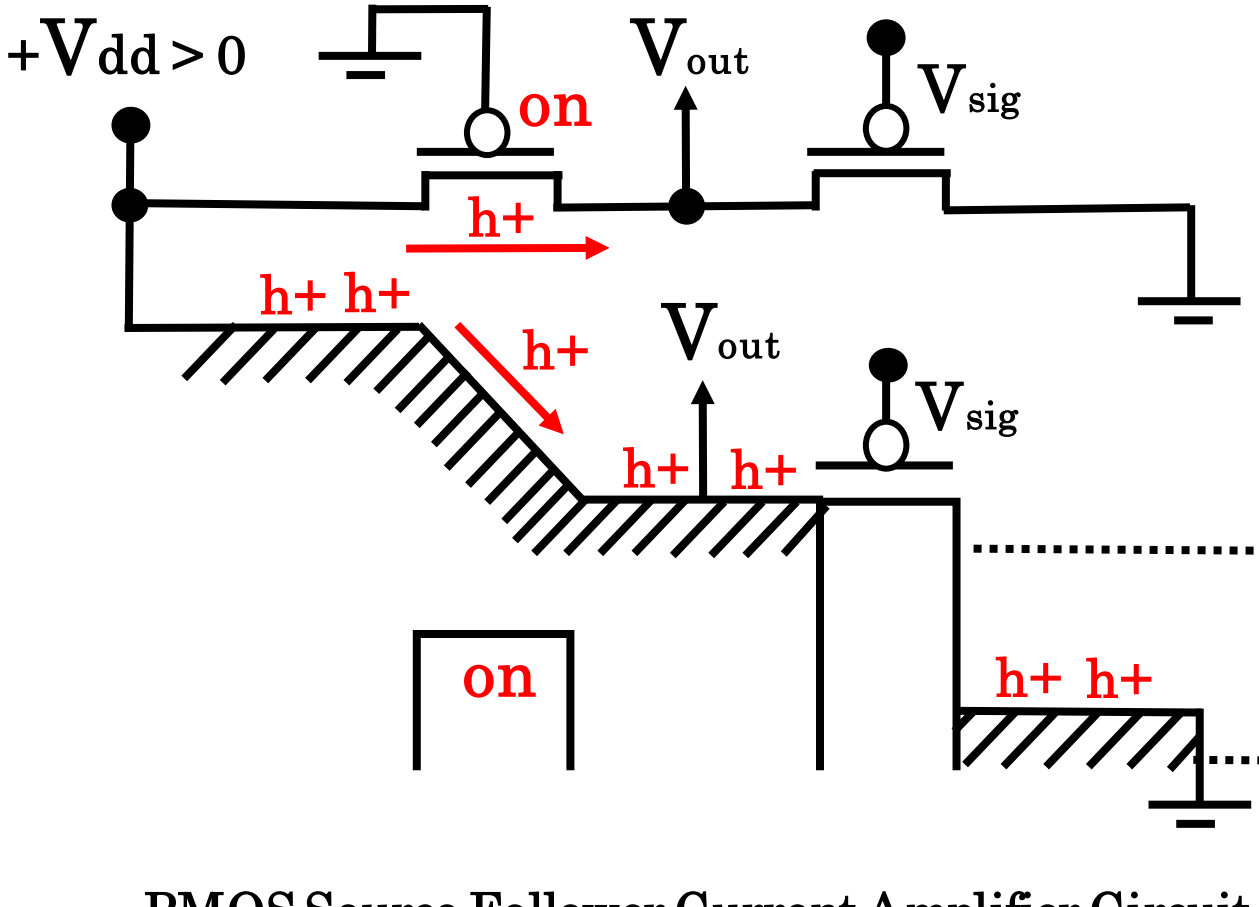
6 In Pixel Source Follower Current Amplifier type Active Circuit

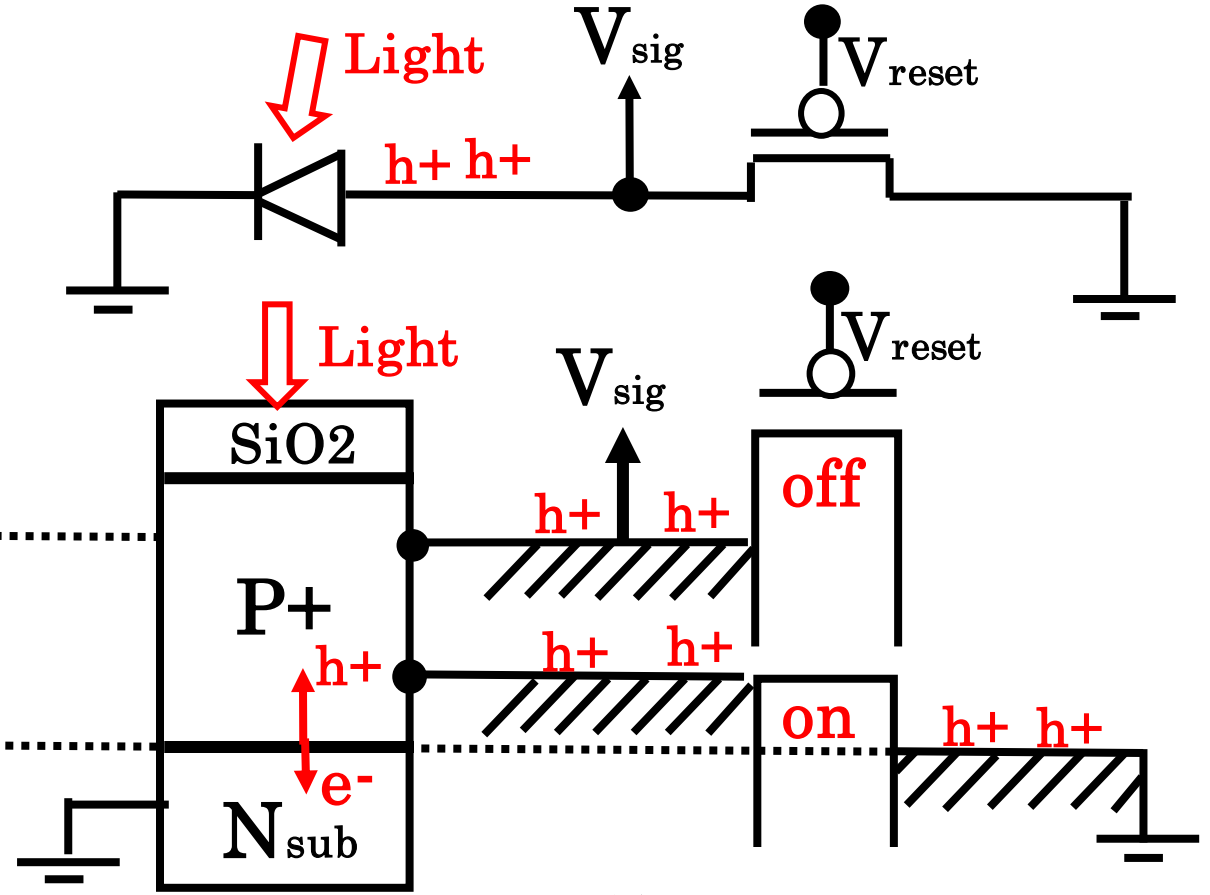
Under Construction

6 In Pixel Source Follower Current Amplifier type Active Circuit

The figure below shows a typical 2T type PMOS Current Amplifier circuit and a 1T PMOS Reset circuit used for a classical floating P+N single junction dynamic photo diode .



