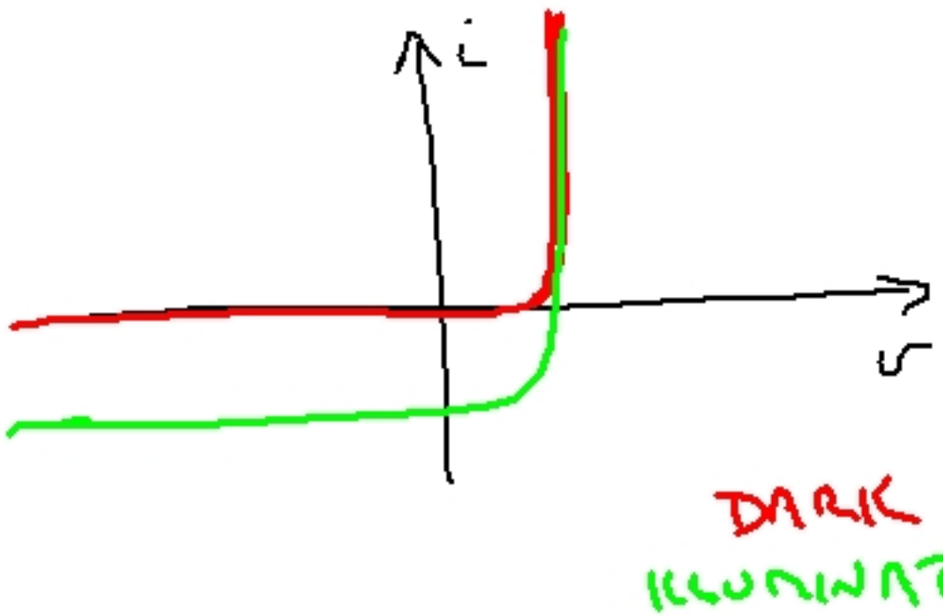
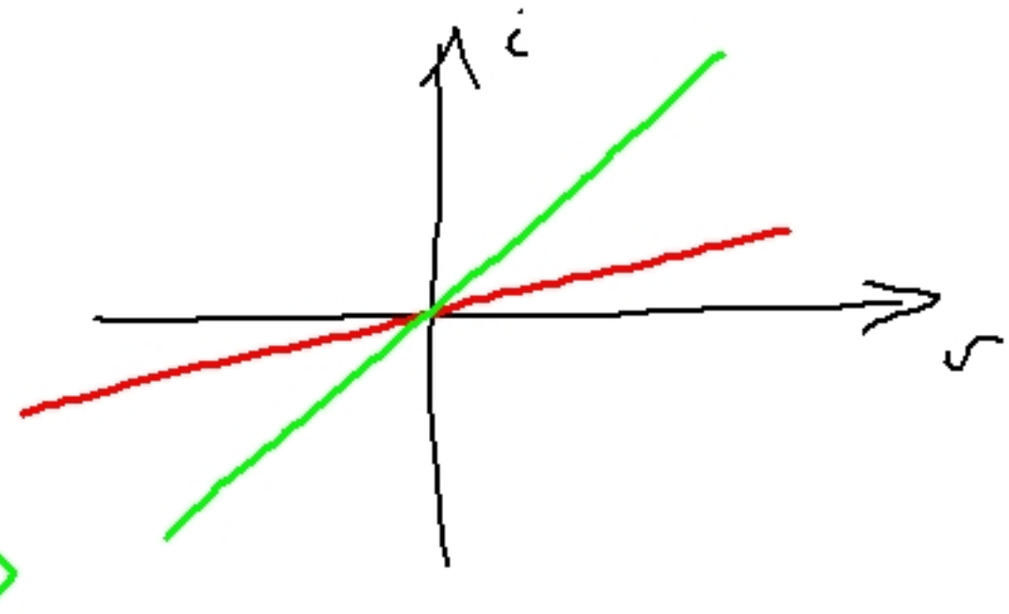
LECTURE 23 -

