

History of Innovations

International Journal of Engineering Research & Technology (IJERT) publishes a paper "CMOS Image Sensors: Recent Innovations in Imaging Technology" by Gagan Khanduri, Dev Bhoomi Institute of Technology, Dehradun, India. Most of the "recent innovations" in the paper are a deep history by now:

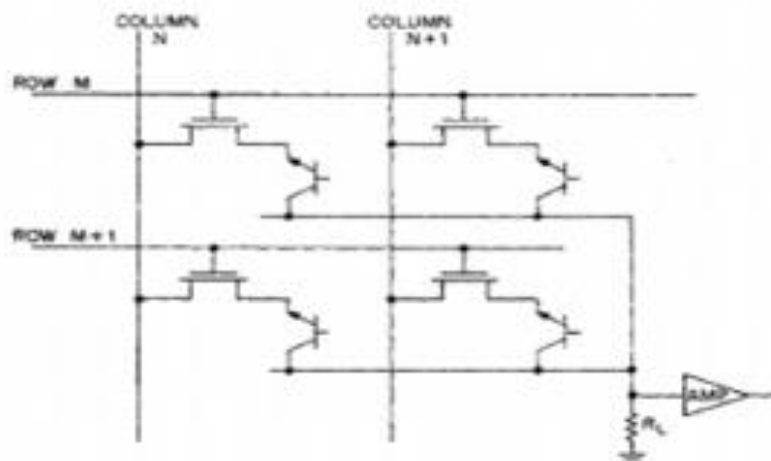


Fig. 1. Passive pixel sensor (PPS) array schematic, as proposed by Dyck and Weckler [3].

[3] R. Dyck, G. Weckler, IEEE Trans. Electron Dev. 15-4 (1968) 196–201.

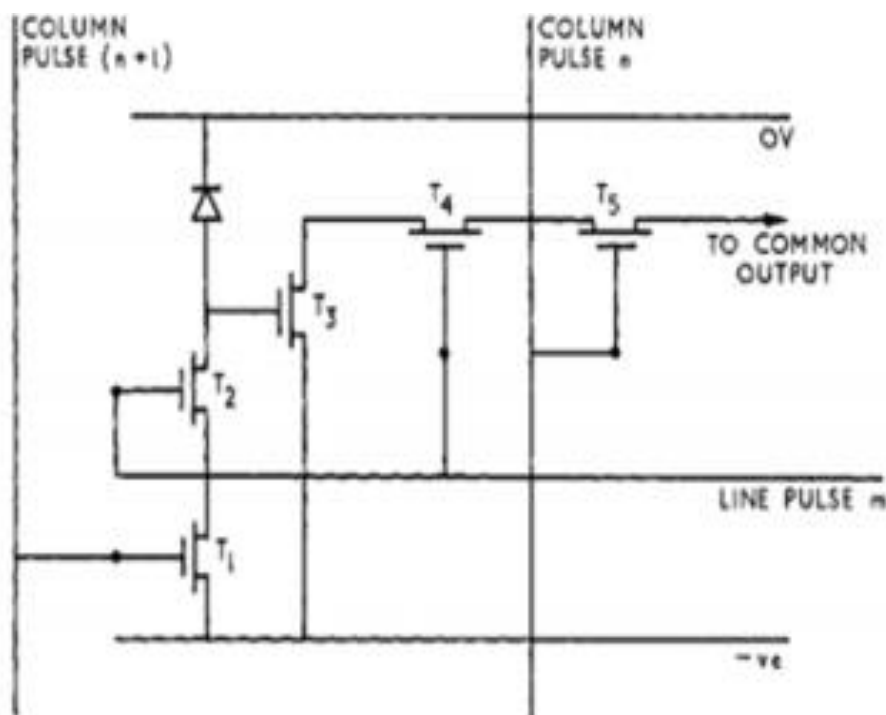


Fig. 3. First active pixel sensor (APS) with a photodiode and buffer amplifier (T3) for voltage sensing mode, as proposed by Noble [4].

