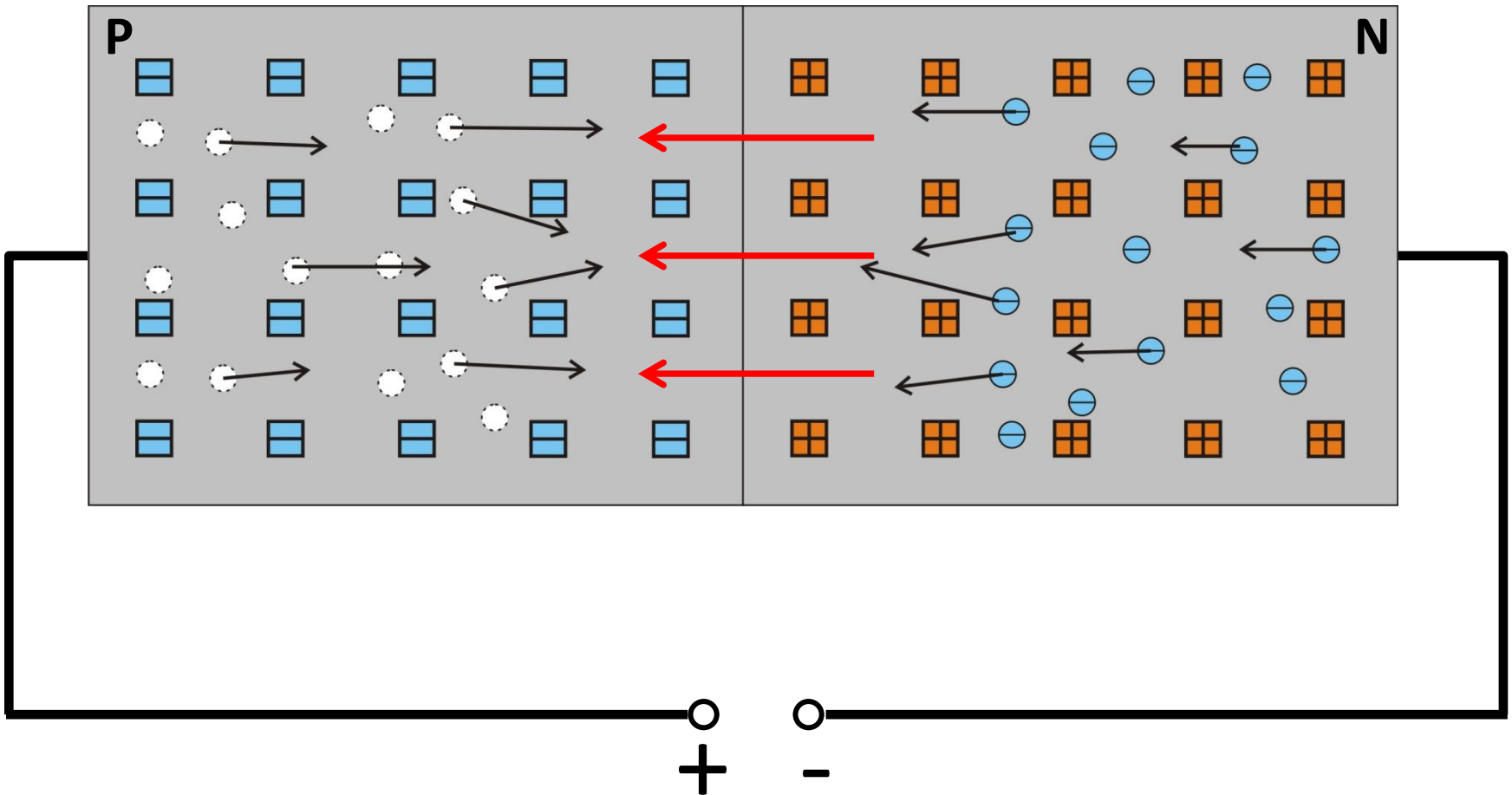
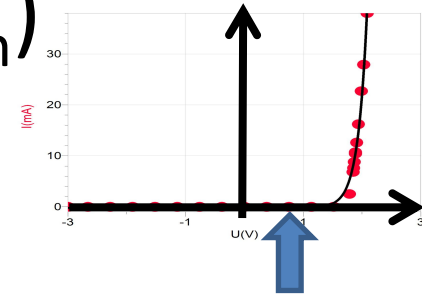


Izpraznjena plast
(*depletion region*)

Zaporna smer ($U < 0$)

