Detectivity Evaluation in SiGeSn/GeSn Multiple Quantum Well Photodetector

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1. Introduction

The theoretical and experimental demonstration of direct band gap Germanium by incorporation of small amount of Tin (Sn) has paved the path of CMOS based optical interconnect [1-2]. The introduction of Sn into Ge not only improves capability of Ge to be used in optoelectronic devices but also extend the response wavelength of Ge to short and wave and mid-infrared wavelength range. These wavelength ranges are very significant in sensing applications which are generally implemented by Group III-V based quantum well infrared photodetector.

In this context, one of the authors had already reported SiGeSn/GeSn strain balanced quantum well photodetector and investigated its performance and characteristic in detail [3-4]. However, it is observed that in single quantum well GeSn based photodetector, the output photo current is not so large as compared to that in its Group III-V counterpart. Therefore multiple quantum well configuration is most potential method to improve the efficiency of GeSn based quantum well photodetector. Detectivity is the most important characteristic to gauge the competency of SiGeSn/GeSn MQWIP. In this work, authors evaluate the detectivity of multiple quantum well photodetector (MQWIP) and studied it under variation of number of well (M).

2. Theory

Firstly photocurrent is evaluated considering the charge transport mechanism among the adjacent well in the multiple quantum well configuration of proposed QWIP as shown in Fig.1 [5]. After photocurrent evaluation, dark current is calculated by solving the charge transfer rate equation in MQWIP in steady state equation[5]. Then with the help of dark current and photo current, detectivity is obtained with the help of following equation.

$$D^{*} = (0.5R_{M})\left[q\left(j_{darkM\_electrons} + j_{darkM\_holes}\right)\right]^{-1/2} \qquad (1)$$

where, D* is detectivity, R_M is responsivity for M quantum wells, $j_{darkM\_electrons}$ is dark current for electrons and j_{darkM_holes} is dark current for holes in quantum well.

3. Result and Conclusions

Detectivity, which indicates the minimum detectable signal, is calculated with the help of Eqn. 1 after calculating the dark current and responsivity as reported by authors [5]. Plot of detectivity with bias for different values of M is shown in Fig. 2. It can clearly be observed that detectivity decreases with increasing bias mainly due to the more dominant effect of bias on the dark current compared to its effect on responsivity. A significant value of maximum detectivity of 2.2 x10^9cmHz$^{1/2}$W^{-1} is obtained for 14 or more number of wells at very low bias.

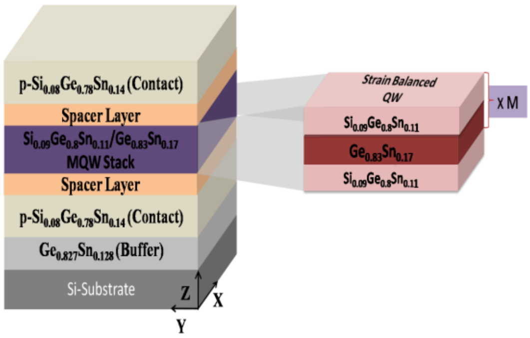

Fig.1.Schematic of SiGeSn/GeSn MQWIP [5]

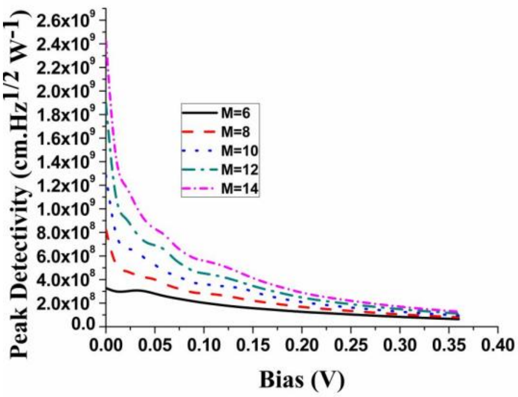

Fig.2. Plot of peak detectivity as a function of bias for different M

References

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