Nanocomposite Semiconductor Ferromagnetic Systems

Tomasz Dietl

Institute of Physics, Polish Academy of Sciences, Warsaw, Poland
University of Warsaw, Poland

There is growing amount of evidences that owing to a significant contribution of *d* orbitals to bonding, semiconductors alloyed with transition metals may allow to fabricate in a self-organized fashion nanocomposite semiconductor/ferromagnetic metal systems with the controllable size, shape, and motive of buried ferromagnetic regions. Recent theoretical and experimental studies indicated that such modulated semiconductors may exhibit novel and hitherto unexplored functionalities in spintronics, but also in photonics and thermoelectrics [1,2].

In the talk we will review extensive studies of MBE grown (Zn,Cr)Te [3], either undoped or co-doped with N or I, and MOVPE-grown (Ga,Fe)N [4,5], either undoped or co-doped with Si or Mg. These materials have been thoroughly characterized by element specific microscopy and synchrotron radiation probes. The finding demonstrate that the transition metal (TM) cations can be distributed in the semiconductor matrix in a way giving rise either to a diluted random alloy or to ferromagnetic condensed semiconductor nanocrystals that aggregate by precipitation or by spinodal decomposition into regions more or less rich in the magnetic component. Since this aggregation correlates with the ferromagnetic response and no spontaneous magnetization is observed in the films without magnetic doping, we take our results as a strong support of the notion that the high-T_C ferromagnetism discovered in a number of magnetically doped oxides and semiconductors results from a non-uniform distribution of the magnetic component.

Interestingly, we find that the aggregation of TM cations exhibits a strong dependence on the growth flow rate and growth temperature, allowing – when appropriately mastered – a control of the solubility limit of the transition metal ions in the semiconductor matrix. Moreover, the formation of the TM-rich nanocrystals and, hence, the ferromagnetic response of the studied systems can be affected by co-doping with donors and acceptors. Our findings guide us to the far-reaching conclusion that the attractive force between magnetic cations can be adjusted through varying their charge state [3-6].

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