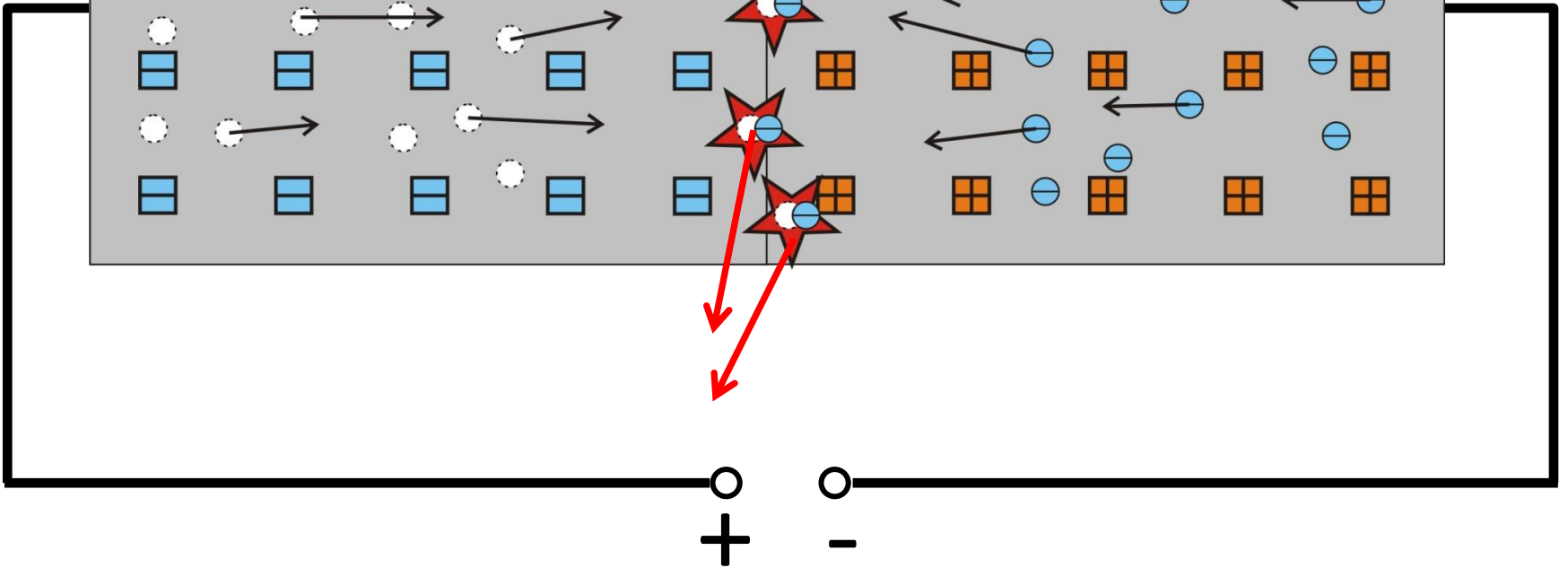
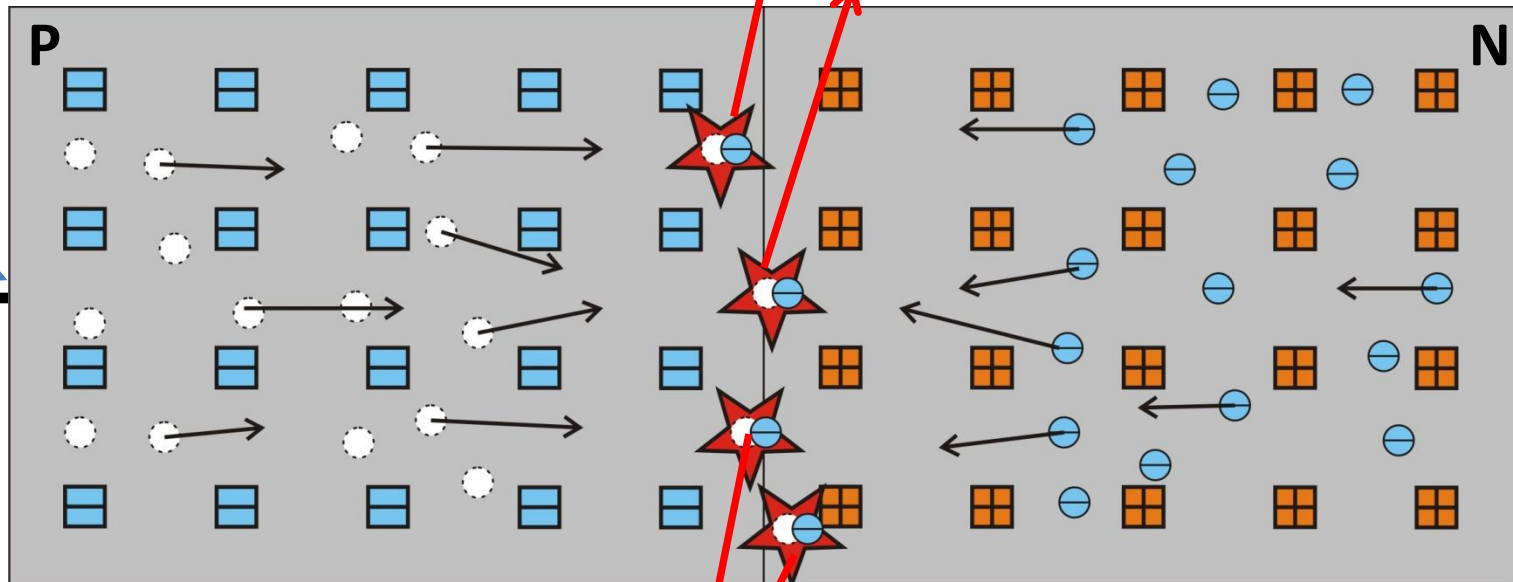
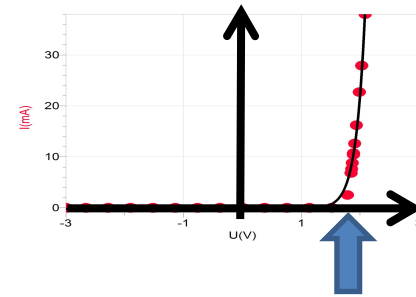


Prevodna smer ($0 < U < U_{on}$)