PHOTODETECTORS

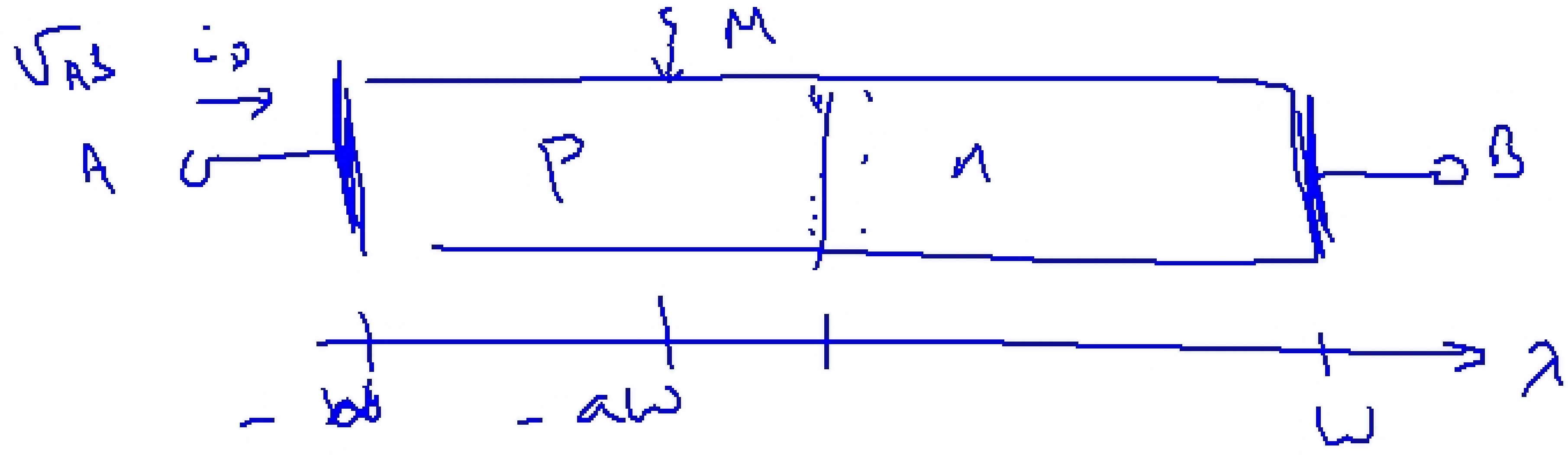
PHOTODIODES



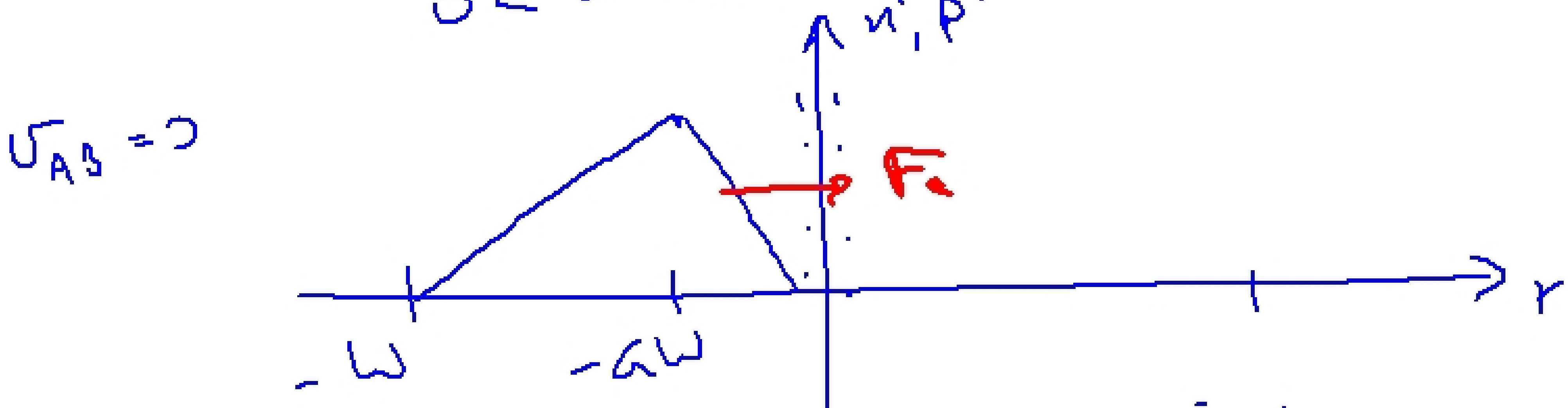
PHOTOCONDUCTORS

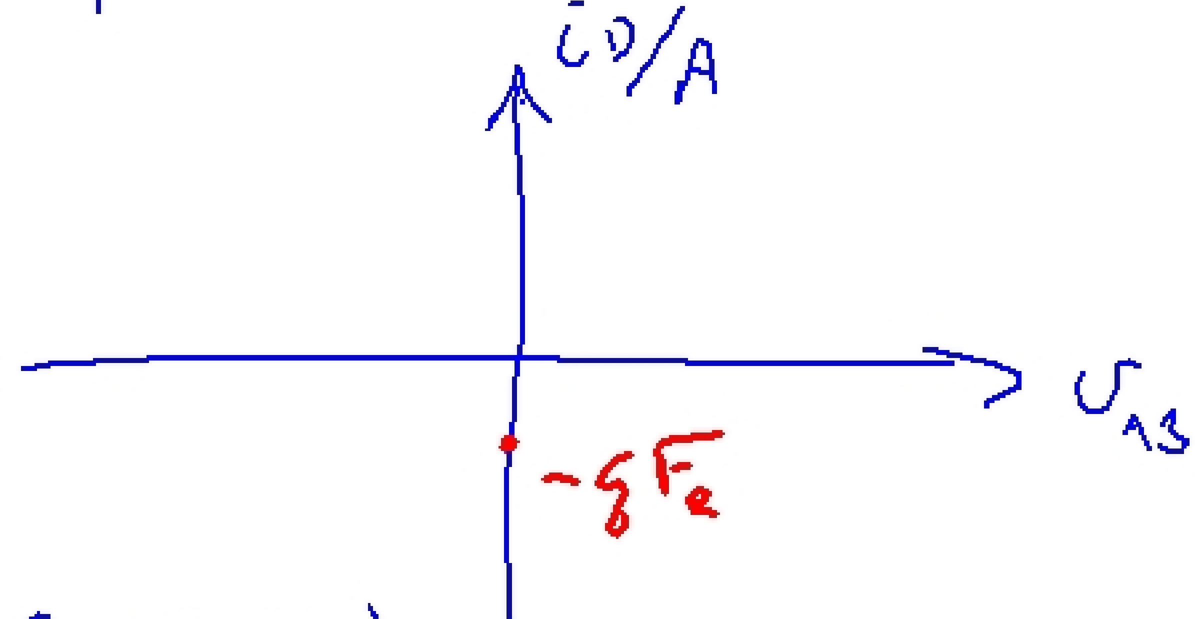


PHOTODIODES



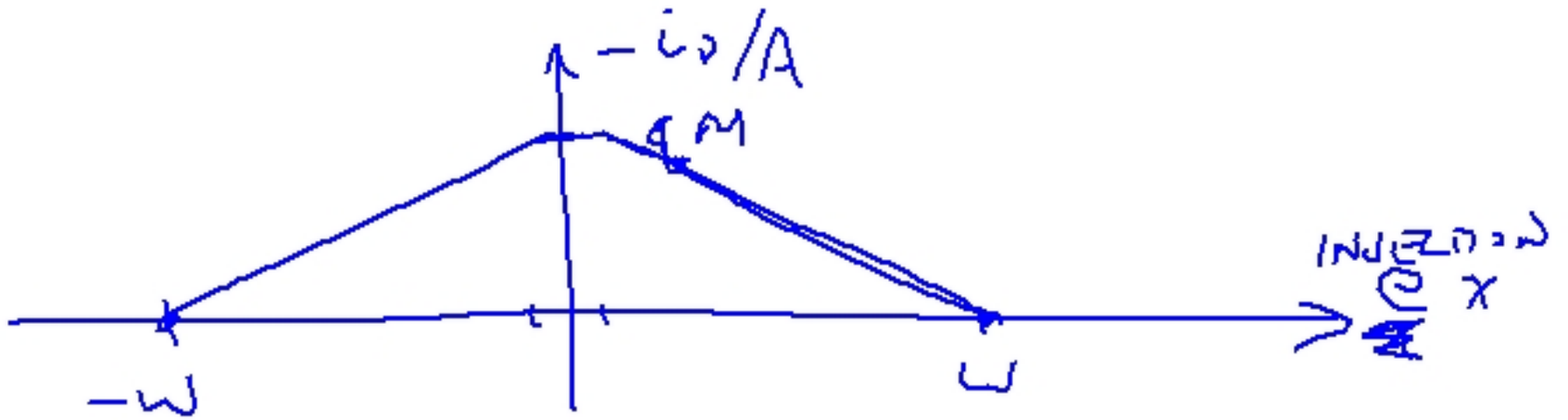
$0 < a < 1$

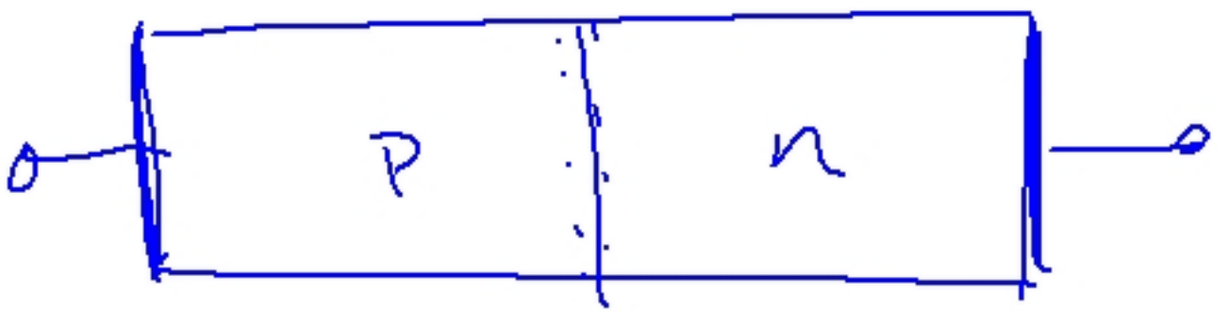


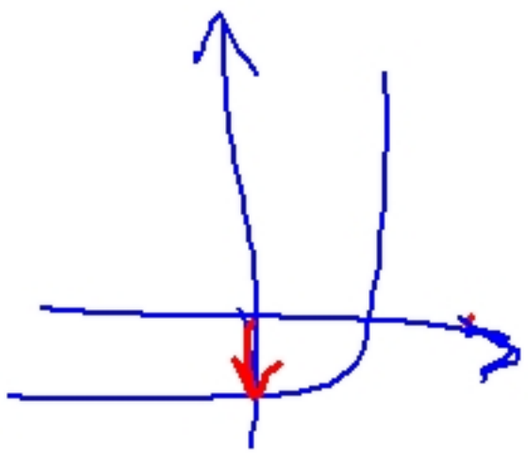


gM carries $I(x)^2$ @ $x = -aW$

$$\frac{i_D}{A} = J_e = -qM(1-a)$$







WANT:

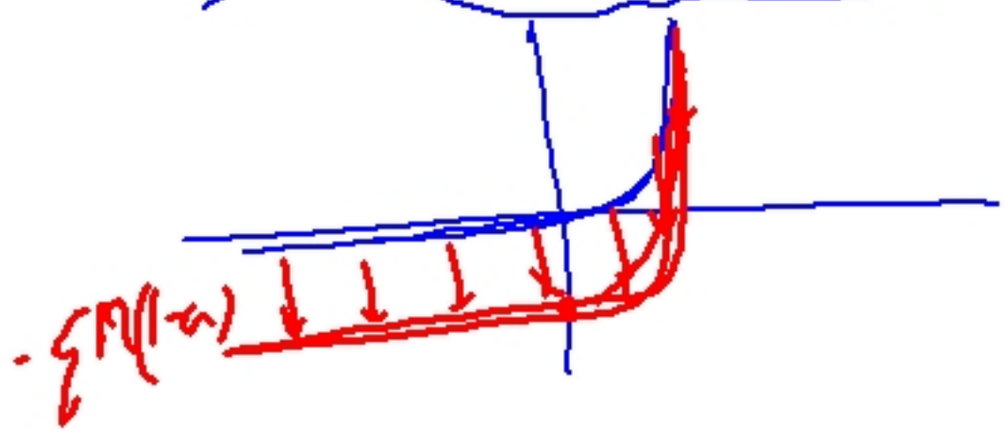
$$i_D(M\text{ea}, v_{AB})$$

$$= i_D(M\text{ea}, 0) + i_D(0, v_{AB})$$

$$i_D(0, v_{AB}) = I_S\left(e^{q v_{AB}/kT} - 1\right)$$

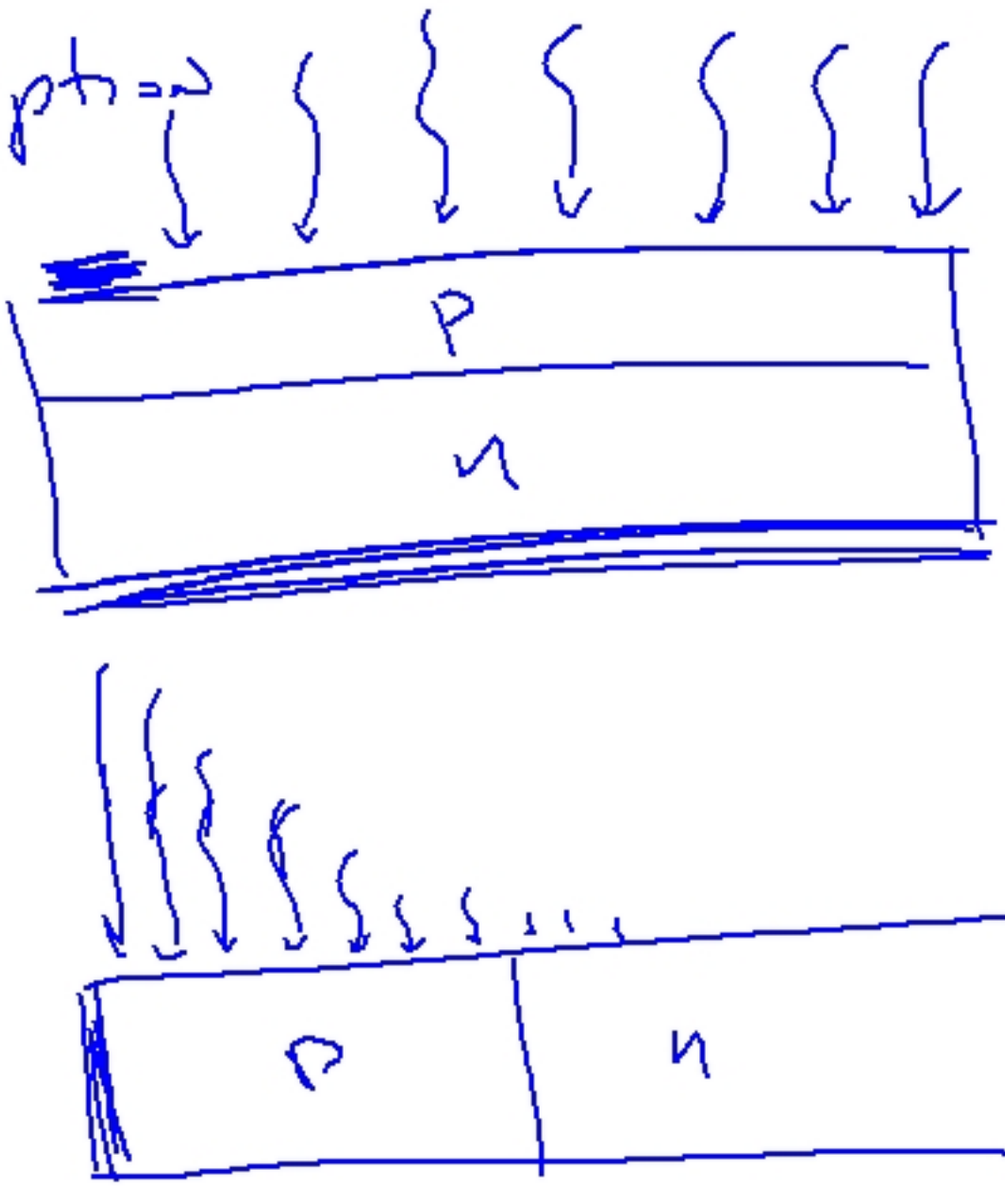
$$i_D(M\text{ea}, 0) = -qM(1-a)$$

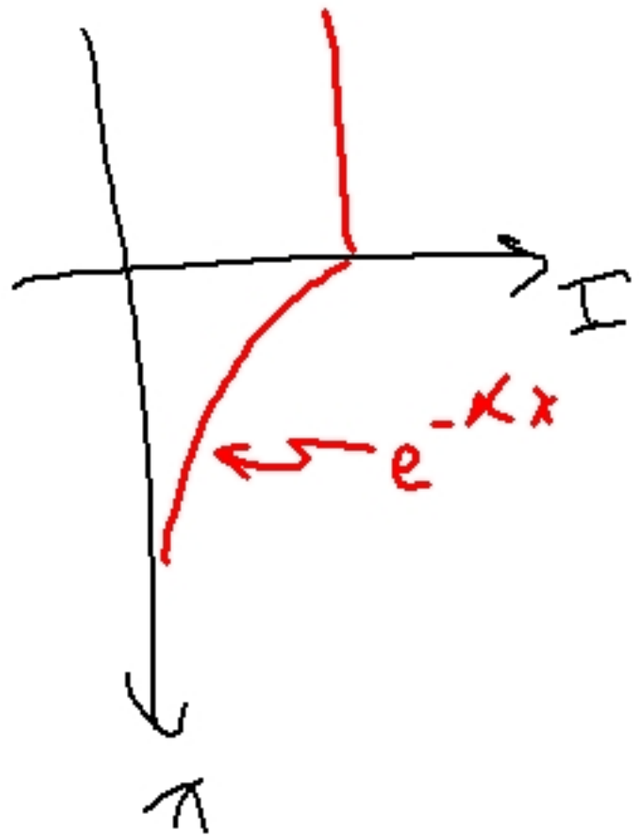
