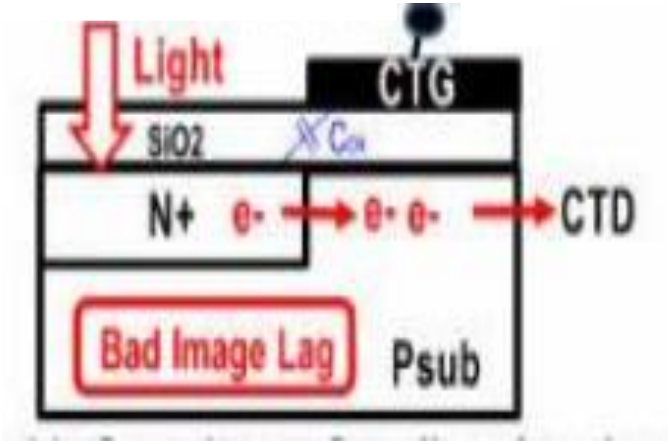
Yoshiaki Hagiwara

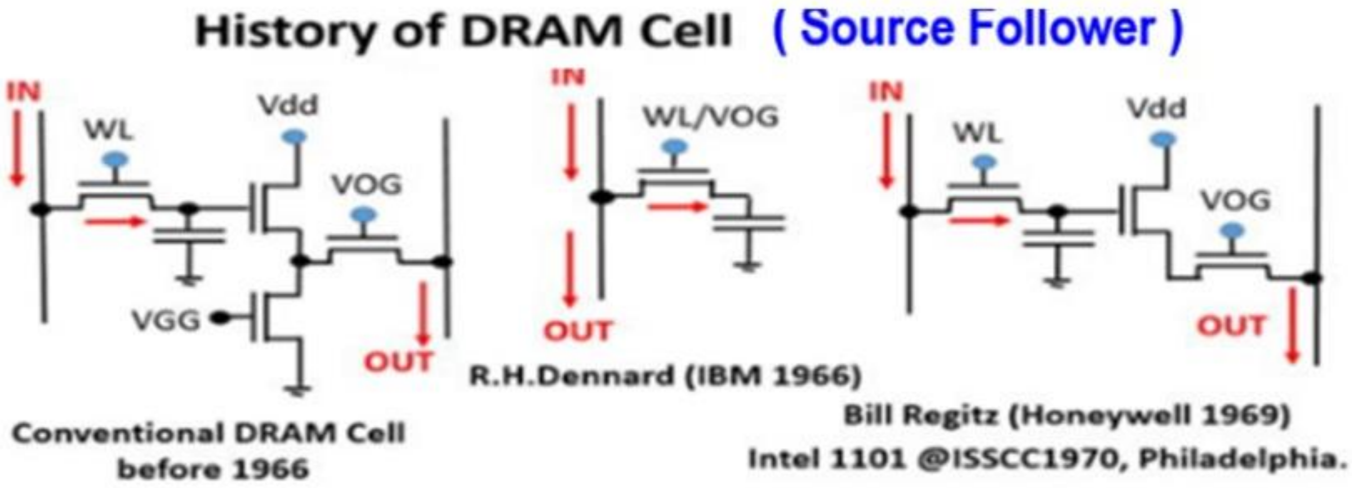
2 Single N+P floating junction type PDD

Under Construction

2 Single N+P floating junction type PDD

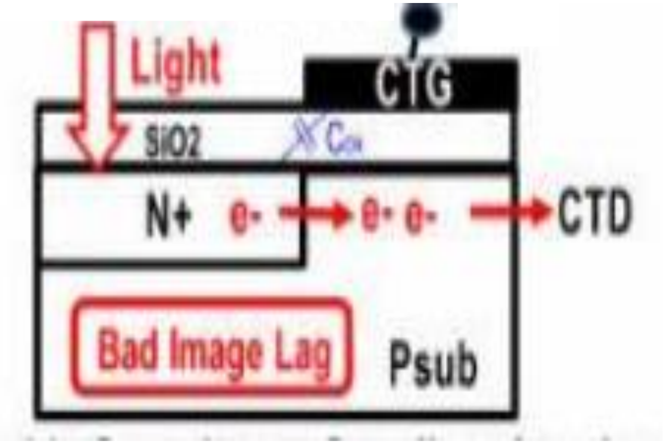
In the advancement of the one transistor one capacitor (1T1C) DRAM cell process technology in early 1970s, the image sensor with the same MOS type charge transfer device (CTD) was attractive since the DRAM memory and the MOS image sensor can be fabricated both with almost the same process technology and also with a very similar output read out circuit configuration although one uses digital MOS output circuits while the other uses analog MOS output circuits.



