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Controlling Curie Temperature of (GaMn)As Through Location of the Fermi Level Within the Impurity Band[1]

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This talk will address the unresolved issue of ferromagnetism in the ferromagnetic semiconductor GaMnAs, a material whose understanding is of central importance to semiconductor-based spintronics. The above unresolved issue concerns the question of whether the ferromagnetic order in GaMnAs is mediated by valence band holes or by holes residing in the impurity band. The results to be presented are based on the investigation of a wide range of GaMnAs samples using a comprehensive set of experiments that include magnetization, electrical transport and magneto-optics, along with studies of microscopic composition by channeling Rutherford back-scattering and particle-induced x-ray emission. These experiments show unambiguously that the holes underlying ferromagnetic order in GaMnAs reside in the impurity band; and that it is not only the concentration of Mn and of holes, but also the specific location of the Fermi level in the impurity band that establishes the Curie temperature of this material. Specifically, we show that having the Fermi level near the middle of the impurity band, where the states are most extended, is more important for raising Tc than increases in the effective Mn or hole concentrations. Since the location of the Fermi level can be controlled by a variety of means both during and after growth, this new understanding automatically provides practical guidelines for increasing the critical temperature.

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