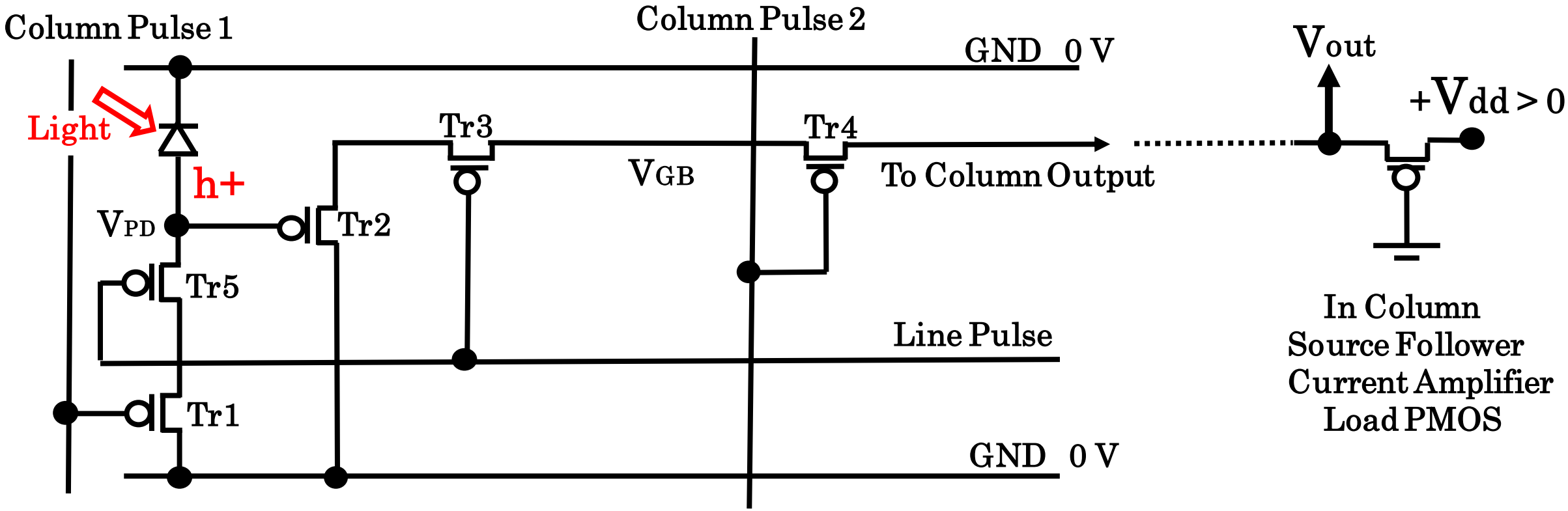
PMOS Source Follower Current Amplifier Circuit



PMOS Reset Circuit

6 In Pixel Source Follower Current Amplifier type Active Circuit

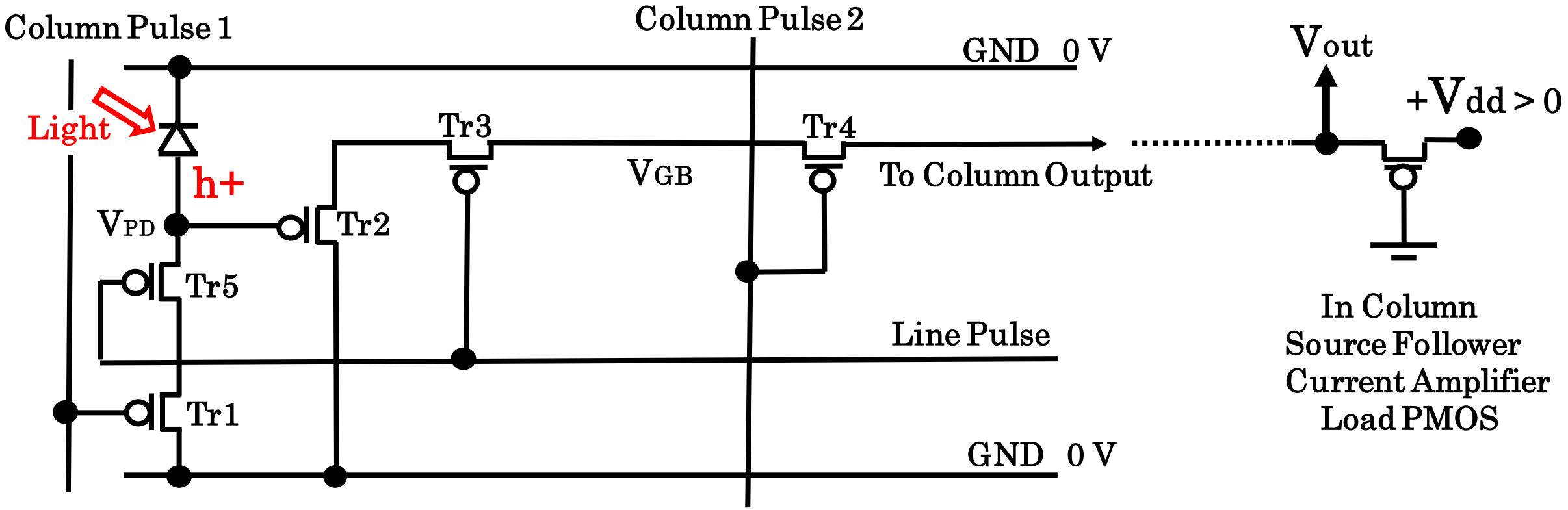
In 1968 Peter Nobel at Plessy proposed an active pixel 5T1C MOS image sensor with the PMOS source follower current amplifier circuit.



Peter Nobel, IEEE Transaction of Electron Devices 15-4 (1968) pp. 202-209

6 In Pixel Source Follower Current Amplifier type Active Circuit

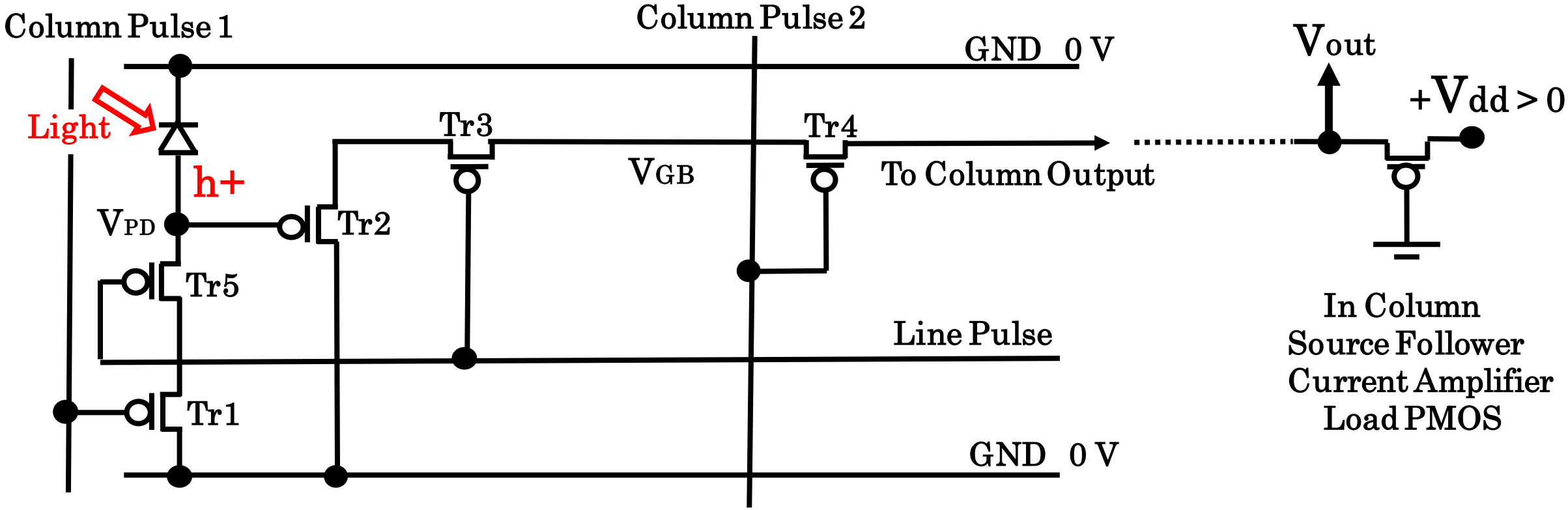
However, this 5T1C active pixel source follower current amplifier circuit was too large to be included in the small picture element (pixel) area of the classical MOS image sensor in the old time of late 1960s.