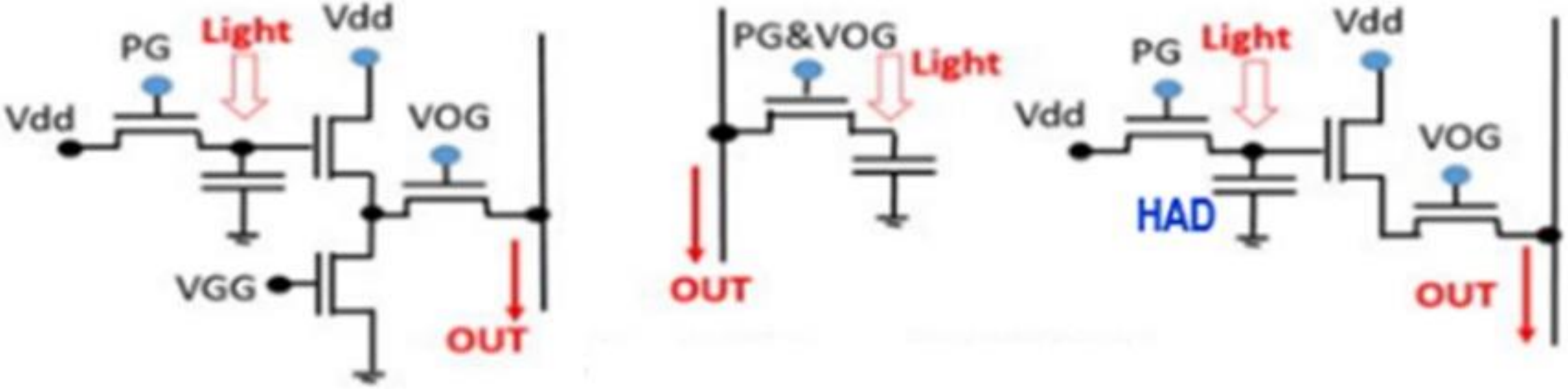


2 Single N+P floating junction type PDD

The classical MOS image sensor cell is also one transistor one capacitor (1T1C) type photo cell. The simple N+ heavily doped floating source region of a MOS transistor is used as the photo charge collecting and storage region.



History of Photo Diode Cell (Source Follower)



Conventional Active Pixel Circuit
Photo Diode in 1966

after Peter Nobel,1966~1968

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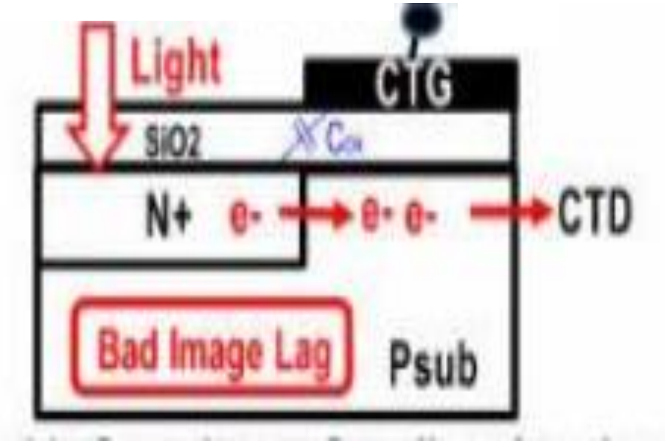
Since the majority carrier photo electrons stored in the heavily doped photo charge collecting and storage N+ region cannot be drained completely when reset, a small amount of the photo signal charge cannot be drained in the limited short reset time duration and the undesired image lag problem occurs.



