Ferromagnetic Heterostructures based on Semiconductors

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Creating a new spin-based electronics (often called "spin-electronics" or "spintronics") is one of the hot topics in the current solid-state physics and electronics research. In order to utilize the spin degree of freedom in solids, particularly in semiconductors the current electronics is based on, we need to fabricate appropriate materials, understand and control the spin-dependent phenomena.

In this talk, I will review the recent developments of epitaxial ferromagnetic heterostructures based on semiconductors towards spintronics. This includes the semiconductor materials and heterostructures having high ferromagnetic transition temperature (III-V based alloy magnetic semiconductors, Mn-delta-doped magnetic semiconductors, and related heterostructures), spin-dependent transport and tunneling [1][2], and their device applications (tunneling magnetoresistance devices and three-terminal devices). Future issues and prospects will be also discussed.

In particular, we show our magnetotransport study on ferromagnetic III-V semiconductor heterostructures with high Curie temperature T_C. In selectively doped heterostructures (Mn-delta-doped GaAs / Be-doped AlGaAs), in which holes are supplied from the Be-doped *p*-AlGaAs layer to the Mn-delta-doped channel, ferromagnetic ordering was clearly observed [3]. In the heterostructure prepared with proper conditions, its T_C was as high as 172 K, far above the T_C of InAs- or GaAs-based random-alloy magnetic semiconductors [4]. Furthermore, we show the control of ferromagnetism in the heterostructures by using gate electric field and light irradiation at relatively high temperatures (~100 K) [5].

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References

[1] M. Tanaka and Y. Higo, Phys. Rev. Lett. **87**, 026602 (2001).
[2] M. Tanaka and Y. Higo, Physica **E13**, 495 (2002).
[3] A. M. Nazmul, S. Sugahara, and M. Tanaka, Appl. Phys. Lett. **80**, 3120 (2002).
[4] A. M. Nazmul, S. Sugahara, and M. Tanaka, cond-mat/0208299 (August 2002); Phys. Rev. **B67** (2003), in press.
[5] M. Tanaka, invited talk at the Annual American Physical Society (APS) March Meeting 2003, paper S7.004, Austin, March 3-7, 2003.

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