# Direct growth of InAs/GaSb type II superlattice photodetector on silicon substrates

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## Introduction

- The project is creating of an InAs/GaSb* type II superlattice (T2SL) MWIR (mid-wave infrared) photodiode directly grown on Si substrate for use in an infrared CMOS camera.
- The first step towards this goal was to compare the basic ***nip*** structure grown directly on Si substrate with the same structure grown also on GaAs substrate.
- This Si structure was the first structure grown using a molecular beam epitaxy machine (MBE), which was built by the MBE group at UCL.
- The results obtained from the GaAs structure and the Si structure are similar in structural and optical properties. The only significant difference was the photoluminescence peak of Si structure which was 39% lower than the one of the GaAs structure[2].
- The current project compares three basic photodiode structures ***nip***, ***pin*** and ***piBn*** (with barrier) grown all on GaAs substrates to maximise the electrical and optical outputs.
- The goal was obtaining detailed analysis of each structure in order to find the structure that yields the best results in order to transfer this onto a Si substrate.
- The new structure to be grown on Si substrate is therefore expected to have improved electrical and optical performance.

* *Si (Silicon), In (Indium), As (Arsenic), Ga (Gallium), Sb (Antimony)*

## Method

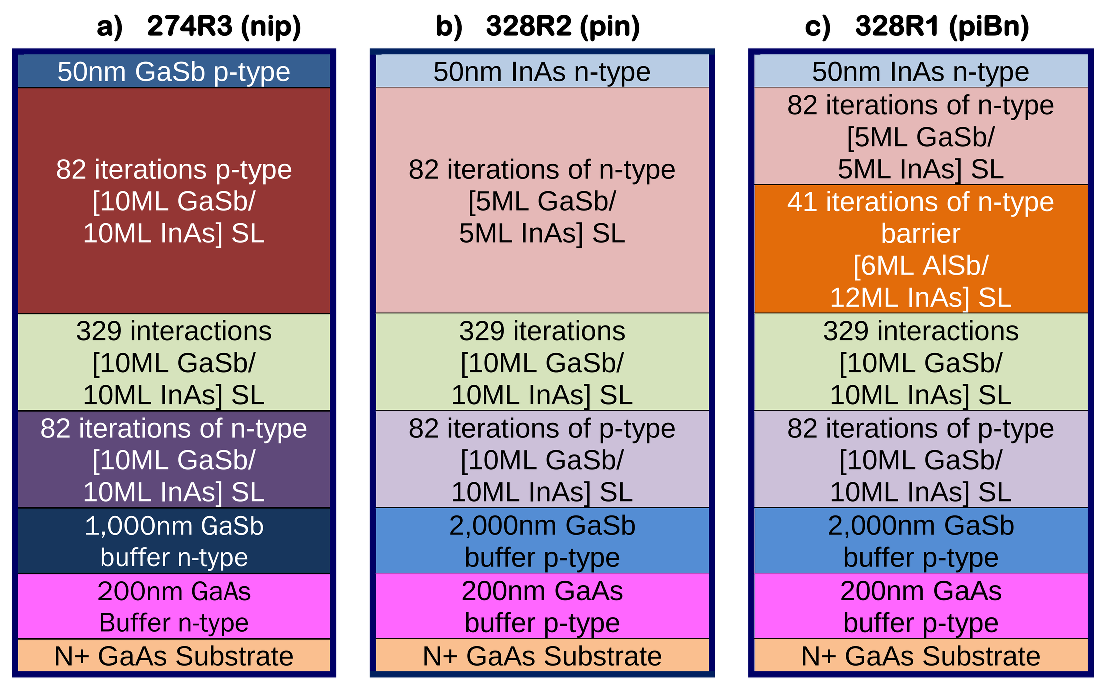


*Figure 1: Epi-layer structures.*
InAs/GaSb* type II superlattice (T2SL) photodiodes were directly grown on GaAs* substrates[1].