Peter Nobel, IEEE Transaction of Electron Devices 15-4 (1968) pp. 202-209

6 In Pixel Source Follower Current Amplifier type Active Circuit

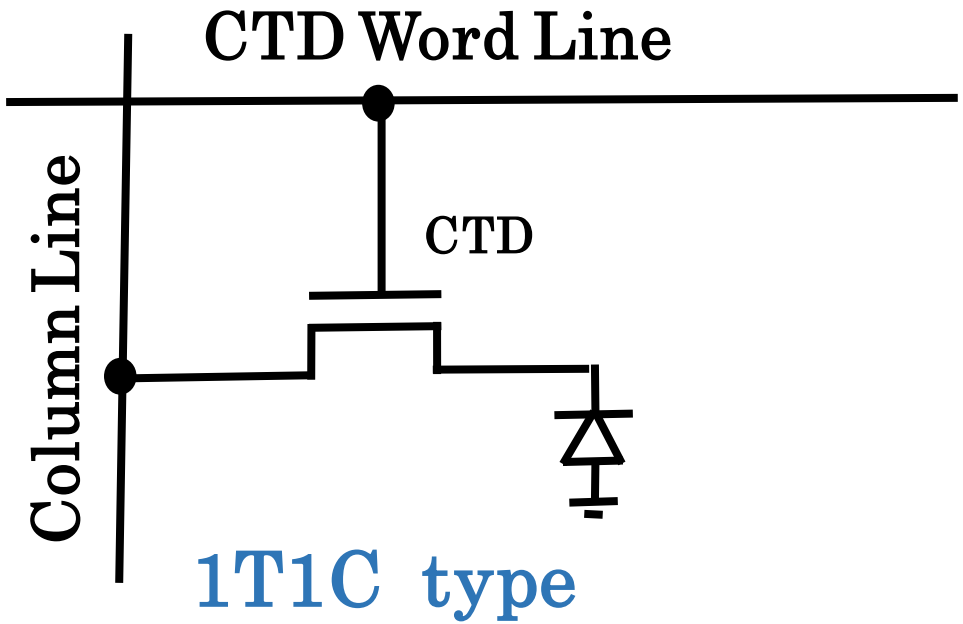
The 1T1C pixel was only the solution. However, with advancements of CMOS process scaling technology, we can now have much more circuit design freedom to include many active circuit elements in one pixel area.

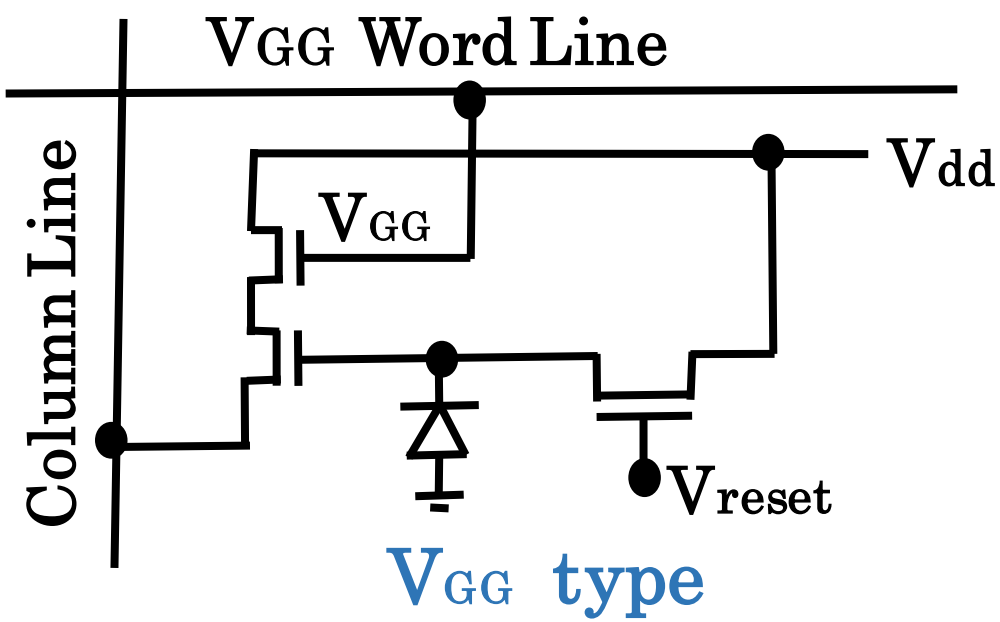


Peter Nobel, IEEE Transaction of Electron Devices 15-4 (1968) pp. 202-209

6 In Pixel Source Follower Current Amplifier type Active Circuit

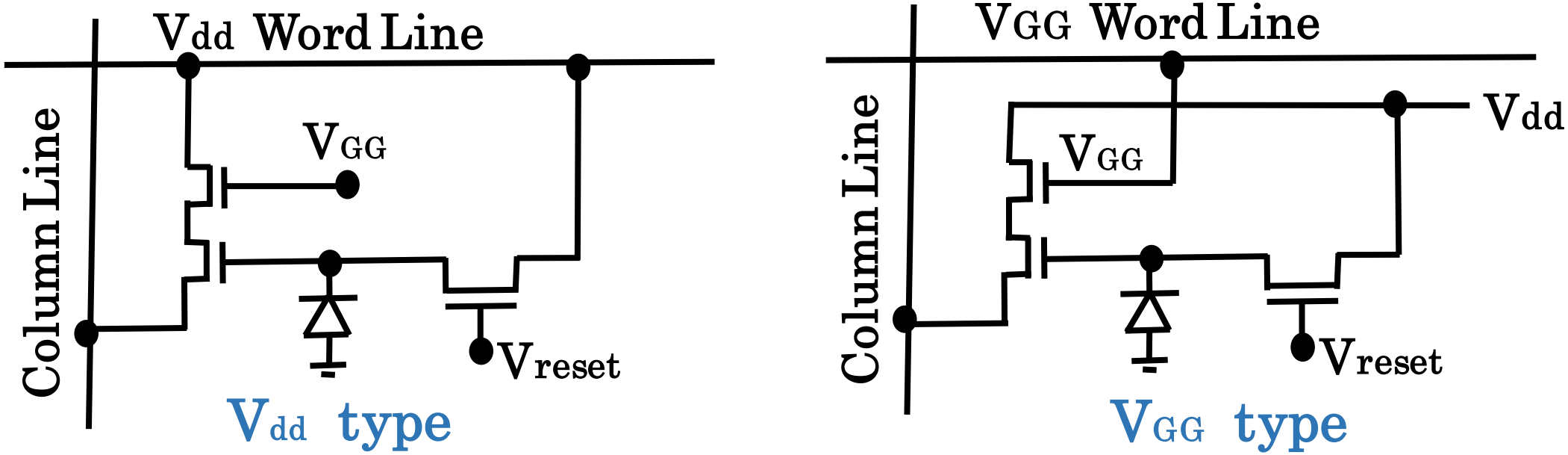
The 1T1C pixel was only the solution. However, with advancements of CMOS process scaling technology, we can now have much more circuit design freedom to include many active circuit elements such as the 3T1C pixel cell with the V_{GG} Word Line type.





6 In Pixel Source Follower Current Amplifier type Active Circuit

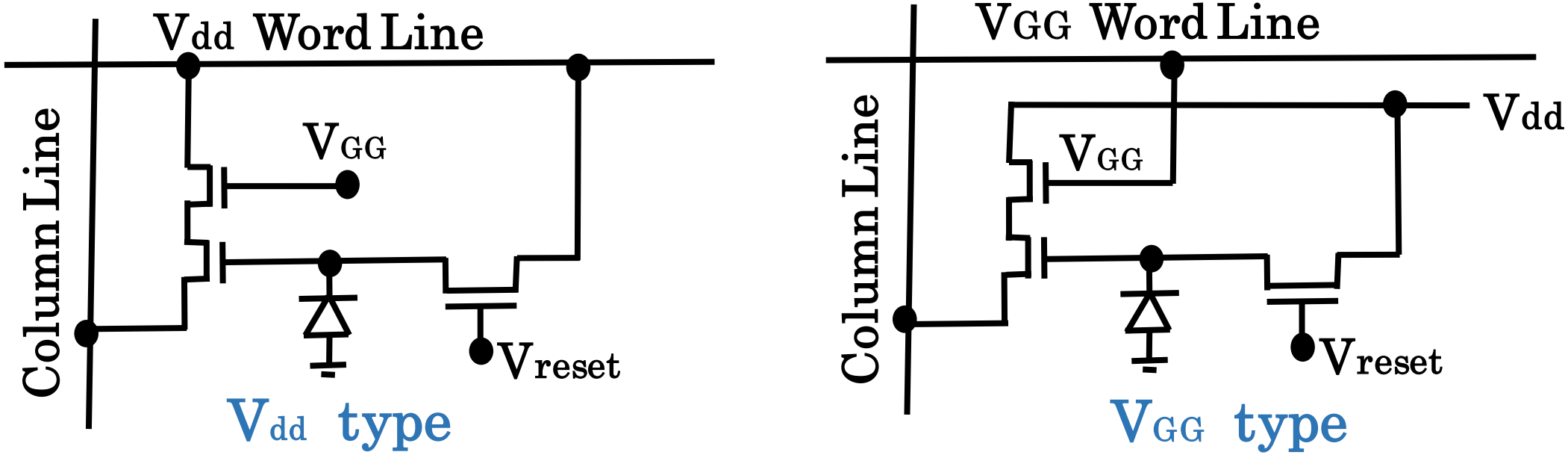
The first active pixel 3T1C large scale MOS image sensor was developed in 1987 by Ando team and was called as Amplified MOS Intelligent Imager (AMI) with the V_{dd} Word Line.



