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Heterojunction Engineering of Semiconductor Ferromagnetism[1]

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While bandgap engineering and wavefunction engineering are established in *nonmagnetic* semiconductor heterostructures, we aim to broaden their field to *magnetic* heterostructures and to extend the degree of freedom in designing spin-related properties in semiconductors. In this study, we introduced delta-doping of magnetic (Mn) impurities in the quasi two-dimensional hole gas at the interface of GaAs/p-AlGaAs heterostructures, and successfully maximized the ferromagnetic order among the Mn spins by overlapping the hole wavefunction with the Mn delta-doping profile. Selectively p-doped heterostructures (Mn-delta-doped GaAs / Be-doped AlGaAs) were prepared by molecular beam epitaxy, in which holes are supplied from the Be-doped p-AlGaAs layer to the Mn-delta-doped channel, and ferromagnetic ordering was clearly observed in magnetotransport measurements [1]. In the heterostructure prepared with proper conditions, its ferromagnetic transition temperature (T_c) was 172 K, higher than the T_c of InAs- or GaAs-based random-alloy magnetic semiconductors [2]. It was also found that in more suitably designed heterostructures with low-temperature annealing, T_c can be higher than 200 K [3]. Furthermore, we show the control of ferromagnetism in the heterostructures by using gate electric field and light irradiation at relatively high temperatures (∼100 K) [4]. [1] A. M. Nazmul, S. Sugahara, and M. Tanaka, Appl. Phys. Lett. **80**, 3120 (2002). [2] A. M. Nazmul, S. Sugahara, and M. Tanaka, Phys. Rev. **B67**, 241308(R) (2003). [3] A. M. Nazmul, T. Amemiya, Y. Shuto, S. Sugahara, and M. Tanaka, submitted. [4] A. M. Nazmul, S. Kobayashi, S. Sugahara, and M. Tanaka, Jpn. J. Appl. Phys. **43**, L233 (2004).

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