TFT addressed high-resolution real-time flat panel X-ray detector

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1. Introduction

Amorphous silicon TFT has been developed as the LCD for mainstream applications. The principal requirements for TFT array are large aperture, low on resistance and high off resistance for fast data writing and for image holding. A new emerging application of TFT array is flat panel x-ray detector for medical systems. For medical diagnostic use, TFT performance is crucial for obtaining high quality diagnostic images under very weak x-ray dose so as to decrease the impact on the human body.

We have developed TFT array for flat panel x-ray detector, focusing on optimization of the TFT array performance to obtain high quality images. In Table I the specifications of TFT for flat panel x-ray detector are summarized and compared with those of LCDs. Figure 1 shows an equivalent circuit of x-ray detector. The principal requirements are small values of noise magnitude and time variation of the noise, to detect very small charge signal in weak dose real-time x-ray imaging for long-time diagnostics.

2. Development

We have developed direct conversion type Se photoconductor flat panel detectors. In direct type mode, scintillator and a-Si photodiodes are not used for the conversion of x-ray to charge signal, though they are used for indirect type detectors. In order to realize high quality real-time images under weak x-ray dose, we focused on the following items of noise.

1) Decrease of AMP noise

The most significant factor of AMP noise is the data line load capacitance. Various noise sources on the data line are amplified in proportion to data line capacitance. By decreasing the size of data and address line cross-area, the data line capacitance is decreased. This is achieved by narrowing the address line width. The increase of address line resistance by narrowing was avoided by employing Al alloy instead of MoW alloy, which was used in our previous detector.

By improving the TFT array design and process, the data line load capacitance decreased by about 15 %. The noise level was improved by about 5 -10 %, which is less than the data line load capacitance decrease. This may be due to other noise sources that kept the same values as previous design.

The employment of Al alloy for address line resulted in address line resistance being 40 % of that for the previous design, which decreased the address pulse delay and improved the non-uniformity of the horizontal direction.

2) Time-dependent noise

Time-dependent noise is the most serious type of noise, because static noise can be cancelled by noise cancel circuit but time-dependent noise is difficult to cancel and results in decreasing dynamic range of the AMP. The source of time-dependent noise is considered to be time variation of the TFT off-current caused by the Vth shift. Time-dependent noise was decreased by improving the film quality and uniformity of various TFT films and by improving TFT array process uniformity. As a result, time stability of the TFT characteristics is improved. This Vth shift is considered to be due to various trap states and mobile ionic impurities.

3. Results

Due to the improvements described above, the non-uniformity of the dark image was decreased and high quality uniform image was realized.

Figure 2 shows the diagnostic image obtained by the developed flat panel x-ray detector. As a result of the improvement of TFT array, good quality image corresponding to the real-time image was obtained under low x-ray dose. The spatial resolution of the image was excellent and superior to that obtainable using indirect conversion type flat panel detectors with scintillator and conventional x-ray films. This is due to the employment of Se direct conversion type.

The detail will be described in the manuscript.

Table I Specifications for detector (FPD) and LCD

		X-ray FPD	TFT-LCD
Color		monochro.	multi color
Pixel size	μm	80-160	150-250
Frame freq.	Hz	15-60	30
On current	A	1E-06	1E-06
Off current	A	1E-13	1E-11
Structurre		low noise	large aperture
Driver circuit		AMP, ADC	DAC

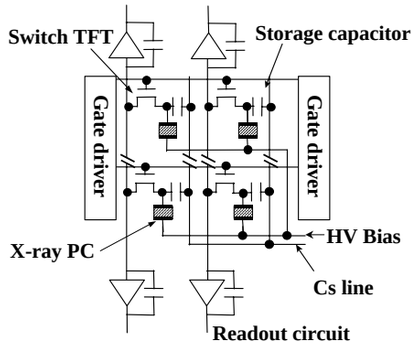

Fig. 1 Equivalent circuit of x-ray detector

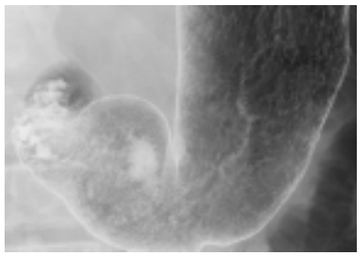

Fig. 2 X-ray image by the FPD