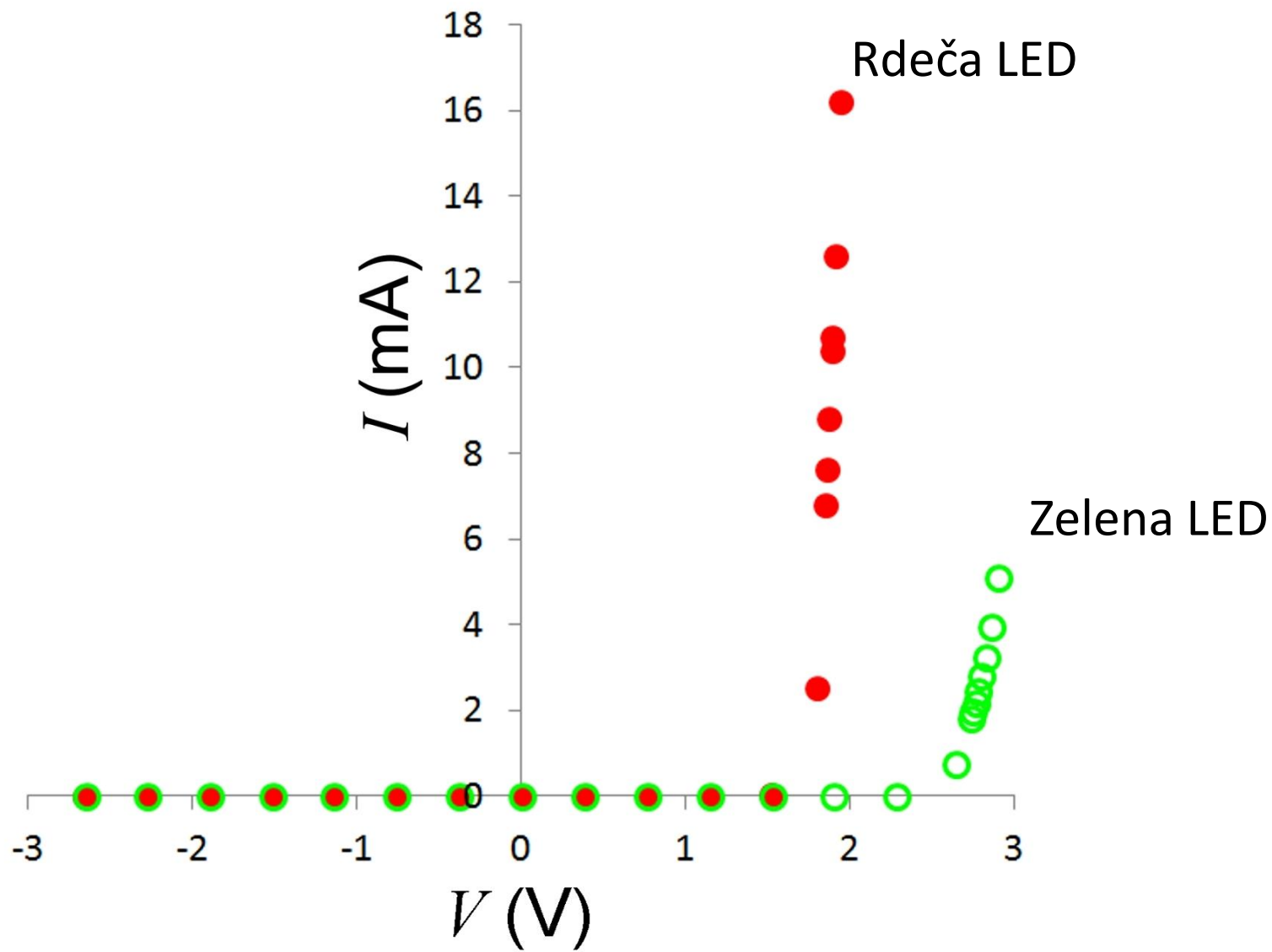


Prevodna smer ($U > U_{on}$)

