Effect of magnetic anisotropy gradient on current-induced skyrmion dynamics in a nanowire

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1. Introduction

In magnetic systems with an inversion asymmetry and large spin-orbit coupling, the anti-symmetric exchange interaction called the Dzyaloshinskii-Moriya interaction (DMI) becomses non-negligible[1,2]. It was predicted theoretically that the DMI is partially responsible for the formation of the magnetic skyrmion[3]. Recently, nano-sized skyrmions are expected to have potential as information unit for spintronics devices [4,5]. However, current driven skyrmion motion has threshold current density corresponding to the edge barrier force [6]. In this work, we investigate threshold current density of skyrmion in a nanowire, By changing perpendicular magnetocrystalline anisotropy constant in edge($K_{u,edge}$).

2. Simulation Scheme

We investigate threshold current density and velocity of skyrmion using Landau-Lifshitz-Gilbert equation with an Slonczewski-like spin-orbit spin transfer torque with current density and anisotropy constant in edge($K_{u,edge}$) as variables. We assume the anisotropy constant change linearly within 10 cells from the edge of nanowire. We use following parameters; nanowire width is 80 nm, thickness is 1 nm, cell size is 1×1×1 nm^3, saturation magnetization is 800 emu/cm^3, damping constant is 0.05, exchange stiffness constant is 1.2×10^{-6} erg/cm, DM constant is 2 erg/cm^2, spin hall angle is 0.4, perpendicular magnetocrystalline anisotropy K_u is 0.8×10^7 erg/cm^3.

3. Result and Discussion

Figure 1 shows threshold current density and maximum velocity of skyrmion can be increased when the $K_{u,edge}$ is much smaller than K_u. This behavior can be understood by the confinement effect originating from the DMI for a finite magnetic system. In case of $K_{u,edge}$ is small, the magnetization vectors in edge are aligned with normal vector of nanowire.

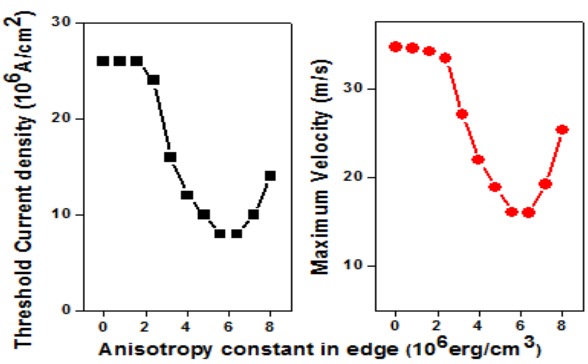

Fig. 1. Threshold current density versus perpendicular magnetocrystalline anisotropy constant in edge.

Therefore, we attribute the increasing threshold current density to abrupt change of magnetization that make strong repulsive force between skyrmion and nanowire edge.

5. References

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