Structural and compositional phase separation in ferromagnetic semiconductor (Zn,Cr)Te

Shinji Kuroda
Institute of Materials Science, University of Tsukuba

In the search for high-temperature ferromagnetic semiconductors, enormous research activities have been devoted to synthesizing novel diluted magnetic semiconductors (DMSs) consisting of various combinations of host semiconductors and magnetic elements. However, the solubility of magnetic impurities in semiconductors is generally low, except for a few cases such as Mn in II-VI compounds, and the incorporation of magnetic impurities beyond the solubility limit would often result in phase separation in which the magnetic impurities aggregate in the crystal. In some cases, the magnetic impurities precipitate as an extrinsic phase (structural phase separation), while in other cases the crystal is phase-separated into regions with high and low contents of the magnetic impurity keeping the same crystal structure (compositional phase separation)[1]. In either case, the aggregated regions of the magnetic impurity cause superparamagnetic behaviours, giving the appearance of high-temperature ferromagnetism.

In this talk, we will show our study on (Zn,Cr)Te[2,3], as a typical example of the phase separation in DMSs. In (Zn,Cr)Te, the co-doping of iodine as a donor impurity induces the aggregation of Cr and results in a significance increase of the apparent Curie temperature[2]. We have investigated how the details of Cr aggregation in iodine-doped (Zn,Cr)Te changes depending on growth conditions, aiming at a kind of "growth diagram" of the phase separation in (Zn,Cr)Te. Nano-scale analyses using element-specific probes of EDX and EELS have been performed on a series of I-doped (Zn,Cr)Te films grown with variations of MBE growth condition[3]. For Cr compositions higher than 10%, it is revealed that the Cr-aggregated regions are formed of an extrinsic phase, which is identified as NiAs-structure CrTe or $Cr_{1-\delta}Te$ of the hexagonal structure, in a particular orientational relation with the zinc-blende structure of the host crystal. In addition, the formation of these hexagonal precipitates is enhanced with the increase of growth temperature. The details of the dependence on the Cr composition and the growth temperature will also be presented.

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