Transport parameters in *a*-Se:As films for digital X-ray conversion material using the moving-photocarrier-grating technique

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The effects of As addition in amorphous selenium (*a*-Se) films for digital X-ray conversion material have been studied using the moving photocarrier grating (MPG) technique We have found an increase in hole drift mobility and recombination lifetime, especially when 0.3% As is added into *a*-Se film, whereas electron mobility decreases with As addition due to the defect density. The transport properties for As doped *a*-Se films obtained by using MPG technique have been compared with X-ray sensitivity for *a*-Se:As X-ray device. The fabricated *a*-Se (0.3%As) based X-ray detector exhibited the highest X-ray sensitivity of 5 samples.

Keywords: moving photocarrier grating, carrier mobility, recombination lifetime

Ⅰ. INTRODUCTION

While traditionally *a*-Se was employed in xerography[1], more recently this material has been used as the X-ray photoconductor in flat-panel X-ray image detectors[2]. The amorphous selenium film that is currently being studied for use an X-ray photoconductor is not pure *a*-Se but rather *a*-Se alloyed with 0.2-0.5% As (normally 0.3% As) and doped with chlorine (Cl) in the 10-20 ppm range, also known as stabilized *a*-Se[3-4]. A small amount of As in *a*-Se film is added to enhance the thermal stability of the amorphous state. But a high As addition induces the undesirable hole traps in *a*-Se:As film The moving photo-carrier grating (MPG) technique allows us to determine the carrier mobility and recombination lifetime of electrons and holes in semiconductors[5-6].

Ⅱ. EXPERIMENT

The dark current flowing in fabricated *a*-Se:As based X-ray detector was measured at dark state while applying an electric field from 2 to 10 $V/\mu m$. The experimental setup for measuring dark current as shown in Fig. 1(a) was composed of a current amplifier (Keithley Model 428) for measuring small dark current, and a power supply (EG&G 558H) for applying high electric field. The measurement of photo current as shown in Fig. 1(b) was similar to that of dark current, with the addition of X-ray exposure. X-ray exposure conditions were 70kVp, 100mA and 0.003s, respectively. Al layer with 2.5 μm thickness was also used as an X-ray absorption layer to control the X-ray dose exposing on the *a*-Se:As film.

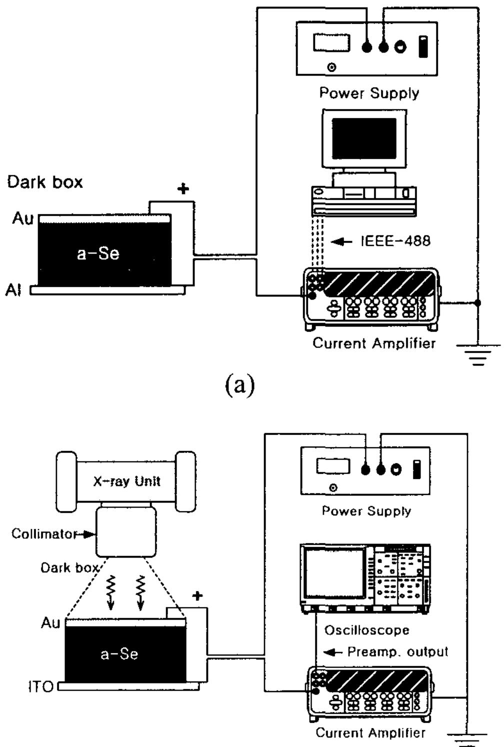

Fig. 1. Block diagram for (a) dark current measurement (b) photo current measurement

III. RESULTS AND DISCUSSIONS

MPG curves for a-Se:As film exhibit the different behavior compared with those for a-Si:H]. The inverted MPG curves in Fig. 2 compared with the MPG curves of a-Si:H is due to the positive photocarrier charges, holes. The dominant mobility carriers are holes for a-Se films, whereas those are electrons for a-Si:H films [7].

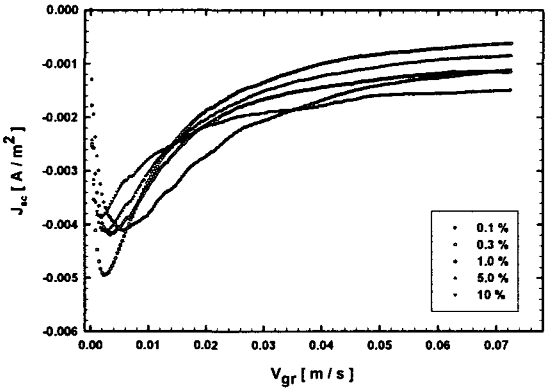

Fig. 2. Current density as a function of υ_{gr}

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. [5]. 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 = 0.1, whereas electron drift mobility decreases as a function of As addition. The hole mobility decreases due to defect density of shallow traps when x exceeds 0.003, whereas hole mobility increases in low As addition $(x \leq 0.03)$.

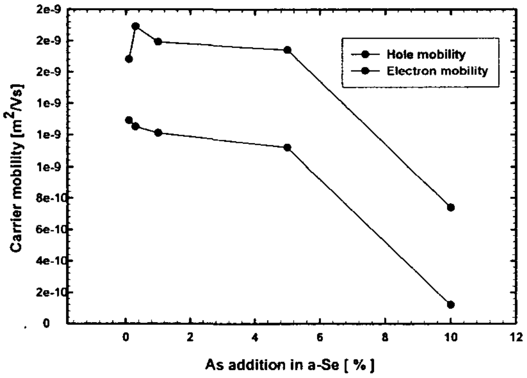

Fig.3. The electron and hole drift mobility as a function of As addition

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. The hole mobility decreases due to defect density of shallow traps when x exceeds 0.003 , whereas hole mobility increases in low As addition $(x \leq 0.03)$.

The measured X-ray sensitivity of the a-Se:As detector as a function of electric field is shown in Fig. 4. The X-ray sensitivity increases as the electric field increase from 2 to 10 $V/\mu m$. Experimental data indicates that the X-ray sensitivity for 0.3% As added a-Se detector exhibits higher value than those for others. The X-ray sensitivity for 0.3% As added a-Se detector was $170\, pC/mR/cm^2$. These results mean that the combined structure between a-Se and As effectively influences the recombination of the electron-hole pair created by X-ray exposure. The a-Se:0.3%As film contributes a stable a-Se structure for collecting a created charges.

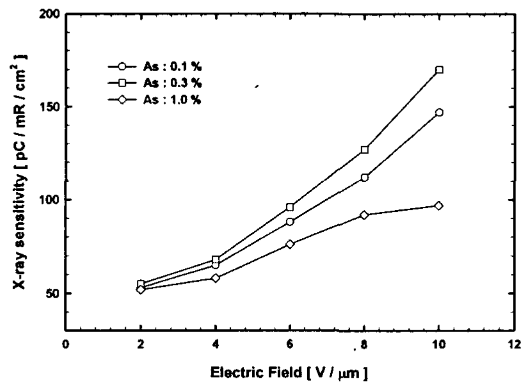

Fig. 4. X-ray sensitivity for a-Se:As films as a function of electric field

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