GaAs/$Al_{0.3}Ga_{0.7}As$ (110)超格子におけるスピン緩和

Spin relaxation in GaAs/$Al_{0.3}Ga_{0.7}As$ (110) superlattice

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【Introduction】In semiconductor spin light emitting diodes or lasers, spin polarized electrons are injected into the active layer from ferromagnetic electrodes. In order to keep spin polarization during transport along the growth direction, we propose to use a superlattice (SL) on a (110) substrate. In this work, spin relaxation time of GaAs/$Al_{0.3}Ga_{0.7}As$ (110) SL is studied by time- and polarization-resolved photoluminescence spectroscopy. As the tunnel coupling between quantum wells (QWs) is increased, the spin relaxation time at room temperature decreases. But even when the miniband width is as large as 25 meV, spin relaxation time is turned out to be 0.7 ns, about 7 times longer than that of bulk GaAs.

【Experimental】The samples are grown on semi-insulating GaAs (110) substrate by molecular beam epitaxy. They consist of 10 periods of 10 nm GaAs QWs/ x nm $Al_{0.3}Ga_{0.7}As$ barriers. We grew four samples with x = 1, 1.5, 2, and 3 nm. In addition, we prepared control samples: isolated QWs consisting of 60 periods of 10nm GaAs/10 nm $Al_{0.3}Ga_{0.7}As$, and a 3 um-thick bulk GaAs on (110) substrates. In time resolved photoluminescence (TRPL) measurements, we employed a picosecond mode-lock Ti:Al_2O_3 laser. The intensity was set at 1 mW. Samples were set in a cryostat and TRPL measurements were carried out at 10-300 K. The photon wavelength was set at 70~75 nm shorter than the PL peak. The TRPL was detected by a streak camera. Under the excitation by right-circular polarized light, both right- ($I^+(t)$) and left-($I^-(t)$) circularly polarized PLs were measured, and from the calculated temporal polarization $P(t) = (I^+(t)–I^-(t))/(I^+(t)+I^-(t))$ we defined the spin relaxation time τ_s by using a fitting function $P(t)$~$\exp(-2t/\tau_s)$.

【Results】In Fig. 1, τ_s is plotted as a function of the miniband width Δ. The inset indicates the relation between barrier width (L_B) and Δ. The dotted line is the spin relaxation time of bulk GaAs at room temperature. τ_s of the isolated MQW was about 6 ns. On the other hand, τ_s was 92±20 ps for bulk GaAs. Among the SL samples, τ_s of the sample with Δ~25 meV was ~0.7 ns, about a tenth of τ_s of isolated QWs. Nevertheless, τ_s was 7 times longer than that of bulk GaAs.

This observation indicates that (110) SL structures are suitable for such as spacer layers in semiconductor spin laser. Temperature dependences of the spin relaxation times in SL are also investigated.

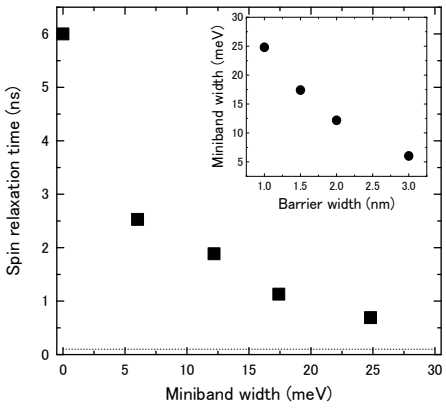

Fig. 1 Miniband width dependence of the room temperature spin relaxation time in GaAs/$Al_{0.3}Ga_{0.7}As$ (110) superlattices. The inset plots the miniband width as a function of the $Al_{0.3}Ga_{0.7}As$ barrier width.

【Acknowledgement】This work is partly supported by Grant-in Aid (19H02181, 19K05243) from the MEXT, Japan.