$$i_D(M\text{ea}, v_{AB}) = I_S\left(e^{q v_{AB}/kT} - 1\right) - qM(1-a)$$



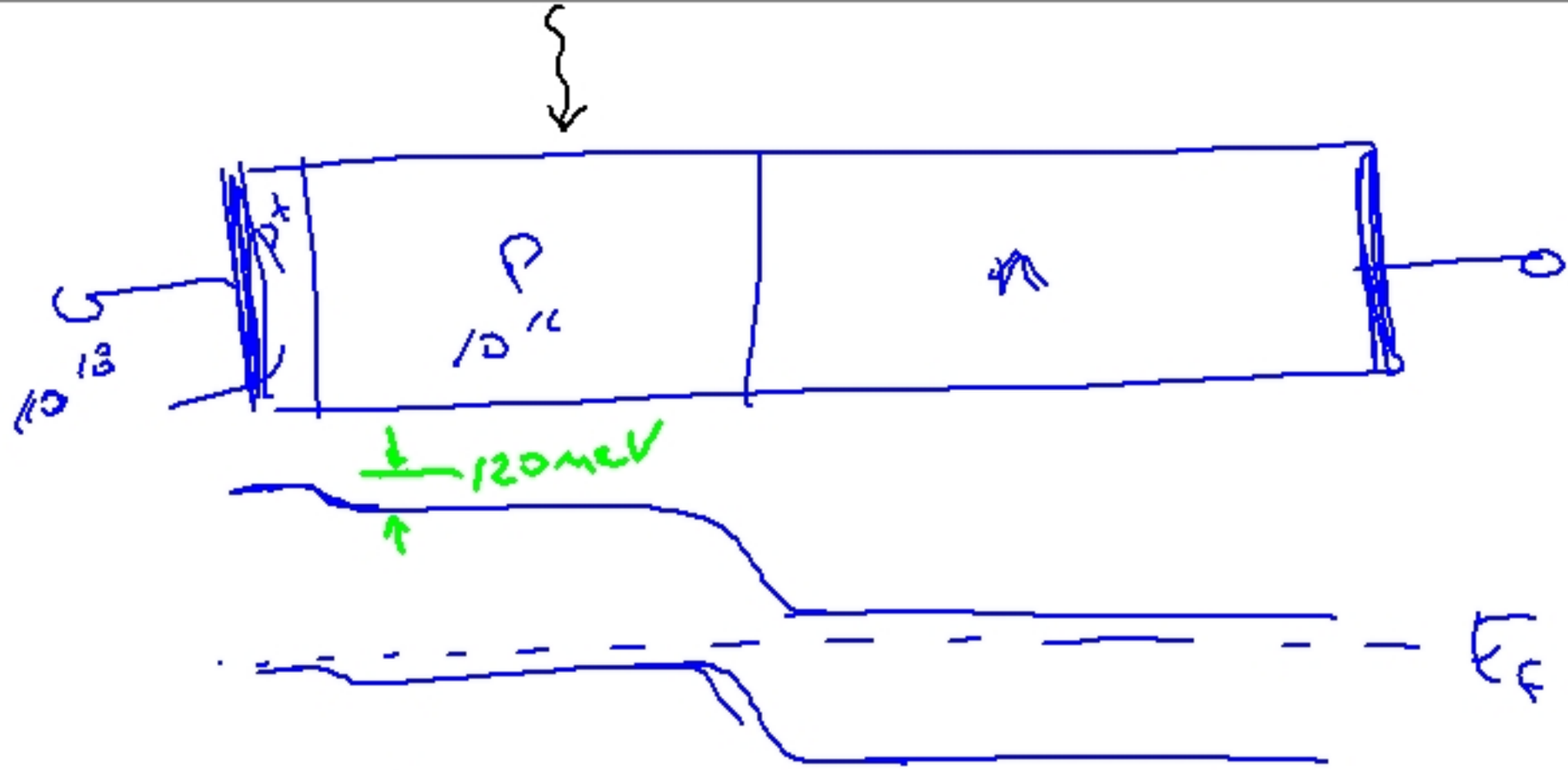
LESSON SO FAR — 100% efficient illuminated IN SCL

Light absorption





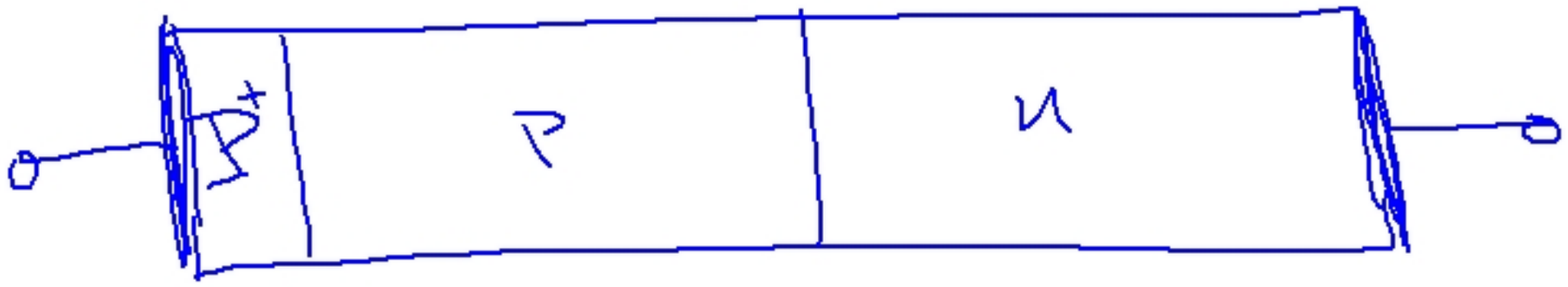
HOW DO WE GET CARRIERS GENERATED NEAR SURFACE TO CROSS THE JUNCTION?



