Digest of Tech. Papers The 7th Conf. on Solid State Devices, Tokyo, Sep. 1975

B-4-1 228 by 248 Cells Charge Coupled Image Sensor with Two-Level Overlapping Poly-Silicon Electrodes

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Charge coupled image sensor[1-2] with 228 (horizontal) by 248 (vertical) cells has been developed. Designing and device characteristics associated with this device are discussed.

Device Constitution The image sensor is consisted of imaging area, memory area, a shift registor and a charge detector to be operated in the frame transfer method.[2] Number of cells in each areas were decided from the requirements for resolution (∿200 TV lines) and the convenience to produce a standard NTSC type of color signal. The electrode system are made of two-level overlapping poly-Si layers isolated by thermally grown oxide layer as shown in Fig.1. The length of under level electrodes (ϕ_2 and ϕ_4) is larger than that of uper ones to improve signal handling capability. A low noise charge detector, shown in Fig.2, is placed adjacent to the shift registor. To realize low noise operation, dc biased electrodes are placed between reset electrode and floating diffusion F as well as final transfer electrode (ϕ_4) and floating diffusion.

Driving method New quasi-two phase charge transfer method is utilized, in which ϕ_1 and ϕ_3 act as only charge transfer gates, Two kinds of interlacing were examined; (1) Photo charges are stored (ϕ_2 and ϕ_4 act as charge storage electrodes.) alternatively in ϕ_2 and ϕ_4 electrode, and (2) They are stored in both ϕ_2 and ϕ_4 simultaneously and transferred into ϕ_2 and ϕ_4 alternatively before the frame transfer. This situation is illustrated in Fig.3.

Result and Discussions

(a) Image obtained. Figure 4 is an example of image obtained by interlacing mode (1). When mode (2) is used, the modulation transfer function, in the vertical direction, improves by about 15% for a pattern of a half of spatial Nyquist frequency. This improvement is considered to occur by reduction of sensor aperture.

(b) Out put wave form. Application of the new charge detector brought the reduction of spike current and random noise that resulted from capacitive coupling between reset, transfer electrodes and floating diffusion. High dynamic range of about 40db was obtained due to low noise operation of the detector.

(c) Signal handling capability. Maximum signal is proportional to the ratio of a charge storage electrode area to a picture cell area. The ratio, 14/40 in this case, is larger than any other structures proposed. It is still possible

to improve this ratio by reducing the length of ϕ_1 and ϕ_3 electrode.

(d) Feasibility of fabrication. Present structure supplies enough margins in making electrodes, contact holes and bus lines and results high yield. Good transfer efficiency (99.98% at 2MHz clock frequency), low dark current (~10nA/cm^2), high sensitivity (0.3A/W for 2870°k W-lamp) and stable performance are accomplished.

Conclusions 228 by 248 cells charge coupled image sensors with two-level overlapping poly-silicon electrodes have been developed. The devices were operated in the new quasi-two phase and improved interlacing mode. High dynamic range was obtained due to the low noise charge detector and large signal handling capability.

References

1) M.F. Tompsett et al. IEEE Trans. Electron Devices, Vol.ED-18 (1971) 992.

2) C.H. Sequin et al. IEEE Trans. Electron Devices, Vol.ED-21 (1974) 712.

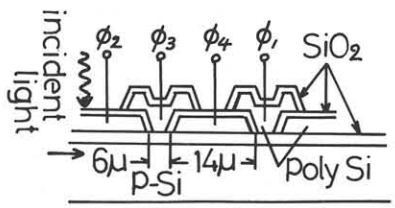

Fig.1 Electrode structure
Electrode width = 28μm
Arrow shows transfer direction

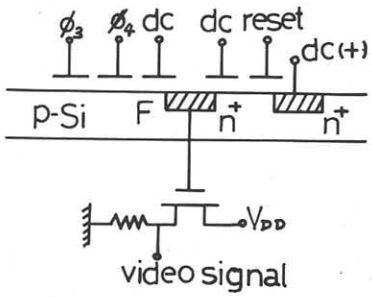

Fig.2 Charge detector

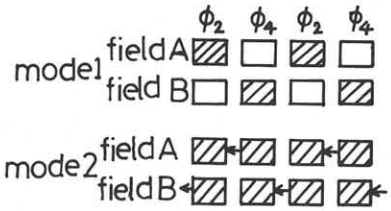

Fig.3 Interlacing methods

Fig.4 Image obtained
Limiting resolution ~180 TV lines
Clock frequency at shift registor = 4.3MHz
Dynamic range ~40db