Reducing Dark Current Mechanisms for Barrier Infrared Photodetector Using Type II InAs/GaSb Superlattices

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Reducing the dark current is one of the key issues to obtain high- performance infrared (IR) photodetector operating in a wide range of wavelength [1]. Many efforts from research groups recently focus on achieving a significantly lower dark current. The barrier implementation is a popular strategy to discard unwanted dark current component including diffusion currents, Shockley-Read-Hall (SRH) current and other leakage currents without impeding the photocurrent [2].

This work investigates theoretically InAs/GaSb Type-II superlattice (T2SL) infrared mid-wave (MWIR) barrier photodetector's photoelectrical performance. To achieve optimal device, two different barrier structures, n-barrier-n (nBn) and p-barrier-n (pBn) are evaluated and compared to pin photodiodes. In our model, the barrier and active region were designed by the same binary material InAs/GaSb, whose bandgap was engineered by changing the composition. Both nBn and pBn could be applied to reduce the dark current but the different mechanisms to optimize the barrier doping in each structure are required, see Figs. 1 and 2. Numerical simulation results suggest both types of barriers obtain an improvement of dark current and operating temperature compare to pin photodiodes. The pBn structure exhibits significantly lower dark current compared to the nBn structures at the same bias voltage. However, when considering the operating bias (photoresponse saturation point), the dark current performance is comparable, see Fig. 3.

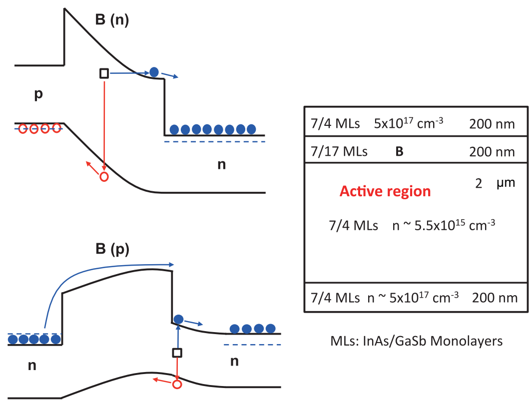
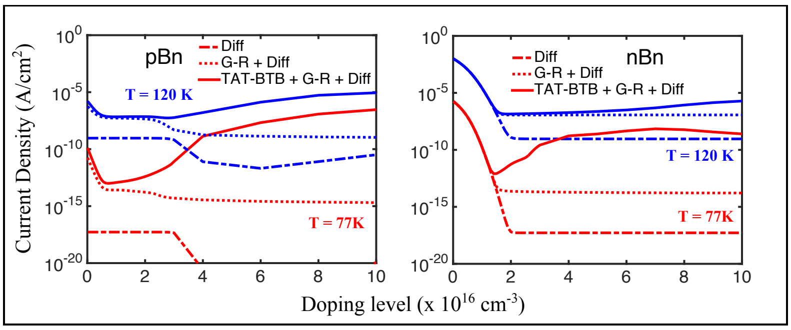


Fig. 1: Mechanism dominant the dark current of (a) pBn and (b) nBn T2SL photodetectors.



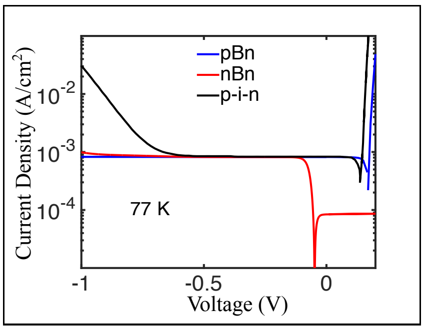


Fig. 2 [left]: Current density at $V = -50\,\mathrm{mV}$ plotted as a function of the doping density in the barrier region. **Fig. 3** [right]: Simulated J–V characteristics for pBn and nBn barrier photodetectors under 300 K background illuminated with barrier doping level $1 \times 10^{16}\,\mathrm{cm}^{-3}$ and $1.5 \times 10^{16}\,\mathrm{cm}^{-3}$, respectively.

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[2] P. Martyniuk *et al.*, Opto-Electron. Rev. **22**, 127 (2014).