Spin-wave Radial-mode Resonant Vortex-core Magnetization Reversals

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Magnetic vortices in magnetic nanodisks are applicable as information carriers to future information storage devices owing to their bistate core orientations with extremely high thermal stability and low-power driven vortex-coreswitching[1]. Vortex core reversals have thus attracted much attention from both fundamental and technological aspects.Until now, vortex core switching is found to be mediated by the nucleation and annihilation of vortex-antivortex pair, by which processes vortex core reversals occur with low-power consumption assisted by resonant vortex gyration excitations[2].

In this presentation, we report on an additional possible means of ultrafast, low-power driven vortex-core switching by using oscillating fields applied perpendicularly to the dot plane. In this case, the oscillating field frequencies are tuned to the spin-wave radial-mode resonance frequencies[3]. We performed micromagnetic simulations on a Permalloy (Py) disk of 160 nm diameter and 7 nm thickness. For the disk's dimensions and geometry, the eigenfrequencies of the radial modes were determined to be f = 10.7, 15.2, and 20.7. To construct phase diagrams of the core switching event on the strength and frequency of external driving fields, we applied oscillating fields perpendicularly to the dot plane in the ranges of 100 to 1400 Oe, and from 8 to 21 GHz. From the simulation results, we found that the threshold field is as low as 200 Oe at 10 GHz and 600 Oe at 14 GHz. These values are smaller by an order of magnitude than the threshold field strength of perpendicularly static magnetic field, ~ 6 kOe, and the reversal times are less than 1 ns because this mechanism does not require resonant gyration excitations to reach its critical velocity required for vortex core switching. The underlying physics of the new mechanism is associated with the exchange energy density localized highly at the core. This mechanism is totally different from the vortex-antivortex pair nucleation and annihilation process. 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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