RESONANT INTERACTION OF BULK PHONONS WITH PHONONS LOCALIZED AT A SUPERLATTICE-LIQUID INTERFACE

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We theoretically investigate the resonant interaction of acoustic phonons with the vibrational modes localized at a superlattice-liquid (SL-L) interface. Using the transfer matrix method, we calculate the phonon transmission rate. In Fig. 1, we show the frequency dependence of the transmission rate calculated for a GaAs/AlAs SL grown on a GaAs substrate and in contact with H_2O. We consider two cases for the stacking order of the constituent layers, i.e., (a) A=AlAs, B=GaAs, or (b) A=GaAs, B=AlAs (see Fig.2). The calculated results are quite different depending on the stacking order. In Fig.1(b), there exist resonant peaks inside the frequency gaps. On the other hand, there is no such a peak in Fig.1(a). Another noticeable feature is that the magnitudes of the peaks in Fig. 1(a) depend sensitively on the number of bilayers (N) of the SL. Figure 2 shows the N-dependence of the height of the peak inside the first gap, which is calculated numerically. It is found that the resonant transmission occurs at a given value of N. To study the physical origin of these distinctive resonances, we derived the general formula describing the resonance line. Based on our formulas, we examine the condition for such a resonance to appear. We also give the equation determining $N = N_{max}$ for which the transmission rate takes a maximum value (~ 1). The N-dependence of the resonance can be explained in terms of simple concepts of energy conservation.

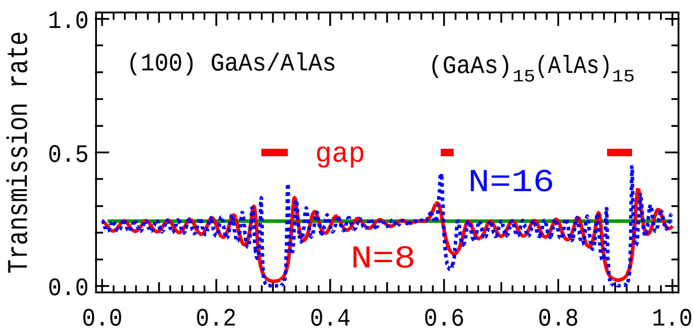

Fig. 1(a)

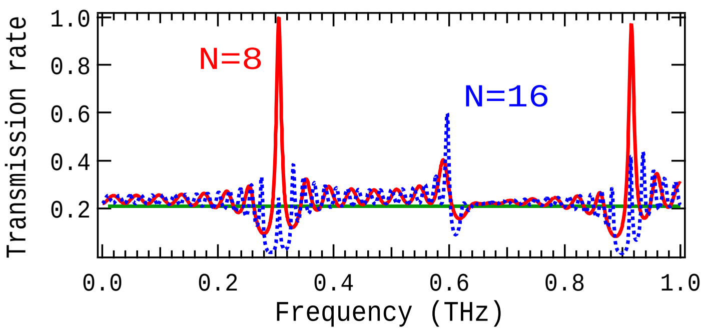

Fig. 1(b)

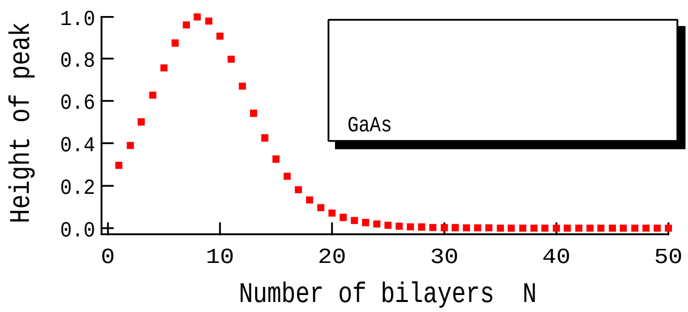

Fig. 2