A New Method on Response Speed of Uni-traveling-carrier Double Heterojunction Phototransistor: Bilateral Incidence from the Base Region

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Abstract: In this paper, a new method to improve the response speed of an SiGe-based uni-traveling-carrier double heterojunction phototransistor (UTC-DHPT) are illustrated. The detailed analysis show that bilateral incidence from the base region has better performances than one incidence from the base region.

1 INTRODUCTION

The heterojunction phototransistor (HPT) can be used in the front end of the optical receiver for opto-electronic integrated circuits (OEICs). Now, most photode-tectors (PDs) are based on III-V materials due to the weak lightabsorption of Si. However, the III-V-based PDs (Y. L. Liu et al, 2015; G. zang, et al, 2014; T. Ishibashi, et al, 1997) are hard to integrate on Si and increase the cost of the hybrid circuits. In order to overcome the drawback of the weak photoabsorption process in Si material and the problems in system integration of III-V-based PDs, the Si–SiGe HPT with 850-nm absorption has been demonstrated (W. J. Huo, et al, 2014; Z. Y. Jiang, et al, 2015). With the rapid development of modern optoelectronic technology, photodetectors are required to have high responsivity and speed as a key component in optoelectronic systems. HPT dectertor has become a research focus in the photoelectric field in recent years. In 1997, Ishibashi proposed a uni-traveling-carrier photodiode (UTC-PD) detector in Japan to increase its responsivity and speed. Recent Papers reported show that application of uni-traveling-carrier into HPT detector will also improve the HPT performance. (J. L. Polleux, et al, 2004) In this paper, the optical responsivity and high frequency characteristics of uni-traveling-carrier double heterojunction phototransistor (UTC-DHPT) through bilateral incidence from the base region are illustrated in detail and compared with traditional UTC-DHPT through one incident from the base region. The UTC-DHPT through bilateral incidence from the base region obtained higher saturation current, higher responsivity and higher response speed.

2 DEVICE CHARACTERISTICS AND DISCUSSION

The two-dimensional structure of SiGe UTC-DHPT are shown in Fig. 1.

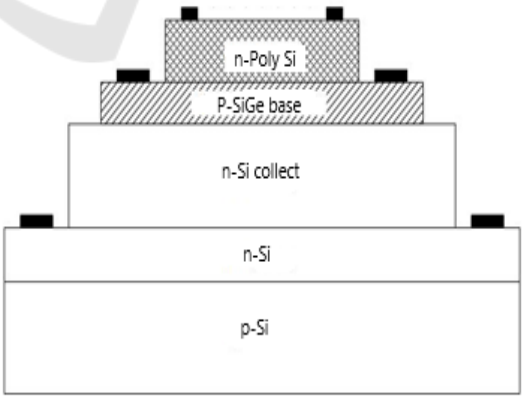

Figure 1. Two-dimensional device structure of UTC-DHPT.

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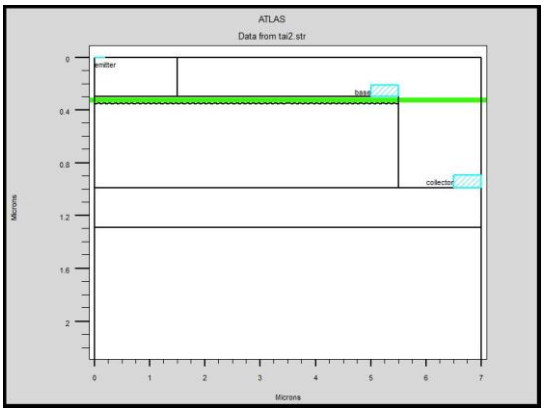
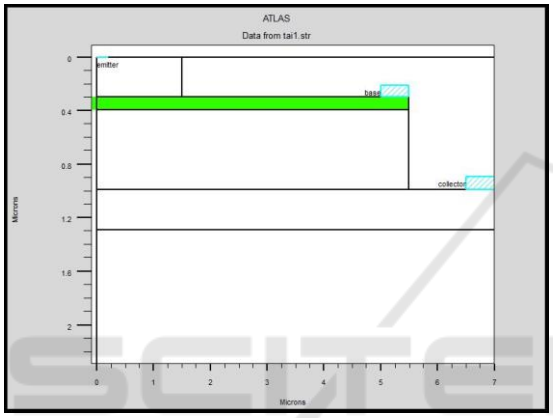


(a) Bilateral incidence



(b) One incident

Figure 2. Two-dimensional device structure of UTC-DHPT based on ATLAS.

