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Integrated a-Si:H Linear Image Sensor Using TFT Type Photo-Sensor

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Synopsis

A new photoconductive sensor is proposed, which has a gate electrode (TFT type photo-sensor). The gate electrode controls the band-bending of a photoconductive layer. Stability and reproducibility is obtained. This structure (MIS structure) allows integration of TFT type photo-sensors, switching TFTs, storage capacitors, and matrix circuits in the same process, farthermore allows a lensless image sensor unit.

TFT type Photo-sensor

The cross section of TFT type photo-sensor is shown in Fig. 1. The photocurrent and γ value depend on the gate voltage (Vgs) is shown in Fig. 2.

In Vgs >0, the channel current is larger than the photocurrent. In Vgs$\leqq$0, the channel current is suppressed,so the ratio of photo/dark current is about 10^3 and γ value is almost constant. Stability of the TFT type photo-sensor is obtained, because in Vgs$\leqq$0 photoconductive layer is depleted near the insulator interface.

Fig. 3 shows photocurrent response on Vgs of the TFT type photo-sensor. At the rise of Vgs, excess current flows, and exponentially decreases to the static current. After the fall of Vgs, current is restricted and gradually recovers. This photocurrent response is due to the slow redistribution of holes in the photoconductive layar. At the rise/fall of Vgs,the hole concentration does not decrease/increase immediately and the excess electrons are injected/swept out in order to keep out charge neutrarity. The excess current causes decrease of γ value, therefore it is necessary that Vgs is constant to drive the TFT type photo-sensor.

Integrated a-Si:H Linear Image Sensor

Equivalent circuit of the image sensor is shown in Fig.4. This image sensor is integrated of TFT type photo-sensors, strage and readout capacitors, transfer and reset TFTs, and 54×32 matrix circuit on a substrate. Source and gate electrodes of TFT type photo-sensors are connected directly (Vgs=0;constant). An analog multiplexer(CMOS IC) is connected with readout capacitors.

The cross section and microphotograph of the image sensor are shown in Fig.5. The channel length/width of TFT type photo-sensors is 316/9 μm, and that of TFTs is 800/10 μm. It is most important that each element with the same MIS structure (Cr/SiN:H/a-Si:H/n^+-a-Si:H/Al) is formed simultaneously.

These elements are driven as following. The photocurrent is charged in the storage capacitor during the storage time. While the 32 transfer TFTs turn on, in parallel, these photo-charges are transfered into readout capacitors. Then the photo charges are read out serially by an analog multiplexer. After this readout, the strage capacitors are reset by 32 reset TFTs. This sequence is repeated 54 times. Here, storage time is 5msec and TFT ON time is 47 μsec.

In this lensless structure, the gate electrode of TFT type photo-sensor functions as a light sheild layer for direct illumination. The illumination window is formed on the glass substrate. Protection over layer is formed by a thin glass plate. The distance between a photo-sensor and a surface of protection over layer is about 70 μm. The light transmitance is about 15 %, which is higher than a rod lens array and the resolution (MTF) is $\geqq$ 60% at 2L.P/mm.

The photograph of the A4-8dots/mm image sensor unit using Xe lamp as a light source is shown in Fig. 6. This image sensor unit has a performance enough to be employed G Ⅲ standard facsimile and document scanner.