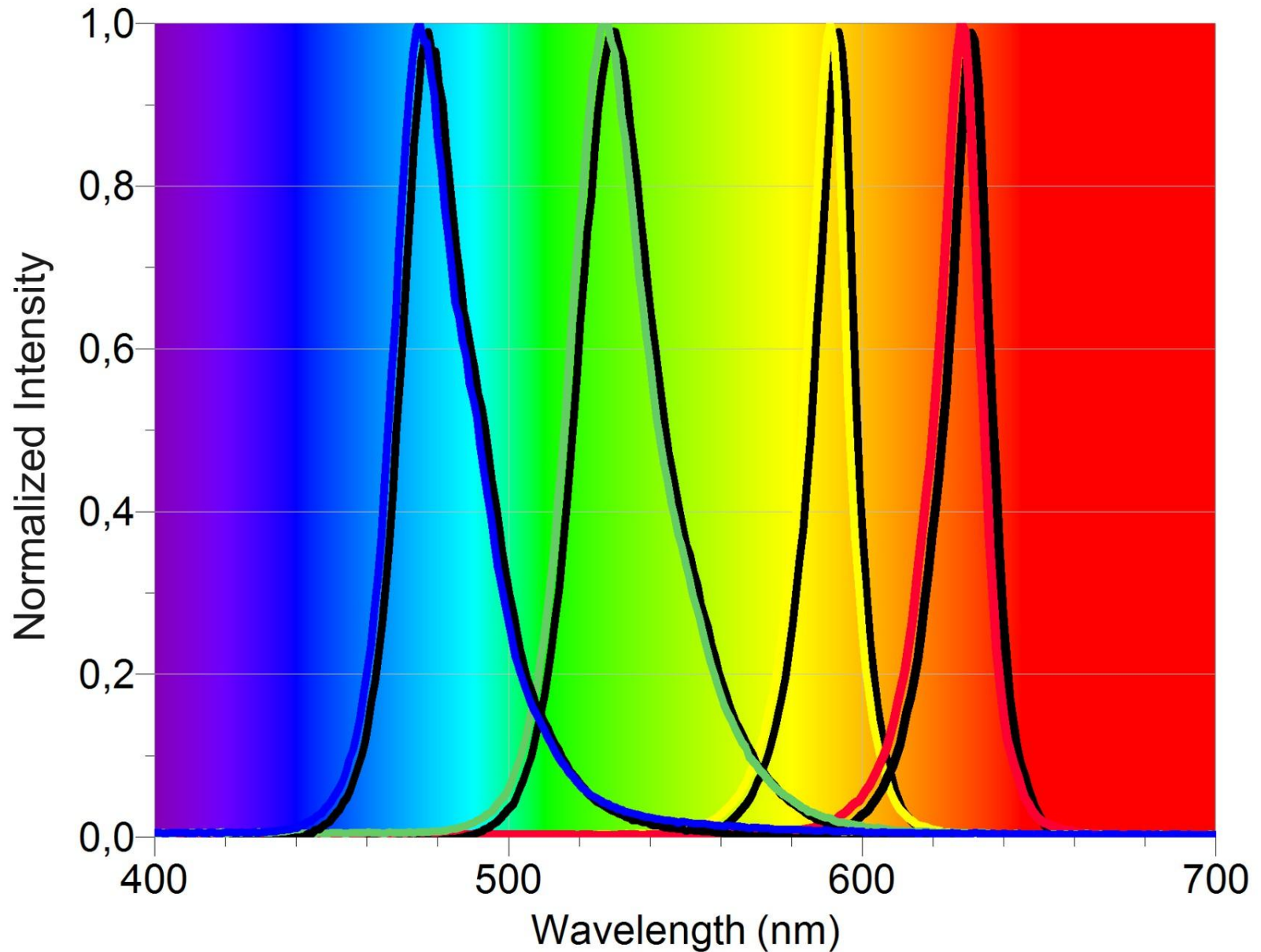
Tukaj izhajajo iz polprevodnika elektroni in pri tem nastajajo vrzeli !



