GaAs/AlGaAs 양자우물 구조에서 Impulsive Stimulated Raman Scattering 방법에 의한 결맞는 포논의 생성

Generation of Coherent LO Phonons in GaAs/AlGaAs MQW's by the Impulsive Stimulated Raman Scattering

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After the invention of the femtosecond pulse lasers, generating and detecting the coherent optical phonons in various materials became possible. In bulk GaAs, which is a polar material, the coherent LO phonons are known to be generated by the ultrafast screening of the surface space-charge fields. However, little is known about the generation mechanisms of coherent phonons in GaAs quantum structures.

In this paper, we show that the generation mechanism of coherent phonons in a quasi-two dimensional GaAs/AlGaAs multiple quantum well (MQW) structure is mainly the impulsive stimulated Raman scattering (ISRS). This is in sharp contrast with bulk GaAs, where ISRS plays only a minor role, if any. In addition, interference between the allowed and the forbidden Raman scattering plays an important role.

We used the reflective electro-optic sampling technique (REOS) on a bulk GaAs and a GaAs/$Al_{0.36}Ga_{0.64}As$ multiple quantum well (MQW) structure at the sample temperature of 12 K The MQW samples have the well width of 15 nm, and the barrier width of 5 nm. With the probe beam polarization fixed parallel to one of principal axes ([100] or [010]), the pump beam polarization was rotated to characterize the polarization dependence of the coherent LO phonon oscillations.

Figure 1(a) shows the coherent phonon oscillations at three different pump-beam polarizations in our MQW sample. Drastic changes in both the amplitude and the phase of the oscillations are observed. In stark contrast, virtually no dependence is found in bulk GaAs (Figure 1(b)). In addition, noticeable asymmetry in the oscillation amplitude is observed between the [110] and the $[1\bar{1}0]$ directions. More detailed angle dependence of the Fourier transformed intensity shows this more clearly (Fig. 2). While the overall angle dependence is sinusoidal, there is almost

a factor of 2 difference between the two peaks. These results clearly demonstrate that while the screening of the surface depletion field is responsible for the coherent LO phonon generation in bulk GaAs, a completely different generation mechanisms exist in GaAs MQW.

All of our observations can be understood if we introduce both the allowed and forbidden Raman scattering tensors as well as their interference. The allowed deformation potential Raman tensor is given as follows: $R_D = \begin{pmatrix} 0 & a \\ a & 0 \end{pmatrix}$, whereas the forbidden, Fröhlich Raman tensor reads: $R_F = \begin{pmatrix} b & 0 \\ 0 & b \end{pmatrix}$, The angle dependence of the coherent phonon oscillation intensity is then: $|b + a\cos(2\varphi)|^2$ This equation fits Fig. 2 rather well, shown in dotted lines with b/a≅0.18.

In conclusion, we have shown that the coherent phonon generation in GaAs MQW is dominated by the ISRS, in sharp contrast with that in bulk GaAs.

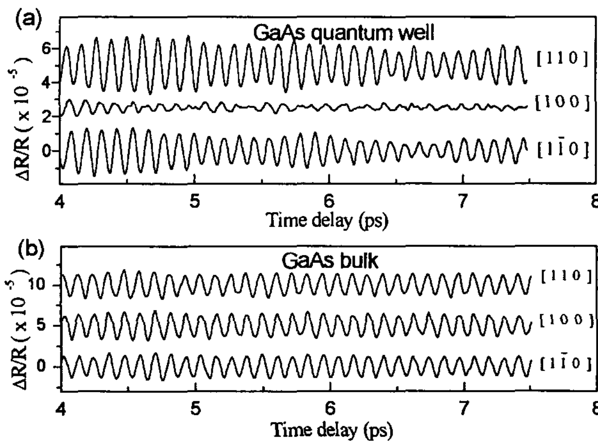

Fig. 1. The REOS signals in time domain obtained in a GaAs MQW (a) and bulk GaAs (b) samples at pump beam polarizations [110], [100] and [1$\bar{1}$0].

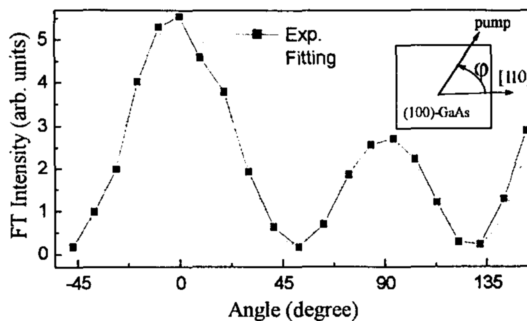

Fig. 2 FFT intensity as a function of the pump beam polarization angle.