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Spectral Response Characteristics of a-Se HARP Films by Te Doping

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1. Introduction

Compact and highly sensitive solid state image sensor was developed using an amorphous selenium(a-Se) HARP film as a photoconversion layer [1]. The effective quantum efficiency of the a-Se HARP film can be increased more than 1, by avalanche multiplication phenomena at a high electric field [2].

In previous report [3, 4], we investigated characteristics of a-Se HARP film for a solid state image sensor. Considering of the endurance voltage of the MOS readout circuit, we determined the thickness of an a-Se HARP film for a solid state image sensor.

The optical absorption for long wavelength incident light must be considered to obtain high sensitivity and good spectral response. To improve the spectral response of the a-Se HARP film for a solid state image sensor, The a-Se HARP film was doped with tellurium(Te). And we investigated the relative sensitivity and quantum efficiency of the a-Se HARP film with Te-doped layer.

2. Experimental

We prepared the a-Se HARP film with same structure such as shown in previous report [4]. The thickness of the a-Se HARP film was 0.4μm, and the thickness of Te-doped layer was 60nm, 90nm, and 120nm, respectively. In this case, the Te concentration of Te-doped layer was 26 wt. %. And 0nm means the a-Se HARP film has not Te-doped layer. This Te-doped layer was sandwiched within the a-Se HARP film. Also the a-Se HARP film was deposited by vacuum evaporation method, and Sb_2S_3 film was deposited to block electron injection from electrode.

3. Results and Discussion

We measured the spectral response of the a-Se HARP film with Te-doped layer as shown in Fig. 1. In this case, the spectral response was measured at a bias voltage of 40V which corresponds to an electric field of $1x10^8$V/m.

From the result, the relative sensitivity at long wavelength region was highly increased by Te doping within the a-Se HARP film. And also the cutoff wavelength of the spectral response was extended into long wavelength region by the increase of Te-doped layer thickness. These results are due to the increase of the photogeneration efficiency at long wavelength region by Te doping.

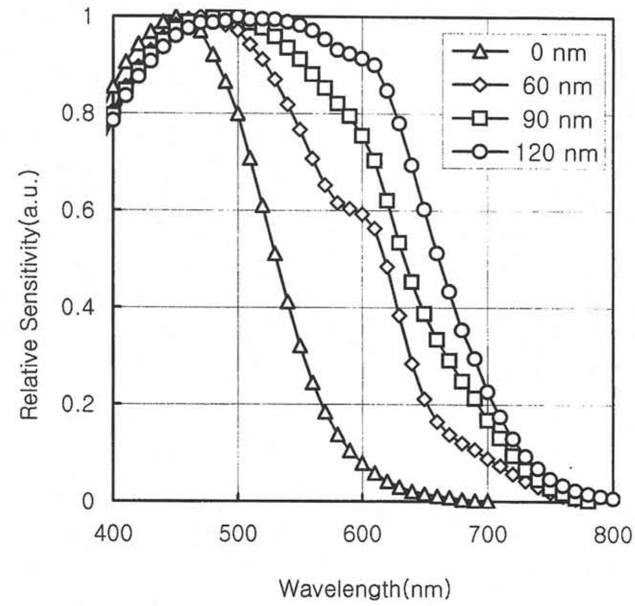

Fig. 1 Spectral response of a-Se HARP film at 40 V.

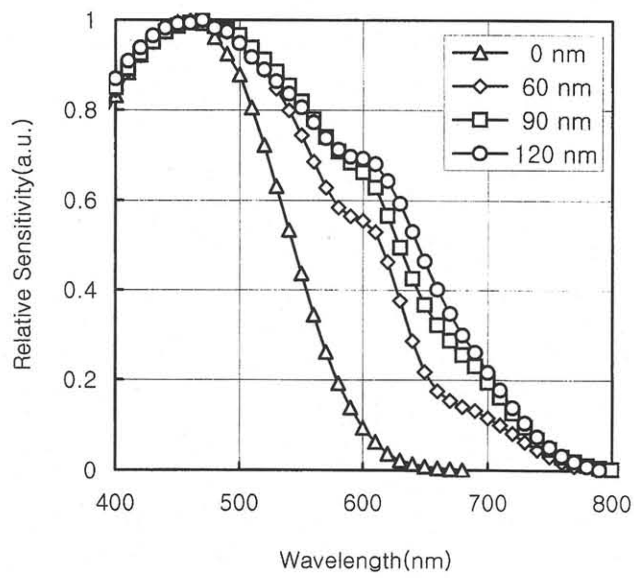

Fig. 2 Spectral response of a-Se HARP film at 60 V.

And the peak wavelength of the relative sensitivity was shifted from blue region to green region by the increase of Te-doped layer thickness.

