スキルミオンの高密度と高速動作を目指した界面エンジニアリング

Numerical study on skyrmion transport with small size and high speed

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In recent years, skyrmion in a magnetic layer next to a heavy metal layer has been attracting attention as a new information carrier owing to its nano-scale size, fast transport by small electric current. In typical, however, the transport velocity is increased by increasing the size and electric current, which leads trilemma [1,2]. On the other hand, the transport velocity can be increased by high spin mixing conductance, and which can be increased by inserting ultra-thin layers into the interface of the magnetic and heavy metal layer [3]. Besides, the interface between a heavy metal and a magnetic layer should have the Dzyaloshinskii-Moriya interaction (DMI) enough to stabilize the skyrmion. Therefore, it is important to find the suitable inserttion material to improve the spin mixing conductance with maintaining the sufficient DMI. We verified the possibility of using it to break through the skyrmion trilemma using a simulation.

The magnetic status and skyrmion transport are calculated by solving the LLG equation. MuMax3 [4] was used for the simulation. The physical parameters were listed in Table Ⅰ. Here, the spin mixing conductance reflects on the current polarization along with the spin Hall angle of the heavy metal layer. Current was applied for 50 ns. Figure 1 shows the velocity as a function of the DMI coefficient when the current polarity was changed from 0.1 to 0.3. The velocity increased as increasing the current polarity. Since the current density is not varied within this simulation, it suggests the possibility of breaking the skyrmion trilemma by changing the current polarity that depends on the spin-mixing conductance and spin Hall angle.

Table Ⅰ

parameter	value
Saturation magnetization (A/m)	1.0×10^{6}
Magnetic anisotropy (J/m^3)	6.8×10^{5}
Stiffness constant (J/m)	1.0×10^{-11}
Current density (A/m^2)	1.0×10^{11}
Current Polarization	0.1
Cell size (nm)	2×2×1
External magnetic field (mT)	90

[1]. Skyrme, T. *Nucl. Phys.*, 31, 556, 1962.

[2]. Sai L, *et al*, *Mater. Horiz*. 8, 854, 2021.

[3]. X ingtao J, *et al*. *Europhys. Lett.* 96, 17005, 2011.

[4]. Arne V., *et al*. *AIP Adv*., 4, 107133, 2014.

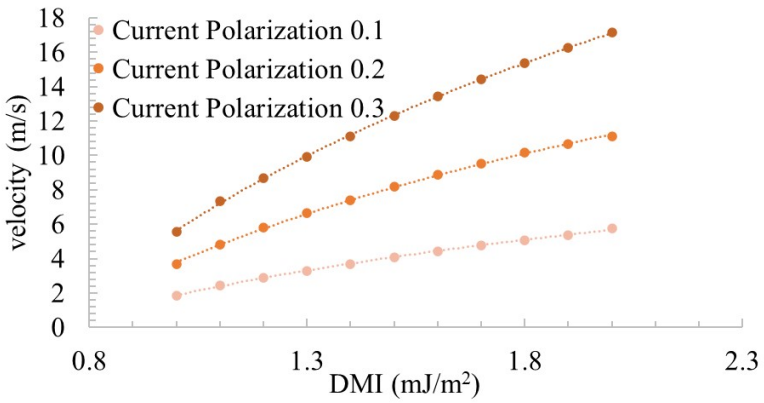

Figure 1 Skyrmion transport velocity dependances on DMI magnitude.