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Antimonide-based short period superlattices for long wavelength infrared photodetection applications

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Infrared photo detectors have many applications. For low level night vision, the two atmospheric windows at 3-5 μm and 8-14 μm are important, while for Earth and Planet monitoring instrumentations, wavelengths greater than 14 μm are of interest. Recently, quantum well infrared photodetectors (QWIP) have achieved good performance. Levine has demonstrated that an InGaAs/InAlAs, and GaAs/AlGaAs n-doped QWIPs (n-QWIPs) can detect IR light in the two atmospheric windows. He has also shown that n-QWIP can detect IR light out to 18 μm. However, the n-QWIP has some limitations - most importantly the dark current density is large which limits the electronic signal processing capabilities. The conceptual basis of achieving far-infrared energy gaps in antimonide-based short period superlattices has been discussed in the literature. In this presentation we report a comprehensive theoretical study of designing novel long wavelength infrared detector materials from type II InAs/InxGa1-xSb strained layer superlattices (SLs) with absorption energies in the 10-12 μm range. Absorption $\alpha(\eta\omega)$ calculations are difficult, however, because of the strong misalignment of the band edges of the two host materials at the interface and because of a large lattice mismatch. The influence from strain, layer thickness, and alloy composition on the SL energy band gap E_g^{SL}, cut-off wavelengths λ_c, and optical matrix elements have been analyzed. A modified empirical tight binding (ETB), effective bond-orbital (EBO) and 8x8 k.p models are employed in the study of band structure. The strain in the ETB is included by scaling the matrix elements according to the Harrison's universal $1/d^2$ rule and by modifying the angular dependence while in the EBO and k.p schemes it is incorporated via the deformation theory. The study of $\alpha(\eta\omega)$ for thin layer SLs in the k.p scheme revealed enhancement of absorption with increasing In composition x in $In_xGa_{1-x}Sb$ at a fixed energy due to the large overlap of electron-hole wave-functions.

Biography

Devki N Talwar, Indiana U of Pennsylvania (IUP), Chair of Department of Physics, conducts research on optical/electronic properties of defects and phonons in semiconductor materials used for various electronic and opto-electronic devices. He has been with Indiana U of Pennsylvania (IUP), Department of Physics, for almost 27 years and is the author of more than 120 refereed journal articles, 3 book chapters and review articles. His expertise in the sophisticated Green's function technique is considered very useful for providing information on the electronic and vibrational properties of defects in semiconductors, quantum wells and superlattices.

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