

Design of photo-electron barrier for the Memory Node of a Global Shutter pixel based on a Pinned Photodiode

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In many image sensors applications an electronic Global Shutter (GS) is needed. In order to operate GS in a CMOS pixel one has to have a Memory Node (MN) within the pixel. The integration of the photo-electron starts and stops simultaneously on all pixels. The information from the CMOS pixel diode is then globally (for all pixels in the sensor) transferred to the MN and read out of the pixel, as in the regular Rolling Shutter (RS) case.

It is well known that a 4T CMOS pixel can be operated in a (GS) mode. In this case the charge collected from the diode is transferred to the pixel Floating Diffusion (FD) and kept there until the read sequence reaches the pixel row. It is also customary to add additional Transfer Gate (TG) to the pixel. The additional TG is used both for the diode reset and as an anti-blooming gate, which helps preventing charge overflow from diode to the MN. While using the well established 4T technology to create a GS pixel has many merits in term of simplicity, this approach might leads to a few drawbacks. This is mainly due to different optimization routes needed for the MN in GS in compared to the FD optimization in a conventional 4T pixel: The regular FD optimization for 4T deals with full-charge transfer and matching the charge capacity of the FD to that of the diode. Moreover on a regular (RS) operation the charge storage time at the FD is on the order of μsec while is GS storage time on the (MN) can reach several msec. In some GS applications the integration time is comparable or even smaller than the storage time. Therefore The MN optimization should deal with information integrity over storage time. Thus, requires minimizing the MN sensitivity to light as well as minimizing the dark-current of the MN.

In this paper we will discuss several aspect of MN optimization. In order to reduce the light sensitivity of the MN we introduced a p-blocking layer beneath the FD n-type implant. We will show that using this implant can reduce the sensitivity of MN to red light by 28% and to green light by 17%. The sensitivity to blue light was changed only by 12% as expected. We will also show the importance of carefully shielding the MN from light by using M1. We will discuss trade-off between the MN dark current and the blocking layer process. Finally, for our chosen process there is practically no effect on the charge transfer characteristic of the pixel.

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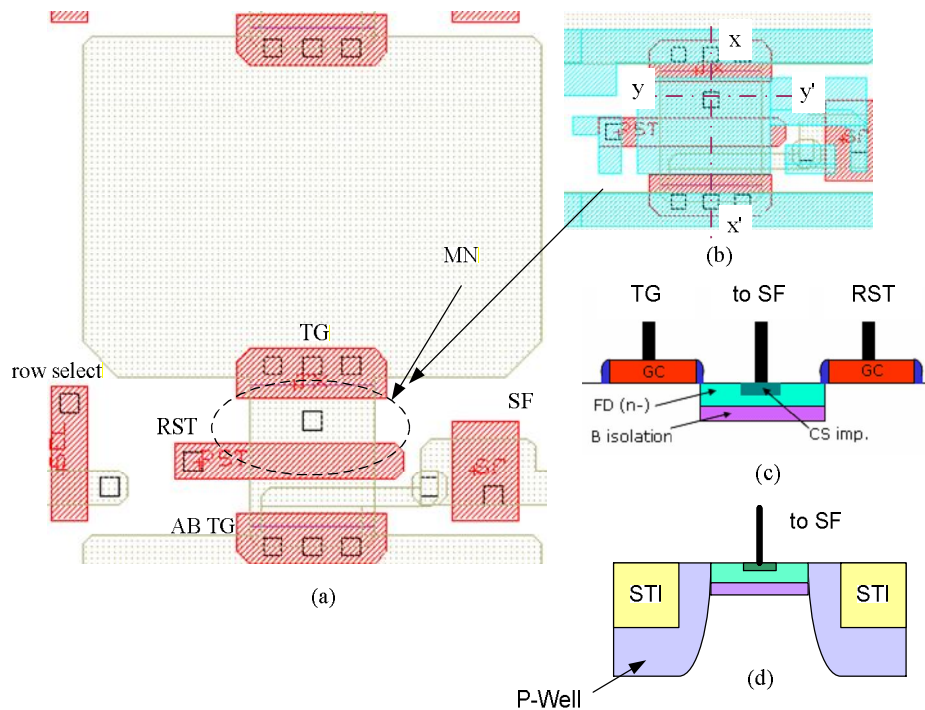


Figure 1: **(a)** Layout of a global shutter pixel based on a fully pinned PD and additional global shutter gate. **(b)** Zoom in on the MN layout: M1 is used to create light shield to the MN. Contacts are used to create a blocking wall between PD and MN. **(c)** x-section of the MN implant scheme along x-x' line (shown in Figure 1b). **(d)** x-section of the MN implant scheme along y-y' line (shown in Figure 1b).

