http://dx.doi.org/10.21611/qirt.2017.035

Fabrication and characterization of InGaAsSb/GaSb photodetectors for SWIR detection

Jun Oh Kim[1†], Nguyen Tien Dai[1], Jehwan Hwang[1], Sang Jun Lee[1*]

[1]Korea Research Institute of Standards and Science, Daejeon 34113, Korea

[†]Presenting Author: jokim@kriss.re.kr
[*]Corresponding Author: sjlee@kriss.re.kr

ABSTRACT

We report on the short wavelength infrared (SWIR) photodetector based on quaternary InGaAsSb. The InGaAsSb samples were grown by molecular beam epitaxy (MBE) system on a GaSb substrate. The InGaAsSb layers were lattice-matched to the GaSb substrate. We took a high resolution X-ray diffractometer (HR-XRD) to investigate the composition and structural quality of InGaAsSb epilayers. In order to measure the optical properties of infrared photodetectors, the InGaAsSb devices were fabricated in 410×410 μm^2 using conventional photolithography. We have measured the spectral response of InGaAsSb based photodetector at room temperature. The cut-off wavelength of photodetector with different composition of InGaAsSb absorption layer was 2.5 µm and 3.0 µm at room temperature.

KEYWORDS: Short wavelength infrared, Molecular beam epitaxy, photodetector, InGaAsSb

1. INTRODUCTION

Short wavelength (1-3 µm) infrared (SWIR) detectors have been received great attention for a variety of applications in military and industrial such as remote sensing, molecular spectroscopy, environmental monitoring, gas detection and night vision.[1] Currently, SWIR detection systems are predominantly based on type-II InAs/GaSb superlattice (T2SL), mercury cadmium telluride (MCT) and extended indium gallium arsenide (EX-InGaAs) technologies. However, MCT have intrinsic draw-back such as inferior material uniformity.[2] For Ex-InGaAs, the material quality is degraded due to increase misfit dislocation density introduced by the lattice-mismatch. Over the past years, the quaternary InGaAsSb materials have been researched for SWIR detection.[3] Recent progress in InGaAsSb technology has made it a promising candidate for high-performance infrared detection in the SWIR due to high speed and lower noise.

2. EXPERIMENTAL

In this work, we have grown, processed, and characterized two InGaAsSb photodetectors grown by molecular beam epitaxy (MBE). The structural quality of InGaAsSb epi layer was performed using HR-XRD. The spectral response was measured using a glow-bar source within the Nicholet 570 Fourier transform infrared spectrometer (FTIR).

2.1 MBE GROWTH OF PHOTODETECTORS

The samples of InGaAsSb infrared photodetector were grown on n-type GaSb substrate using a molecular beam epitaxy with an As_2 and Sb_2 valve cracker source. Fig. 1 illustrates the layer structure of the AlGaSb/InGaAsSb infrared photodetector. The device consisted of an n-type (2×10^{18} cm^{-3}) 300 nm thick GaSb buffer layer, an n-type (2×10^{18} cm^{-3}) 300 nm thick InGaAsSb bottom contact layer, an n-type (2×10^{16} cm^{-3}) 2000nm thick InGaAsSb absorption layer, a 60 nm unintentionally doped $Al_{0.3}Ga_{0.7}Sb$ layer and an n-type (2×10^{18} cm^{-3}) 200 nm thick InGaAsSb for top contact layer. The $Al_{0.3}Ga_{0.7}Sb$ barrier was used to create an nBn detector, which has a large conduction band offset compare to the InGaAsSb absorber. Two InGaAsSb samples were grown on GaSb substrate, where the composition of In and As were 28%, 25% (sample A) and 17%, 14% (sample B), respectively. After growth, the samples were characterized using HR-XRD. Diffraction patterns were obtained from the (004) reflection. The results indicated that the $In_{0.28}Ga_{0.72}As_{0.25}Sb_{0.75}$ layer was lattice matched to the GaSb substrate as shown in the Fig. 1, where the $In_{0.17}Ga_{0.83}As_{0.14}Sb_{0.86}$ sample was lattice mismatched to substrate.