[4] Peter J. W. Noble, IEEE Trans. Electron Dev. 15-4 (1968) 202–209.

When one T type DRAM was developed in early 1970s, one T type classical MOS image sensor was developed, at the same time, with the N+P single junction type dynamic photo capacitance. But the classical MOS image sensor had the floating surface N+P junction photo diode which had a serious image lag problem. Historically the single N+P junction type photodiode was replaced by CCD/MOS dynamic photo capacitor and then which was again soon replaced in 1975 by the double and then triple junction type dynamic photo transistor and thyristor , invented in 1975 by Yoshiaki Hagiwara at Sony. Now we have CMOS image sensors with digital CMOS signal outputs and with the three T type or the four T type active in-pixel source follower current amplifier circuits, which was invented originally by Peter Noble in 1968. The following two circuits were then developed.

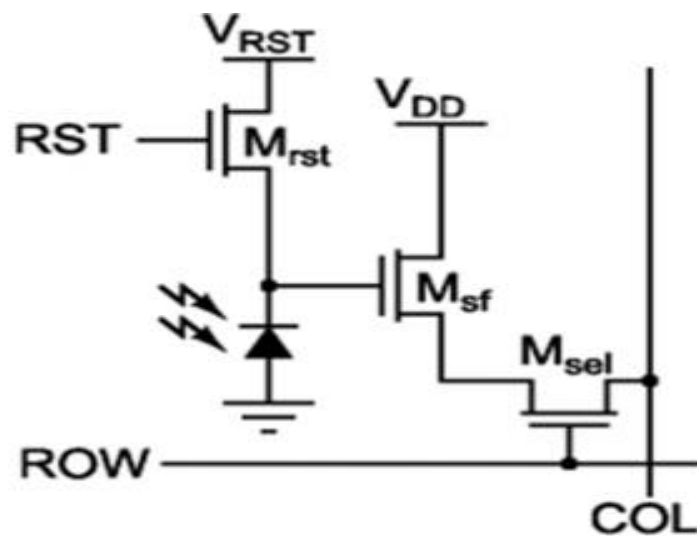


Figure 4. A Three-transistor (3T) active pixel sensor (APS)

This 4T type Active Pixel source follower circuit shown below has Global Shutter function of floating diffusion (FD) type buffer memory for CMOS Image sensors.

