

Quantum Well Based Detectors for Phonon and Far-Infrared Detector Applications

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Quantum well-based detectors have been shown to be very useful in night vision applications around the 10 μm wavelength range. In principle, such quantum well detectors can be engineered to operate at much longer wavelengths and can also be used as phonon detectors. To this end we investigate, both theoretically and experimentally, device structures with a single quantum well. Our first design involves a two-dimensional electron gas (2DEG), where the electrons are weakly confined in a triangular quantum well, and a three dimensional electron gas (3DEG) separated from the 2DEG by region of insulating GaAs. The conduction band structure of such a device is shown in Fig. 1. The size of the barrier between these two conducting layers is strongly dependent on the thickness and doping concentration of the GaAs as shown in Fig. 2. The detector can be operated by either applying a negative or a positive bias voltage between the 2DEG and 3DEG. Under the positive bias the operation of the device is analogous to that of a homojunction internal photoemission detector in which case energy cutoff of the detector is given by the barrier height. Under negative bias transitions, in addition to barrier height, the energy difference between the subbands of the triangular quantum well plays a role in the spectral response of such a detector. When the barrier height is sufficiently small such a device can also be used to detect bulk and interface phonons. The relative contribution of these two kinds of phonons can be extracted from the detector response for both polarities of bias. The phonon selection rules, spectral response, phonon and photon quantum efficiency, and dark current will be discussed as functions of device parameters.

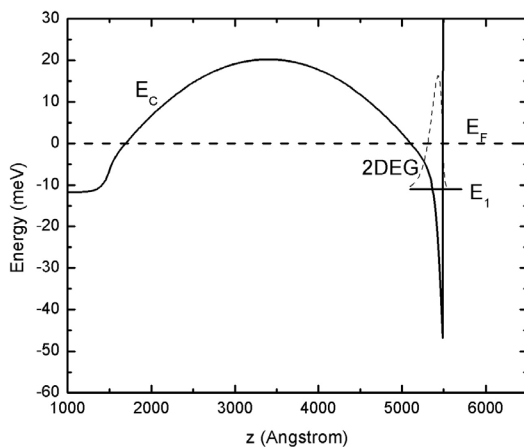


Figure 1. Conduction band diagram calculated for a detector structure with an inverted 2DEG and 3DEG separated by a 4000 Å region of p-type GaAs with an acceptor concentration of 10^{15} cm^{-3} . E_f is the Fermi energy and E_1 is the ground state energy of the triangular confinement potential. The wavefunction amplitude for the ground state is shown in arbitrary units by the dashed line.

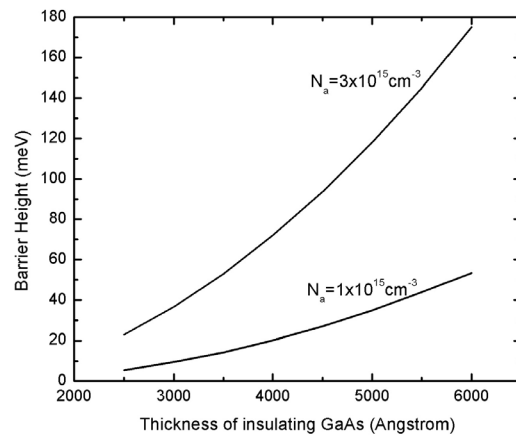


Figure 2. The barrier height versus the thickness of insulating GaAs region for two different acceptor concentrations.