∴ SURFACE BARRIER LAYER WORKS WELL

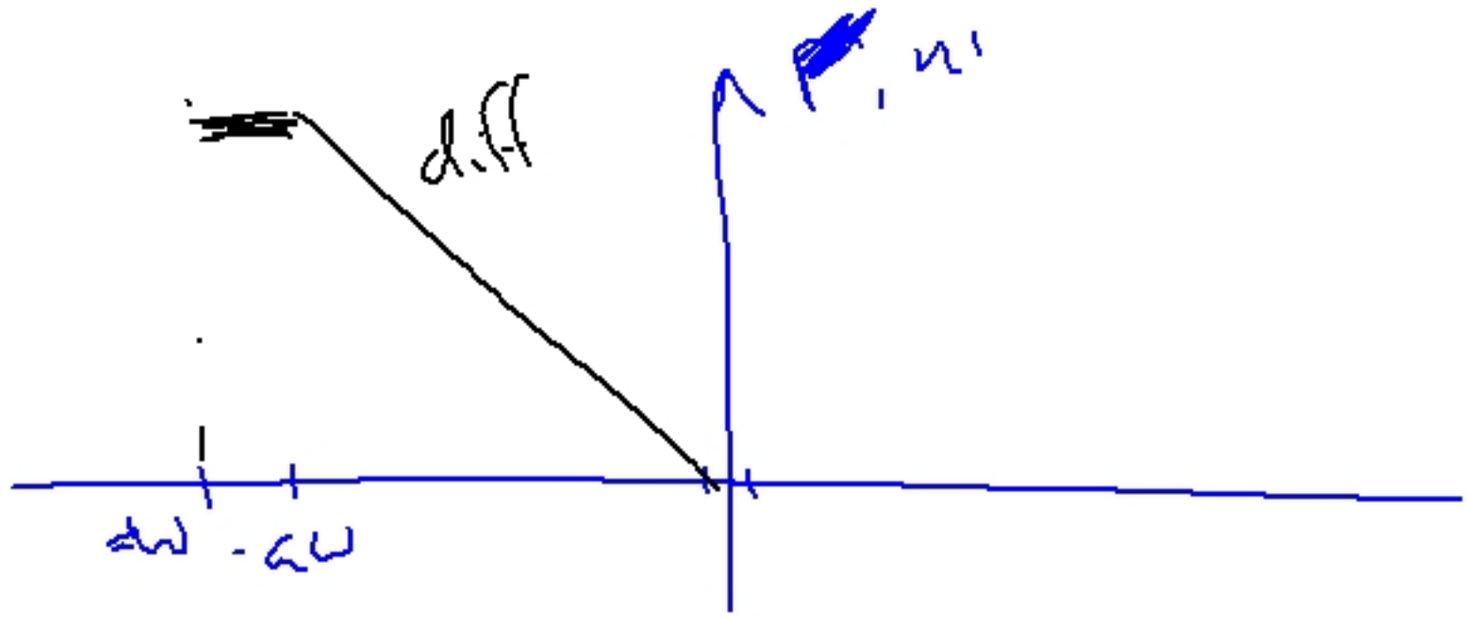
BUT THERE IS STILL APPRECIABLE ABSORPTION IN THIS P+ LAYER

SOLUTION — WIDE BANDGAP WINDOW LAYER



THIS GIVES GOOD RESPONSIVITY (ie. high η)

WHAT ABOUT SPEED ?



COMPARE TRANSIT TIME ACROSS d

$$\tau_{tr\ Diff} = d^2/2D_e$$

$$\tau_{tr\ Drift} = \frac{d}{v_{drift}} = \frac{d}{S_{sat}}$$

$$\frac{\tau_{tr\ Drift}}{\tau_{tr\ Diff}} = \frac{2D_e}{S_{sat}\, d}$$

$$= \frac{2\times10^2}{10^3} = 0.2$$

$d = 1\mu m = 10^{-4}$ cm

$S_{sat} = 10^7$ cm/s

$D_e = 10^2$ cm^2/s

$$\tau_{drift} = \frac{1}{5} \tau_{diff}$$

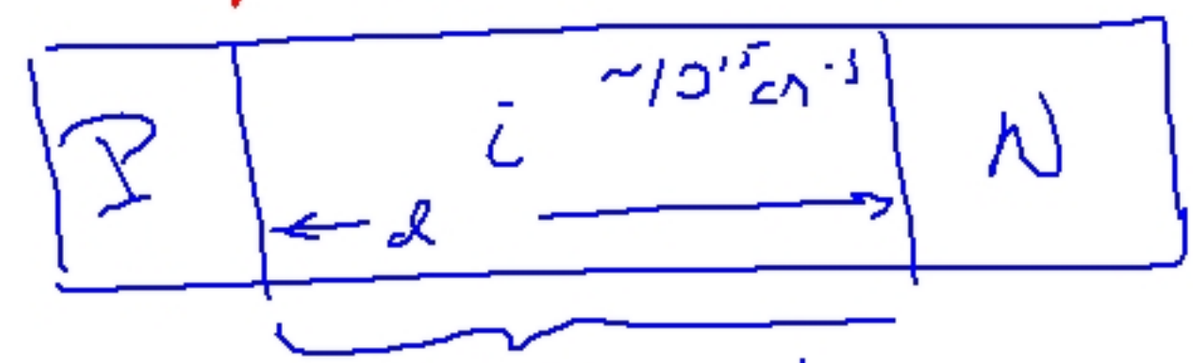
Tells us diode would be much faster if all light was absorbed in a depletion region!

To get a depletion region that is 1-2 μm wide @ a few volts, you need very light doping.

