T2-P021

Energy-band model on photoresponse transitions in biased asymmetric dot-in-double-quantum-well infrared detector

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The PR transitions in asymmetric dot-in-double-quantum-well (DdWELL) photodetector is identified by bias-dependent spectral behaviors. Discrete n-i-n infrared photodetectors were fabricated on a 30-period asymmetric InAs-QD/[InGaAs/GaAs]/AlGaAs DdWELL wafer that was prepared by MBE technique. A 2.0-monolayer (ML) InAs QD ensemble was embedded in upper combined well of InGaAs/GaAs and each stack is separated by a 50-nm AlGaAs barrier. Each pixel has circular aperture of 300 um in diameter, and the mesa cell (410x410 ㎛^{2}) was defined by shallow etching. PR measurements were performed in the spectral range of 3∼13 ㎛ (∼ 100-400 meV) by using a Fourier-transform infrared (FTIR) spectrometer and a low-noise preamplifier. The asymmetric photodetector exhibits unique transition behaviors that near-/far-infrared (NIR/FIR) photoresponse (PR) bands are blue/red shifted by the electric field, contrasted to mid-infrared (MIR) with no dependence. In addition, the MIR-FIR dual-band spectra change into single-band feature by the polarity. A four-level energy band model is proposed for the transition scheme, and the field dependence of FIR bands numerically calculated by a simplified DdWELL structure is in good agreement with that of the PR spectra. The wavelength shift by the field strength and the spectral change by the polarity are discussed on the basis of four-level transition.