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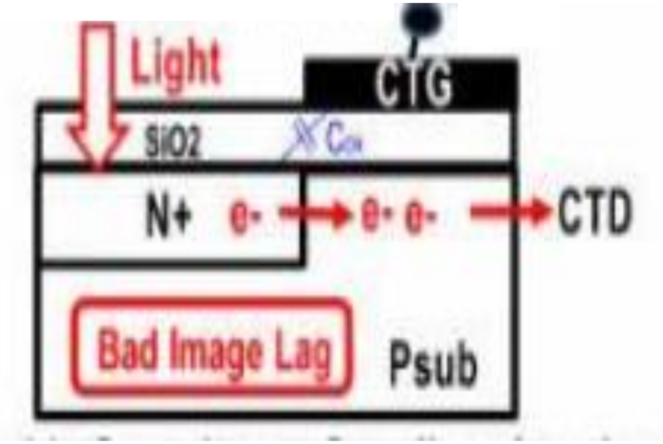
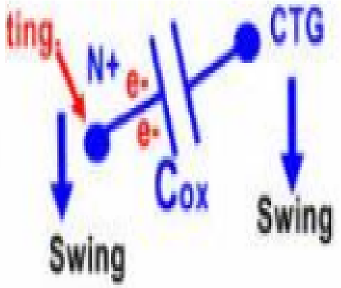
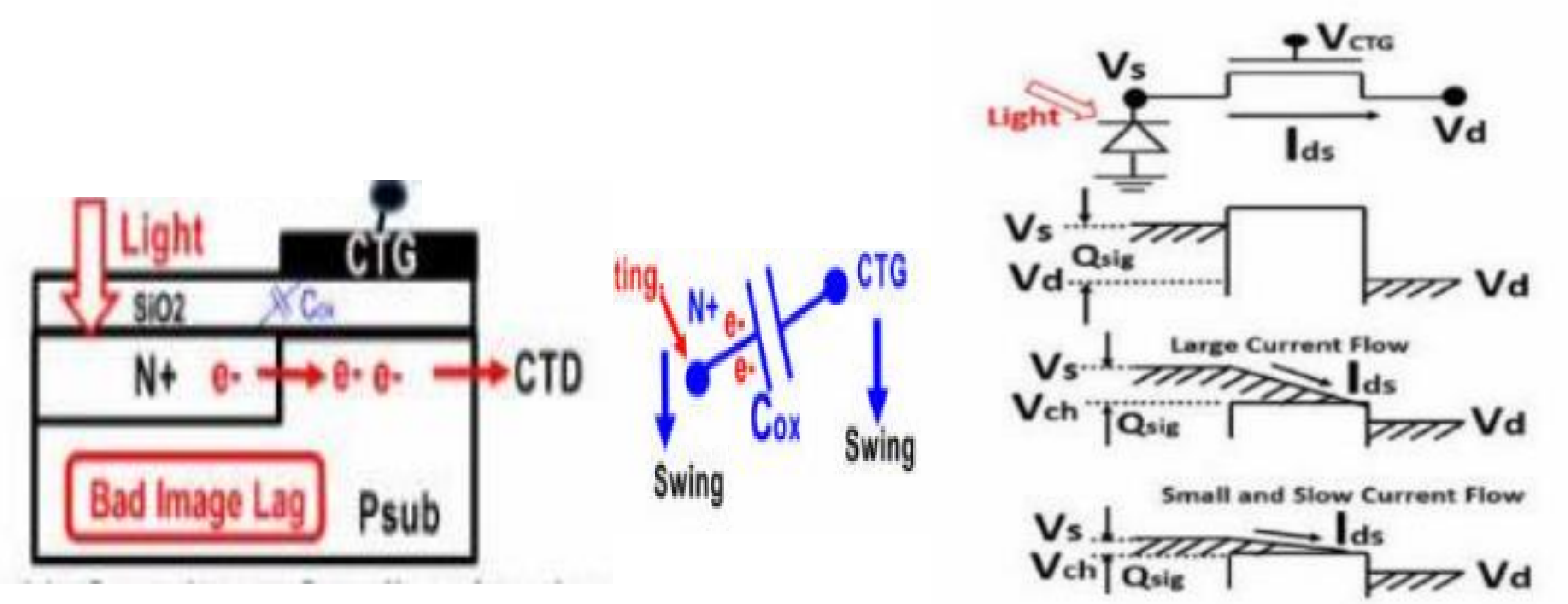
Since the heavily doped N+ region is floating, the parasitic oxide capacitance Cox between the charge transfer gate (CTG) and the N+ floating region cannot be ignored. The reset clock pulse of the charge transfer gate (CTG) has a strong influence to fluctuate the surface floating potential Vs of the heavily doped N+ charge storage region.