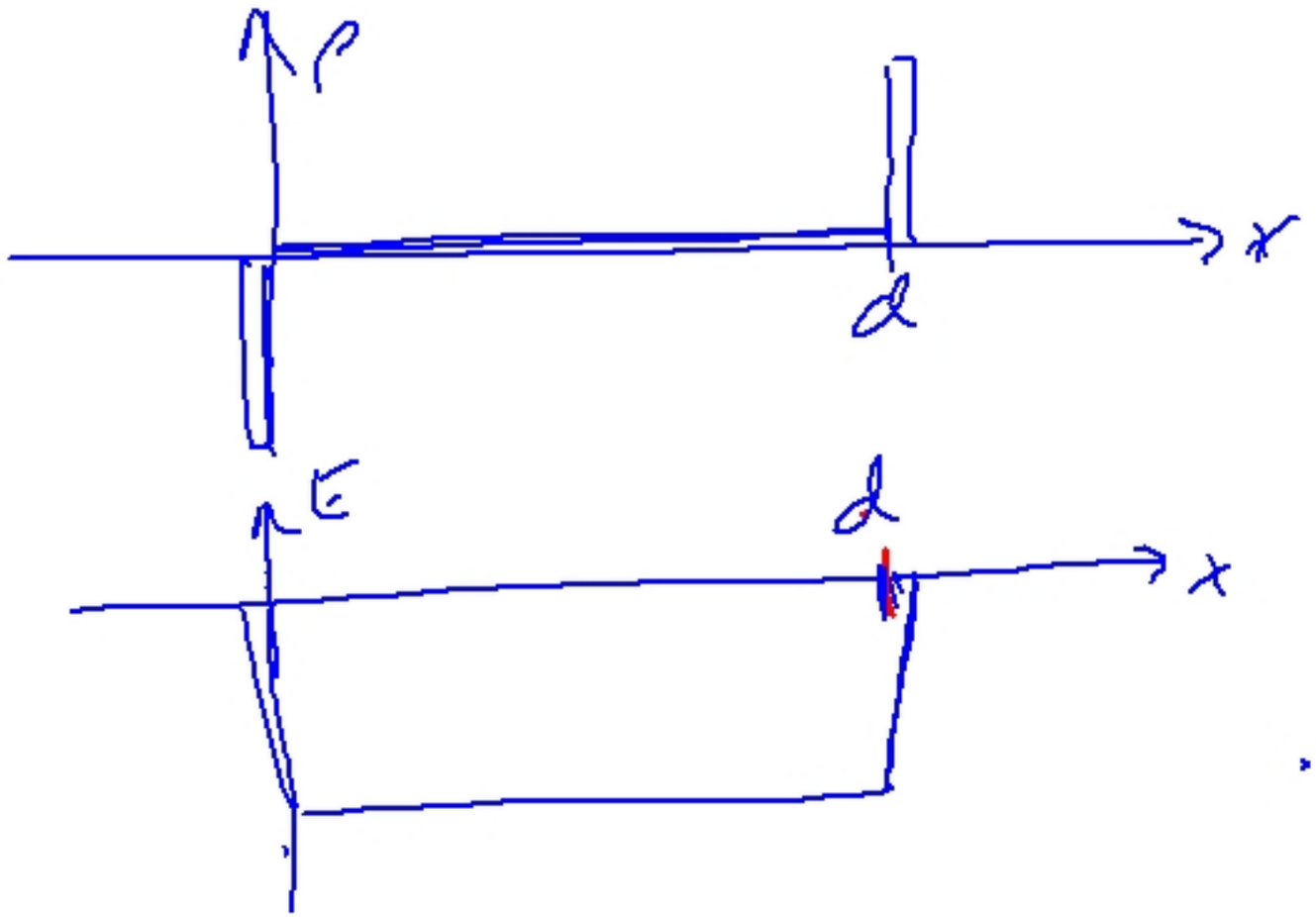
⟹ p-i-n

P - i - N

absorbing region + drift region



$d \approx 1-2\,\mu m$ typ.