Fig 2 shows the the incident way of the optical beam, bilateral incidence area has the same as one incident. The optical beam of 1.55μm across the optical window is injected into the exposed base with the collector biased at Vce = 2 V. The collect current(IC) of bilateral incidence is higher than one incident when light power increasing from 0.1 mW to 0.25 mW as show in Fig 3 and Fig 4. Thus, bilateral incidence obtained higher maximum responsivity as light power increasing from 0.1 mW to 0.25 mW.

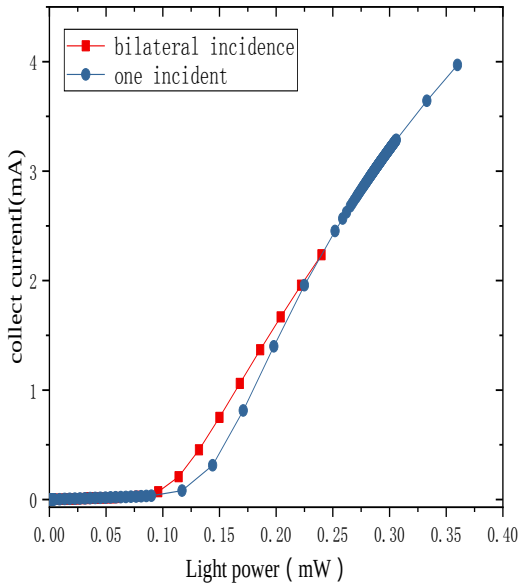


Figure 3. collector current of the bilateral incidence and one incident as a function of with incident light power.

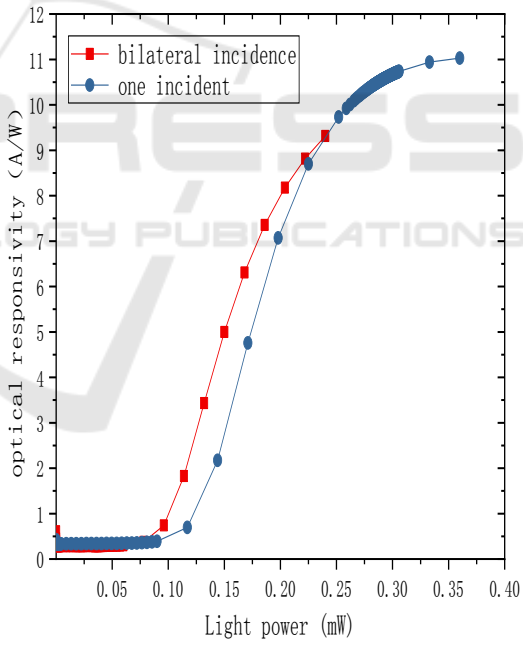


Figure 4. The optical responsivity of the bilateral incidence and one incident as a function of light power.

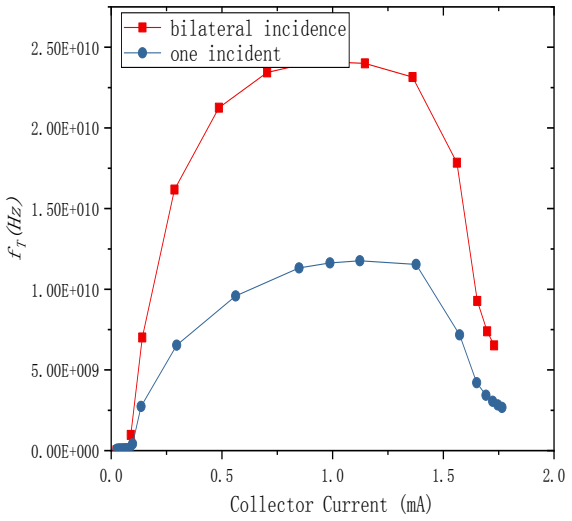


Figure 5. Dependences of fT on IC of bilateral incidence and one incident.

The $fT-Ic$ curves of the bilateral incidence and one incident were extracted with V ce = $2V$, as the Fig.5 shows. The maximum fT of bilateral incidence reaches 2.5*1010Hz as collector current of 1mA, and the maximum fT of one incident is 1.1*1010Hz as collector current of 1.1mA. It is apparent that fT of bilateral incidence is higher than one incident.

3 CONCLUSIONS

In this paper, the saturation current, optical responsivity and high frequency characteristics of the UTC-DHPT with bilateral incidence from the base region have been studied in detail. The results show that UTC-DHPT with bilateral incidence from the base region has a higher saturation current and maximum optical response than one incident. The collect current(IC) and maximum responsivity of bilateral incidence is higher than one incident when light power increasing from 0.1 mW to 0.25 mW. Meantime, fT of bilateral incidence is higher than one incident.

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