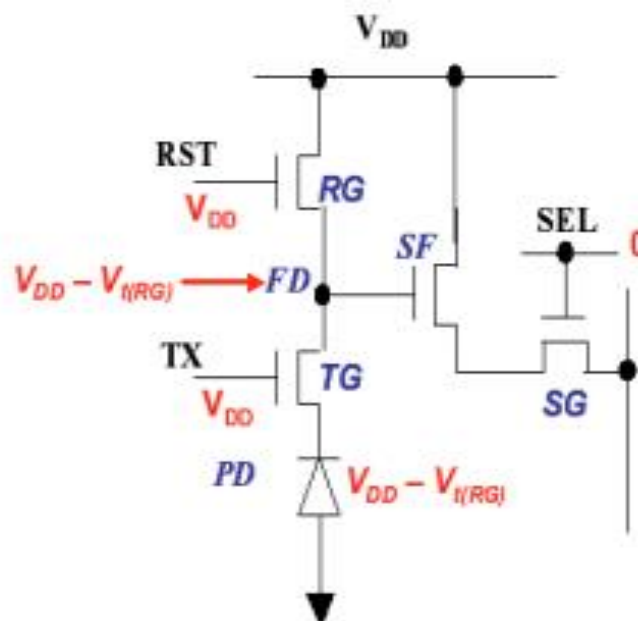
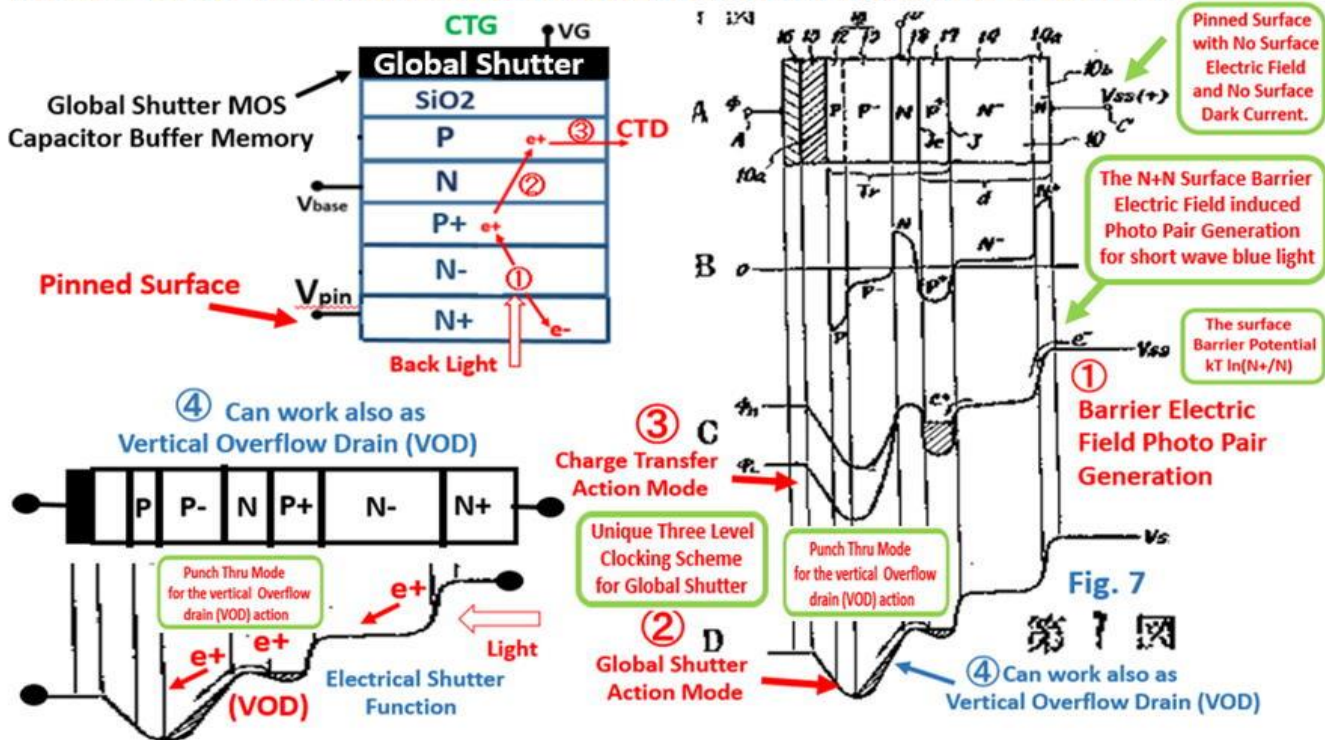


Fig. 5.A four-transistor (4T) active pixel sensor (APS)schematic during reset operation.

Global Shutter Function was originally invented by Yoshiaki Hagiwara in 1975 in the form of CCD/MOS capacitor type buffer memory, instead of PN junction type.

Japanese Patent 1975-127646

Triple Junction N+N-P+NP-P junction type Buried Pinned Photodiode with Built-in MOS Capacitor Buffer Memory Global Shutter Function and the surface N+N doping slope Barrier Electric Field Photo Pair Generation



Double Junction (PNP or NPN) type Buried Pinned Photodiode originally invented by Yoshiaki Hagiwara at Sony in 1975.

See Japanese Patent Application JPA 1975-127647

The evidence that Hagiwara invented Pinned Photodiode is given in Fig. 7 of JPA 1975-127647.

- (1) the P+P or N+N surface barrier doping profile resulting in very high blue light sensitivity
- (2) the built-in MOS Capacitor Buffer Memory for Global Shutter Function for CMOS imagers
- (3) Pinned flat surface potential of no surface electric field gives very low surface dark current
- (4) Complete Charge Transfer gives No Image Lag.