## Results and Discussion

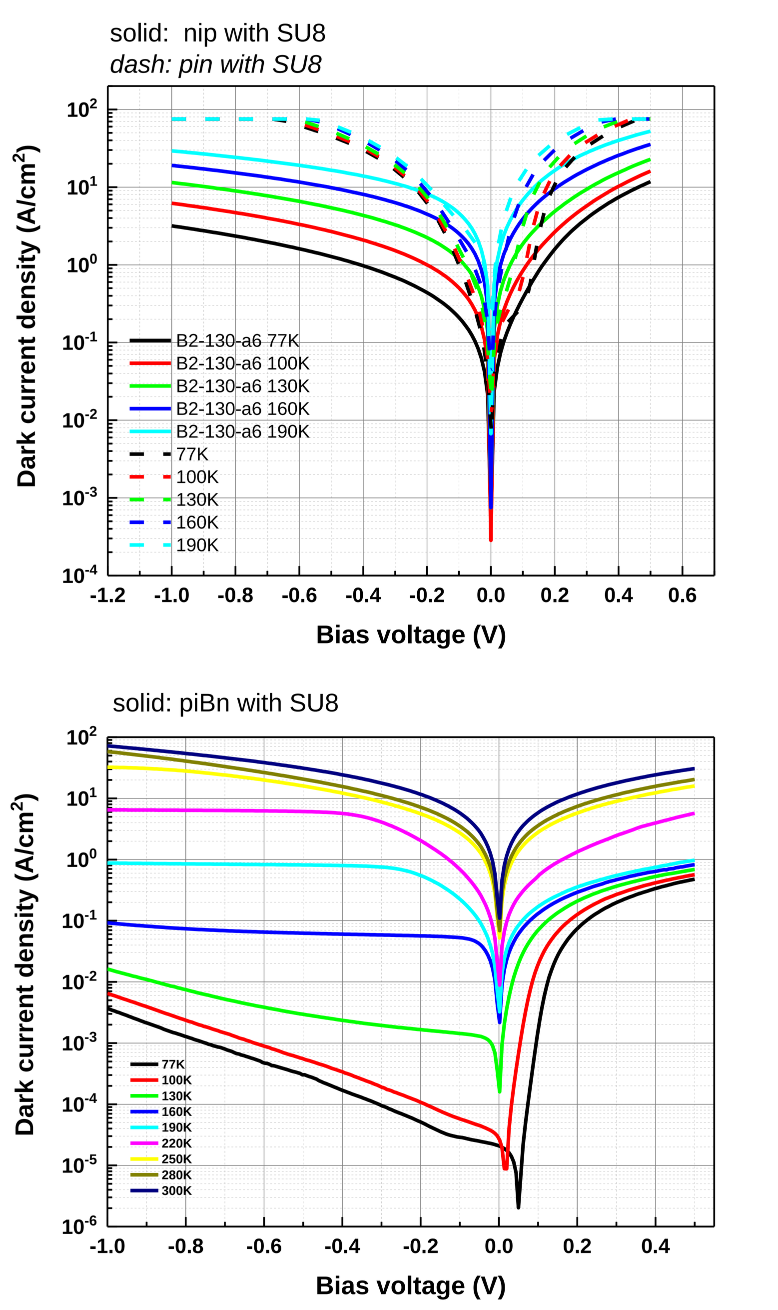


*Figure 2: Dark current vs Bias voltage.* The results were compared at 77K and -0.8V, where ***nip*** is 1x10$^0$A/cm$^2$, ***pin*** is 8x10$^2$A/cm$^2$ and piBn is 1x10$^{-3}$A/cm$^2$.

