The transport property of direct conversion material a-Se:As film for digital radiography

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Carrier mobility was measured using time-of-flight (TOF) measurements to investigate the transport properties of holes and electrons in stabilized a-Se film. A laser beam with pulse duration of 5 ns and wavelength of 350 nm was illuminated on the surface of a-Se with thickness of 400 μm. The measured transit times of hole and electron were about 8.73 μs and 229.17 μs, respectively. The experimental results showed that the hole and electron drifting mobility were 0.04584 $cm^2V^{-1}s^{-1}$ and 0.00174 $cm^2V^{-1}s^{-1}$ at 10 V/μm.

Keywords: Amorphous selenium, Mobility, Time of Flight, Digital Radiography,

1. INTRODUCTION

The present flat panel sensors utilize stabilized amorphous selenium (a-Se) as a x-ray photoconductor to convert x-ray photons to collectable charge carriers. The a-Se layer that is currently being studied for its use as an x-ray photoconductor is not pure a-Se but rather a-Se doped with 0.2-0.5% As and 10-30 ppm Cl, also known as stabilized a-Se. The suitability of the stabilized a-Se is largely determined by its charge on generating, transporting and trapping properties. In this paper, time-of-flight (TOF) of drifting electrons and holes in stabilized a-Se film was used to investigate electron and hole drift mobility.

2. EXPERIMENTAL

2.1 Time of Flight (TOF) technique

Fig. 1 shows the schematic diagram illustrating the principle of TOF measurement. A voltage was applied across the a-Se layer sandwiched between Au electrode and ITO electrode for collecting charges. The applied bias (V) appeared across the thickness of a-Se layer since the external resistance is much less than the a-Se resistance. A short light pulse of 5nm from laser light source (350 nm) was employed to photo-generate free charges. The transit across a-Se layer produced a measurable current in the external circuit. The transient voltage, $R_{L,}$ was monitored on an oscilloscope (LeCroy LC 334AM, USA) as a photo response signal.

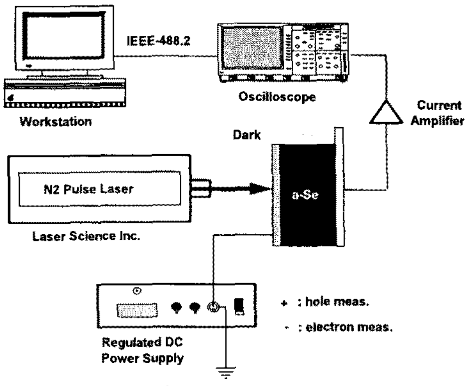

Fig. 1. The schematic diagram for TOF measurement

2.2 Transit time

A time-of-flight technique was used to measure the transit time and mobility of hole and electron. To time resolve the current transient, the duration, 5ns of laser pulse must be short compared to the shortest measurable transit time and the absorption coefficient of a-Se layer must be sufficiently large so that the light is absorbed in a narrow region close to the top electrode. The transit voltage across R is monitored on an oscilloscope. Charge transport property is based on *Schubweg* limitation, which means that $\mu_{\tau E}$, the carrier *Schubweg*.

2.3 Drift Mobility

Drift mobility is given by:

$$\mu = \frac{L}{t_T E} = \frac{L^2}{t_T V}[cm^2/v \cdot s]$$

$$V = E \cdot L \quad \text{: applied bias} \tag{2}$$

The a-Se film revealed no temperature-dependence in this study. therefore temperature-dependence was not a factor in analysis.

3. RESULTS AND DISCUSSION

3.1 Transit time

The transient current TOF signals for a-Se layer (400 μm) are shown in Fig. 2 and Fig. 3. The transient TOF waveforms were taken after the application of 10 V/μm across the a-Se layer. The transit times of hole and electron are 8.72 and 229.2 μs, respectively, at a voltage bias of 10 V/μm.

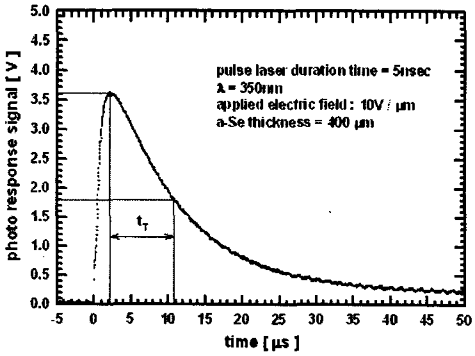

Fig. 2. Photo response signal of hole

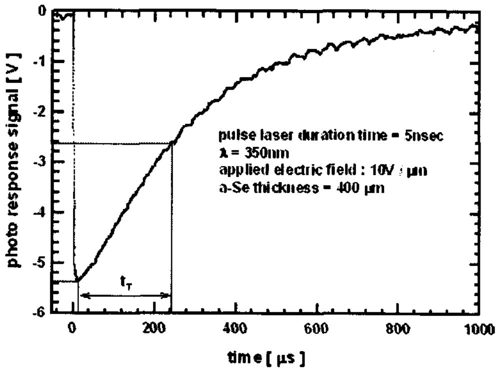

Fig. 3. Photo response signal of electron

3.2 Mobility

The drift mobility of hole and electron exhibited observable field dependence up to 4 V/μm, as shown in Fig. 4 and 5.

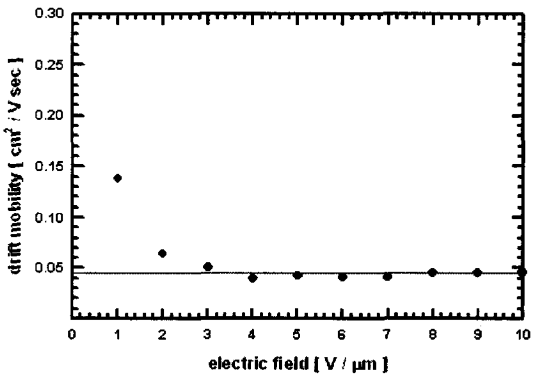

Fig. 4. The drift mobility of hole
as a function of applied electric field.

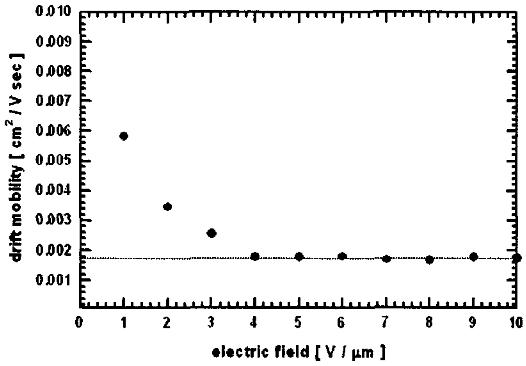

Fig. 5. The drift mobility of electron
as a function of applied electric field

The drift mobility of hole and electron at 10 V/μm are 0.04584 and 0.00174 $cm^2V^{-1}s^{-1}$, respectively. After careful analysis, this apparent difference in hole mobility seems to be due to both the temperature dependence and doping quantity of stabilized a-Se film.

4. CONCLUSIONS

The drift mobility of electron and hole was measured in stabilized a-Se using a time of flight technique. We have demonstrated that it is possible to measure the x-ray sensitivity of stabilized a-Se detector. The transit times of the hole and electron are strongly dependent to the electric field applied for collecting the carriers. The measured transit times of the hole and electron were about 229.17 μs and about 8.73 μs at 10 V/μm, respectively. The drift mobility of hole and electron in stabilized a-Se layer with 0.3% As and 30ppm ppm Cl was 0.04584 and 0.00174 $cm^2V^{-1}s^{-1}$ at 10 V/μm.