The moving photocarrier grating technique for the determination of transport parameters in *a*-Se:As films

Chang Hee Park Kwang Sei Lee, Jae Hyung Kim
School of Computer Aided Science, Inje University, Kimhae, Kyungnam, 621-749, Korea

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

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

The moving photocarrier grating(MPG) technique for the determination of the carrier mobilities and the recombination lifetime in a-Se:As films have been studied. The electron and hole drift mobility and the recombination lifetime of *a*-Se films with arsenic (As) additions have been obtained. We have found an increase in hole drift mobility and recombination lifetime, especially when 0.3% As is added into *a*-Se film. However, the electron mobility exhibits no observable change up to 0.5% As addition in *a*-Se films. 0.3% As added *a*-Se film also exhibits the maximum short circuit current densities per laser intensity of $5.29\times10^{-7}A/W$.

Keywords: moving photocarrier grating, carrier mobility, recombination

Ⅰ. INTRODUCTION

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 [1-2]. A small amount of As in *a*-Se is added to enhance the thermal stability of the amorphous state. But it induces the undesirable hole traps in *a*-Se film. It is well known that doping *a*-Se film with small amounts of Cl in the ppm range is necessary to reduce the deep traps associated the arsenic atoms.

While a several MPG measurements have been carried out on the transport properties of amorphous silicon (*a*-Si) sample in the past, the transport phenomena for *a*-Se films using MPG method has not been accomplished yet. We focus on the transport properties of $a-Se_{1-x}As_x$ samples which are related with the underlying electron and hole drift mobilities and recombination lifetimes.

Ⅱ. EXPERIMENT

The experimental setup used for the MPG measurement is shown in Fig.1. Coherent laser beam is split into two parts using a beam splitter, which interfere at the surface of the sample under an angle δ. Thus, an intensity grating with spatial period $\Lambda=\lambda/[2\sin(\delta/2)]$ is created. The MPG technique was applied to $a-Se_{1-x}As_x$ (x = 0.001, 0.003, 0.01, 0.05) films. The laser angles δ for *a*-Se:As samples were 33.2° which gives $\Lambda=0.93\mu m$.

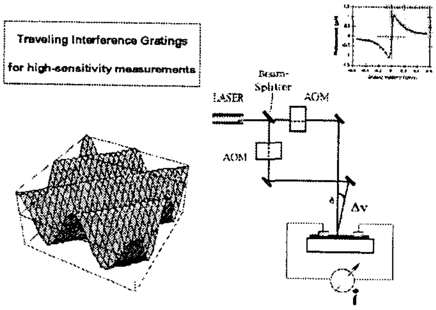

Fig.1. Experimental set-up for the moving photo-carrier grating (MPG) measurement

Ⅲ. RESULTS AND DISCUSSIONS

The short circuit currents measured for $a-Se_{1-x}As_x$ samples as a function of υ_{gr} are plotted in Fig. 2. MPG curves for *a*-Se:As films exhibit the different behavior compared with those for *a*-Si:H. The sign of the short circuit current is compatible with $\mu_p>\mu_n$ The inverted MPG curves of $a\text{-}Se_{1-x}As_x$ 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 [6].

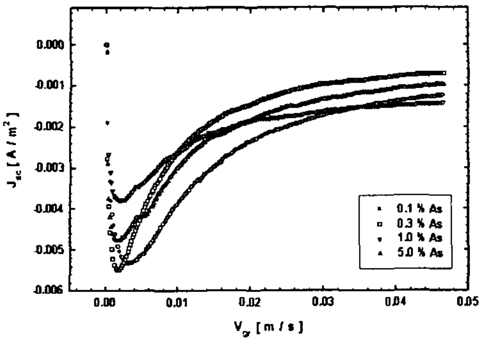

Fig.2. Current density for different As addition as a function of υ_{gr}

Fig. 3 shows the maximum current densities per laser intensity, J/I_0 for $a-Se_{1-x}As_x$ films as a function of As addition, which shows an apparent increase of J/I_0 for $a-Se_{1-x}As_x$ at x = 0.003. The reason for this behavior is that a small amounts of As in a-Se film increase the thermal stability and the current density due to holes, but the transport characteristic of As doped a-Se film deteriorates when As addition exceeds 0.03%, due to shallow hole traps in $a-Se_{1-x}As_x$ films.

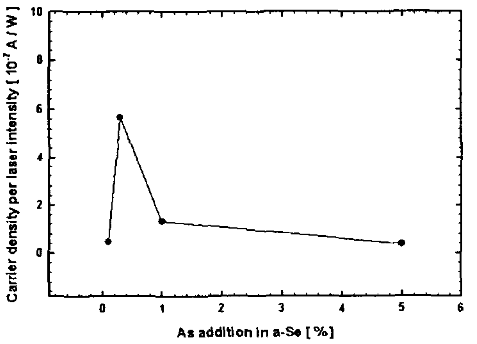

Fig. 3 Maximum current density per laser intensity as a function of As addition.

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. [4]. The electron and hole drift mobility for $a-Se_{1-x}As_x$ films are plotted as a function of As addition in Fig. 4. The hole drift mobility exhibits the apparent increase at the As addition of x = 0.003 between x = 0.001 and x = 0.05, whereas electron drift mobility doesn't show observable change 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

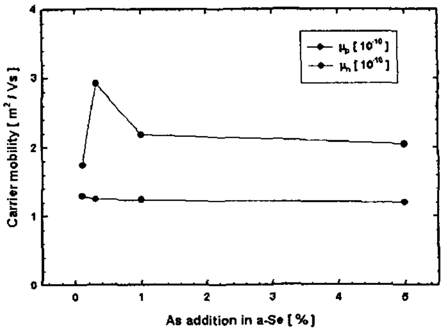

Fig. 4. The electron and hole drift mobility as a function of As addition

The dependence of the recombination lifetime on the As addition in a-Se films is shown in Fig. 5. τ_R increases with respect to As addition up to 5%. The a-Se:As(0.3%) film also exhibits apparent increase in recombination lifetime. 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 [2].

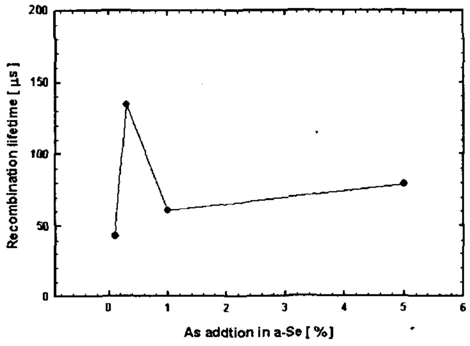

Fig. 5. The recombination lifetimes for a-Se:As films as a function of As addition

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