Ando et al, "Amplified MOS Intelligent Imager", TV Society Technical Report, Vol.11 No.41 pp.1075-1082 (1987)

6 In Pixel Source Follower Current Amplifier type Active Circuit

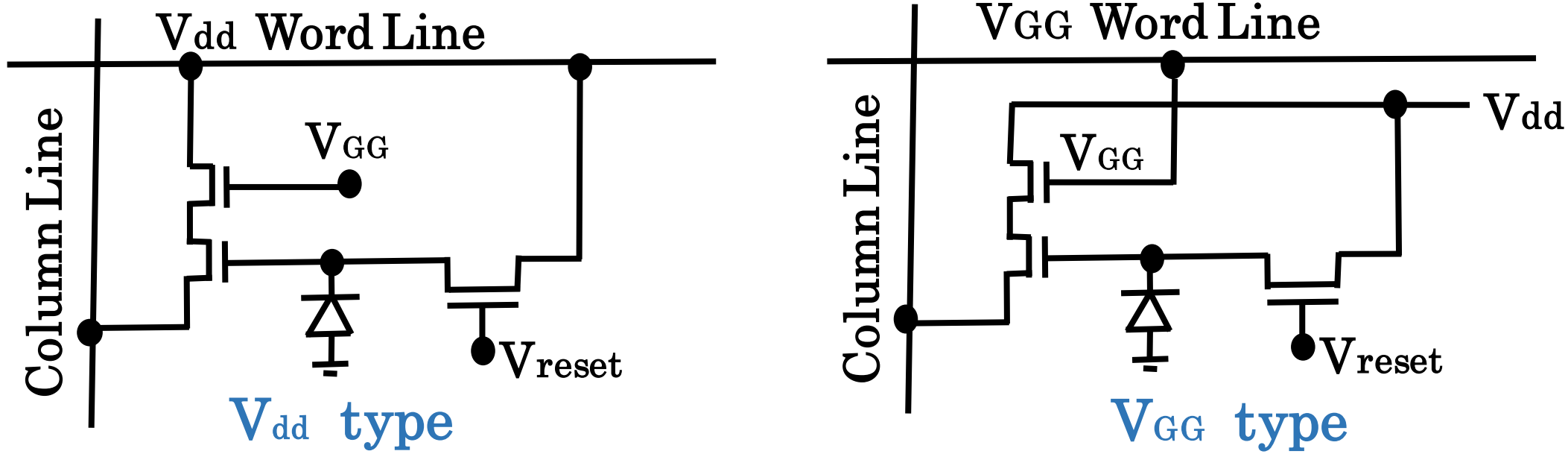
The 2/3 inch optical lens format with 250K picture elements was then developed in 1990 achieving – 59 dB Fixed Pattern Noise(FPN) level and 130 μA output current at 130 lx light intensity.



Ando et al, "Stacked AMI", TV Society Technical Report, Vol.14 No.74 pp.17-111082 (1990)

6 In Pixel Source Follower Current Amplifier type Active Circuit

By 1997 the CMOS Active Pixel Sensor (APS) with the V_{GG} Word Line has become more prevailing and the CMOS type CTD image sensor performance began to surpass CCD type CTD image sensor.

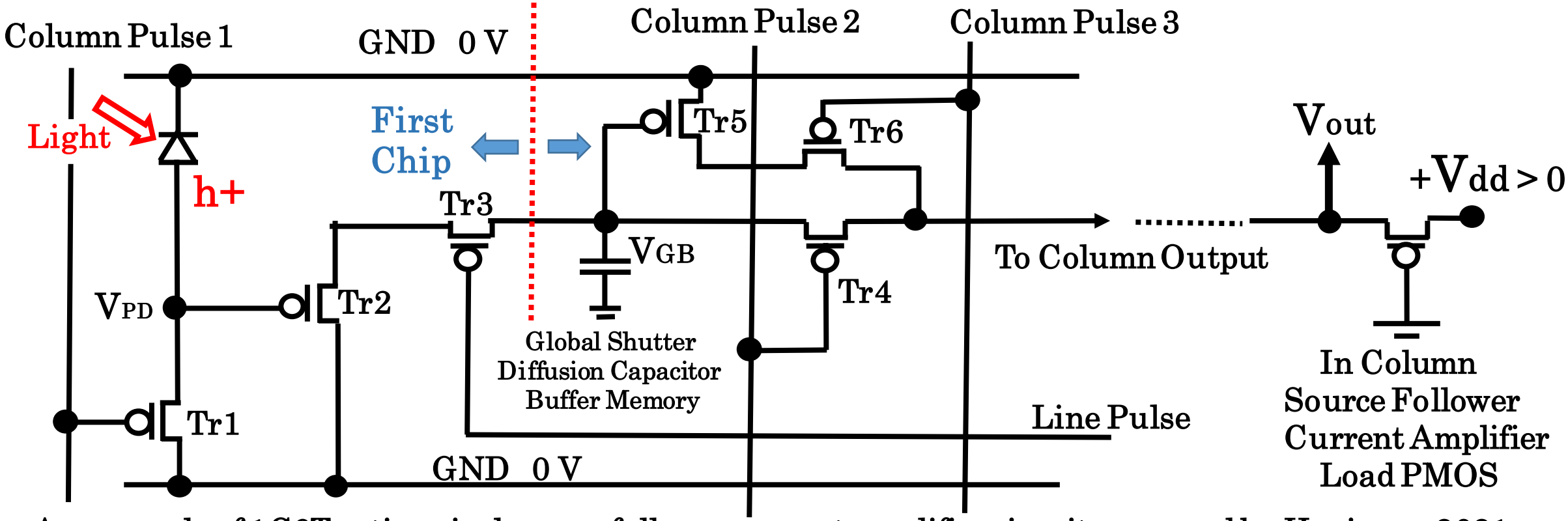


E.Ohba el al, " A ¼ inch 330K Square Pixel Progressive Scan CMOS Active Pixel Image Sensor", ISSCC Dig. Of Tech. Papers, pp. 180-181 (1993)

