Interaction between Spin Waves and Domain Walls in Magnetic Nanowires

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Current driven manipulations of domain wall (DW) motions in patterned magnetic thin-film nanowires via the spin transfer torque (STT) are of growing interest in the research areas of nanomagnetism and spintronics[1], owing to its potential applications to solid-state data-storage[2] and data-processing devices[3]. More recently, fundamental understandings of the nontrivial dynamic behaviors of DW motions driven by magnetic fields and/or spin-polarized currents have been advanced from experimental[4], numerical simulation[5], and theoretical[6] studies. However, interaction between DWs and SWs has not been studied[7,8]. In this presentation, we report on the results of a study on transverse wall (TW)-type DW motions driven by propagating SWs through their interaction. We also propose that traveling SWs are an alternative means for the manipulation of DW motions in nanostrips.

In this study, we chose an approach of micromagnetic numerical calculations[9] on a model system of a Permalloy (Py) nanostrip of thickness t =10 nm, length l = 3005 nm, and width w = 50 nm, where a head-to-head TW-type DW was placed at the center position (x=0). We perturbed locally the magnetizations at either strip ends using single harmonic sinusoidal fields for the generation and the injection of SWs having specific frequencies. From this simulation, we found that the TW moves by propagating SWs having f_{sw} = 18 GHz, whereas there is no motion of the TW for a frequency of f_{sw} =13 GHz. These results evidence that the TW motions can be controlled by interaction between the TW and the propagating SWs of specific frequencies. In order to obtain more information on the relationship between f_{sw} and the velocity of TW motions, we also examined the variation of the TW velocity with ranging from 0 to 45 GHz. It was found that specific frequencies of SWs, namely, =14.5, 18, 24, 27, and 32 GHz, can drive effectively TW motions with the corresponding velocities, 1.1, 5.9, 4.6, 2.1, and 0.8 m/s, respectively. It was also found that the TW velocity varies with the frequency and the amplitude of propagating SWs. These characteristic frequencies of SWs for driving the TW motions can be understood in terms of the resonant excitation of several local modes associated with the TW structure inside this type of DW through the interaction of the SWs of f_{sw} being tuned to those of the local modes of the TW. The local modes within the TW and the frequency peaks in the average velocity-versus-f_{sw} curve are in quantitative agreements. The results provide an alternative means of using propagating SWs for controlling DW motions in nanostrips. This work was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (No. 20110000441)

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