Raman Spectra of $^{70}Ge/^{76}Ge$ Isotope Heterostructures with Argon 488nm and 514.5nm Excitations

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We report on Raman investigations of phonons in three different $^{70}Ge/^{76}Ge$ isotope heterostructures. In contrast to conventional heterostructures such as GaAs/GaAlAs and Si/Ge, the Raman polarizability of the $^{70}Ge/^{76}Ge$ heterostructures can be calculated exactly without any approximations. Therefore, the isotope heterostructures provide the ideal test ground for the theory of phonons including the penetration depth of laser light in low dimensional semiconductors.

In this work we show clearly that the temperature dependencies of the penetration depths of 488 nm and 514.5 nm Ar^+ laser lines in Ge are different. Using molecular beam epitaxy (MBE), we have grown $^{70}Ge/^{76}Ge$ heterostructures with three different thicknesses of the ^{70}Ge top-layers (~8, 16 and 32 nm for Sample A, B, and C, respectively) formed on ~70 nm-thick ^{76}Ge buffer layers. The penetration depths of 488 nm and 514.5 nm lines into Ge are estimated to be ~16 nm [1], i.e., the thickness of the top ^{70}Ge layer in Sample B is designed to be equal to the penetration depth. Fig. 1 and 2 show the Raman spectra of Sample A, B, and C recorded at 300K and 10K, respectively. As expected, the intensity of the ^{70}Ge phonon peak relative to that of the ^{76}Ge peak becomes stronger in Sample C than in A. Also the spectra for A, B, and C taken at 300K do not change very much for the two excitation wavelengths, 488 nm and 514.5 nm [Fig.1 (a) and (b)]. However, the spectra recorded at 10K [Fig. 2 (a) and (b)] change drastically with the excitation wavelength. The penetration depth of 514.5 nm is clearly larger than that of 488 nm laser light at 10K. Our finding implies that the temperature dependence of the penetration length is significantly different for the two wavelengths. Further experiments and theoretical calculations are in progress. We plan to provide complete analysis at the conference.

[1]. L. Vina, *et al.*, Phys. Rev. B **30**, 1979 (1984)

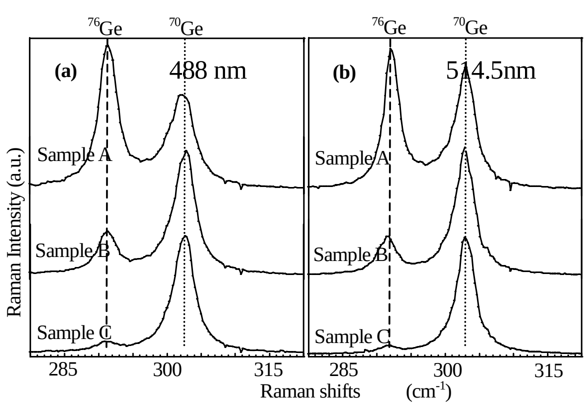

Fig. 1 Raman spectra recorded at 300K using (a) 488 nm and (b) 514.5 nm Ar^+ laser lines.

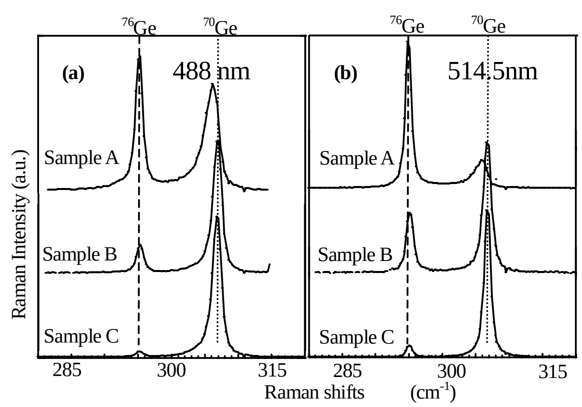

Fig. 2 Raman spectra recorded at 10K using (a) 488 nm and (b) 514.5 nm Ar^+ laser lines.