Povezava med U-I in
spektrom svetlobe, ki
jo oddaja LED



Spektri barvnih LED

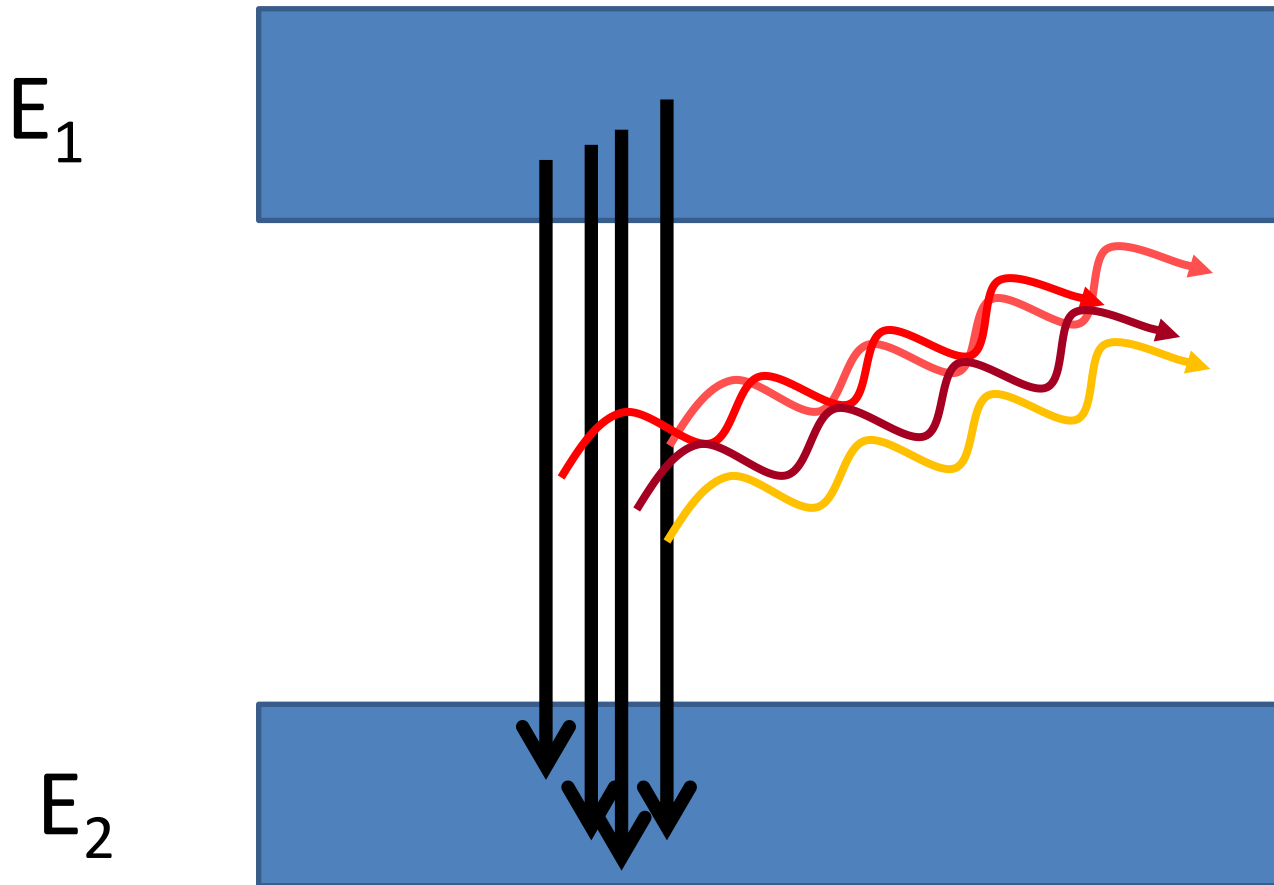


	Vršna valovna dolžina	Energija fotonov	Odpiralna napetost
Rdeča	629 nm	1,97 eV	1,51 V
Rumena	590 nm	2,10 V	1,57 V
Zelena	527 nm	2,35 V	2,03 V
Modra	473 nm	2,62 V	2,23 V

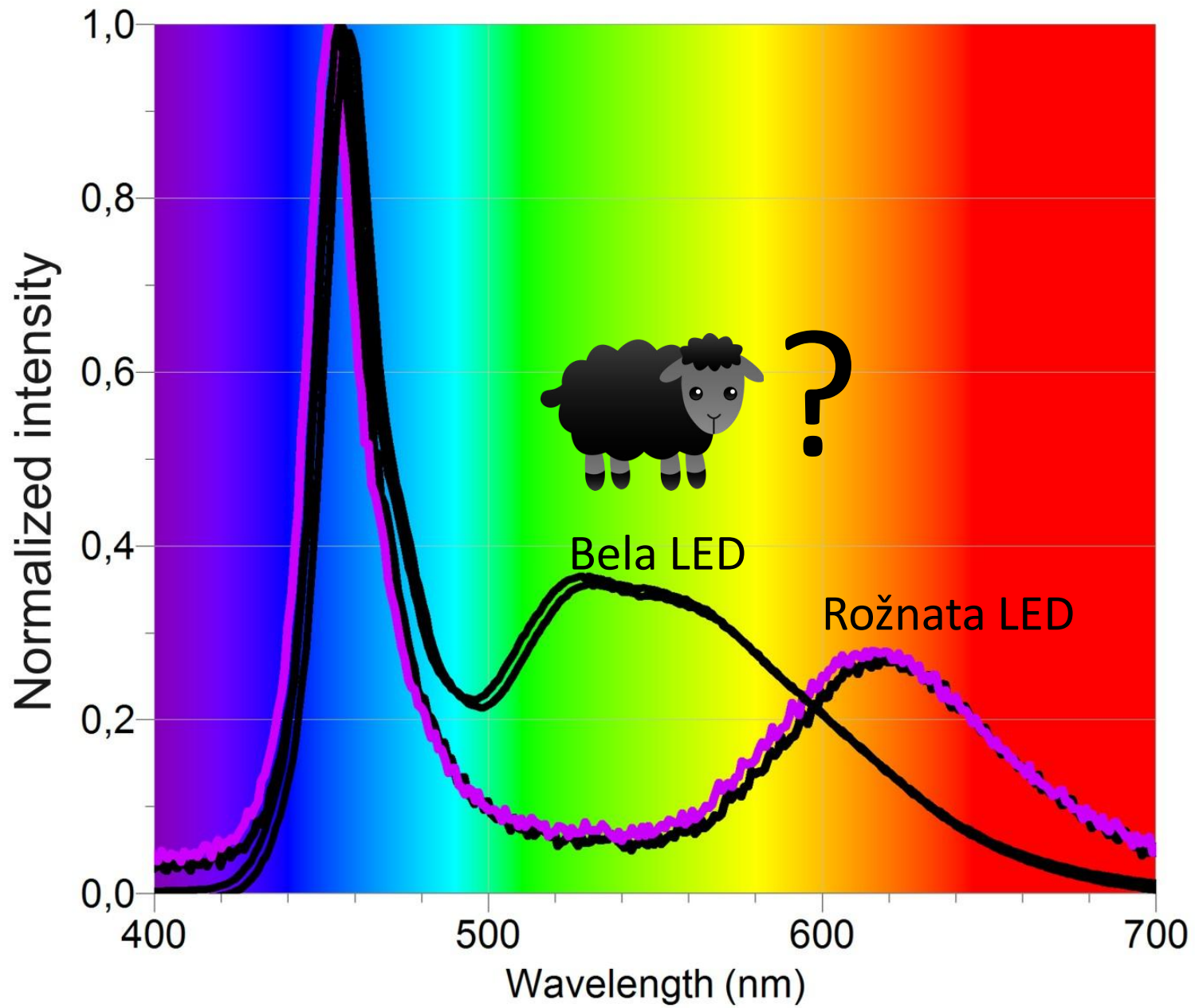
Energija fotona:
$$E = h\nu = \frac{hc}{\lambda} = \frac{1240 \cdot \text{nm} \cdot \text{eV}}{\lambda[\text{nm}]}$$

$e \cdot U_{\text{on}}$ je sorazmerna z energijo fotonov, očitno pa so prisotni še drugi procesi

Rekombinacija e-vrzel = prehodi med energijskimi pasovi atomov ob katerih se nahaja vrzel => spekter izsevane svetlobe je ozek pas valovnih dolžin