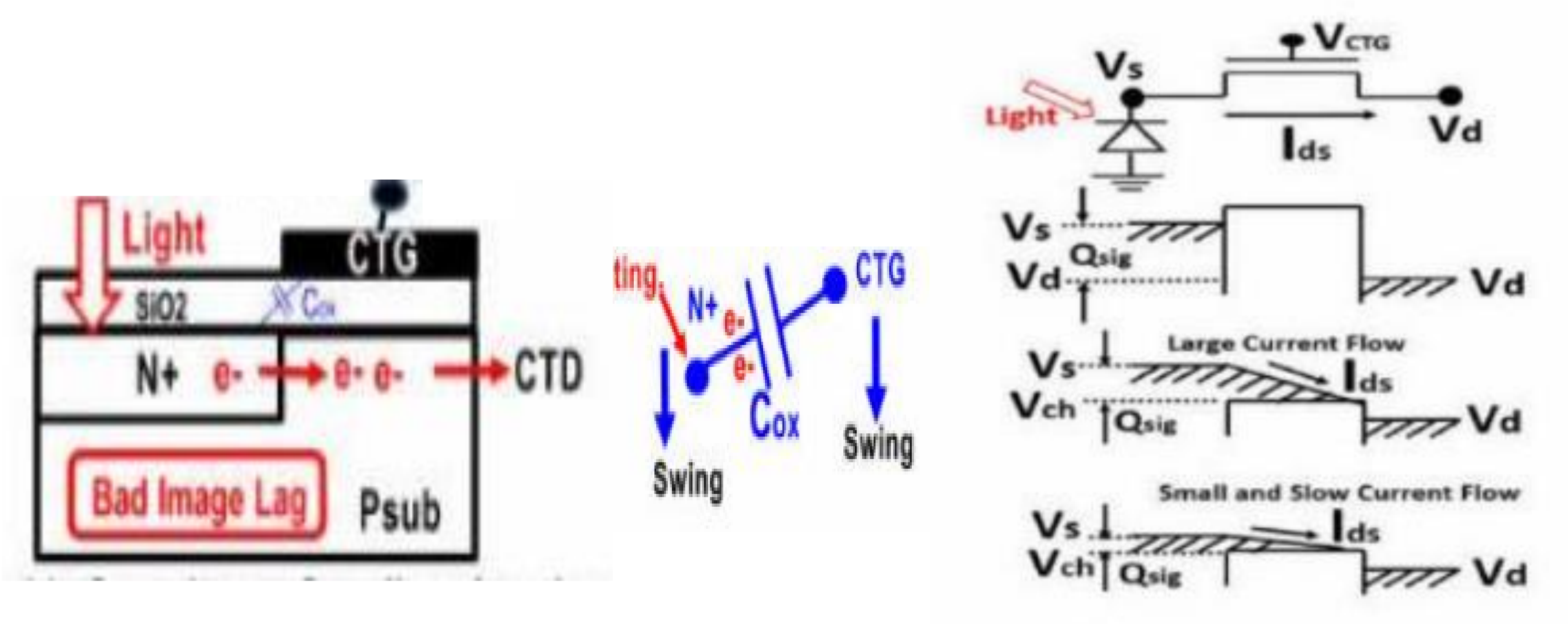
2 Single N+P floating junction type PDD

As the signal charge is drained when reset, the potential level Vs of the floating N+ signal charge storage region eventually becomes very close to the channel potential level ($V_G - V_{th}$) under the charge transfer gate (CTD).



2 Single N+P floating junction type PDD

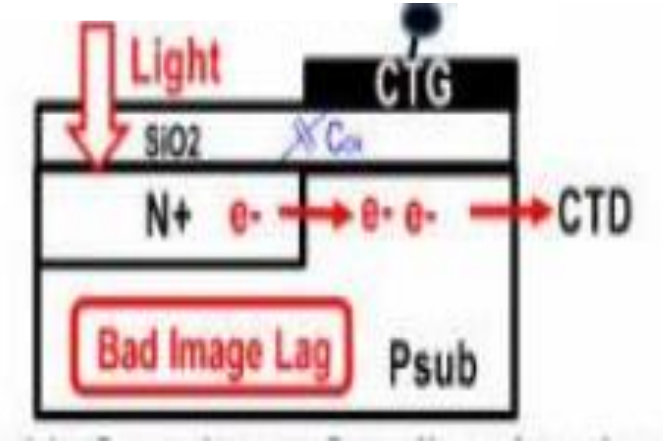
The MOS transistor drain current $Id = k\,(Vs - Vch)^2$ at the saturation mode is proportional to the square of the difference (Vs – Vch) of the surface potential Vs of the N+ charge storage region and the channel potential $Vch = (V_G - Vth)$.

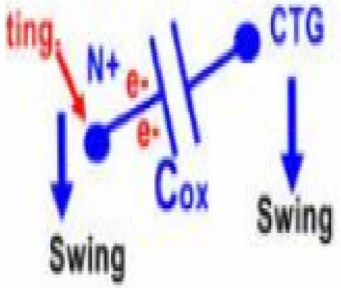


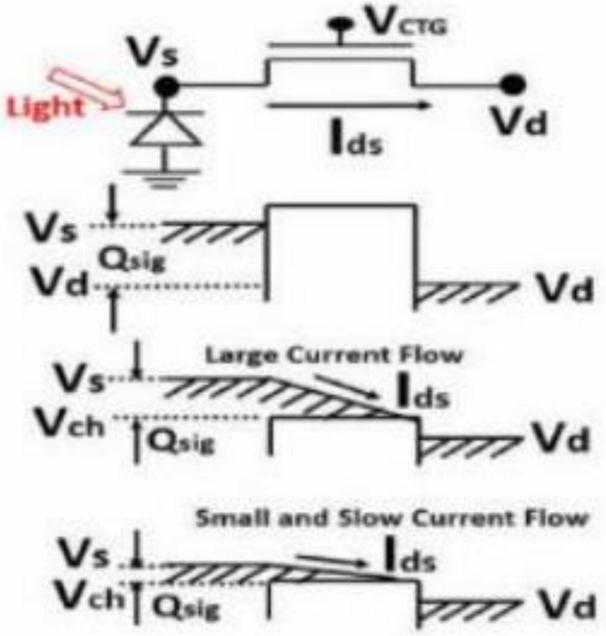
$$Id = k\,(Vs - Vch)^2$$

2 Single N+P floating junction type PDD

The MOS transistor drain current $Id = k(Vs - Vch)^2$ becomes eventually very, very small when the level of the surface potential Vs of the N+ charge storage region gets close to the channel potential Vch.





