Magnetic anisotropy properties of tetragonal and cubic Mn_3Ga thin films

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Mn_3Ga has received renewed attention in recent years because of the variation of magnetic properties depending on the crystal structure. One is a triangular antiferromagnet for the hexagonal ($D0_{19}$) phase, which is easily obtained by arc melting. The other is a ferrimagnet for the tetragonal ($D0_{22}$) phase, which is achieved by annealing the hexagonal material at high temperatures. Another is an antiferromagnet for the cubic Heusler ($D0_3$) phase, which is synthesized using a nonequilibrium technique, but has not been studied in experiments. The cubic phase has been predicted to exhibit completely compensated ferrimagnetic spin order with a half metallic band structure.

This report focuses on the tetragonal and cubic Mn_3Ga thin films grown on MgO(100) substrates without any buffer layer by DC/RF magnetron sputtering method. The optimal deposition conditions for tetragonal phase were found to be 400°C of deposition temperature, 35 W of RF power, and 5 mTorr of Ar gas pressure in our sputtering system. The tetragonal Mn_3Ga films exhibit high perpendicular magnetic anisotropy, low saturation magnetization, and high spin polarization. Importantly, we first succeeded to fabricate the cubic Mn_3Ga films as varying the RF power. The cubic Mn_3Ga is an antiferromagnet with the Neel temperature T_N = 420 K, while the tetragonal Mn_3Ga is a ferromagnet with T_C = 830 K. Under certain conditions between two phases, there is a mixed phase of tetragonal and cubic structures, where we found a shift of hysteresis loop due to the exchange bias effect between the ferromagnetic/tetragonal and antiferromagnetic/cubic Mn_3Ga phases.