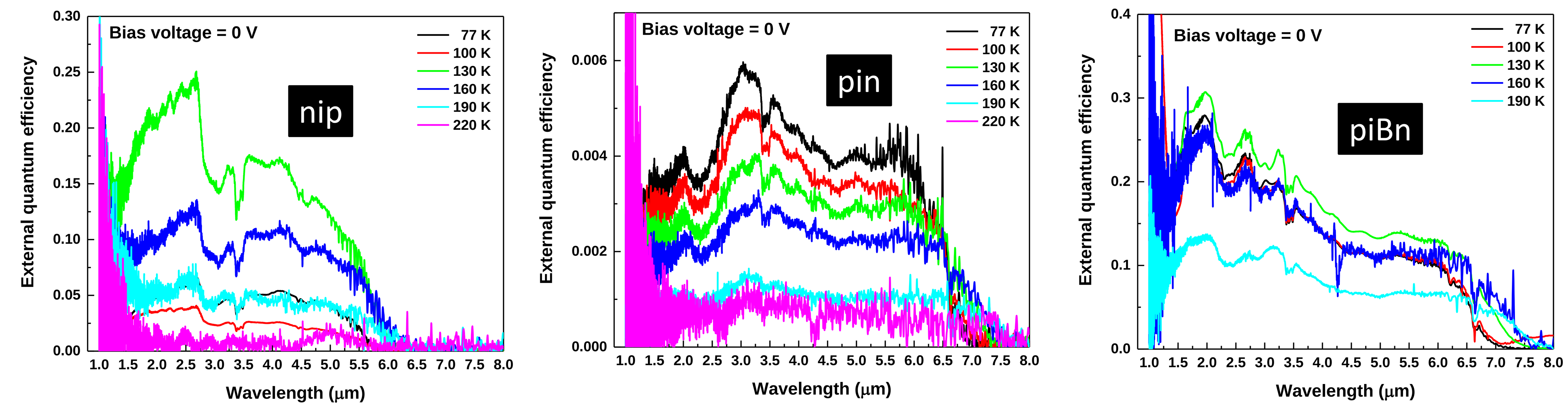


*Figure 3: External Quantum Efficiency (EQE).* The results were obtained at zero bias voltage and 130K. The highest peak of the ***nip*** is 25% at 2.5μm, ***pin*** is less than 4% at 3μm and ***piBn*** value is 30% at 2μm.

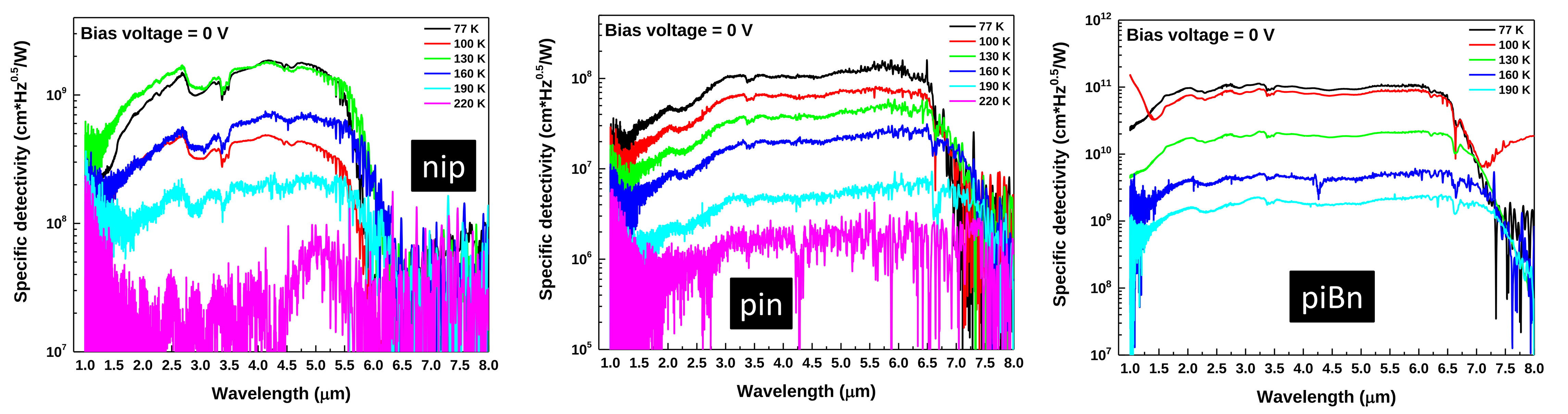


*Figure 4: Specific Detectivity (D*).* The results were obtained at zero bias voltage, 77K and 3μm. The difference between ***pin*** and ***piBn*** is around. 3 orders, while the difference between ***nip*** and ***piBn*** is around 2 orders.