J. E. D. Fuwitz, et al ," An 800K Pixel Color CMOS Consumer Still Camera", SPIE Vol. 3019, pp. 115-124, (1997)

6 In Pixel Source Follower Current Amplifier type Active Circuit

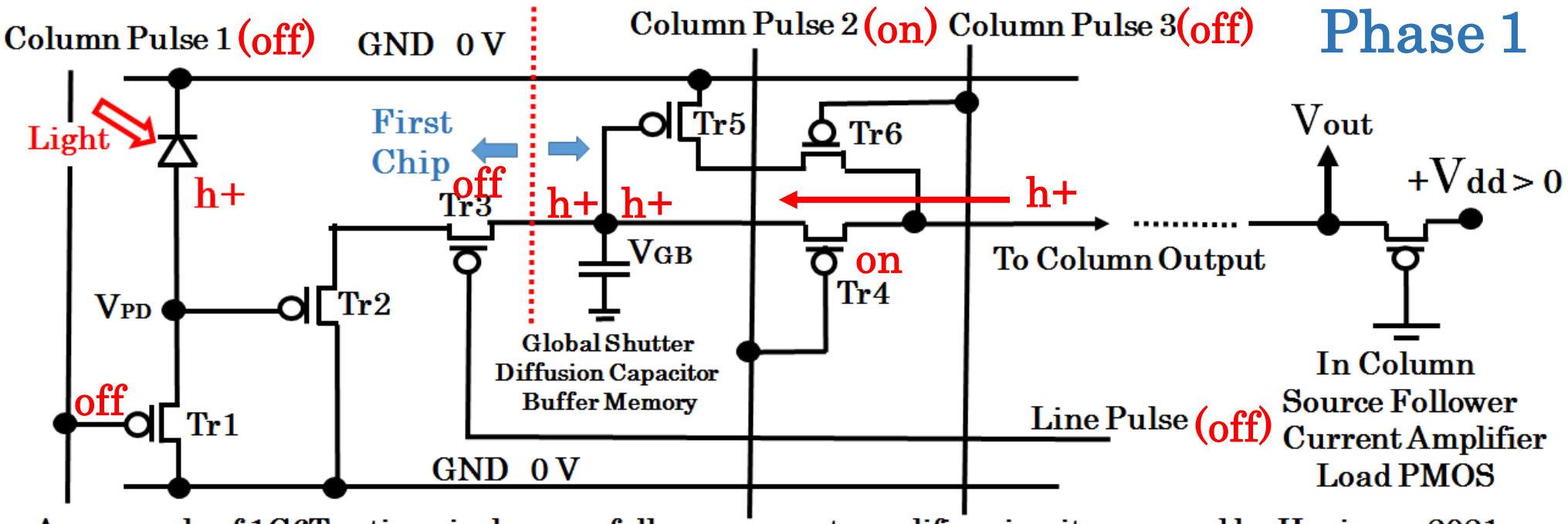
The figure below shows an example of 1C6T type active pixel with the double source follower current amplifier circuits with Global Shutter function which is suitable to be used for the multi-chip 3D integration.



An example of 1C6T active pixel source follower current amplifier circuit proposed by Hagiwara 2021.

6 In Pixel Source Follower Current Amplifier type Active Circuit

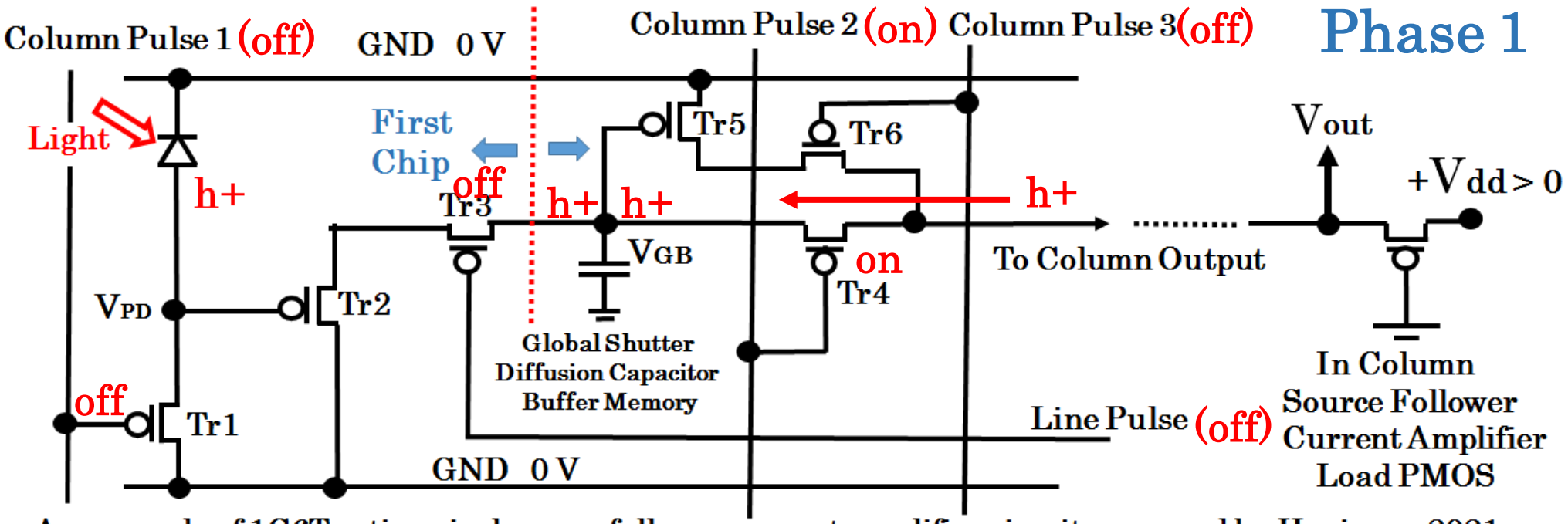
At the initial Phase 1 stage of photo signal charge integration time, Column Pulse 2 is set to be in on state to have Global Shutter Diffusion Capacitor Buffer Memory potential V_{GB} fully charged at the preset charge level of the Vdd power line for the positive hole (h+) charge carriers,



An example of 1C6T active pixel source follower current amplifier circuit proposed by Hagiwara 2021.

6 In Pixel Source Follower Current Amplifier type Active Circuit

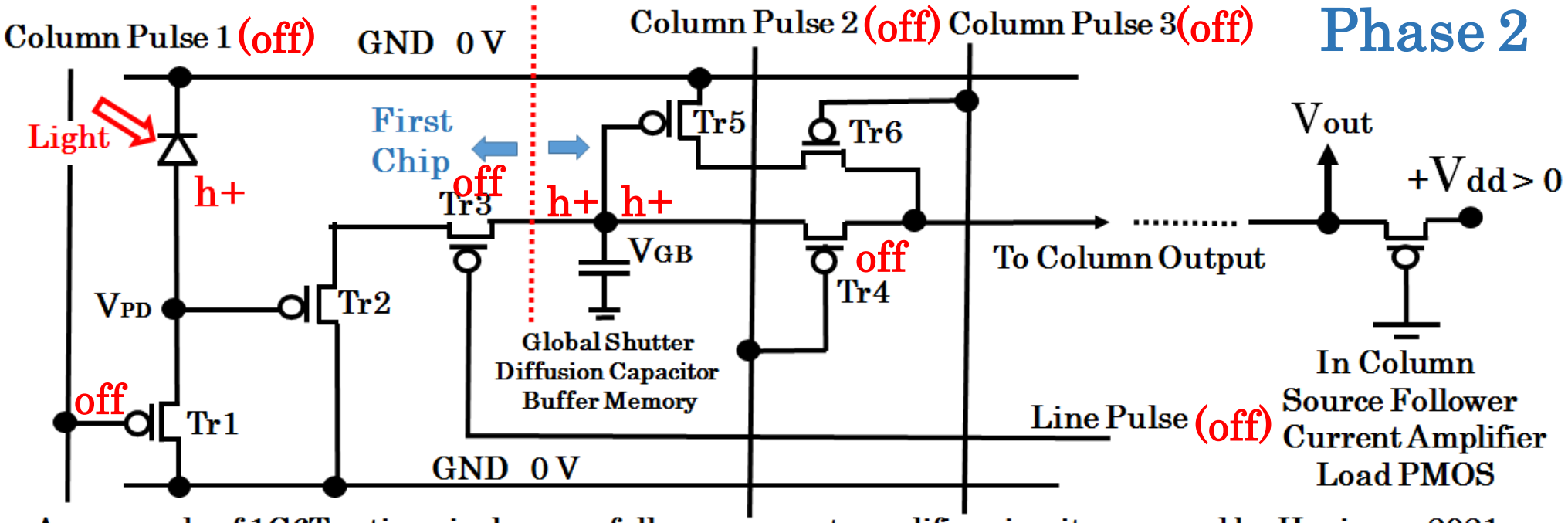
That is, the Tr4 charge transfer gate (CTG) is open and the voltage level V_{GB} of the Global Shutter Buffer Memory Capacitor is preset at the power line voltage level $+V_{dd} > 0$. The excess photo signal charge can be drained at any time by controlling the Tr1 CTG voltage level.



An example of 1C6T active pixel source follower current amplifier circuit proposed by Hagiwara 2021.