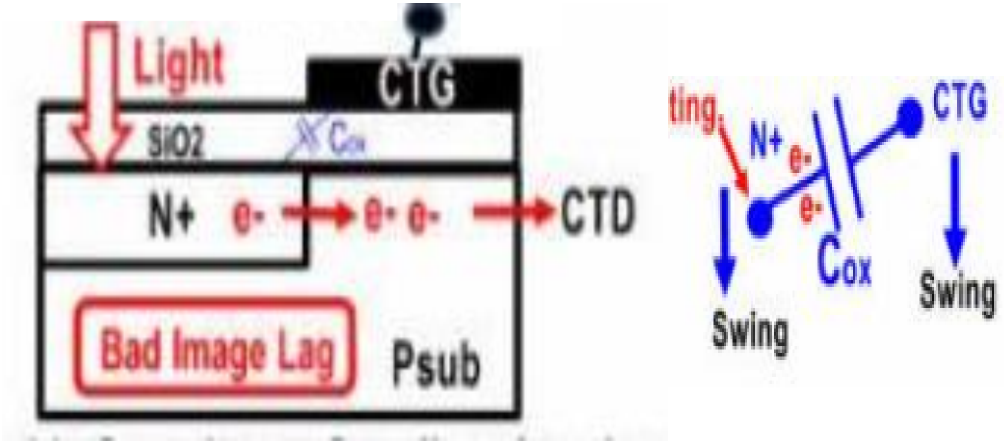


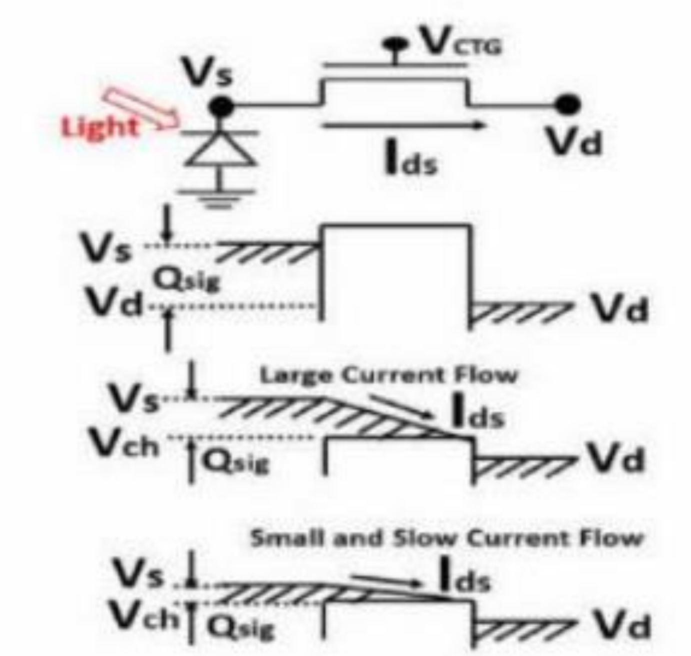
$$Id = k(Vs - Vch)^2$$

As $Vs \rightarrow Vch$,
$Id \rightarrow 0$

2 Single N+P floating junction type PDD

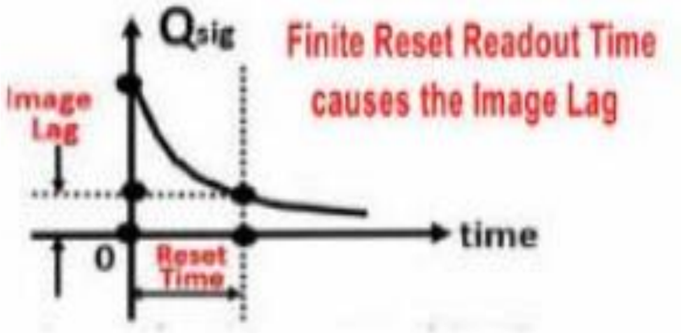
The channel conductance gets very small and with the limited short reset time duration, the signal charge cannot be drained completely, resulting a serious image lag problem.





