Extended cut-off wavelength nBn detector utilizing InAsSb/InSb digital alloy absorber

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Mid-wavelength infrared (MWIR) detectors covering 3-5μm atmospheric transmission windows are of great interest for NASA Earth Science missions. The recently demonstrated nBn or XBn barrier photodetectors offer many advantages for realization of high performance infrared imagers (IR). In our research we investigated a novel approach to extend a cut-off wavelength of Sb-based nBn detectors. We incorporated a series of single InSb monolayer into InAsSb bulk that allowed to realize a digital alloy absorber with an extended cut-off wavelength of λ = 4.6 μm at T = 200 K. The cut-off wavelength extension to 4.6μm is technologically important for realization of detectors covering CO_2 absorption line at 4.26μm. At the same time, the constructed digital alloy InAsSb/InSb is a fascinating material system that has an energy bandgap smaller that the random allow with the same material composition. The developed nBn detectors with 2μm thick absorber showed a temperature independent quantum efficiency QE≈0.45 for back-side illumination without antireflection coating. The dark current density was jd=5×10^{-6} A/cm^2 at T = 150K, and increased to jd = 2×10^{-3} A/cm^2 at T = 200K. At temperatures of T = 150K and below, the demonstrated photodetectors operate in background limited (BLIP) mode, with detectivity D*(λ)=3-6x10^{11} (cmHz$^{0.5}$/W) for the background temperature of 300K, and f/2 field of view.

Metamorphic $InAsSb_x/InAsSb_y$ heterostructures- new materials for infrared photonics

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Recently proposed short period metamorphic $InSb_xAs_{1-x}/InSb_yAs_{1-y}$ superlattices (SLs) manifest a new class of quasi 3D materials with ultra-low bandgap. Application of the virtual substrate approach relieves strong limitations dictated by the substrate lattice constant and makes it possible to grow materials with high crystalline quality in the entire range of the alloy compositions. We present experimental and theoretical analysis of the carrier energy spectrum and band structure parameters of short period metamorphic strain compensated $InSb_xAs_{1-x}/InSb_yAs_{1-y}$ SLs with different periods and layer thicknesses. We demonstrate that the SL bandgap measured with the interband magneto-absorption technique can be varied in the range from 120 to 0meV by changing the SL period and strain.

The electron effective mass extracted from cyclotron resonance peak tends to decrease with the bandgap reaching $0.006m_0$ in SL with Eg=55meV. To our knowledge this is the lowest effective mass ever measured in a III-V system. Cyclotron resonance peak energy in SLs with the $E_g \sim 0$ shows square root dependence on the magnetic field in the range from 0 to 16T. This manifests a linear character of the electron dispersion, so the SLs belong to a new class of Dirac materials. The energy spectrum in the SLs with a nearly zero bandgap is linear in a wide energy range. The Dirac velocity, determined by the material parameters of SL layers is ~ $7x10^5$m/s. Electron spectrum in the growth direction is probed by the magneto-absorption in Voigt geometry. In low magnetic fields the electron spectrum corresponding to the carrier motion in the growth direction can be characterized by an effective mass of $0.017m_0$. The impacts of dimensional quantization, tunneling and band interaction on the SL band structure as well as vertical hole transport in metamorphic $InSb_xAs_{1-x}/InSb_yAs_{1-y}$ superlattices will be discussed.