6 In Pixel Source Follower Current Amplifier type Active Circuit

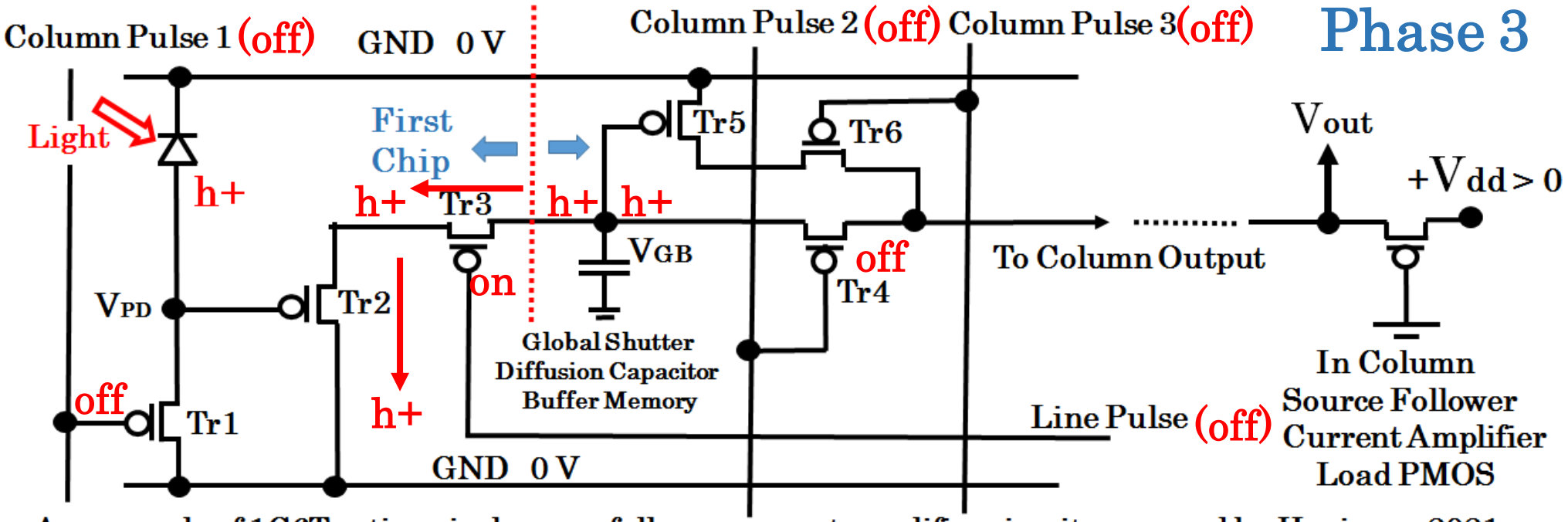
At the next phase 2 the Tr4 charge transfer gate is closed by setting Column Pulse 2 in off state. At this stage of the photo signal charge integration time, all of the three Column Pulses 1,2,3 and Line Pulse are set in off state, that is at a positive off voltage value, closing off off of the Tr1, Tr3 ,Tr4,Tr5 and Tr6 MOS gates except the Tr2 MOS gate.



An example of 1C6T active pixel source follower current amplifier circuit proposed by Hagiwara 2021.

6 In Pixel Source Follower Current Amplifier type Active Circuit

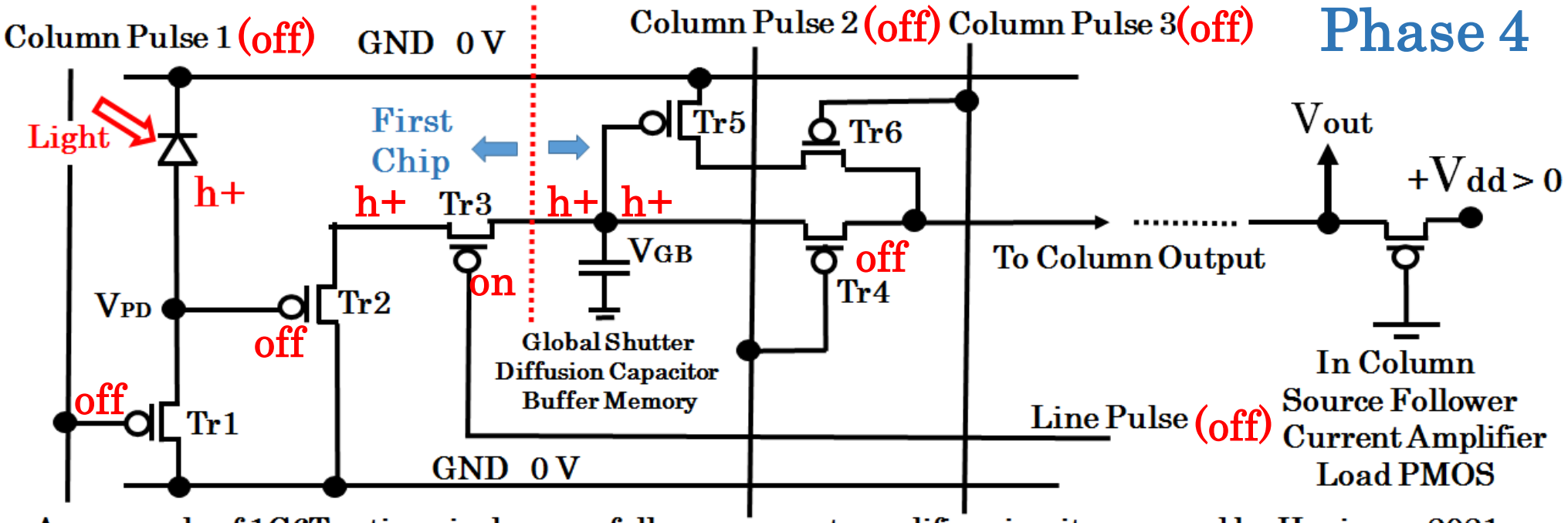
At any desired clocking time of the phase 3 timing, by setting Line Pulse in on state, the Tr3 CTG becomes open and begins to drain the some portion of the preset charge stored in Global Shutter Buffer Memory (V_{GB}), which is limited by the level determined by the channel potential of the Tr2 CTG.



An example of 1C6T active pixel source follower current amplifier circuit proposed by Hagiwara 2021.

6 In Pixel Source Follower Current Amplifier type Active Circuit

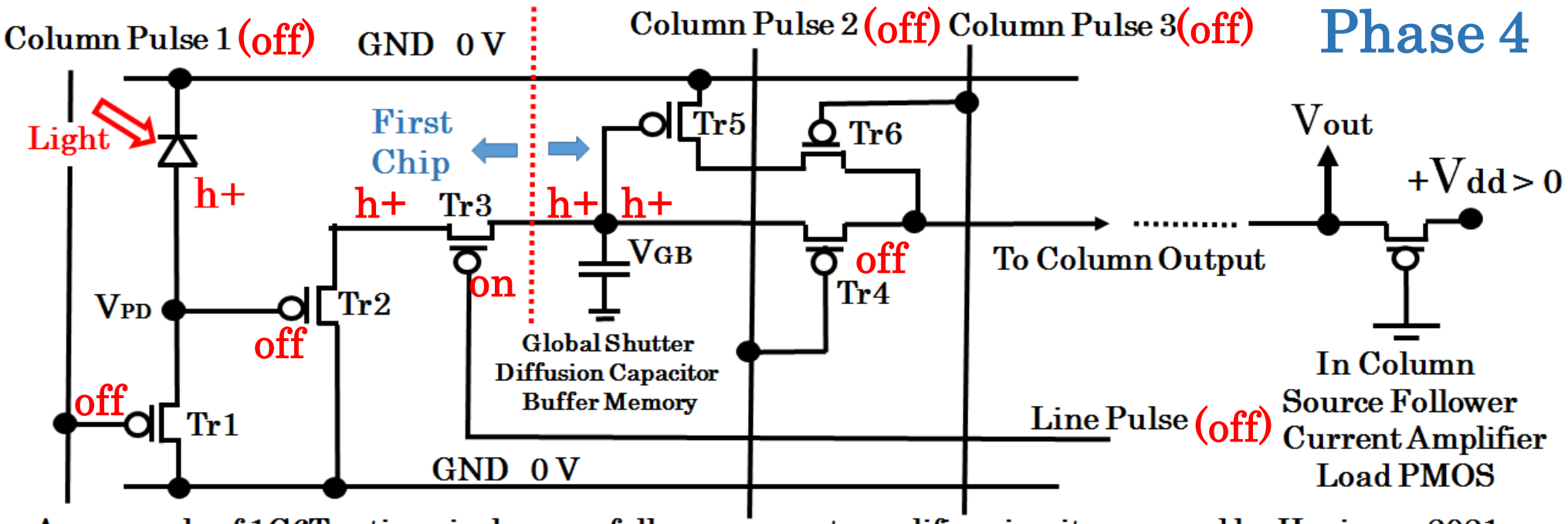
Eventually the potential level V_{GB} becomes equal to the channel potential of the Tr2 CTG, reaching Phase 4, the Tr2 MOS transistor will be in off state and stop draining the charge from the Global Shutter Diffusion Capacitor Buffer Memory.