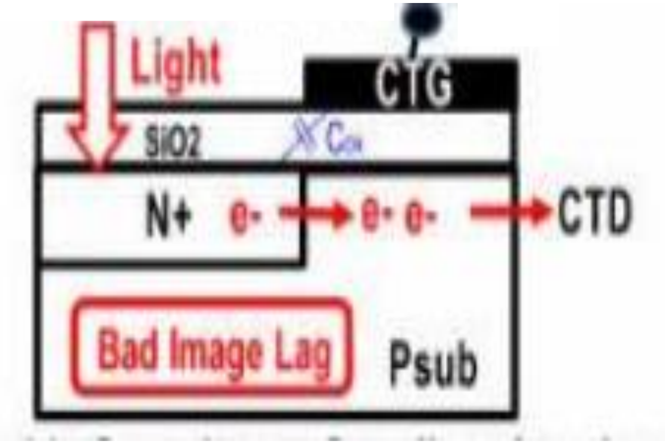
$$Id = k\,(\,Vs - Vch\,)^{2}$$

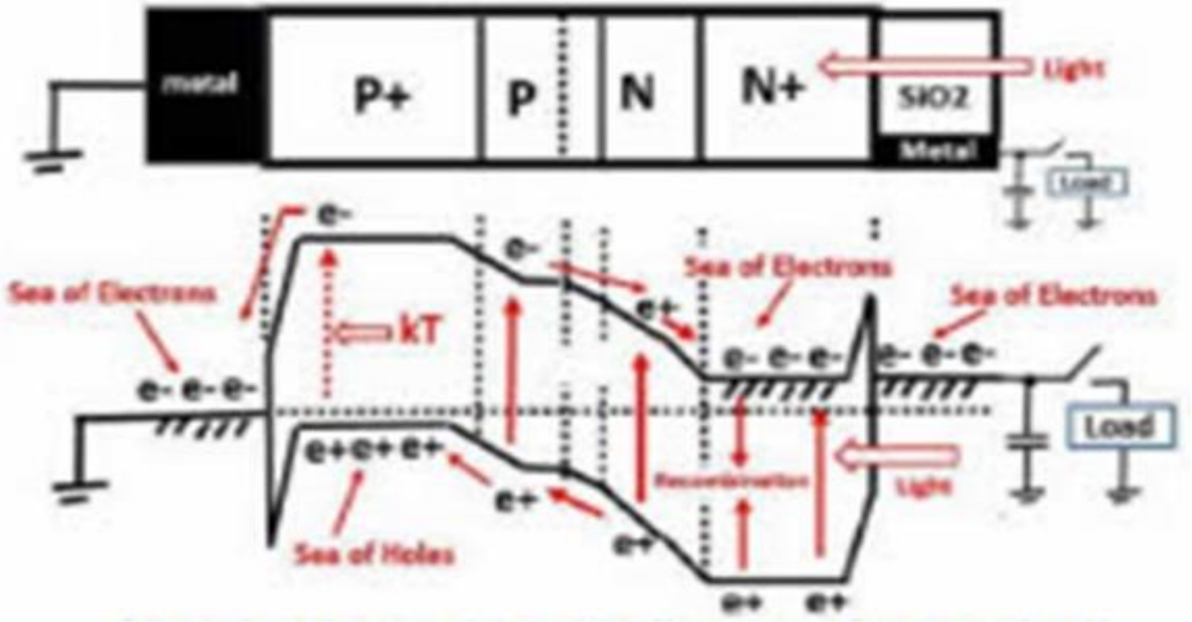
As Vs → Vch,
Id → 0



2 Single N+P floating junction type PDD

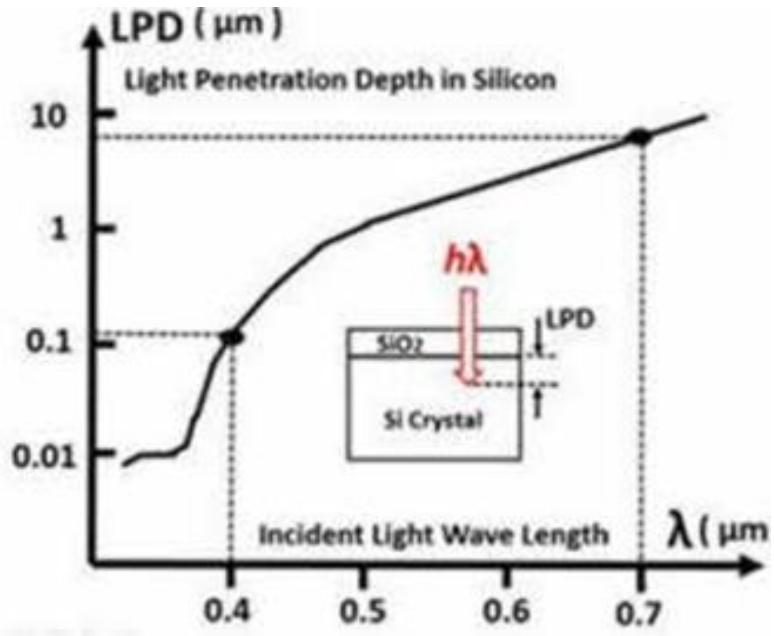
Since the surface potential Vs of the heavily doped N+ photo charge storage region is floating and flat, there is no electric field needed to separate the photo electron and hole pairs generated at the semiconductor surface.

