

Title	半導体シングルヘテロ接合における集団的サブバンド間電子励起による共鳴光散乱の理論
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Citation	
Issue Date	2001-09
Type	Thesis or Dissertation
Text version	none
URL	http://hdl.handle.net/10119/2902
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Description	Supervisor:片山 信一, 材料科学研究科, 修士

Theory of Resonant Light Scattering by Intersubband Electro-Excitations in Semiconductor Single Heterojunctions

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Light scattering spectra by coupled intersubband plasmon-longitudinal optical excitations have been studied in semiconductor heterostructures such as modulation doped quantum-well (MQW) structures and single heterojunctions. In a recent work, the absence due to the upper branch of the coupled intersubband plasmon-LO phonon modes from quasi-electron gas (2DEG) doped $\text{Ga}_{1-x}\text{As}_x/\text{GaAs}$ single heterojunction was reported [1]. The I peak was also not seen in the earlier data by Pinczuk and Worlock [2] in single heterojunction.

In this thesis we have developed a theory of resonant light scattering by intersubband excitations in semiconductor single heterojunctions. Our theory involves the dynamical density of states of 2DEG taking into account electron-electron and electron-phonon interactions. We consider density excitations in 2DEG coupled with LO phonons via the depolarized electric field time Green's function technique, general expressions for light scattering intensity are obtained. To explore the origins of the absence of the I peak, we carried out numerical calculation of spectral intensity based on the self-consistent subband energies and wave functions, intersubband transition with energy splitting E .

We found that the Coulomb interaction plays the important role to determine the depolarization from the intersubband transitions, and the dynamical electron-electron Coulomb interaction dielectric function is enhanced as the frequency approaches the LO phonon frequency. We have depicted the intensity as a function of ω for $L_{11} = 5, 10, 20 \text{ \AA}$ and damping constants for electrons and phonons $\Gamma_e = \Gamma_{ph} = 1 \text{ meV}$ in Fig. 1. As L_{11} decreases from 20 to 5 \AA , the I peak approaches the LO phonon frequency and the intensity diminishes sharply. However, as the I frequency side and its intensity increases. Figures 2(a) and (b) show the experimental and our calculated values of I are 19.2 meV and 5.12 \AA , assuming 2DEG concentration $N = 5.3 \times 10^{11} \text{ cm}^{-2}$ at $T = 9 \text{ K}$. Our calculated peak is extremely weak compared with the experimental peak. Therefore, it can be concluded that the absence of the I peak is due to the smallness of L_{11} (5 \AA) of MQW [2] so that the strong anti-screening by the ionic dielectric function occurs to the decrease of scattering intensity by the I peak.

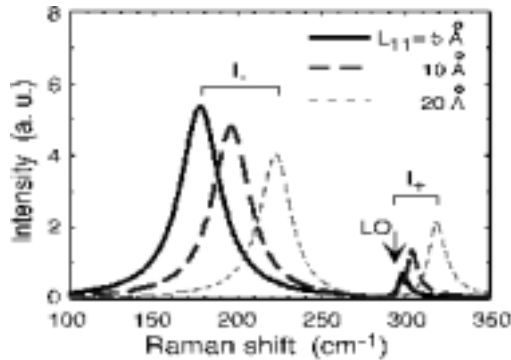


Fig.1: Calculated light scattering intensities of I and L lines for $L_{11} = 5, 10, 20 \text{ \AA}$

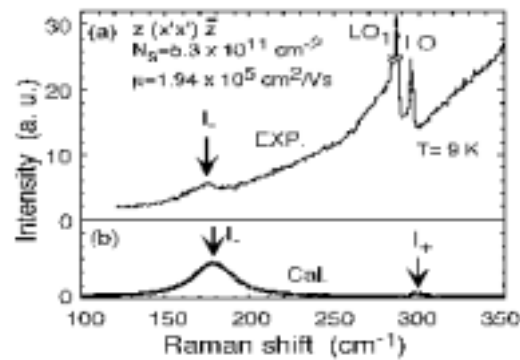


Fig.2: Comparison of experimental intensity (a) with calculated intensity (b)

References

- [1] S. Katayama, M. Koyano and S. Yamada, *Phys. Rev. B* **35**, 5921 (1987).
- [2] A. Pinczuk and J.M. Worlock, *Phys. Rev. Lett.* **48**, 69 (1982).

Keywords: resonant light scattering, intersubband excitations, coupled plasmon-phonon