III-V:Mn Ferromagnetic semiconductors prepared by ion implantation

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Ferromagnetic semiconductors (FSs) have been under intensive investigation during the last decade. Until now, the prototype ferromagnetic semiconductor GaMnAs has revealed a variety of unique features induced by the combination of its magnetic and semiconducting properties. As a non-equilibrium process, ion implantation can overcome the difficulty that the Mn concentration in ferromagnetic III-V (FS) is far beyond the solid solubility of Mn in III-V compounds. However, the activation of dopants remains challenging due to the clustering of implanted ions during post-annealing. The solubility limit is a fundamental barrier for dopants incorporated into a specific semiconductor. On the other hand, one notes that the solubility limit in the liquid phase is generally much larger than that in the solid phase. Short-time annealing within nanoseconds regime allows the epitaxial growth from a liquid phase. The approach combining ion implantation and pulsed laser melting allows us to prepare ferromagnetic semiconductors covering the full spectrum of III-V compound semiconductors.

We have successfully synthesized ferromagnetic Mn doped III-V from InAs and GaAs to InP and GaP with different bandgaps. The results of magnetization, magnetic anisotropy, resistivity, anomalous Hall effect, magnetoresistance and x-ray magnetic circular dichroism obtained from the synthesized samples confirm the intrinsic origin and the carrier-mediated nature of the ferromagnetism. Moreover, in different III-V hosts we observe distinct differences regarding the magnetic anisotropy and conduction mechanism which are related with the intrinsic parameters such as the lattice mismatch, energy gap and the acceptor level of Mn. These results could allow a panorama-like understanding of III-V:Mn based ferromagnetic semiconductors.

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