The Magnetic Properties of Mn_5Ge_3 Grown on PMN-PT Thin Films

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It is of great importance to show the electric field manipulation of magnetic properties in the field of spintronics and memory devices. One approach for achieving voltage control of magnetization is to use a hybrid piezoelectric/ferromagnetic device in which a voltage applied to the piezoelectric induces a strain in the ferromagnetic layer, which in turn affects the magnetic properties. To control several physical properties of various as-grown functional ferromagnetic thin films, ferroelectric PMN-PT single crystals have been widely used as piezoelectrically active substrates [1-3]. It has been previously indicated that permanent strain on Mn_5Ge_3 induced by the growth on a substrate with the different lattice constant varies the magnetization and Curie temperature [4]. Since Mn_5Ge_3 has a strong magnetization at room temperature and the ability to control the magnetic properties by strain, Mn_5Ge_3 is a very advantageous material.

In this study, we examined the structural and magnetic properties of thin Mn_5Ge_3 films grown on PMN-PT (011) substrate by solid-phase epitaxy with various thicknesses of Ge and Mn layers. Sample growth was performed by Molecular Beam Epitaxy (MBE), under the pressure of 1 x 10^{-9} mbar. The samples were prepared by depositing Ge layer at around 150° C then Mn layer at RT followed by annealing for 20 min at 330° C to allow Mn atoms to diffuse into the Ge layer and form Mn_5Ge_3 structure. Insitu XPS measurements performed to investigate the electronic structure and atomic concentration of the elements. The relationship between the magnetic properties and Ge and Mn layer thickness was investigated by means of vibrating sample magnetometer (VSM) and Electron Spin Resonance (ESR) over a wide range of temperatures. All the samples are a ferromagnetic with a Curie temperature of 300° C. Lower Mn layer thickness led to smaller magnetization and higher coercive field. The highest squareness ratio (Mr/MS) of 0.55 is obtained for samples with the lowest Mn layer thickness, indicating that they have a single magnetic domain. Upon switching the ferroelectric polarization from P_{up} to P_{down}, we observe a relative change in the total magnetic moment of the films.

References:

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