Current characteristics depending on the doping concentration of the barrier in the GaSb based unipolar detector

<u>Jong Hun Lee</u>[1], Geun Hyeong Kim[1] Tae In Kang[1], Jong Su Kim[1*]
Sang Jun Lee[2], Dong Wan Kim[2]
[1] Department of Physics, Yeungnam University, Gyeongsan 38541, Republic of Korea
[2]Korea Research Institute of Standard and Science, Dajeon 34113, Republic of Korea

The nBn detector consists of an n-type contact layer, a unipolar barrier that prevents electron transport, and an n-type absorber. Compared to the p-i-n structure, the nBn detector offers advantages such as low dark current and high-temperature operation. Due to these characteristic, nBn detector has been actively researched over the past years, particularly regarding the barrier doping concentration.

In the nBn detector, the dark current is known to decrease as the increase of the barrier donor doping concentration [1]. However, Zhu has reported that Te doping in AlGaSb occur deep trap in 1988 [2]. These deep traps occur the leakage current such as trap assist tunneling (TAT) in the nBn detector. In addition, because the effect of barrier doping concentration on photocurrent has not been further investigated yet, to investigate the current characteristics of GaSb-based nBn detector depending on barrier doping concentration I-V measurements were performed. Dark current density at 80 K, 0.2 V were measured 0.009 A/cm^2 (undoped), 0.013 A/cm^2 (2x10^{15} cm^{-3}), 0.108 A/cm^2 (2x10^{16} cm^{-3}). Due to the negligible generation-recombination (G-R) current at low temperature, these results indicate the increase of TAT current due to rise of Te-related deep trap concentration. The exponent proportion of photocurrent to excitation light power at 300 K, 1 V were 0.43 (undoped), 0.63 (2x10^{15} cm^{-3}), and 1.21 (2x10^{16} cm^{-3}). The exponent of lower than unity indicate that the carrier loss due to the recombination [3]. The reduce of carrier loss as the increase doping concentration was attributed that carrier injection due to the TAT and more efficiently carrier extraction due to higher carrier velocity. In conclusion, this study shows the importance of appropriate barrier doping concentration when the design of nBn detector through the rise of dark current and reduce of photocurrent loss as the increase of barrier doping concentration.

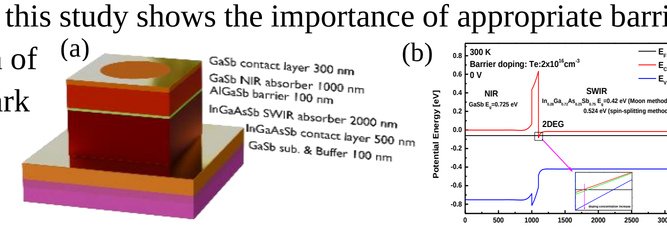


Figure 1. (a) sample structure, (b) band diagram

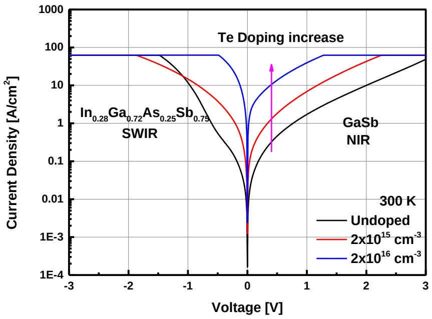
[1] Ting, D. Z., Soibel, A., Khoshakhlagh, A., et al. IRSI XXIV **9973**, 12-22 (2016).

[2] Zhu, Y., Takeda, Y., & Sasaki, A. JAP 64, 1897-1901 (1988).

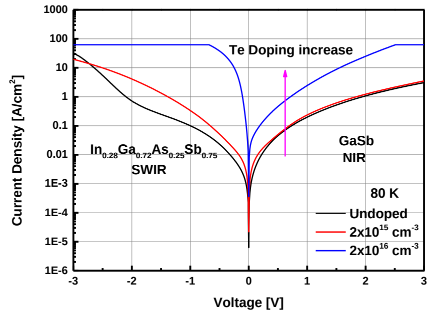
[3] Dalapati, P., Yamamoto, K., Kubo, T., Egawa, T., & Miyoshi, M. Optik 245, 167691 (2021).

[+] Author for correspondence: jongsukim@ynu.ac.kr

Suplementary information:



(a)



(b)

Figure 2. Dark current measure results at (a) 300 K, (b) 80 K.

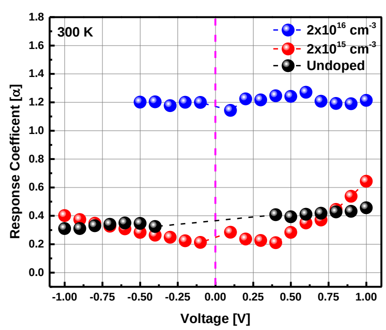
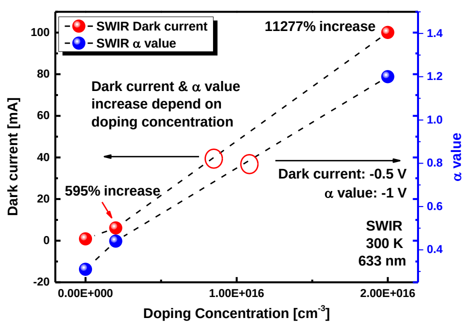
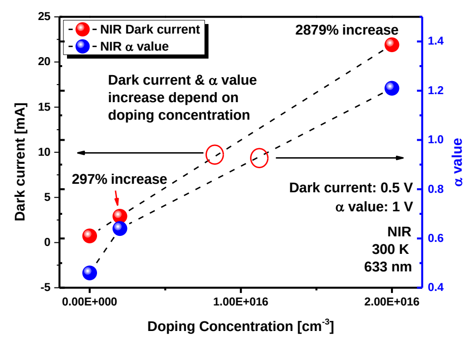


Figure 3. Results of power law fitting at various voltage using I-V raw data



(a)



(b)

Figure 4. doping concentration of dark current and photocurrent response (a) SWIR, (b) NIR detect region.