## References

[1] J. Chen et al; *Growth and fabrication of InAs/GaSb type II superlattice mid-wavelength infrared photodetectors;* Nanoscale Research Letters, vol. 6, (1), pp. 635, 2011.

[2] C. Gonzalez Burguete et al; *Direct growth of InAs/GaSb T2SL photodiode on Si substrate;* IET Optoelectronics, vol. 12 (1), 2018.

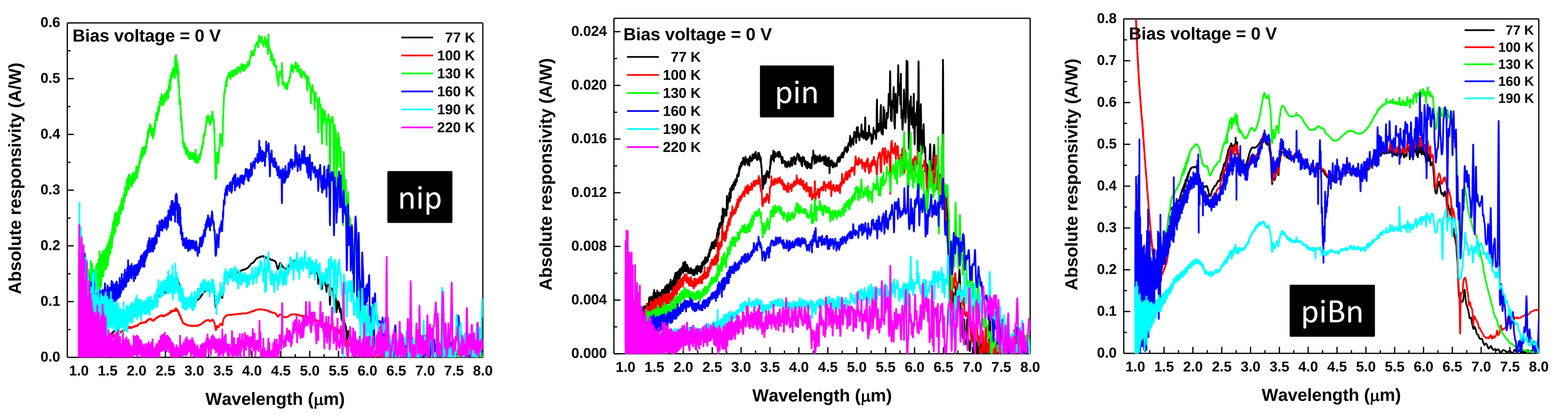


*Figure 5: Absolute Responsivity (R).* The results were obtained at zero bias voltage and 130K. The ***nip*** and ***piBn*** have similar results in value while the ***pin*** is too small to be considered. The cut-off is ***pin*** and ***piBn*** is 6.5μm and ***nip*** is 5.5μm.

## Conclusion

- The ***piBn*** structure depicts the lowest dark current at 1x10$^{-3}$A/cm$^2$ making this the best structure, however, the values of dark current are spread over five orders between the temperature of 77K and 300K, implying that the application of the passivation was of poor quality.
- The ***piBn*** depicts the highest quantum efficiency at 30% making the barrier an improvement of 750% over the ***pin*** structure.
- The addition of the barrier will create the same improvement over the ***nip*** structure, which was used on the first photodiode directly grown on Si substrate. Therefore an ***nip*** structure with a barrier will make an excellent candidate to transfer onto a Si substrate.

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