Growth and magnetic characterization of germanium manganese Quantum Dots

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Germanium-manganese alloys are an interesting playground for fundamental studies on the physics of magnetic interactions. It is also well known that the physical properties of a material are usually changed by nanostructuration. However, a proper combination of high density and low sizes of the nanostructures is required to effectively affect the physical properties of a material [1].

In this work, molecular beam epitaxy (MBE) has been employed to grow nanostructured crystalline GeMn alloys in the form of Q-Dots through a 3-step process. First, we oxidized a silicon substrate surface and then, with a dip in a diluted HF solution, this oxidized layer was cleaned away, simultaneously creating a clean hydrogenated surface [2]. GeMn Q-Dots were then grown in a self-assembled mode by exploiting the Stranski-Krastanov epitaxial growth. We were able to synthesize denser Q-Dots arrays and control the substrate surface by hydrogen thermal desorption.

Samples were characterized both on site by means of Reflection High Energy Electron Diffraction (RHEED) and ex-situ by Scanning Electron Microscopy (SEM, figure 1a). Atomic Force Microscopy (AFM) was used to measure size and density of nanostructures (figure 1b). Magnetic hysteresis loops were obtained between 2.5 and 300 K under a maximum applied field H = 70 kOe); some selected results are shown in figure 1c. The unsaturating behaviour of M(H) emerging at low temperature may be related to disordered magnetic states at the Q-dot surfaces.

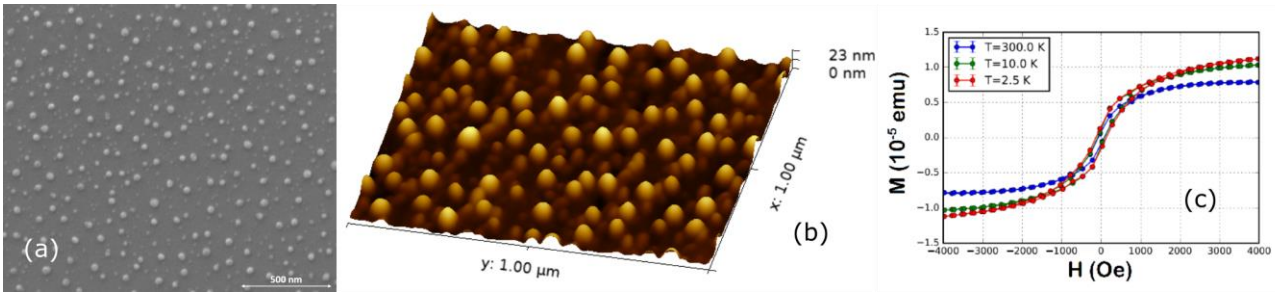

Figure 1. (a) SEM image, (b) corresponding AFM 3D image and (c) hysteresis loops of a Q-Dots array.

[1] V. Le Thanh et al. Phys. Rev. B 58 (1998) 13115

[2] V. Le Thanh et al. Thin Solid Films 428 (2003) 144