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Characteristics of InGaAs/GaAs/AlGaAs Double Barrier Quantum Well Infrared Photodetectors

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Quantum wells infrared photodetectors (QWIPs) have been used to detect infrared radiations through the principle based on the localized stated in quantum wells (QWs) [1]. The mature III-V compound semiconductor technology used to fabricate these devices results in much lower costs, larger array sizes, higher pixel operability, and better uniformity than those achievable with competing technologies such as HgCdTe. Especially, GaAs/AlGaAs QWIPs have been extensively used for large focal plane arrays (FPAs) of infrared imaging system. However, the research efforts for increasing sensitivity and operating temperature of the QWIPs still have pursued. The modification of heterostructures [2] and the various fabrications for preventing polarization selection rule [3] were suggested. In order to enhance optical performances of the QWIPs, double barrier quantum well (DBQW) structures will be introduced as the absorption layers for the suggested QWIPs. The DBWQ structure is an adequate solution for photodetectors working in the mid-wavelength infrared (MWIR) region and broadens the responsivity spectrum [4]. In this study, InGaAs/GaAs/AlGaAs double barrier quantum well infrared photodetectors (DB-QWIPs) are successfully fabricated and characterized. The heterostructures of the InGaAs/GaAs/AlGaAs DB-QWIPs are grown by molecular beam epitaxy (MBE) system. Photoluminescence (PL) spectroscopy is used to examine the heterostructures of the InGaAs/GaAs/AlGaAs DB-QWIP. The mesa-type DB-QWIPs (Area : 2 mm×2 mm) are fabricated by conventional optical lithography and wet etching process and Ni/Ge/Au ohmic contacts were evaporated onto the top and bottom layers. The dark current are measured at different temperatures and the temperature and applied bias dependence of the intersubband photocurrents are studied by using Fourier transform infrared spectrometer (FTIR) system equipped with cryostat. The photovoltaic behavior of the DB-QWIPs can be observed up to 120 K due to the generated built-in electric field caused from the asymmetric heterostructures of the DB-QWIPs. The fabricated DB-QWIPs exhibit spectral photoresponses at wavelengths range from 3 to 7 μm. Grating structure formed on the window surface of the DB-QWIP will induce the enhancement of optical responses.

Acknowledgements

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References

[1] B. F. Levine, “Quantum-well infrared photodetectors,” J. Appl. Phys., Vol. 74, no. 8, 1993.
[2] S. D. Gunapala, S. V. Bandara, J. K. Liu, C. J. Hill, S. B. Rafol, J. M. Mumolo, J. T. Trinh, M. Z. Tidrow, and P. D. LeVan, “Megapixel QWIP Focal Plane Array And 320×256 Pixel Co-Located Mid-Wave And Long-Wave Dual-Band QWIP Focal Plane Array,” Proceedings of SPIE, Vol. 5732, pp.295-308, 2005.
[3] C. J. Chen, K. K. Choi, L. Rokhinson, W. H. Chang, and D. C. Tsui, “Corrugated quantum well infrared photodetectors for polarization detection,” Appl. Phys. Lett., Vol. 74, no. 6, pp. 862-864, 1999.
[4] E. Luna, A. Guzmán, J. L. Sánchez-Rojas, J. M. G. Tijero, R. Hey, J. Hernando, and E. Muñoz, “Growth and characterization of modulation-doped double barrier quantum well infrared photodetectors,” J. Vac. Sci. Technol. B, Vol 21, pp. 883-887, 2003.

Keywords: Infrared detectors, quantum wells, QWIP, photovoltaic

Material	Doping density	Thickness	
GaAs	undoped	700 nm	
$Al_{0.3}Ga_{0.7}As$	undoped	30 nm	
n-GaAs	1×10^{18} cm^{-3}	500 nm	
$Al_{0.3}Ga_{0.7}As$	undoped	40 nm	
GaAs	1×10^{18} cm^{-3}	1 nm	× 10
$In_{0.1}Ga_{0.9}As$	undoped	2 nm	
GaAs	1×10^{18} cm^{-3}	1 nm	
$Al_{0.3}Ga_{0.7}As$	undoped	4 nm	
GaAs	1×10^{18} cm^{-3}	1 nm	
$In_{0.1}Ga_{0.9}As$	undoped	2 nm	
GaAs	1×10^{18} cm^{-3}	1 nm	
$Al_{0.3}Ga_{0.7}As$	undoped	40 nm	
$Al_{0.3}Ga_{0.7}As$	undoped	2 nm	× 10
GaAs	undoped	2 nm	
n-GaAs	1×10^{18} cm^{-3}	500 nm	
SI GaAs substrate			

Fig. 1. Schematic of the 10-layer InGaAs/GaAs/AlGaAs DB-QWIP heterostructures grown by MBE.

