ELECTRONIC STRUCTURE AND MAGNETIC PROPERTIES OF SELF-ORGANIZED MnSb AND MnAs DOTS GROWN BY MBE ON GaN SURFACE

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Ferromagnetic/semiconductor hybrid structures have acquired a considerable attention recently because of a growing necessity to integrate magnetism into the contemporary semiconductor technology. To achieve this, semiconductors compatible ferromagnets are required, which will retain their ferromagnetic properties at above room temperature. Among many possible materials manganese-based magnetic compounds, such as MnSb and MnAs, are one of the most promising candidates. MnSb is characterized by a Curie temperature of 590 K, much higher than the one of MnAs (320 K). Another important advantage of MnSb is the possibility of growing high quality epitaxial films on different *III-V* semiconductor substrates. It was already shown that MnSb dots can be applied for high sensitivity magnetic field detectors, due to the huge magnetoresistance effect occurring at room temperature [1].

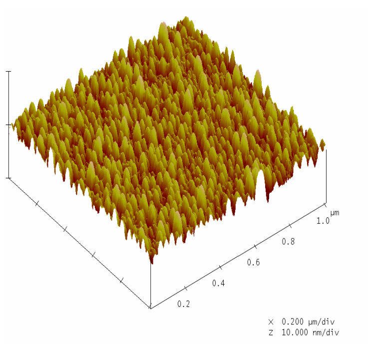

Figure 1. MnSb/GaN surface morphology obtained by Atomic Force Microscopy.

In this paper we summarize our comparative studies of photoemission and magnetic properties of self-organized MnAs and MnSb quantum dots (QD). The MBE growth is performed stepwise on clean, high quality GaN(000$\underline{1}$)-(1×1) surfaces, *in situ* prepared by Ar^+ ion sputtering and annealing.

The 3D growth is confirmed *in situ* by RHEED observations and *ex situ* by AFM characterization. A deposition of 6 ML of MnSb resulted in dots with typical diameter of 40-50 nm and height of 3-3.5 nm. 6 and 8 ML of MnAs produced dots with similar or smaller dimensions, depending on the initialization of the growth mode [1]. The electronic structure of the dots was determined by the analysis of resonant photoemission data. The photoemission measurements were carried out for photon energies close to the Mn 3*p*→3*d* transition to observe the changes of the Mn 3*d* states distribution. The difference between EDC curves obtained at resonant and antiresonant conditions clearly shows the Mn 3*d* states contribution to the valence band region and the CIS analysis indicates a single Fano profile.

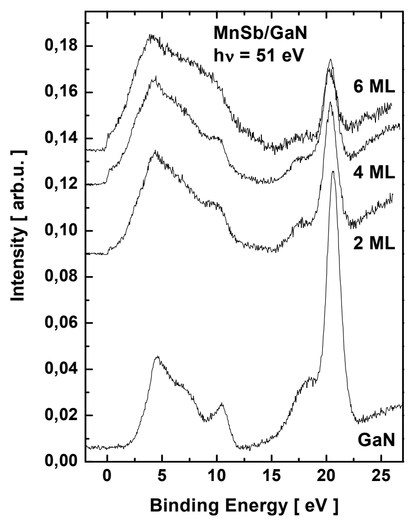

Figure 2. EDC set obtained for photon energy 51 eV (resonance conditions) for MnSb/GaN after each stage of MnSb growth.

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The MnSb dots exhibit metallic character while MnAs dots, grown by the same manner, have half-metallic character characteristic of zinc-blende MnAs. Thus, the observed previously formation of half-metallic MnAs in self-organized dots seems to be exceptional in the family of manganese pnictides. We connect this to the crystal lattice misfit and different strains at the MnAs/GaN and MnSb/GaN interfaces.

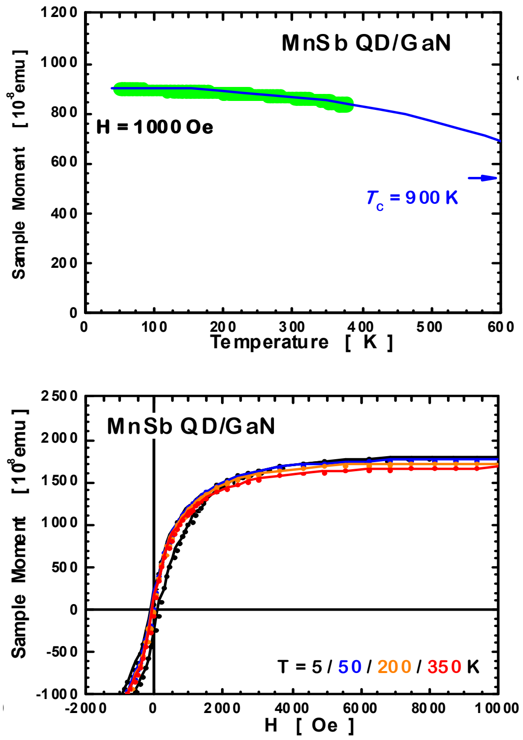

Figure 3. Magnetic (SQUID magnetometry) investigation of MnSb dots on GaN substrate. (Left) Green points: temperature dependence of the magnetic moments at 1000 Oe; blue line: Brillouin function 'fitted' to the data indicates a possible T_C of about 900 K. (Right) M-H dependency at various temperatures indicates a superparamagnetic-like collective behaviour of the dots. The presence of increasing apparent coercivity upon lowering the temperature or remanence indicates the existence of a blocking mechanism.

Magnetic properties of the MnSb dot array were measured using a SQUID magnetometer. The measurements confirm the granular character of the layers, as the basic magnetic characteristics of both systems are typical of a blocked superparamagnet with an average size of the magnetic moment of the single magnetic 'molecule' corresponding nicely to the average volume of the dot. More importantly, despite electronic and crystallographic differences, both systems shows considerably enlarged, approximately 50-100% (well beyond our current experimental limit), T_C. Such an increase of T_C in self-organized magnetic QD, if confirmed in other systems, could be of a profound importance in the search for functional materials for future spintronics applications.

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