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Tunneling magnetoresistance in GaMnAs-based double-barrier heterostructures

S. Ohya*, P. N. Hai*, and M. Tanaka*,**

* *Department of Electronic Engineering, The University of Tokyo, Tokyo, Japan*

E-mail: ohya@cryst.t.u-tokyo.ac.jp

** *Japan Science and Technology Corporation, Saitama, Japan*

III-V-based ferromagnetic-semiconductor quantum heterostructures, such as GaMnAs / AlAs / GaAs / AlAs / GaMnAs and GaMnAs / AlAs / GaMnAs / AlAs / GaMnAs double-barrier resonant tunnelling diode (RTD) structures, are expected to realize new functions for future 'spintronic' devices by combining a tunneling magnetoresistance (TMR) and quantum-size effects. However, no clear observation of resonant tunnelling has been reported in such ferromagnetic quantum heterostructures, thus further investigation is needed.

We grew $Ga_{0.94}Mn_{0.06}As$ (20 nm) / AlAs(*d* nm) / $In_{0.4}Ga_{0.6}As$ (0.42 nm) / AlAs (*d* nm) / $Ga_{0.94}Mn_{0.06}As$ (20 nm) RTD structures with various AlAs thicknesses on a p+GaAs (001) substrate by low-temperature molecular-beam epitaxy. Figure 1 shows the experimental result of the AlAs thickness dependence of TMR. In several RTDs, we observed negative TMR. The TMR ratio oscillated between positive and negative values with increasing *d*. Also, we calculated the TMR ratio of these RTD structures using the Luttinger Kohn **k·p** Hamiltonian, suggesting that this experimentally obtained TMR oscillation is related to the resonant tunnelling effect[1].

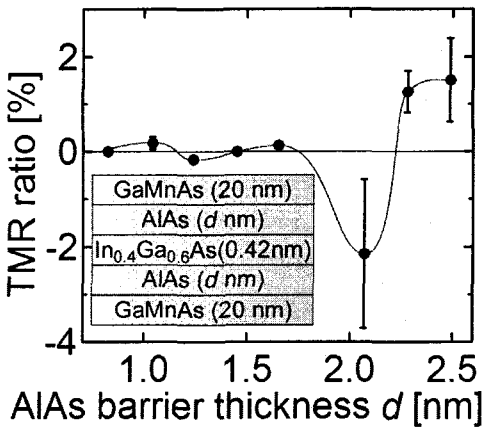

Fig. 1 Experimental result of TMR ratio *vs.* AlAs thickness *d* of GaMnAs / AlAs/ $In_{0.4}Ga_{0.6}As$ / AlAs / GaMnAs at 7.0 K with a magnetic field applied along [100] in plane and with a bias voltage of 10 mV.

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[1] S. Ohya, P. N. Hai, and M. Tanaka, Appl. Phys. Lett. **87**, 012105 (2005).