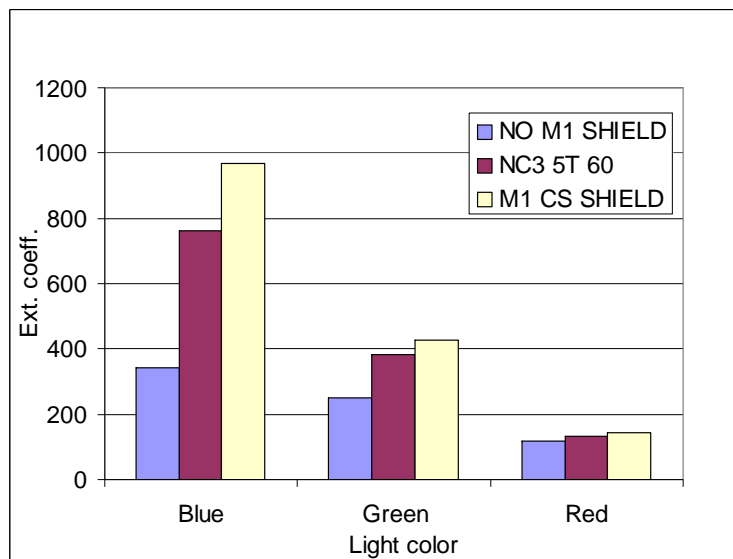


Figure 2: **(a)** Effect of M1 shield on extinction coefficient for three light colors: Green (523nm), Red (660nm) and Blue (470nm). Measurements are taken with diffused light source and #2.8. Devices are manufactured with u-lenses and with out color filters

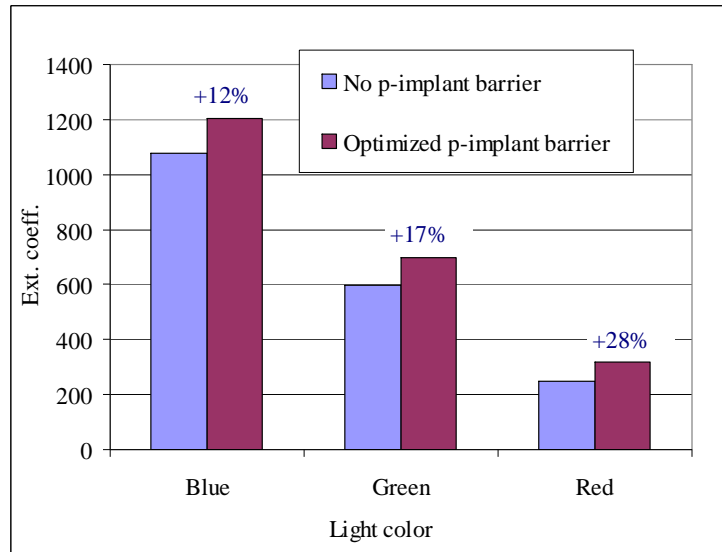


Figure 3: Effect of p-blocking layer implant on extinction coefficient

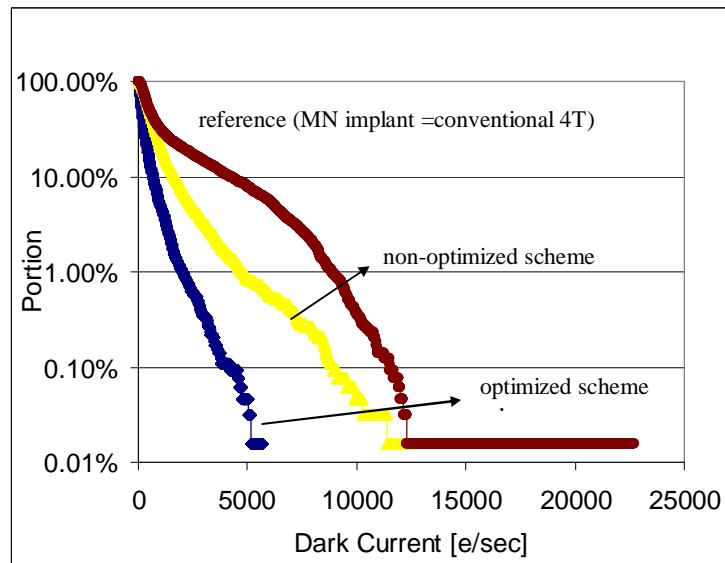


Figure 3: Dc distribution at the MN: **reference** - this is the distribution of a device with the regular 4T implant; **non-optimized scheme** – this device was manufactured with relatively heavy p-implant – This device gives about 40% improvement of red extinction coefficient compared to reference. **optimized scheme**. The best process - this device gives only 28% improvement for the red extinction coefficient but reduces dark current and reduces number of bright spots.