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Improved Device Performance Due to AlxGa1-xAs Barrier in Sub-monolayer Quantum Dot Infrared Photodetector

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Quantum dot infrared photodetectors (QDIPs) based on Stranski-Krastanov (SK) quantum dots (QDs) have been widely explored for improved device performance using various designs of heterostructures. However, one of the biggest limitations of this approach is the "pancake" shape of the dot, with a base of 20-30 nm and a height of 4-6 nm. This limits the 3D confinement in the quantum dot and reduces the ratio of normal incidence absorption to the off-axis absorption. One of the alternative growth modes to the formation of SK QDs is a sub-monolayer (SML) deposition technique, which can achieve a much higher density, smaller size, better uniformity, and has no wetting layer as compared to the SK growth mode. Due to the advantages of SML-QDs, the SML-QDIP design has attractive features such as increased normal incidence absorption, strong in-plane quantum confinement, and narrow spectral wavelength detection as compared with SK-DWELL. In this study, we report on the improved device performance of InAs/InGaAs SML-QDIP with different composition of $Al_xGa_{1-x}As$ barrier. Two SML-QDIPs (x=0.07 for sample A and x=0.20 for sample B) are grown with the 4 stacks 0.3 ML InAs. It is investigated that sample A with a confinement-enhanced (CE) $Al_{0.22}Ga_{0.78}As$ barrier had a single peak at 7.8 μm at 77 K. However, sample B with an $Al_{0.20}Ga_{0.80}As$ barrier had three peaks at (~3.5 μm, ~5 μm, ~7 μm) due to various quantum confined transitions. The measured peak responsivities (see Fig) are ~0.45 A/W (sample A, at 7.8 μm, V_b=−0.4 V bias) and ~1.3 A/W (sample B, at 7 μm, V_b=−1.5 V bias). At 77 K, sample A and B had a detectivity of 1.2×10^{11} cm.$Hz^{1/2}$/W (V_b=−0.4 V bias) and 5.4×10^{11} cm.$Hz^{1/2}$/W (Vb=−1.5 V bias), respectively. It is obvious that the higher D* of sample B (than sample A) is mainly due to the low dark current and high responsivity

Keywords: Quantum dot infrared photodetectors, AlxGa1-xAs barrier, sub-monolayer quantum dot

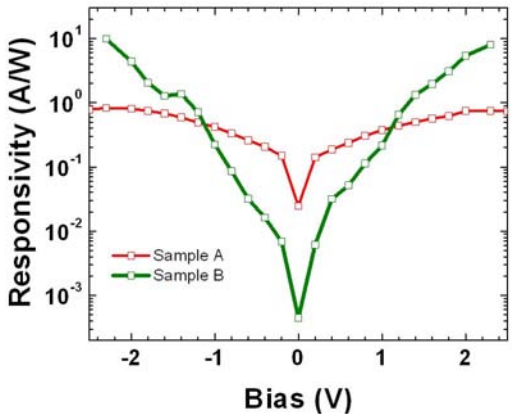

Fig. 1.