電流誘起磁壁移動特性の細線幅依存性

Wire width dependence of current-induced domain wall motion properties

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Current-induced domain wall (DW) motion offers a scalable switching method for high-speed and high-reliability spintronics devices. The DW motion has been demonstrated in Co/Ni multilayer with the width of down to 20 nm [1]. Since its performance increases with decreasing the wire width [2], it is of great importance to clarify the factors that govern the width dependence of DW-motion properties. Here, we experimentally investigate the width dependence of threshold current density (J_{th}) for DW motion in Co/Ni wire with various widths down to less than 20 nm. In addition, from a micromagnetic simulation, we discuss the way to reduce the device size.

Co/Ni multilayer, deposited by dc magnetron sputtering, is processed into Hall devices with various widths (w). Figure 1(a) shows the measured w dependence of J_{th}. We find that J_{th} shows a minimum at around 30 nm, below which it increases with decreasing w. For w < 20 nm, DW motion is not observed below the studied current density range, which is plotted as open symbols. To understand the origin of the observed results, we perform a micromagnetic simulation to calculate the DW-width parameter (Δ) and hard-axis anisotropy field ($H_{k\perp}$), to which J_{th} is known to be proportional [3]. In Fig. 1(a), the calculated J_{th} is also plotted, which well reproduces the experimental results. This indicates that the theoretical model well describe the w dependence of J_{th}. In light of these findings, we further investigate how to extend the scaling limit using the simulation (Fig. 1(b)). We find that, by increasing the wire thickness, the width that gives the minimum J_{th} decreases, i.e., smaller J_{th} is obtained at smaller w; however it in turn increases the threshold current (I_{th}) due to the increasing cross area. On the other hand, small I_{th} at reduced dimension can be obtained in case that large anisotropy energy density K is assumed.

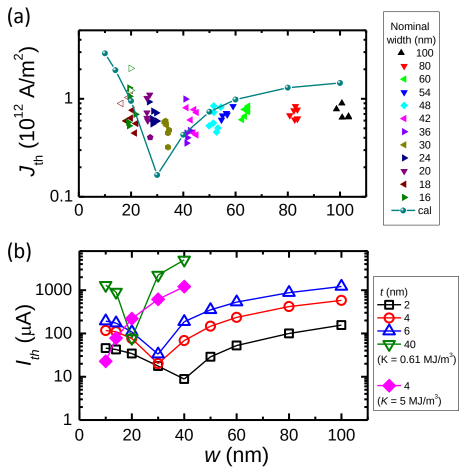

Figure 1: w dependence of (a) J_{th} obtained from experiment and calculation, and (b) calculated I_{th} for various parameters.

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