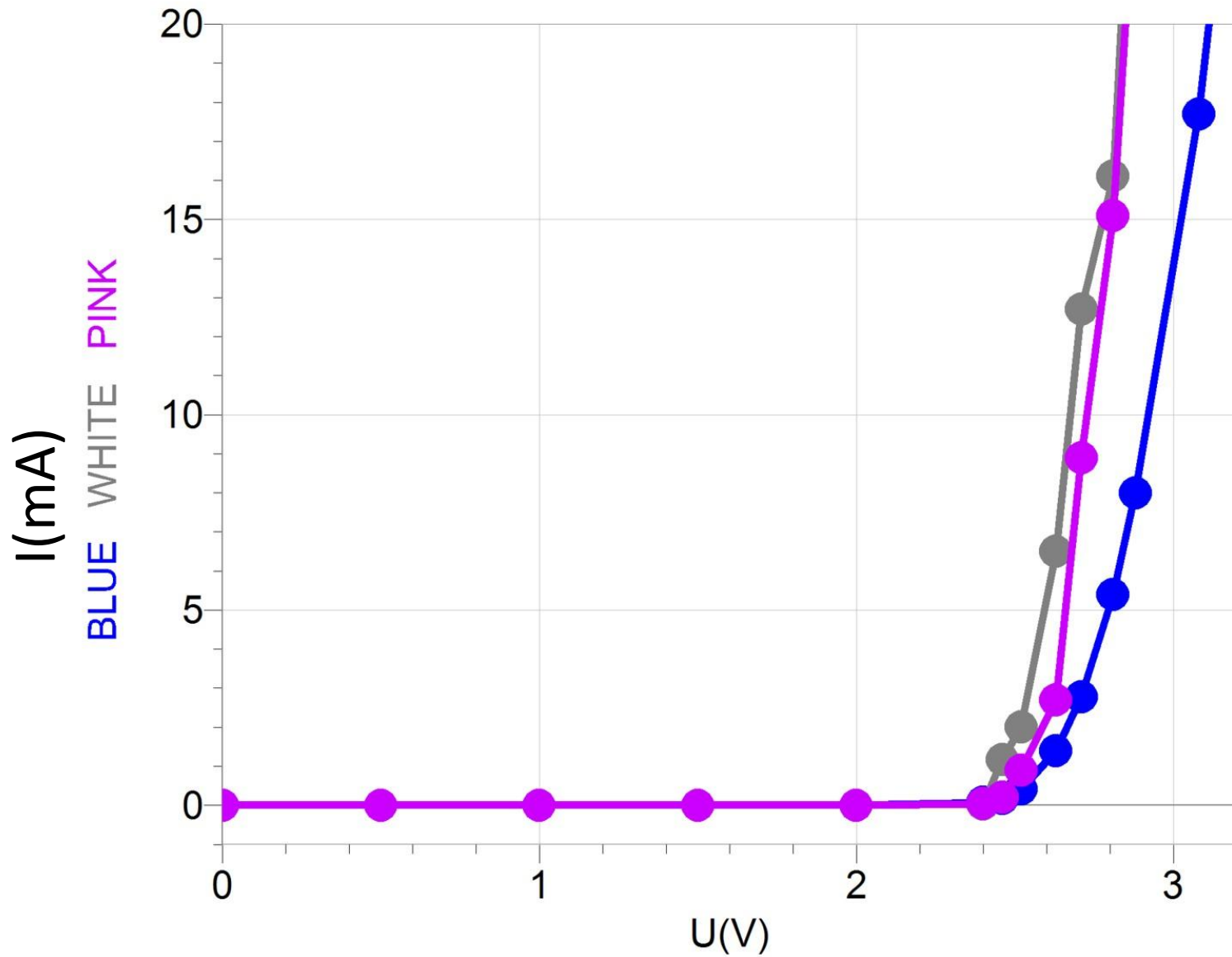


BELA IN ROŽNATA LED

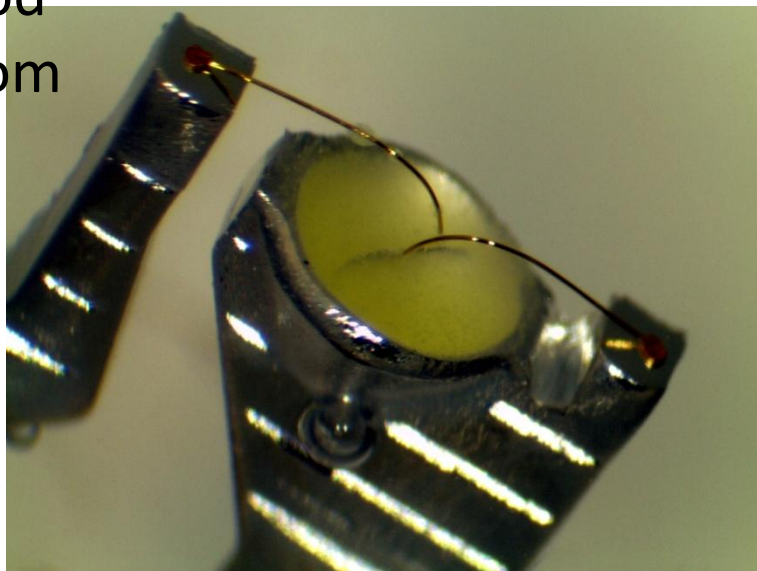


Kako sta narejeni bela in
rožnata LED?