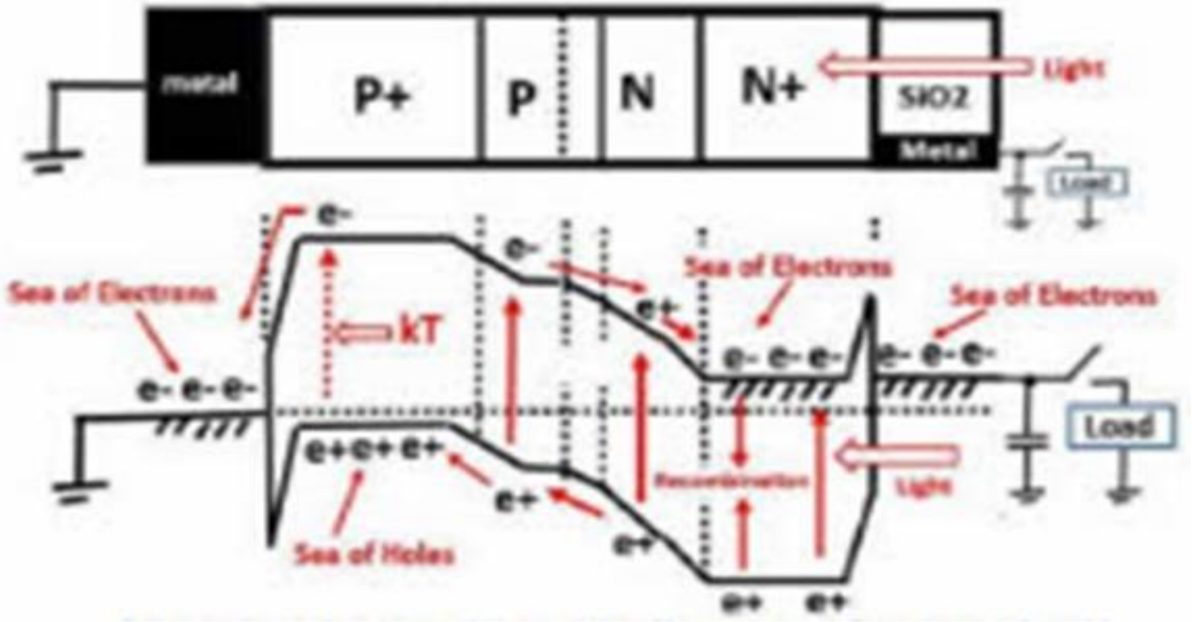




2 Single N+P floating junction type PDD

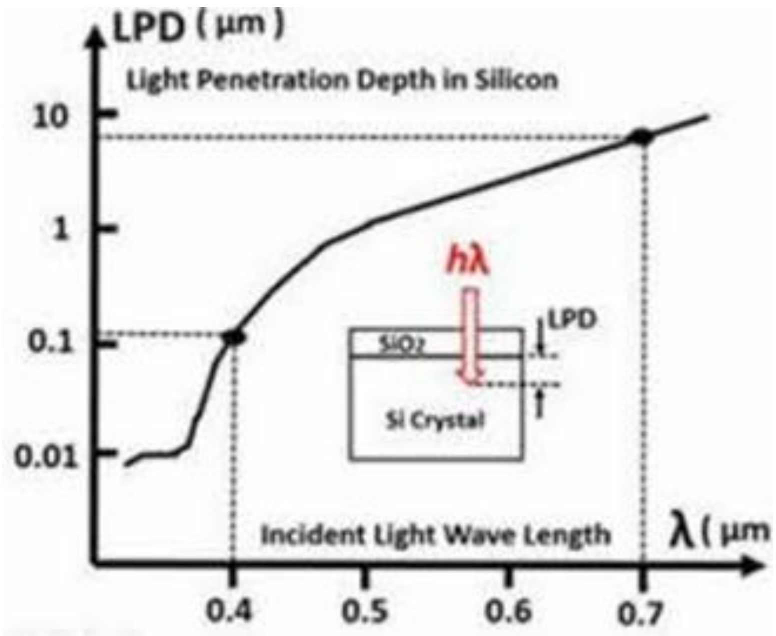
Since the short wave blue light cannot penetrate more than one tenth of a micrometer in depth in the silicon crystal and also because the PN junction cannot form in such a vicinity of the silicon surface, the photo electron and hole pairs generated from the short wave blue light will feel no electric field to separate them.

