Magnetic and optical properties of GaMnN nanocrystals obtained by vapor-assisted aerosol synthesis and imide route method

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Spintronics demand for ferromagnetic semiconductors with high Curie temperature materials and theoretical predictions of room temperature ferromagnetism in p-type GaMnN, has boosted immense interest in fabricating of this material by various techniques. So far, GaMnN has been obtained in form of microcrystalline powder, bulk samples or epitaxial layers. In this communication the magnetic and optical properties of GaMnN nanocrystals obtained by two methods: vapor-assisted aerosol synthesis (VAAS) and anaerobic synthesis and pyrolysis of polymeric gallium imide (IMIDE) are reported.

The obtained samples contained up to 2.5% (molar) of Mn. X-ray diffraction (XRD) patterns supplemented with energy dispersive X-ray (EDX) data showed that the dominant phase is GaMnN. Some other phases, in particular Mn(II)O were also found. Electron paramagnetic resonance (EPR) measurements revealed a single, structureless resonance line with a g-factor equal to 2.008 ± 0.003 suggesting presence of Mn^{2+} centers in the GaMnN samples. The shape of the line and its width indicate exchange interaction between Mn^{2+} ions.

Magnetization of the samples was measured as a function of magnetic field (up to 6 T) and temperature (2-100K) using a SQUID (superconducting quantum interference device) magnetometer. In general, all samples showed overall paramagnetic (PM) behaviour well described by the effective Brillouin function with S=5/2. Mn concentration of VAAS samples, estimated from magnetization, was nearly the same for all the samples (about 1.5%) regardless the initial ratio of Ga/Mn ingredients put in the growth reactor. In the IMIDE samples the maximal observed Mn concentration was much higher, ranging to about 2.5%. Small ferromagnetic (FM) and antiferromagnetic (AFM) contributions to PM magnetization were also observed. They result most probably from Mn_xN_y or $Ga_{1-x}Mn_x$ precipitations (FM) and MnO (AFM). It was found that PM magnetization saturates with magnetic field more slowly than predicted by Brillouin function for noninteracting Mn ions. The effect becomes more pronounced for samples with high Mn concentracion. Such beavior reflects the antiferromagnetic interaction between Mn ions and confirms results of EPR.

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