A new class of Fe-doped III-V ferromagnetic semiconductors with high Curie temperatures and their quantum heterostructures

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By actively using not only charge transport of electrons and holes but also their spins, we can create a variety of new phenomena and functional materials. This field, called spintronics, is emerging and rapidly making progress in many subfields. In this presentation, we focus on one of the most interesting and important materials, ferromagnetic semiconductors (FMSs) which have the properties of both ferromagnets and semiconductors, and their heterostructures. We review the recent progress in the studies of a new class of FMSs, Fe-doped narrow-gap III-V semiconductors, and their applications. Using low-temperature molecular-beam epitaxy, we have successfully grown both p-type FMSs [(Ga,Fe)Sb [1], insulating (Al,Fe)Sb [2]] and n-type FMSs [(In,Fe)As [3], (In,Fe)Sb [4]]. The most notable feature in these Fe-based FMSs is that the Curie temperature T_C increases monotonically as the Fe content increases; and there is a tendency that T_C is higher as the bandgap becomes narrower. Intrinsic ferromagnetism with high T_C (> 300 K) has been observed in $(Ga_{1-x},Fe_x)Sb$ with $x \geq 23\%$ [1] and $(In_{1-x},Fe_x)Sb$ with $x \geq 16\%$ [4], which are promising for practical spintronics devices operating at room temperature. Furthermore, we extended this study to quantum heterostructures containing FMSs, and revealed a variety of novel phenomena [5-13]; these new properties of the Fe-doped FMS-based heterostructures and devices provide novel functionalities for future spin-based electronics.

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