Fig. 2 shows the spectral response of the a-Se HARP film measured at bias voltage of 60V which corresponds to an electric field of 1.5×10^{8}V/m, in an avalanche region.

In contrast to the result at 40V, the peak wavelength of relative sensitivity at 60V was nearly same. And the relative sensitivity of the a-Se HARP film with Te-doped layer at long wavelength region was lower than that of the a-Se HARP film at 40V.

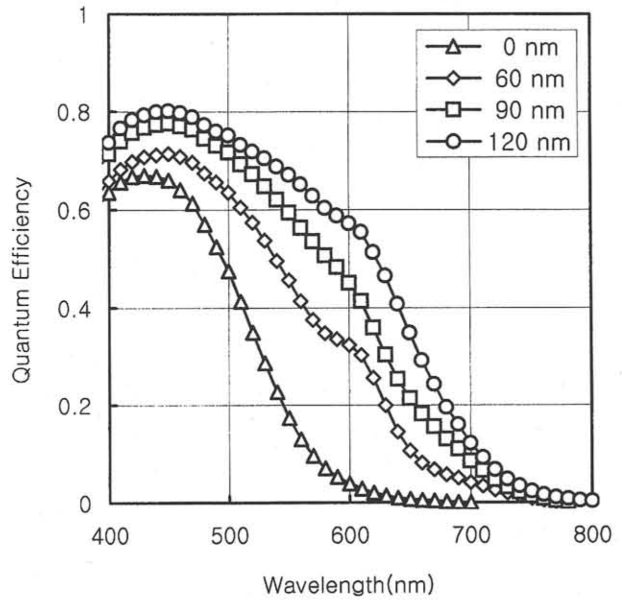

Fig. 3 Quantum efficiency of a-Se HARP film at 40V.

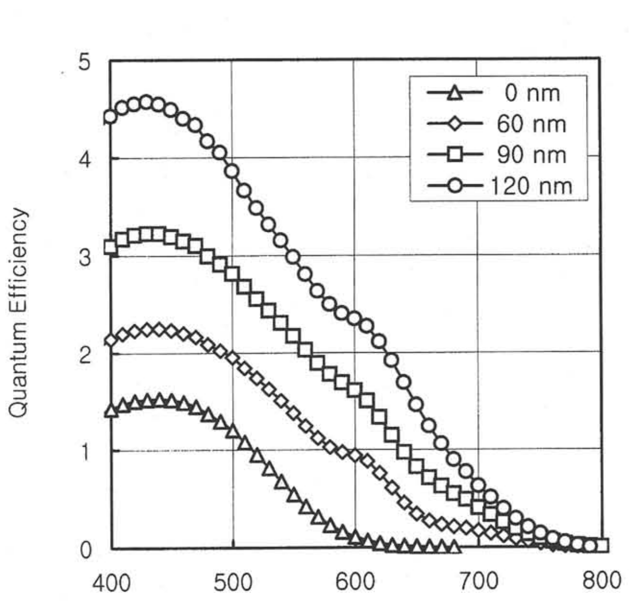

Fig. 4 Quantum efficiency of a-Se HARP film at 60V.

In an avalanche region, the avalanche multiplication factor of the a-Se HARP film at short wavelength region is higher than its value at long wavelength region. Therefore the relative sensitivity of the a-Se HARP film at long wavelength region at 60V was lower than its value at 40V.

Fig. 3 shows the quantum efficiency of the a-Se HARP film at 40V. In this case, the quantum efficiency was lower than 1, by low electric field in non-avalanche region. But the quantum efficiency of the a-Se HARP film with Te-doped layer at long wavelength region was increased by the increase of Te-doped layer thickness.

And also the dependence of the quantum efficiency of the a-Se HARP film on Te doping at short wavelength region was low. It is considered most of carriers were generated at surface of the a-Se HARP film by short wavelength incident light.

Fig. 4 shows the quantum efficiency of the a-Se HARP film with Te-doped layer at 60V. The quantum efficiency of the a-Se HARP film at short wavelength region was highly increased by the increase of Te-doped layer thickness.

It could be explained by the following reason. In this structure of the a-Se HARP film with Te-doped layer [4], the electric field of the a-Se layer is higher than that of Te-doped layer which has relatively low resistance. Therefore the avalanche multiplication factor of the a-Se layer at short wavelength region at 60V is higher than that of Te-doped layer.

4. Conclusions

The spectral response characteristics of the a-Se HARP films with Te-doped layer were investigated. The thickness of Te-doped layer was 60nm, 90nm, and 120nm, respectively. The relative sensitivity of the a-Se HARP film was increased by the increase of Te-doped layer thickness. This a-Se HARP film with Te-doped layer which has a good spectral response in visible region can be applied as a photoconversion layer for a solid state image sensor.

Acknowledgments

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