An example of 1C6T active pixel source follower current amplifier circuit proposed by Hagiwara 2021.

6 In Pixel Source Follower Current Amplifier type Active Circuit

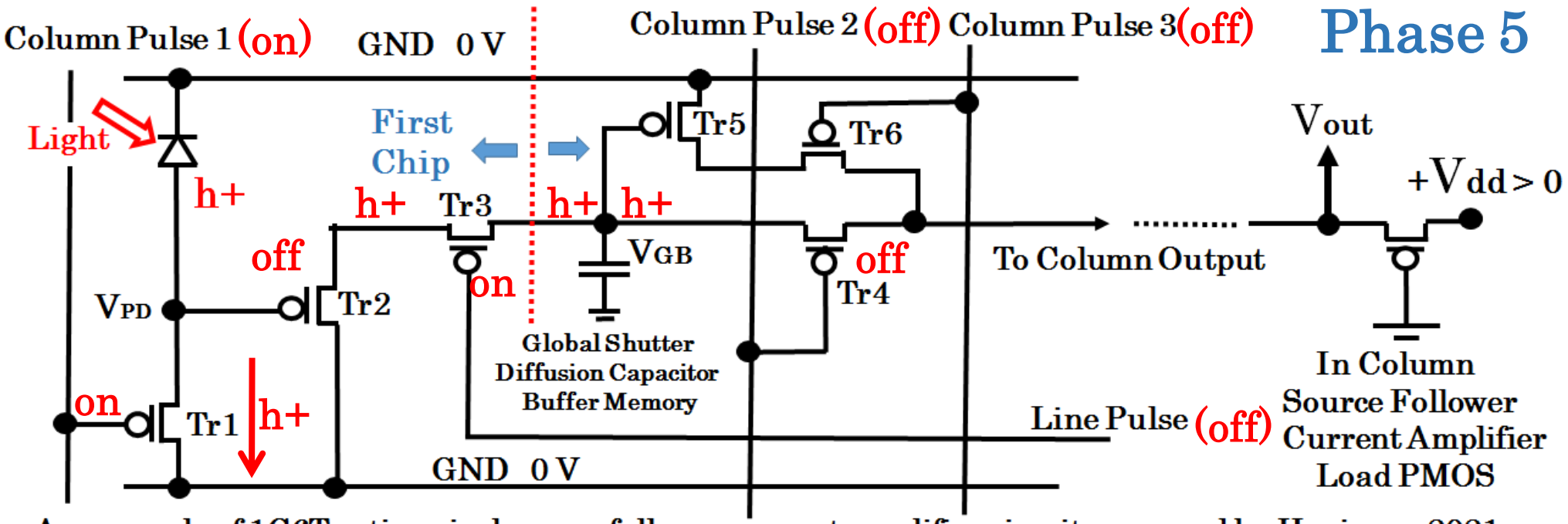
Since the channel potential of the Tr2 transistor is controlled by the potential level V_{PD} of the floating P+ region of the dynamic P+N single junction photodiode, this means that the photo signal information (V_{PD}) stored in the floating P+N photo diode is now instantly transferred to the Global Shutter Diffusion Capacitor Buffer Memory.



An example of 1C6T active pixel source follower current amplifier circuit proposed by Hagiwara 2021.

6 In Pixel Source Follower Current Amplifier type Active Circuit

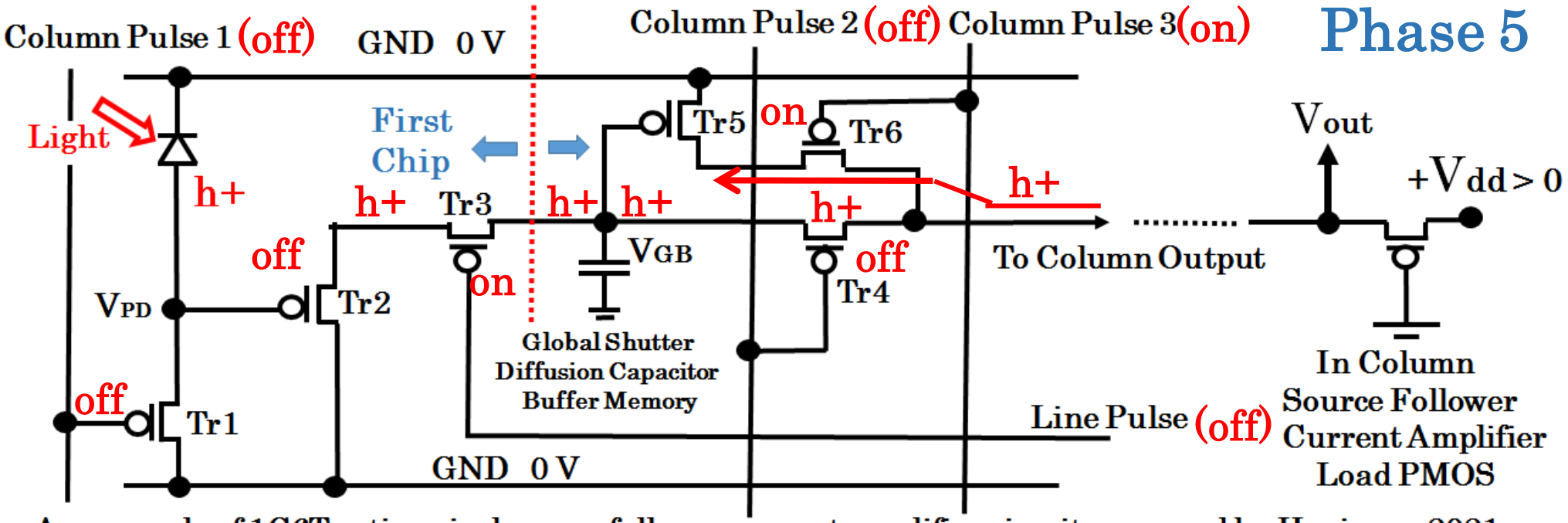
Now the photo charge stored in the floating P+ region of the dynamic P+N single junction photodiode is no longer needed, and by opening the Tr1 reset gate in this Phase 5 clock timing, the photo charge stored in the floating P+ region is completely drained and reset.



An example of 1C6T active pixel source follower current amplifier circuit proposed by Hagiwara 2021.

