Chapter 5 Conclusion

In this experiment, we have successfully fabricated (001) IrMn/CoFe by using Cu as an underlayer on Si substrates. Furthermore, the φ scan results showed the epitaxial relationship is Si(001)// Cu(001)// IrMn(001)// CoFe(001) and Si[110]// Cu[100]// IrMn[100]// CoFe[110].

When a magnetic field was applied during depositions, the induced unidirectional (K_e) and uniaxial (K_u) anisotropies broke the pure biaxial symmetry, resulting in an unusual double shifted loop in the direction perpendicular to the bias field. To further investigate the magnetization reversal in the (001) IrMn/CoFe system. The hysteresis loops measured from a vector coil, a pick-up coil locating in the orthogonal direction (y-direction) to the applied field direction (x-direction), provide understanding of magnetization reversal behaved as coherent rotation at θ=90°.

To determine the anisotropy constants in (001) IrMn/CoFe system, we used the Stoner-Wohlfarth (coherent rotational) model to calculate the Ke (unidirectional), Ku (uniaxial) and Kb (biaxial) anisotropy constants. Compared to the variation of the He, Hc and Hs with different IrMn thickness, we have conclude that for samples with a small thickness of IrMn, the unpinned interfacial IrMn spin may rotate when the magnetization of CoFe reversed, which contributed to enhanced coercivity (Hc) and uniaxial anisotropy K_u of CoFe. With increasing the thickness of IrMn, the total anisotropy energy of IrMn ($K_{IrMn}V_{IrMn}$) increased so the spins of IrMn were more stable and not easily rotated when the magnetization of CoFe was reversed. Consequently, the increased exchange field and K_e was observed;

meanwhile, increased unidirectional anisotropy broke the pure biaxial symmetry so H_s increased with H_e .

Based on the Stoner-Wohlfarth (coherent rotational) model, the further investigation of the asymmetric magnetization reversal in different angles was performed by observing the coercivity difference in M_X and M_Y loops between the experimental and simulated ones. Furthermore, we suggested that at the θ=20° and 30°, the magnetization reversal behaves as rotational like in the decreasing fields while it proceeds by domain wall nucleation and growth for increasing fields. However, the opposite behaviors may occurred when the θ=60° and 70°.

In addition, the unusual time dependent phenomenon was observed in (001) IrMn/CoFe system. In this case, the magnetic properties drastically change with increasing the time scale. Several measurements were carried to find out the reasons for this phenomenon, however, the physical meaning is still unclear now.

Without any post annealing process, we have successfully demonstrated the MgO (001) structure by using the underlayers of (001) IrMn/CoFe, we believe that this promising approach may be interesting in application of MTJ in the future.