P.N SPECTRUM

$$V_{out} = i_{ph} R_{in}$$

$$\tau_{RC} = (C_{det} + \cancel{C_{in\,amp}}) R_{in}$$

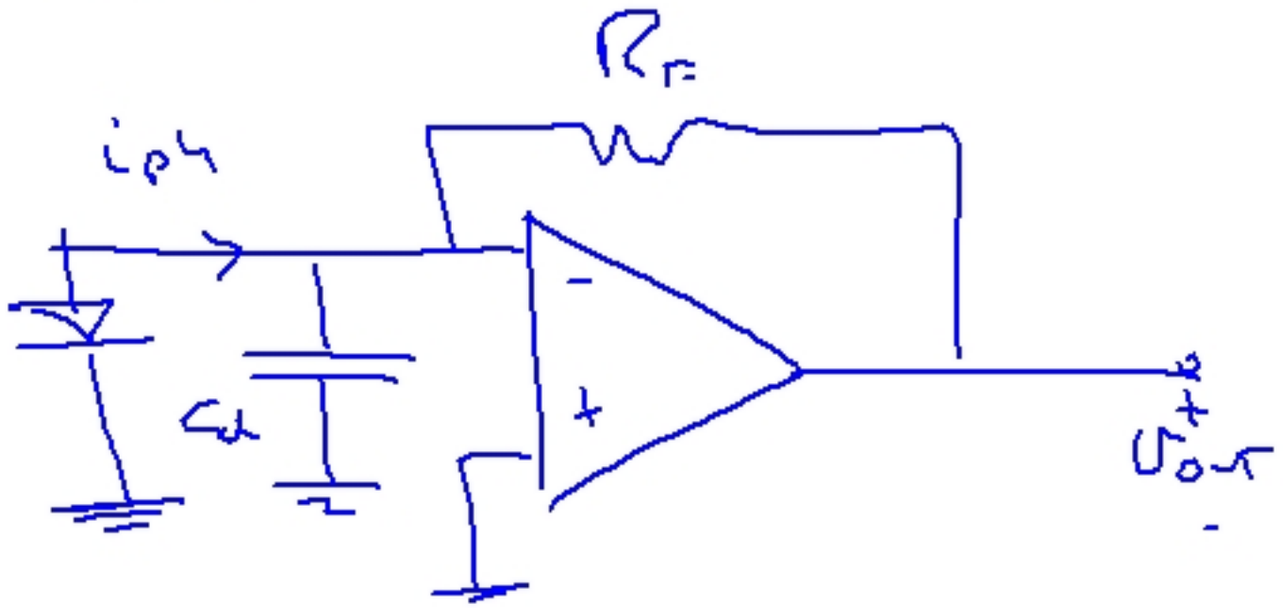
$$\approx \frac{\epsilon A}{d} R_{in}$$

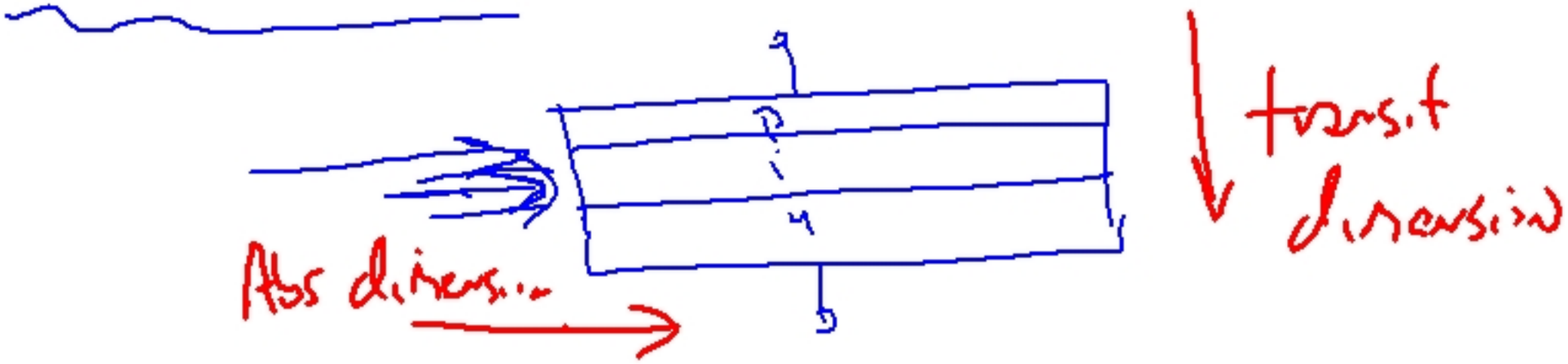
$$\tau_{tr} = \frac{d}{S_{sat}}$$

$$\tau_{TOT} = \frac{d}{S_{sat}} + \frac{\epsilon A}{d} R_{in}$$

$$\tau_{TOT\,min} = 2\sqrt{\frac{\epsilon R_{in} A}{S_{sat}}}$$

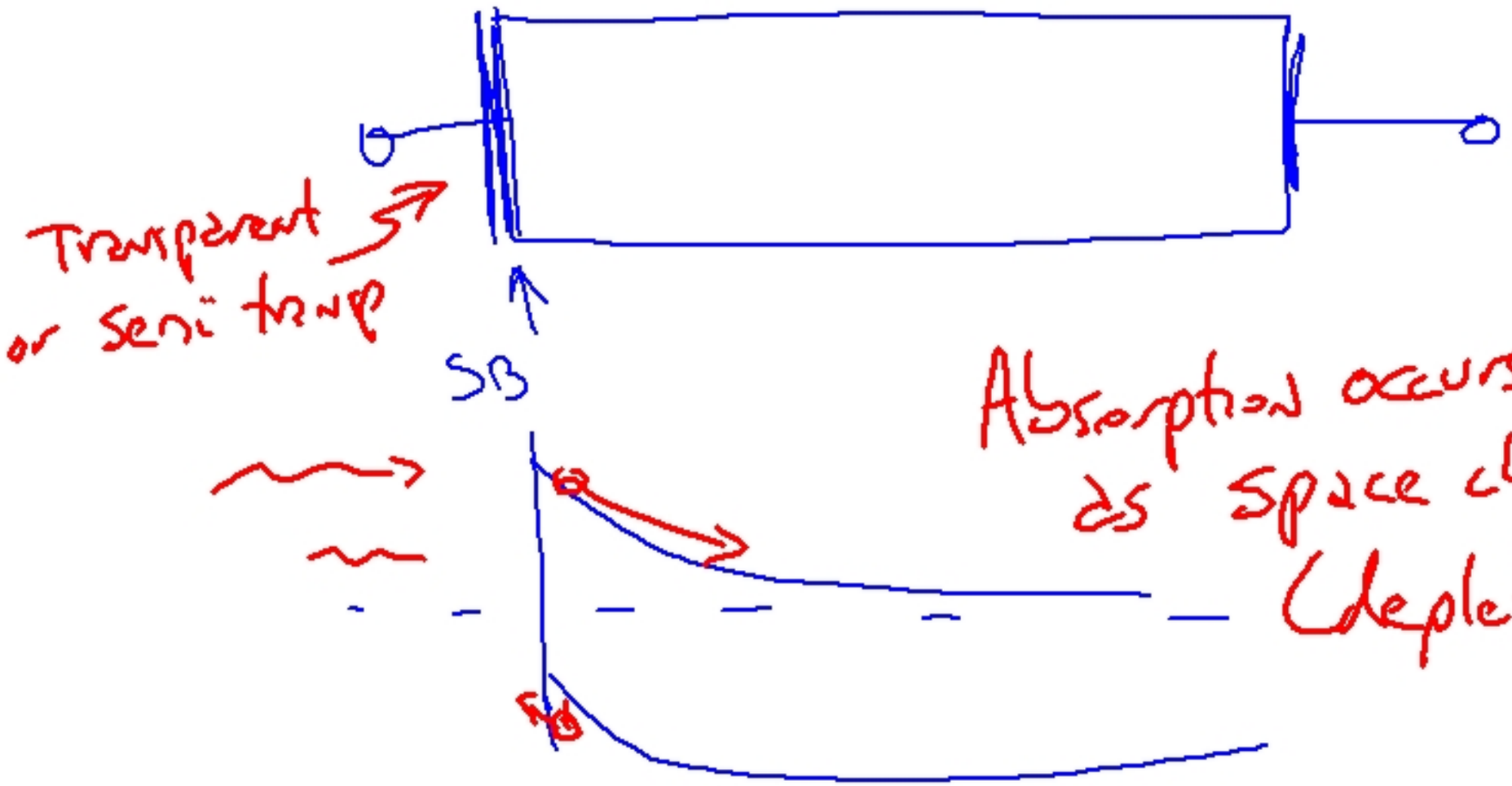
$$d_{opt} = \sqrt{S_{sat}\,\epsilon\, R_{in} A}$$

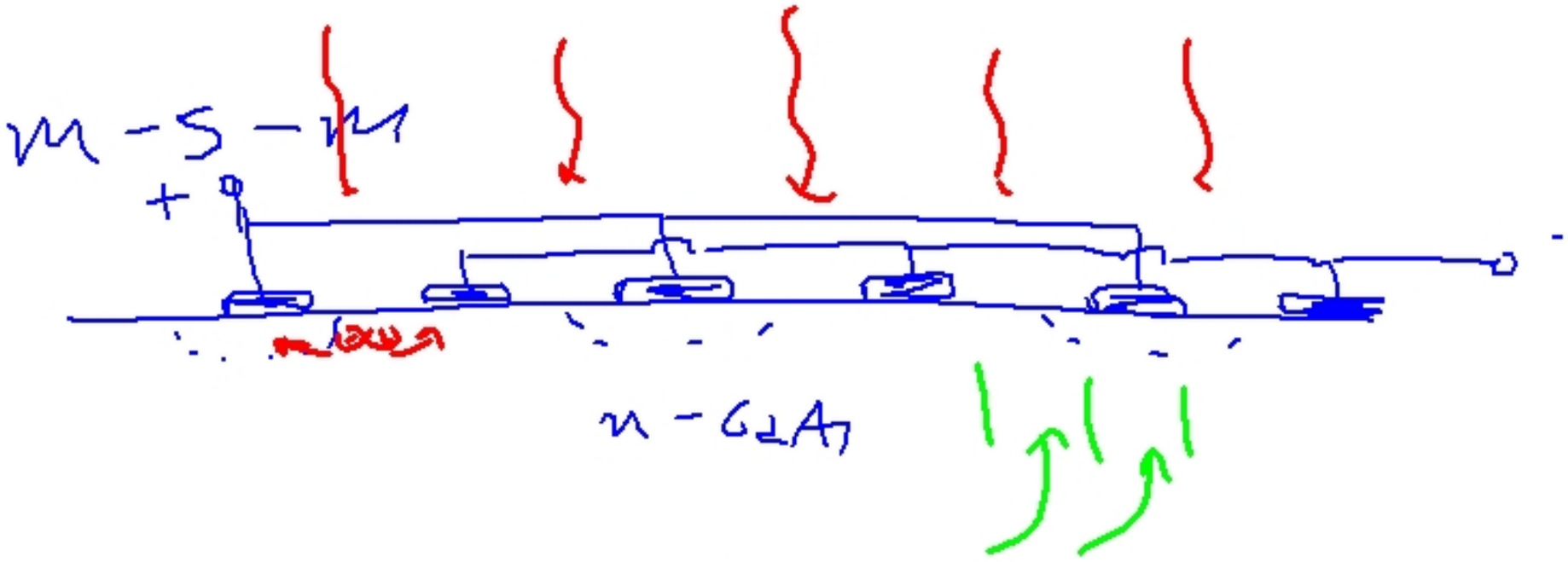




P-n diode
P-i-n diode

Metal-semiconductor diode
(Schottky barrier)