http://dx.doi.org/10.21611/qirt.2017.035

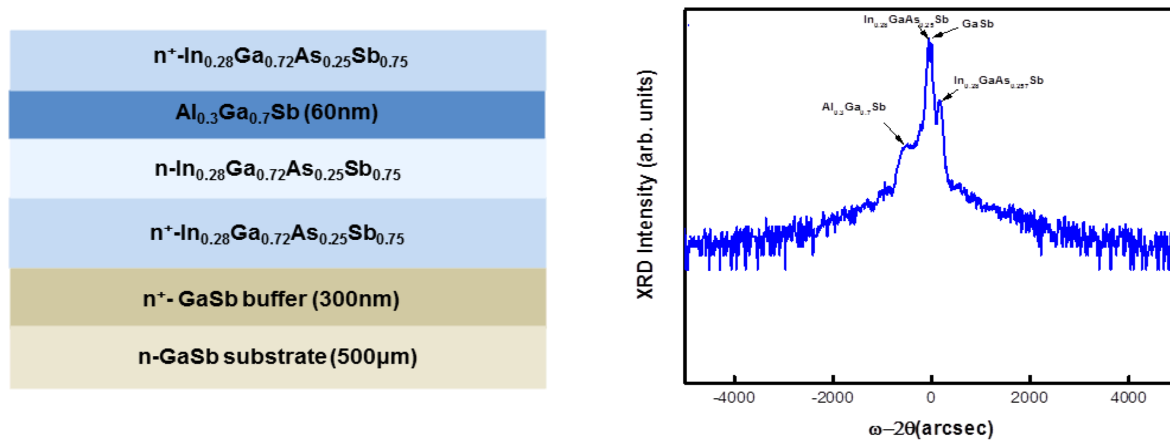

Fig. 1 Schematic view of InGaAsSb photodetector and HR-XRD result

2.2 DEVICE FABRICATION AND CHARACTERIZATION

The InGaAsSb devices were performed in 410×410 μm^2 using a photolithography for the front-illuminated structure, where the device had a circular aperture of 300 µm in each mesa. Afterwards, the ohmic contact metals of Ge/Au/Ni/Au were deposited on the top and bottom contact layer. Subsequently, the contact annealing at 380 ℃ was performed on the devices using rapid thermal annealing. The Spectral response measurement was performed using a glow-bar source within the Nicholet 570 Fourier transform infrared spectrometer (FTIR) as a function of temperature. The photodetectors were measured under zero voltage bias. Two samples were characterized in order to compare the device performances. The cut-off wavelength of sample A and B was 3.0 µm and 2.5 µm at room temperature, which is due to the bandgap of absorber material.

3. CONCLUSIONS

In conclusion, the two nBn photodetectors, one with lattice-matched (sample A) and the other lattice-mismatched (sample B) to the substrate, were demonstrated based on quaternary InGaAsSb material and AlGaSb barrier layer. The structures were grown using the molecular beam epitaxy technology. The HR-XRD indicated good material quality of the InGaAsSb layer. Room temperature spectral response of sample A and B were obtained with the cutoff wavelength at 3.0 µm and 2.5 µm, respectively.

ACKNOWLEDGMENT

This work was supported by the KRISS grant GP2017-0031 and the AOARD grant FA2386-14-1-4094 funded by the U.S. government (AFOSR/AOARD).

REFERENCES

[1] B. Carter, E. Shaw, J. Olesberg, W. Chan, T. Hasenberg, M. Flatte, High detectivity InGaAsSb pin infrared photodetector for blood glucose sensing, Electronics Letters, 36 (2000) 1301–1303.

[2] J.D. Phillips, K. Moazzami, J. Kim, D.D. Edwall, D.L. Lee, J.M. Arias, Uniformity of optical absorption in HgCdTe epilayer measured by infrared spectromicroscopy, Applied Physics Letters, 83 (2003) 3701.

[3] H. Shao, A. Torfi, W. Li, D. Moscicka, W.I. Wang, High detectivity AlGaAsSb/InGaAsSb photodetectors grown by molecular beam epitaxy with cutoff wavelength up to 2.6, Journal of Crystal Growth, 311 (2009) 1893-1896.