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An Amorphous Si High Speed Linear Image Sensor

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Introduction At present, MOS photo diode arrays or CCD image sensors are widely used as a facsimile reader. However, these IC image sensors need a large optical path length and it is difficult to construct a compact image sensing element. For that reason, a document width CdS-CdSe[1)] and Se-Te-As[2)] linear image sensors have been developed. However, in the CdS-CdSe sensor[1)], photoresponse time is measured to be 12 ms which is too slow to be used in high speed GIII (5 ms/line) mode facsimile. As for Se-Te-As sensors, Se-Te-As films are easily recrystallized at the temperatures around 80°C and there is a concern with reliability. Recently, a 32 bits amorphous Si(a-Si:H) sensor array of a planer structure is reported[3)] whose photoresponse time is 5 ms and the photocurrent level deviation (S) is ±25%. To improve the response time and uniformity of the photocurrent, we have developed a-Si:H sensor array constructed in a sandwich structure. The device attains high and uniform photocurrent levels, large photo-to darkcurrent ratio(P/D) and can read a document at a speed of less than 5 ms/line.

Experimentals A structure of our a-Si:H sensor is shown in Fig. 1. Amorphous Si films were deposited by capacitance coupled RF glow discharge. Typical deposition condition is shown in Table 1. The major physical properties of the deposited a-Si:H films are as follows: Optical gap(E_g^{opt}) is about 1.7 eV, ESR spin density is less than $10^{16}cm^{-3}$, IR absorption peaks are obtained only at 2000 and 630 cm^{-1}. The deviation of the film thickness is less than ±5% in the range between 0.5 and 2.0 μm. The DC I-V characteristics and their dependence on lower electrode materials are shown in Fig. 2. From the experiment, Al was chosen because of its excellent blocking characteristics. Cr-Au and Ni show large darkcurrent levels. In this measurement, a 10 W fluorescent lamp (Toshiba Green) which has a peak intensity at 530 nm has been used. The uniformity of photo-(I_p) and dark-(I_d) currents levels for each one of 32 bits sensor elements was shown in Fig. 3. Bias voltage of -5.0 V was applied to an upper transparent electrode and lower electrodes (Al) were grounded. The I_p uniformity is excellent and S is less than ±5%. P/D ratio is larger than $2x10^3$. Rise time(τ_r) and fall time (τ_f) of the photoresponse measured by using green LED of 100 lux, modulated by 250 Hz are shown in Fig. 4. Both τ_r and τ_f are found to be about 0.5 ms at -5.0 V. An example of reproduced images by using the a-Si:H sensor elements (40 bits, 8 bits/mm) is shown in Fig. 5. Light source is the fluorescent lamp mentioncd above and an image formation is made of compact converging fibers of the optical path length of 64 mm which can be shorten to 1/2 or less if necessary. An output unit used to print Fig. 5 is a thermal printer(6 lines/mm) of Fuji Xerox TC 480 Facsimile.

Conclusions An amorphous Si linear image sensor which has a sandwich structure has been developed. The sensor has large and uniform photocurrent levels, large photo-to darkcurrent ratio, fast response time and can be operated by convenient low voltage of -5.0 V. A document width linear image sensor as shown in Fig.6 was fabricated which can be used as a compact high speed image sensing element for GIII mode facsimile.

References (1) K. Komiya et al., IECE(Japan), IE80-72, 1980. (2) H. Yamamoto et al., 9th Conf. Image Tech., 115, 1978. (3) T. Motosugi et al., spring meeting of JAPC, 29a-T-7, 1981.

PARAMETER	RANGE
RF Power	0.027-0.066 W/cm^2
Gas	100% SiH_4
Pressure (back)	2×10^{-6} Torr
(depo)	0.2-1.0 Torr
Substrate Temp.	230 °C
Electrode Distance	40 mm
Deposition Rate	0.3-0.6 nm/sec

Table 1 Typical deposition condition of a-Si films.

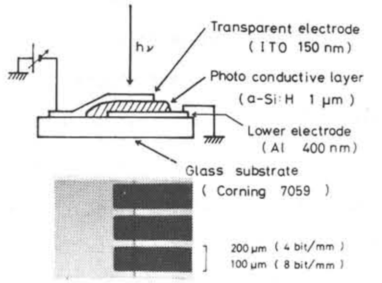

Fig. 1 Cross section and optical microscopic view of the device.

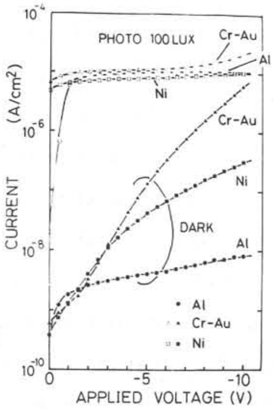

Fig. 2 I-V characteristics and their dependence on lower electrode materials.

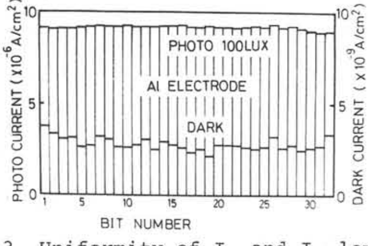

Fig. 3 Uniformity of I_p and I_d levels.

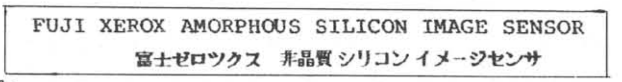

Fig. 5 Example of reproduced images by the a-Si sensor elements.

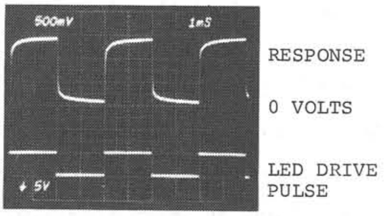

Fig. 4 Photoresponse of the sensor elements.

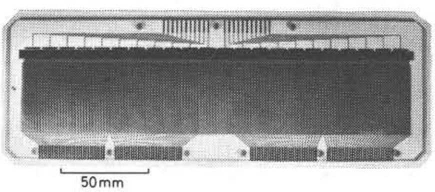

Fig. 6 Document width a-Si image sensor.