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Optical susceptibility of third order harmonic generation in a strained $B_xGa_{1-x}N/BN$ nano-well

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Abstract : Wide band gap group III-N materials are given due attention for the huge potential applications for fabricating novel opto-electronic devices. Group III nitride wide band gap semiconducting materials, in general, have a high melting point, high thermal conductivity and transparency to a large spectrum. These materials can be used for short-wavelength light-emitting diodes, laser diodes and optical detectors and high electron mobility transistors [1]. Group III nitride heterostructures have huge spontaneous and piezoelectric polarization. Boron nitride is found to be in the hexagonal phase with the zinc-blende structure and it is hard material [2].

Boron nitride and Gallium nitride materials are considered to be the promising wide band gap candidates ranging from the ultraviolet to the visible regions of the spectrum. In the present work, the binding energy of a hydrogenic donor and the third order susceptibility of third order harmonic generation are discussed in a $B_xGa_{1-x}N/BN$ quantum well. The barrier material is taken as GaN semiconductor whereas the Boron nitride material acts as inner well material. The energy eigen value and thereby the hydrogenic binding energy are obtained using variational technique within a single band effective mass approximation. The nonlinear optical property is investigated using density matrix method. The results can be applied for short wavelength optical devices.

Keywords.. Optical susceptibility, effective mass, binding energy, hydrogenic donor, density matrix

Introduction

Boron nitride and Gallium nitride materials are considered to be the promising wide band gap candidates ranging from the ultraviolet to the visible regions of the spectrum [1]. Boron nitride material is given attention due to the its exotic physical properties such as extreme hardness more than diamond, high melting point, and interesting dielectric, mechanical thermal properties and high oxidation resistance. It is predicted to have piezoelectricity and it can be applied for room-temperature hydrogen storage [2].

1. Model and calculation

The taken Hamiltonian of the hydrogenic impurity in a Boron based GaN coupled quantum well, within the framework of effective mass approximation, can be written as

$$H = -\frac{\hbar^2}{2m_e^*(E)}\nabla^2 - \frac{e^2}{\varepsilon r} + V(z) \qquad [1]$$

The expression for built-in electric field in $B_xGa_{1-x}N$ and GaN quantum well is given by

$$F^{B_xGa_{1-x}N} = -\frac{(P_{SP}^{BGaN} + P_{PE}^{BGaN} - P_{SP}^{BN})L_b}{\varepsilon(2\varepsilon_e^{BN} L_w + \varepsilon_e^{BGaN} L_b)} \qquad [2]$$

and

$$F^{BN} = 2\frac{(P_{SP}^{BGaN} + P_{PE}^{BGaN} - P_{SP}^{BN})L_w}{\varepsilon(2\varepsilon_e^{BN} L_w + \varepsilon_e^{BGaN} L_b)} \qquad [3]$$

The nonlinear susceptibility due to the electron Raman scattering is given by [4,5]

$$\chi_{3\omega}^{3}(\omega_{out};\omega_p,+\omega_s,-\omega_p) = \frac{-2i\rho e^4 |\langle \psi_i | \vec{r} | \psi_f \rangle|^4}{\varepsilon_0 \hbar^3 [i(\omega_i - 2\omega_s + \omega_p) + \Gamma][i(\omega_p - \omega_s) + \Gamma]} \times \left[\frac{1}{i(\omega_i - \omega_s) + \Gamma} + \frac{1}{i(\omega_p - \omega_i) + \Gamma} \right] \qquad [4]$$

Where, the line broadening $\Gamma = 1/\tau$ is the relaxation rate for states i and f and $\hbar\omega$ is the photon energy.

Result and discussion

The subband energy of the electron in the conduction band in the Boron based Group-III-nitride semiconductor is computed taking into the geometrical confinement. And thereby, hydrogenic binding energy is obtained by choosing a suitable trail wave function. The linear intersubband optical transition is computed. Third order susceptibility of third harmonic generation.

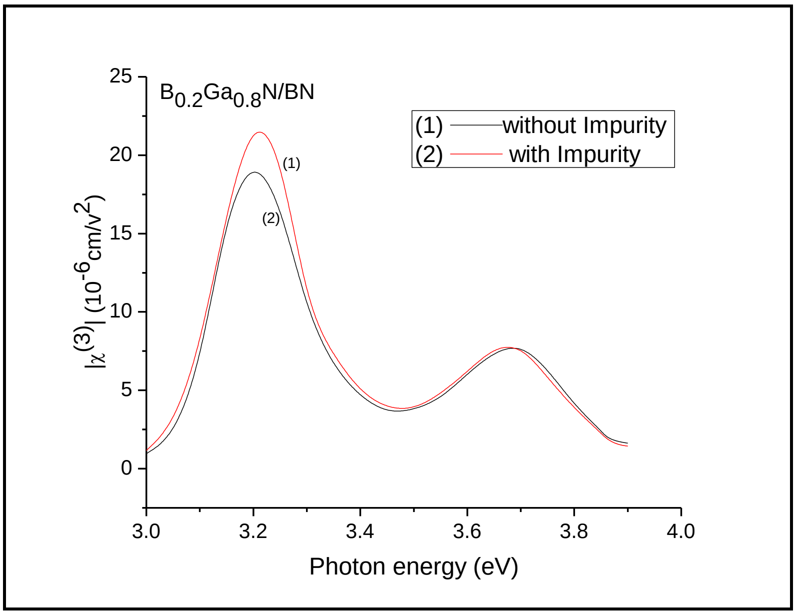

Figure1. Variation of third-order susceptibility of third harmonic generation as a function of incident photon energy in a $B_xGa_{1-x}N$/BN quantum well

Figure 1 shows the variation of third-order susceptibility of third harmonic generation as a function of incident photon energy with and without the donor impurity in a $B_xGa_{1-x}N$/BN quantum well width 50 Å with

$\hbar\omega_0$ = 50 meV. It is observed that the third order susceptibility has two peaks for both the cases, with and without adding impurity. Further, it is observed that the magnitude of the resonant peak moves towards the higher energies with the donor impurity. It is noted from the figure that the relaxation time has more influence on the third-order susceptibility; hence the magnitude of the third-order susceptibility is found to be higher energies for longer relaxation time. And hence, the damping factor decides the lifetime of the excitons in the confined states [3]. As the outcome, the relaxation time has more influence on the third-order susceptibility of third harmonic generation.

References

1. Abdelhadi LACHEBI and Hamza ABID , Turk J Phys 2008;32:157.
2. S. Daouda, K. Loucif, N. Bioud and N. Lebgaa, Acta Phys.Pol.A 2012;122:109.
3. S.Shao, K.X.Guo, Z.H.Zhang, N.Li and C.Peng, Superlatt Microstruct. 2010; 48: 541.
4. S.Baskoutas, E.Paspalakis and A.F.Terzis, Phys. Rev.B 74 (2006)153306.
5. Wenfang Xie, Superlatt.Microstru.53 (2013) 49.

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