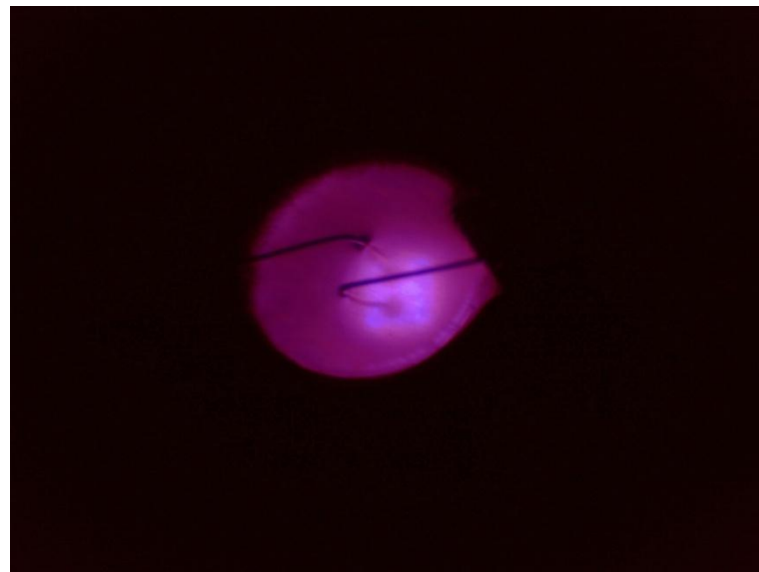
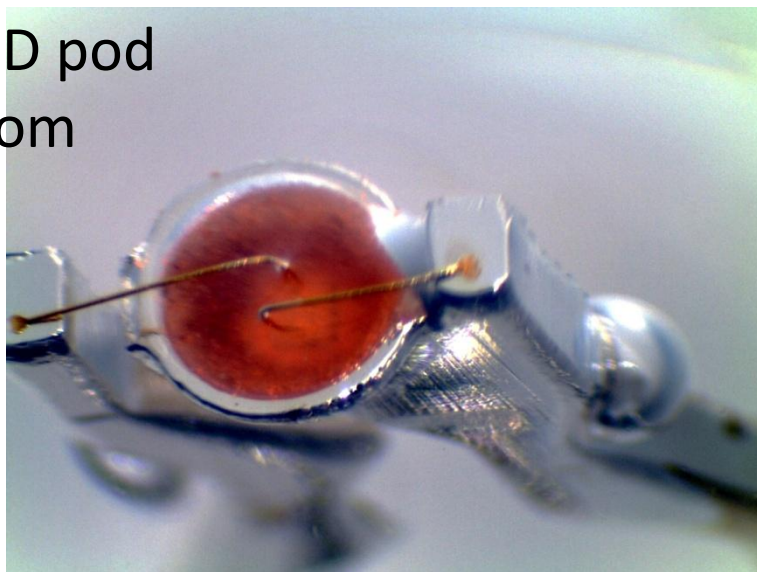
Predlagajte več razlag!
Predlagajte testne poskuse!



