Perpendicular magnetic anisotropy properties of tetragonal Mn_3Ga epitaxial films under various deposition conditions

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Mn_3Ga has received renewed attention in recent years because of their multiple structural and magnetic properties for potential applications in spintronics [1]. The hexagonal ($D0_{19}$) phase, that is a triangular antiferromagnet, is easily obtained by arc-melting. On the other hand, the tetragonal ($D0_{22}$) phase, that is a ferrimagnet, is obtained by annealing the hexagonal material at high temperatures [2][3]. The tetragonal epitaxial films exhibited high perpendicular magnetic anisotropy, low saturation magnetization, and high spin polarization [3], which are satisfied with the criteria of spin transfer torque magnetic random access memories (STT-MRAMs). For a practical application to STT-MRAM devices, it is necessary to improve the interface nature and optimize the deposition condition. In this study, we succeeded to grow epitaxial films of tetragonal Mn_3Ga directly on MgO(100) without any buffer layer by using DC/RF magnetron sputtering method. We changed the deposition conditions; such as deposition temperature (350 - 450°C), RF power (35 - 45 W), and Ar working pressure (2 - 7 mTorr). X-ray diffraction data revealed that the growth direction is the c-axis perpendicular to the film plane. Scanning electron microscope images showed that the top surface is smooth and the maximum thickness is about 290 nm. When the deposition temperature increases, the grain size grows larger, but the samples grown at 450°C show a secondary phase of MnGa. The optimal deposition conditions are 400°C, 35 W, and 5 mTorr in our sputtering system. For the field perpendicular to the film plane, clear hysteresis loop was observed with the coercive field H_C = 1.4 T at room temperature. By extrapolating the hard magnetization data for the field parallel to the film plane, the anisotropic constant was estimated about $K_1 = 1 \times 10^6$ J/m^3. These results are promising to use it as one of magnetic components in STT-MRAM devices.

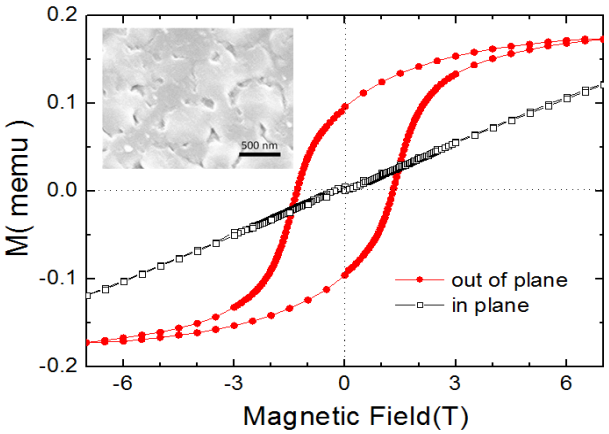

Fig. 1. Magnetization of Mn3Ga thin film deposited on MgO(100) at room temperature.

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