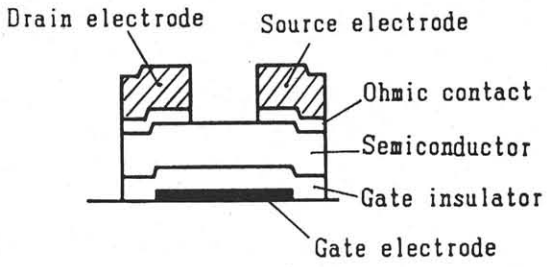


Fig.1. Cross sectional view of TFT type photo-sensor

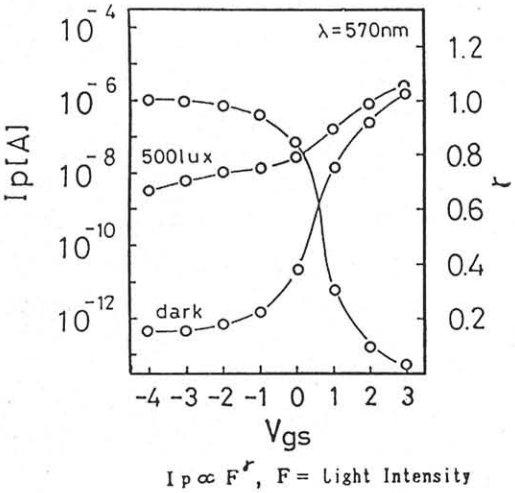


Fig.2. Characteristics of TFT type photo sensor

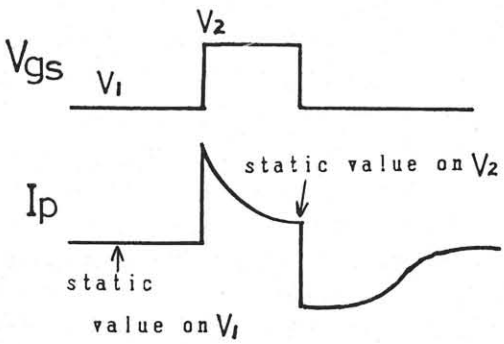


Fig.3. Photocurrent response on pulse gate voltage

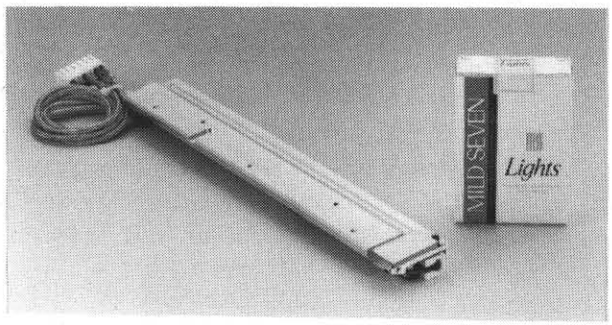


Fig.6. Photograph of the image sensor unit using Xe lamp

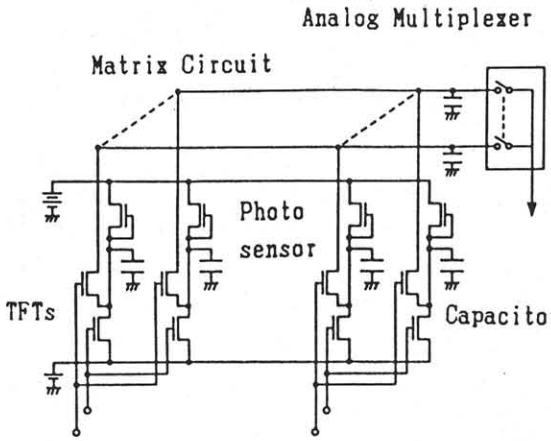
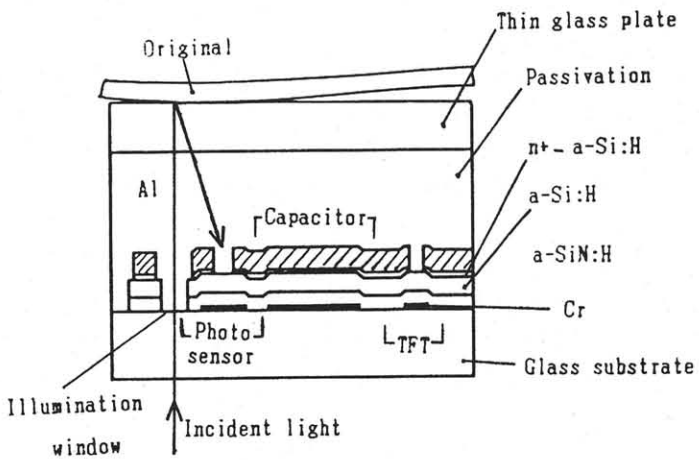


Fig.4. Equivalent Circuit of the image sensor



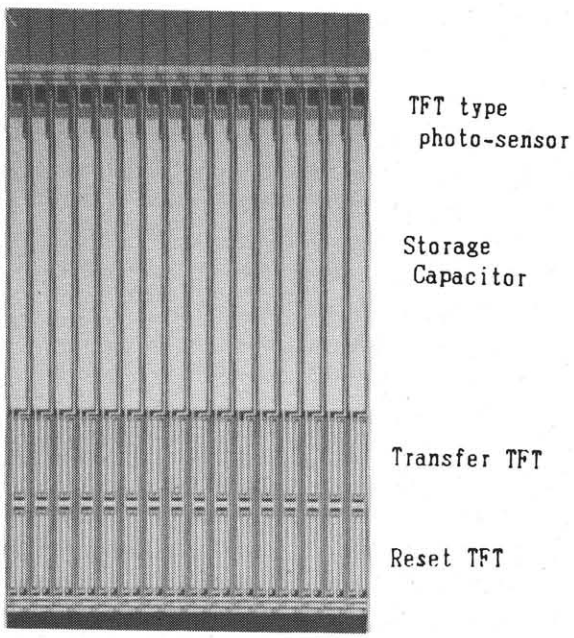


Fig.5. Cross sectional view and microphotograph of the image sensor