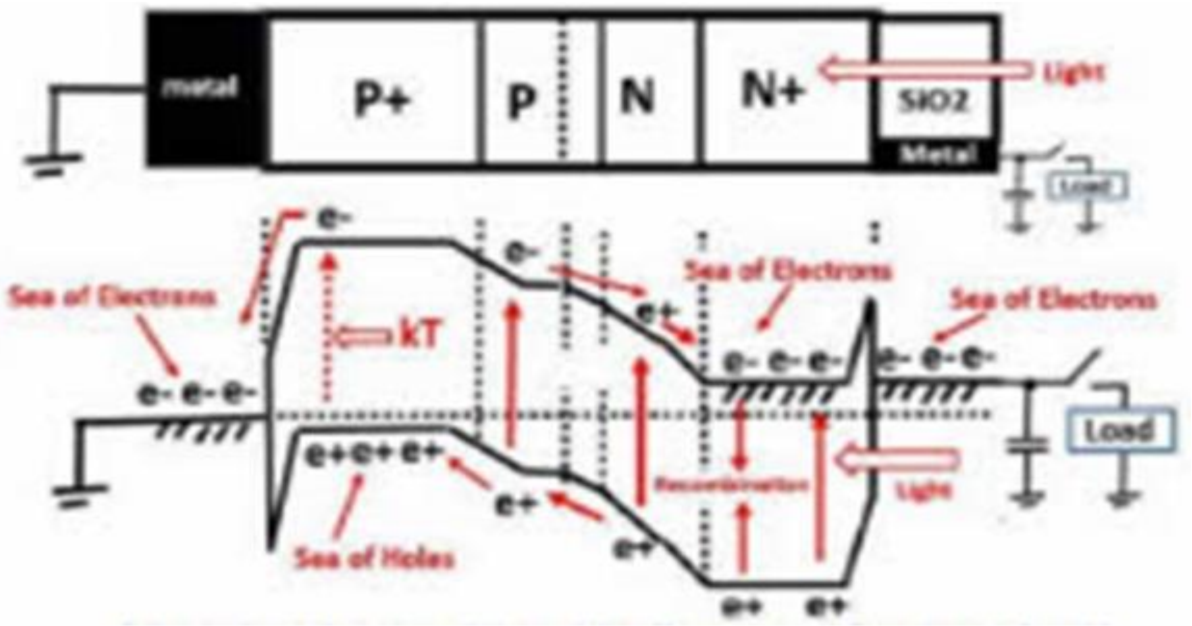




2 Single N+P floating junction type PDD

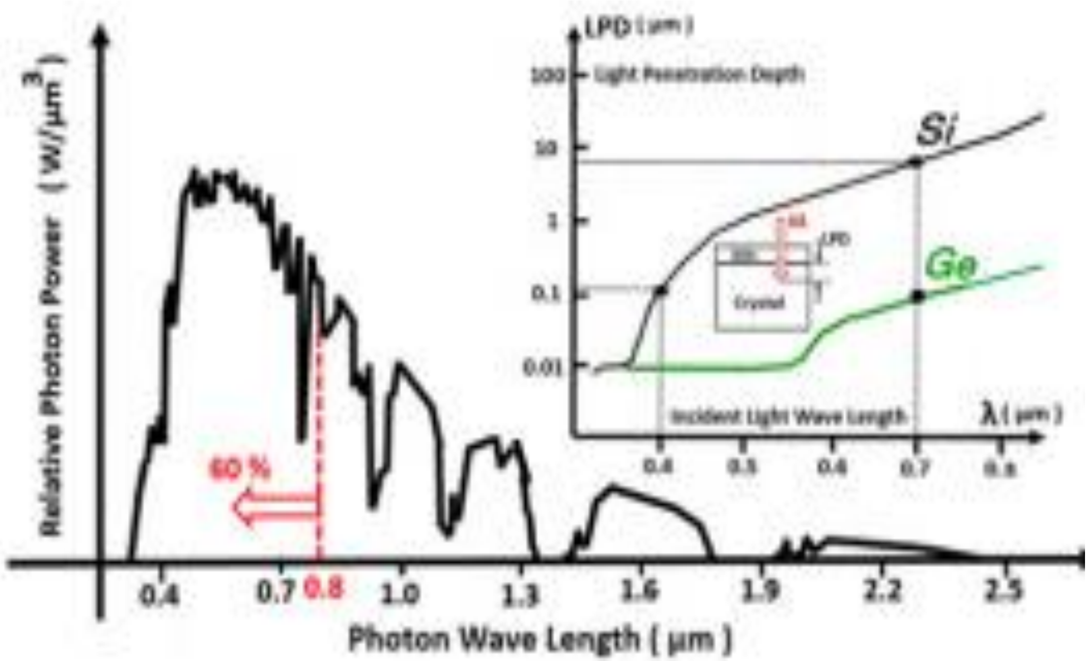
The photo electron and hole pairs generated from the short wave blue light will stay where they were. And eventually they themselves will recombine again. Consequently, the N+P single floating junction type image sensor has a very poor short wave blue light sensitivity.

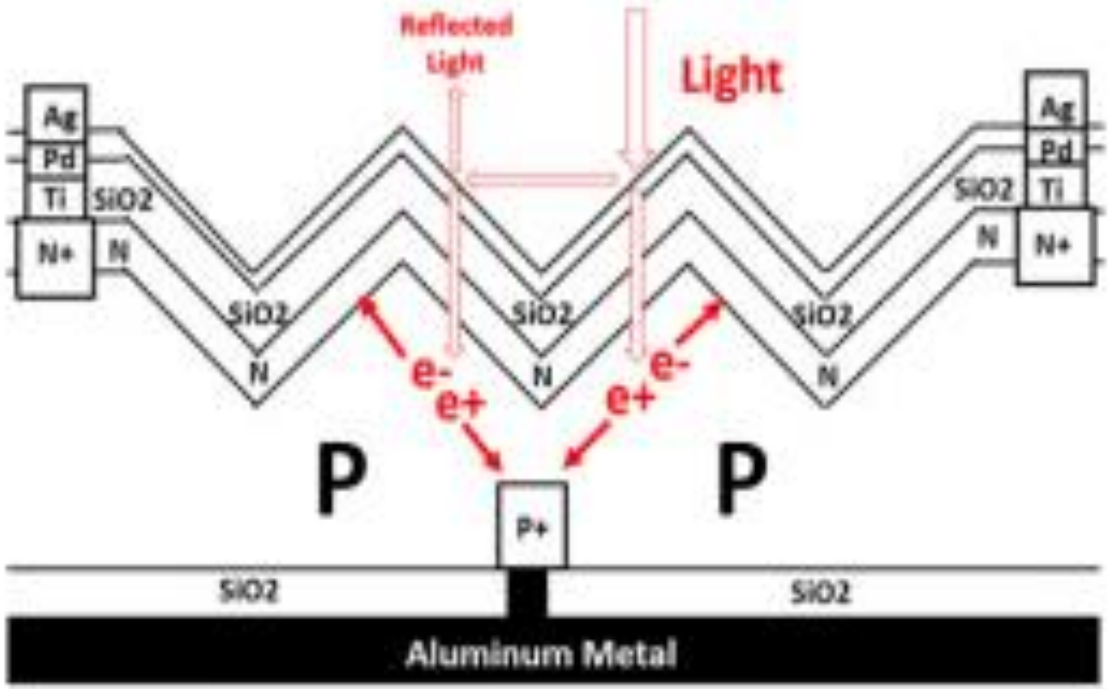




2 Single N+P floating junction type PDD

A typical conventional solar cell is formed by this single floating junction type photodiode and is expected to have a poor short wave blue light sensitivity.





2 Single N+P floating junction type PDD

Since the sun light spectrum has a very strong energy peak at the short wave blue light, the conventional solar cell is also expected to have a very limited and poor energy conversion efficiency theoretically.