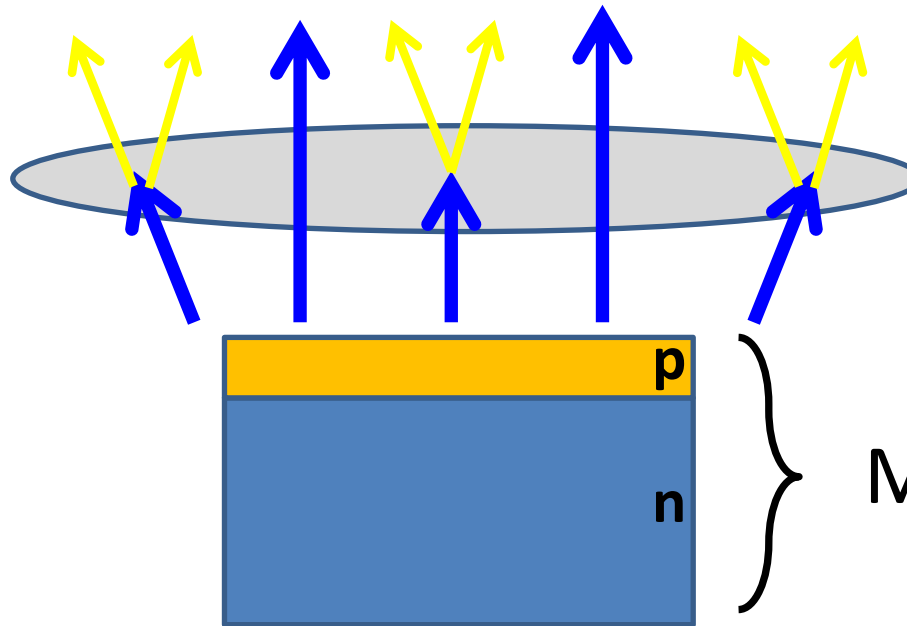
Bela LED pod
mikroskopom



Rožnata LED pod
mikroskopom



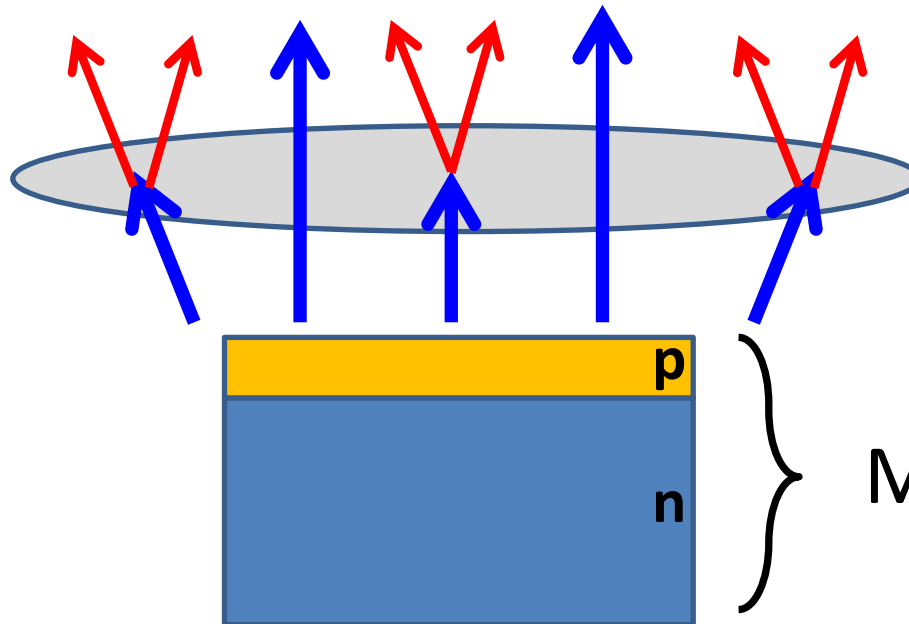
Mešanica modre in rumene je
bela svetloba



Fluorescentna
snov
(modra=>rumena)

Modra LED

Mešanica modre in rdeče je
rožnata svetloba



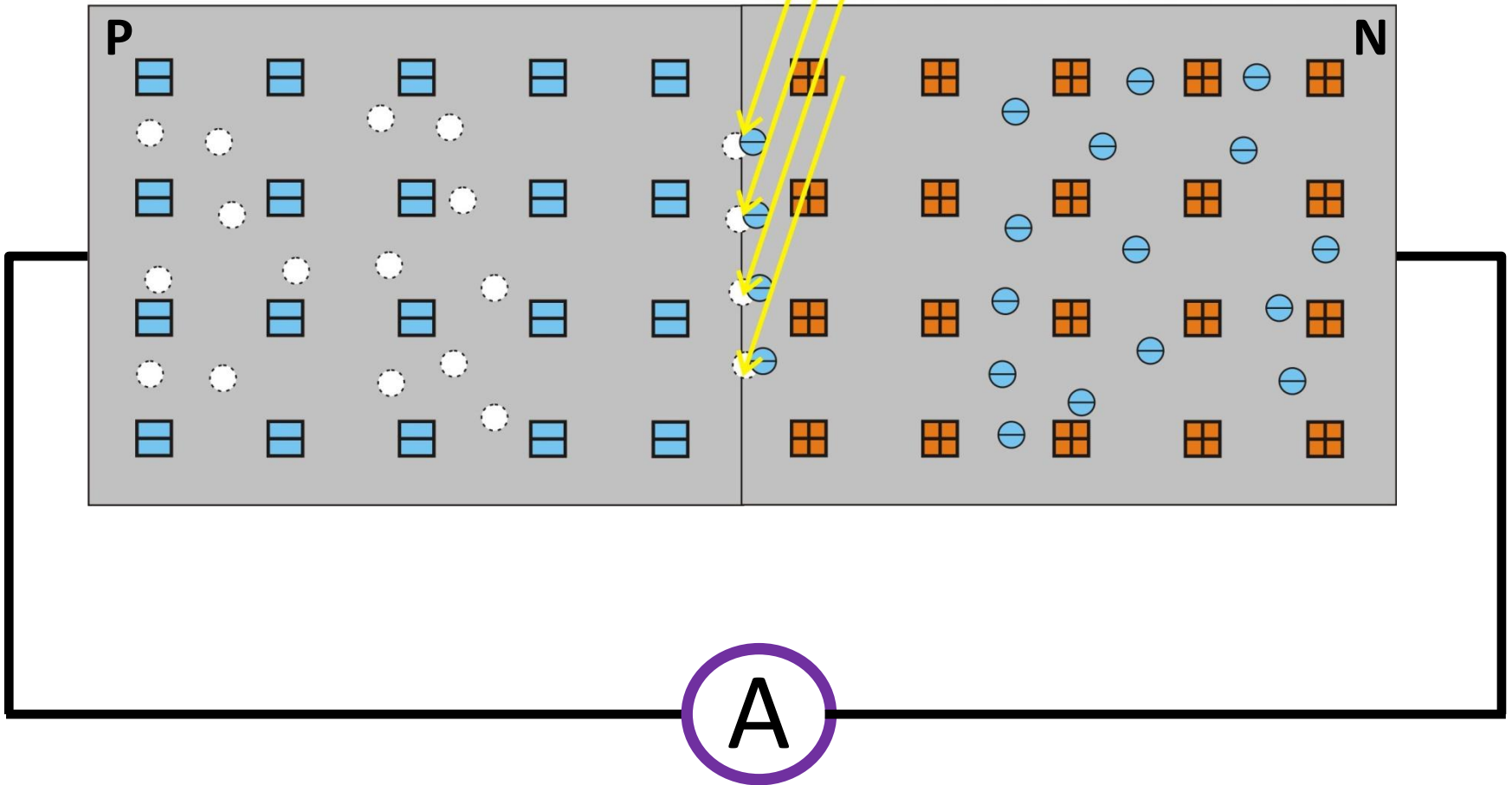
Fluorescentna
snov
(modra=>rdeča)

Modra LED

Testni poskus: naredimo sami belo
in rožnato LED iz modre LED!

LED kot sončna celica

Fotoni ustvarijo pare elektron-vrzel



LED kot sončna celica

Notranje E polje
razmakne nosilce naboja