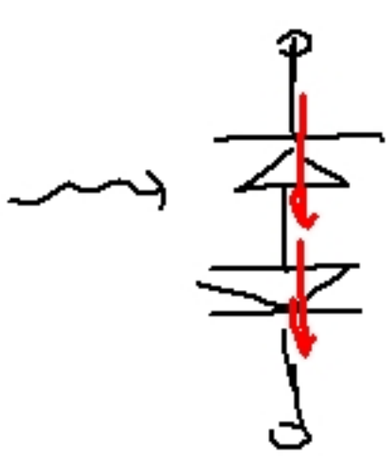


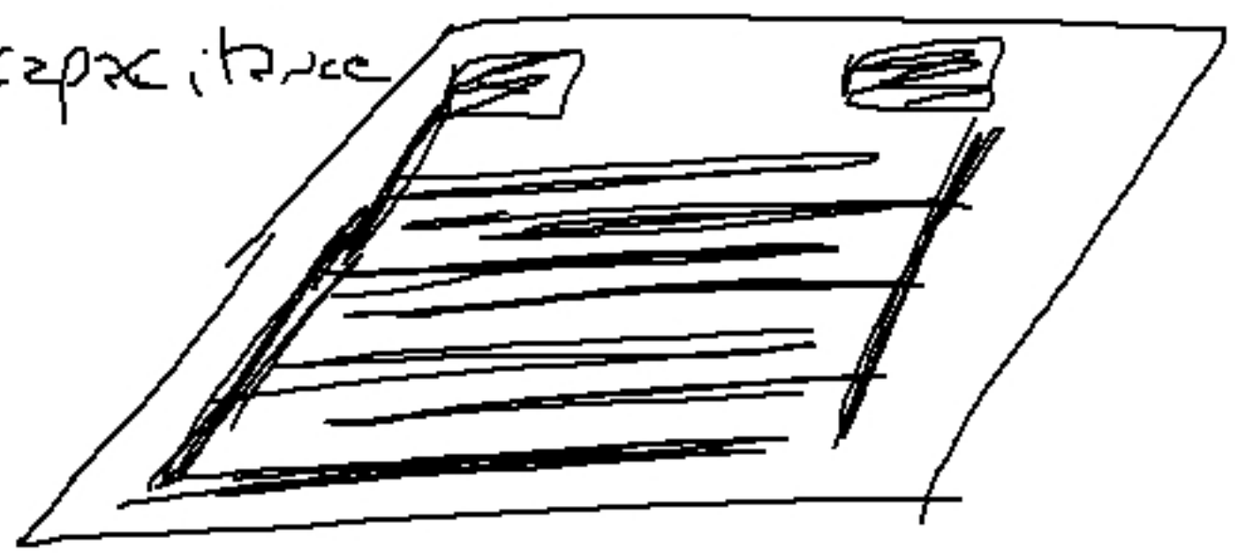


Simple to make

Diodes can be very small ⇒ very fast

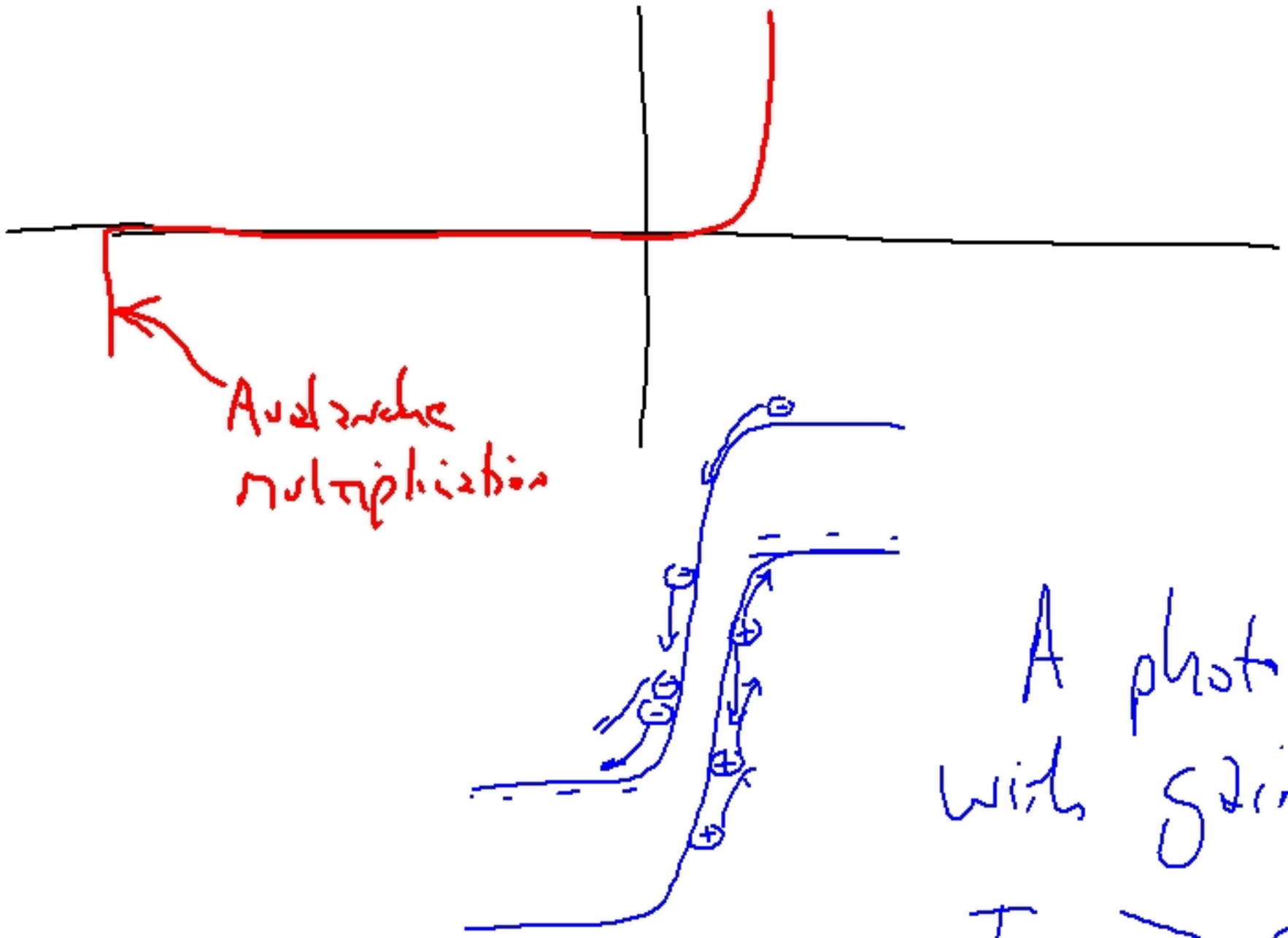
Very low capacitance





FINAL PHOTODIODE

AVALANCHE PHOTODIODES



A photodiode with gain

$I_{ph} > gMA$