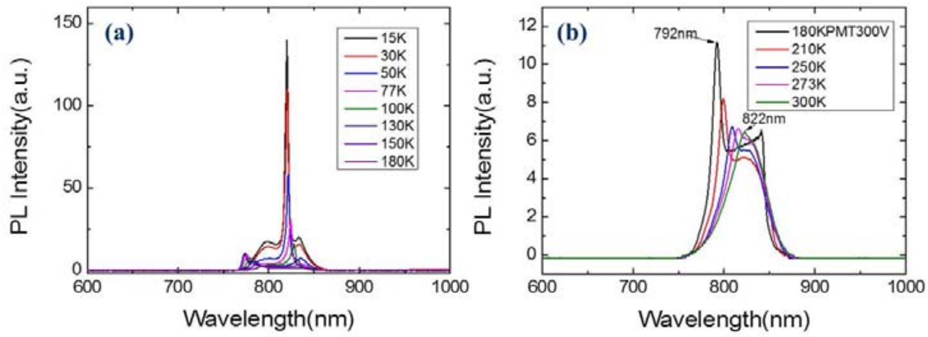

Fig. 2. PL characteristics of the DB-QWIP under temperature (a) less than and (b) above 180 K.

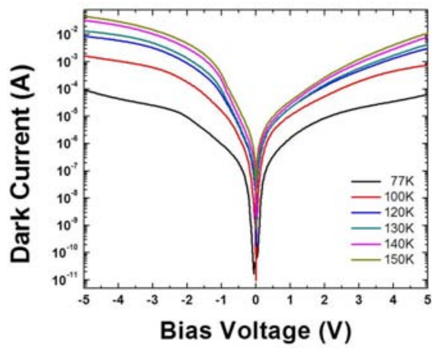

Fig. 3. Dark currents of the fabricated DB-QWIPs at the various temperatures.

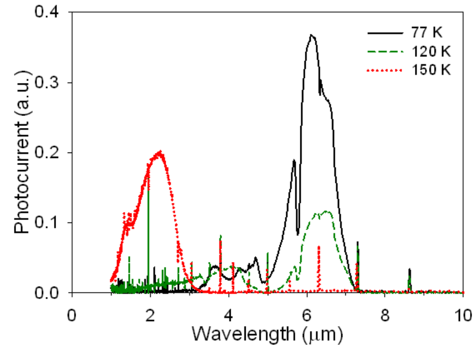

Fig. 4. Spectral photocurrents of the DB-QWIP operating in photovoltaic-mode at different temperatures.

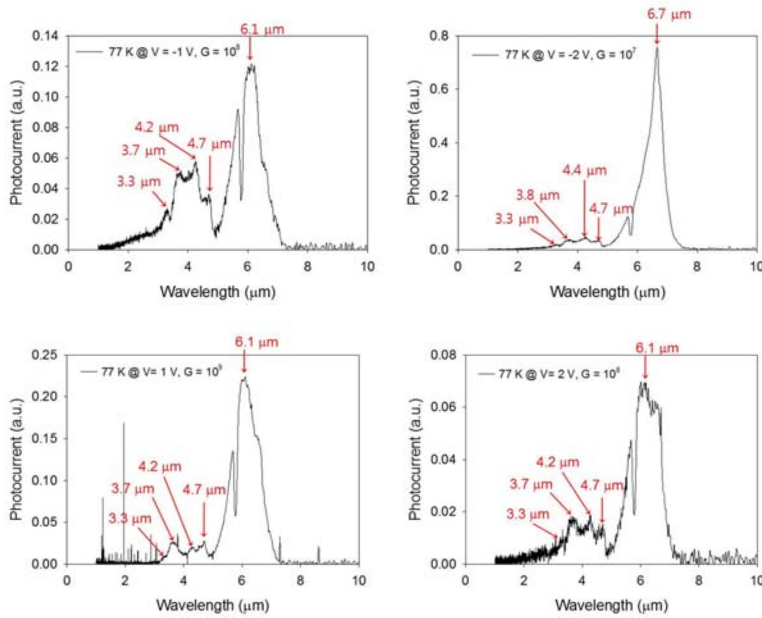

Fig. 5. Applied bias dependent spectral photocurrents of the DB-QWIP at 77 K.