6 In Pixel Source Follower Current Amplifier type Active Circuit

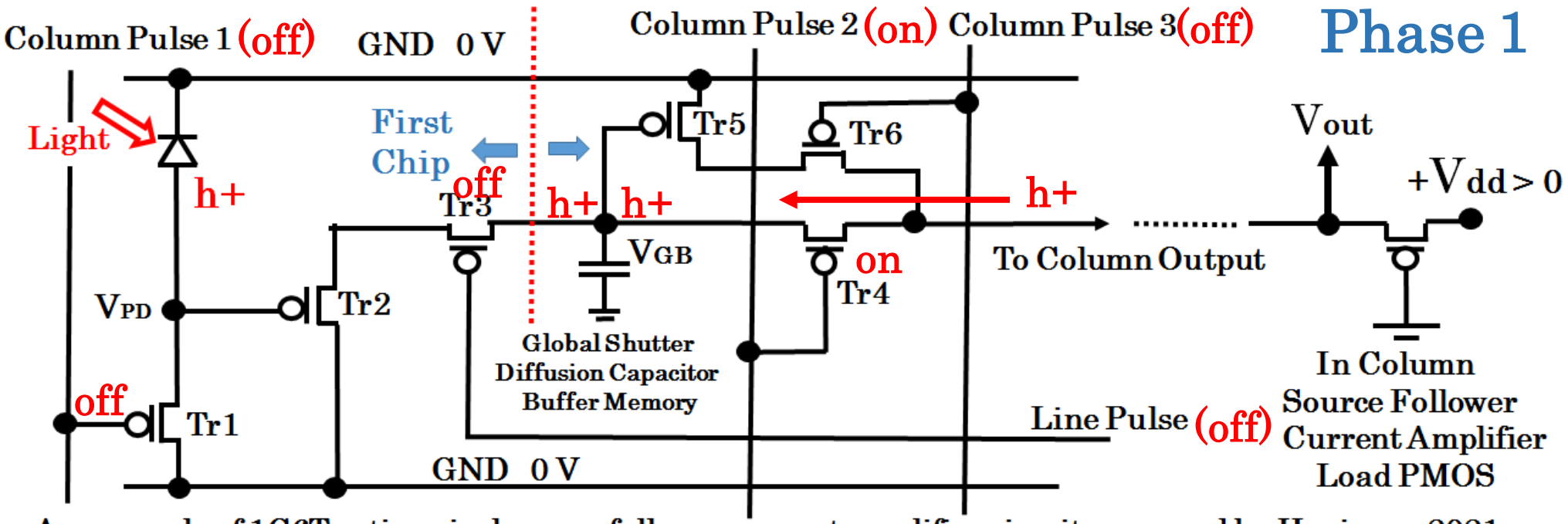
At the next clock timing Phase 5,Column Pulse 3 is set in on state. The Tr6 CTG becomes open and the signal charge can be amplified by the second stage source follower current amplifier circuit which is composed of the drive MOS Tr5 and the pass MOS Tr6. Again, the same load PMOS transistor serves the second stage current amplifier.



An example of 1C6T active pixel source follower current amplifier circuit proposed by Hagiwara 2021.

6 In Pixel Source Follower Current Amplifier type Active Circuit

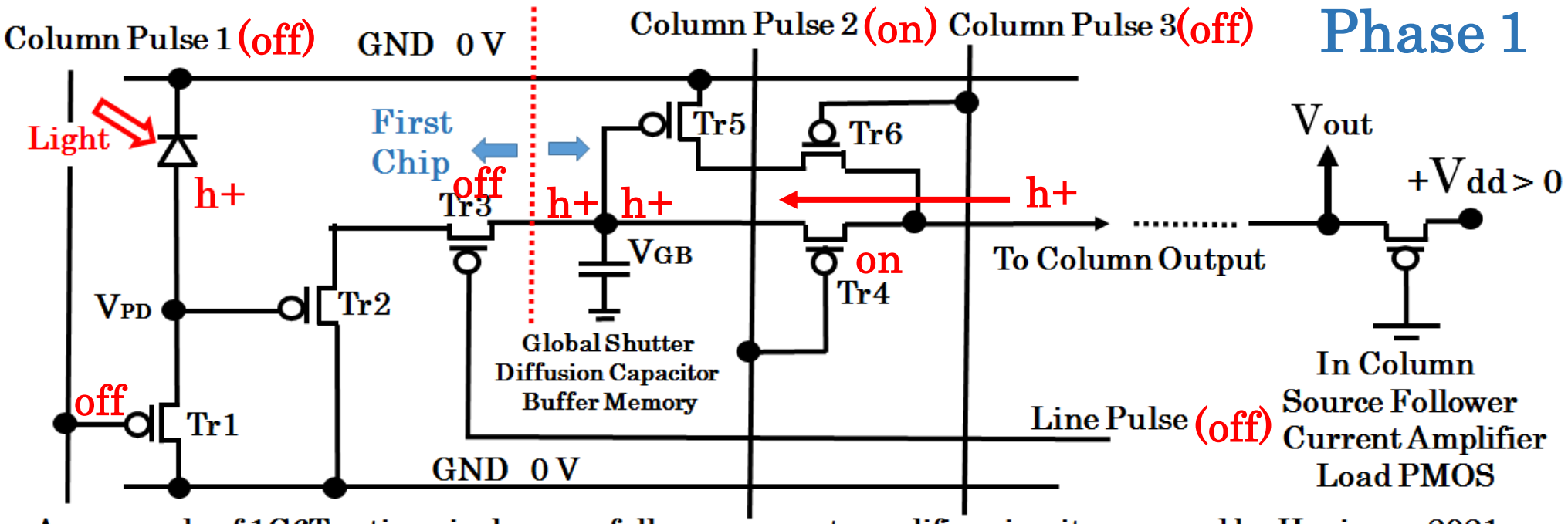
At the final stage, which is also the initial Phase 1, Column Pulse 2 is set on state to have Global Shutter Diffusion Capacitor Buffer Memory potential V_{GB} which is fully charged again at the preset voltage level V_{dd} of the power line for the positive hole (h+) charge carriers.



An example of 1C6T active pixel source follower current amplifier circuit proposed by Hagiwara 2021.

6 In Pixel Source Follower Current Amplifier type Active Circuit

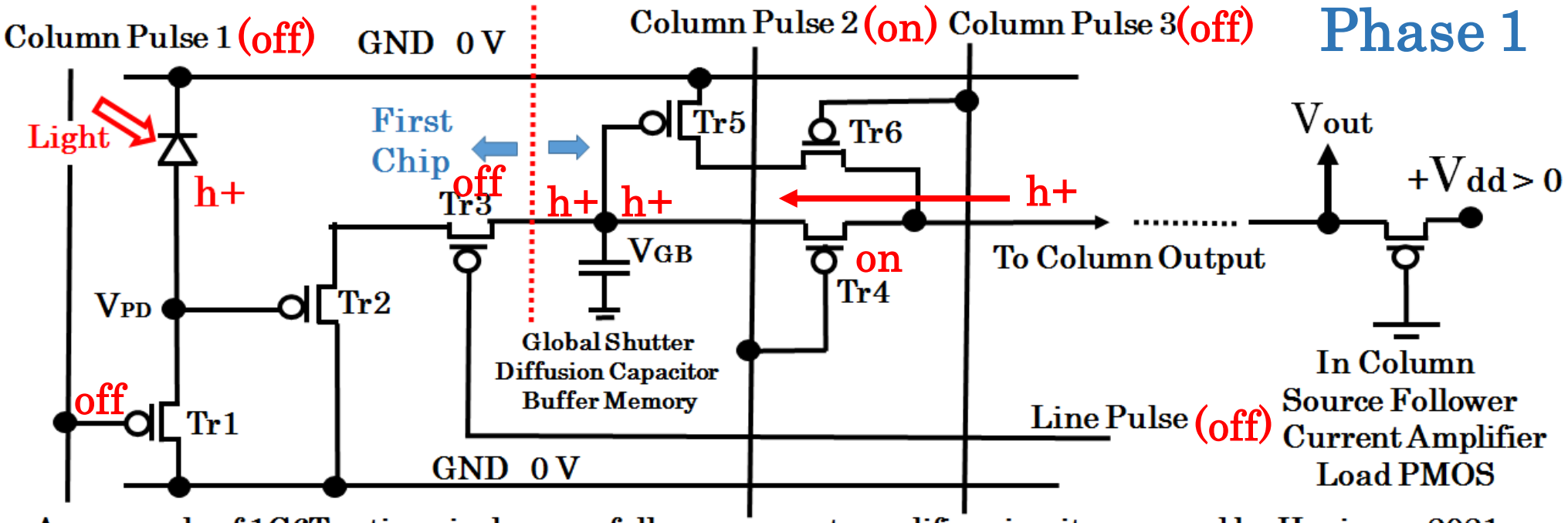
In this way, Electrical Shutter Function and Global Shutter Function both can be achieved by this 1C6T active pixel double source follower current amplifier circuit.



An example of 1C6T active pixel source follower current amplifier circuit proposed by Hagiwara 2021.

6 In Pixel Source Follower Current Amplifier type Active Circuit

With advancements of CMOS process scaling technology, we can now have much more circuit design freedom to include many active circuit elements in one pixel area. Electrical Shutter Function and Global Shutter Function both can be achieved by this 1C6T active pixel double source follower current amplifier circuit as an example by the author.



An example of 1C6T active pixel source follower current amplifier circuit proposed by Hagiwara 2021.