Measurement of Drifting Mobility and Transit Time of Holes and Electrons in Stabilized a-Se Film

Jae Hyung Kim
School of Computer Aided Science, Inje University, Kimhae, Kyungnam, 621-749, Korea

Chang Hee Park
Dept. of Radiologic Technology, Daegu health College, Daegu, 702-722, Korea

Sang Hee Nam
Medical Image Research Lab., Inje University, Kimhae, Kyungnam, 621-749, Korea

E-mail : jhkim@physics.inje.ac.kr

The transport property of stabilized amorphous selenium typical of the material used in direct conversion x-ray imaging devices was studied using the moving photo-carrier grating (MPG) technique and time-of-flight (TOF) measurements. For MPG measurement, the electron and hole mobility, and recombination lifetime of *a*-Se films with arsenic (*As*) additions have been obtained. For TOF measurement, 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.

Ⅰ. INTRODUCTION

We focus on the transport properties of $a\text{-}Se_{1-x}As_x$ films related to the underlying electron and hole drift mobility and recombination lifetime. The dependence of recombination lifetime on the *As* addition in *a*-Se film is reported. Time-of-flight (TOF) of drifting electrons and holes in stabilized *a*-Se film was also accomplished to investigate the transient time of holes and electrons.

Ⅱ. EXPERIMENT

1. MPG measurement

The experimental setup used for the MPG measurement is shown in Fig. 1. Two coherent laser beams of wavelength λ form an interference pattern on the sample surface. The beams impinge under an angle δ resulting in an intensity grating with spatial period $\Lambda=\lambda/[2\sin(\delta/2)]$. The light intensity at the surface of the sample (the *x* coordinate) has a spatial and temporal dependence:

$$I(x,t)=(I_1+I_2+2\sqrt{I_1I_2}\cos(kx-\omega_{gr}t),$$

Where I_1 and I_2 are the intensity of the two beams, and *k* is the spatial frequency ($k=2\pi/\Lambda$), ω_{gr} is the angular grating velocity ($\omega_{gr}=2\pi\upsilon_{gr}/\Lambda$).

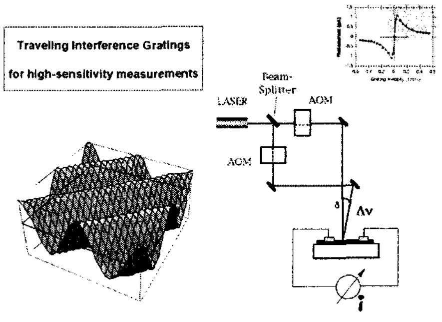

Fig.1. Experimental set-up for the MPG measurement

The MPG technique was applied to $a\text{-}Se_{1-x}As_x$ (between x = 0 and 0.1) films. The laser angle δ for MPG measurement samples was 21.1°, which gives the grating period of Λ=1.45μm.

1. Time of Flight (TOF) measurement

The principle of TOF measurement is as follows: 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 the free charges.

Ⅲ. RESULTS AND DISCUSSIONS

1. MPG measurement

The short circuit currents measured for *a*-$Se_{1-x}As_x$ ($0.001 \le x \le 0.1$) films as a function of υ_{gr} are plotted in Fig. 2. MPG curves for *a*-Se:*As* film exhibit the different behavior when compared with those for *a*-Si:*H*[5]. The inverted MPG curves of *a*-Se:*As* film compared with the MPG curves of *a*-Si:*H* are due to the positive photo-carrier charges, holes. The dominant mobility carriers are holes for *a*-Se films, whereas those are electrons for *a*-Si:*H* films.

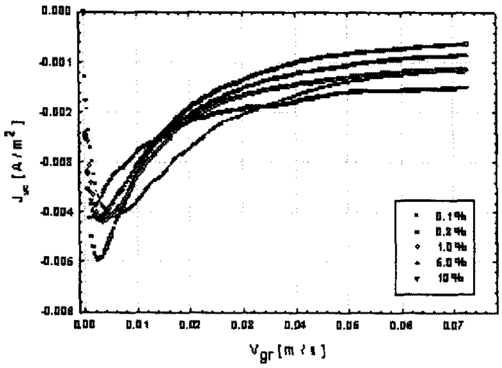

Fig. 2. Current density as a function of υ_{gr} for Λ=1.45μm.

The carrier mobilities μ_n and μ_p are obtained by fitting the measured short circuit current to the theoretical expression derived by U. Haken et al.. The electron and hole drift mobility for *a*-$Se_{1-x}As_x$ films are plotted as a function of *As* addition in Fig. 3. The hole drift mobility exhibits the apparent increase at the *As* addition of x=0.003 between x= 0.001 and x=0.01, whereas electron drift mobility decreases with As addition.

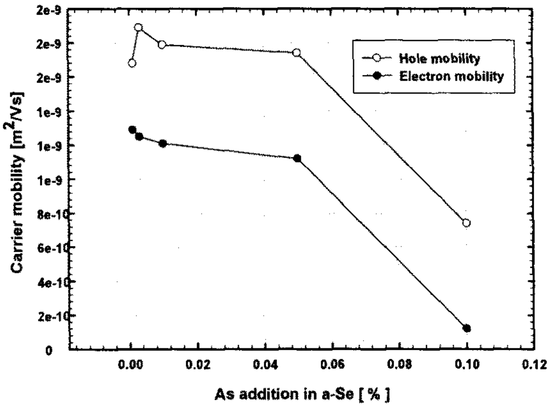

Fig. 3. The electron and hole drift mobility

The dependence of the recombination lifetime on the *As* addition in *a*-Se films is shown in Fig. 4. We have found the apparent increase of τ_R at the x=0.003 between x=0.001 and x=0.1, and τ_R increases with respect to *As* addition when *As* addition exceeds x=0.01. We assign this change to the contribution of two factors: a small additions of *As* in *a*-Se films up to x= 0.003 enhance the electric conductivity of *a*-$Se_{1-x}As_x$ films, while further *As* addition induces the undesirable hole traps in *a*-Se samples.

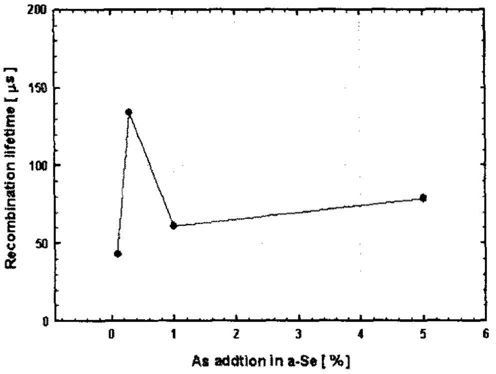

Fig. 4. The recombination lifetimes for *a*-Se:*As* films

3. TOF measurement

The transient current TOF signals for *a*-Se layer (400 μm) are obtained. The transit time becomes dependent on applied electric field to raise charge collection as a theoretical anticipation value. The transit times of hole and electron are 8.72 μs and 229.2 μs at a voltage bias of 10 V/μm, respectively. TOF transient photocurrents exhibited similar behaviors with those in *a*-$Se_{0.966}Te_{0.034}$ alloy photoreceptor film reported by S. O. Kasap previously.