BA07

Direct Current Effect on the Magnetization Reversal of Microstructured CIP Spin Valves

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We report a study of the direct current effect on the magnetization reversal of microstructured spin valve. A SEM-modified electron beam lithography in conjunction with ion beam etching process was used to fabricate the elliptical spin valve element, followed by a second step of lithography for patching nonmagnetic current/voltage leads. The spin valve devices were electrically characterized using differential magnetoresistance (MR) measurements. The MR curves using a low sensing ac current only were first carried out with external magnetic field applied parallel to current/pinning direction. The field scanned minor loops may reveal distinct metastable states during magnetization reversal, depending on the aspect ratio of the device. The metastable states were further investigated by scanning with various field ranges and thus sub-minor loops were observed. Furthermore, the low sensing ac current was superimposed with dc currents scanned with various ranges for the study of current driven magnetization reversal. The current scan data taken in the absence of external magnetic field illustrate that the magnetization configuration was switched from state to state having a resistance-current loop. By correlating the current scanned curves with those many field scanned sub-minor loops, we will elaborate how the direct current exerts an effect on the domain wall nucleation/annihilation and/or spin torque transfer in the CIP spin valve devices.

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Out-of-plane DC Current Driven Vortex Excitations in Soft Magnetic Nanodots: Vortex Gyrotropic Motion and Vortex-core Reversal Behaviors

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The spin-transfer torque (STT) of spin-polarized currents is a promisingly reliable means of switching the orientation of magnetizations in magnetic elements of submicron size (or smaller). Nonuniform magnetizations such as the magnetic vortex structure can also be excited by spin-polarized currents, and thus it becomes an emerging research field of spin dynamics and nanomagnetism owing to its potential applications to future solid-state information storage devices [1-4]. Very recently, the resonant vortex gyrotropic motions and vortex-core reversals in confined nanodots excited by currents flowing in the direction parallel with the film normal have been studied with nano-pillar multilayer structures that consist of a magnetic spin polarizer, a non-magnetic layer, and a free magnetic layer [5,6]. In these studies, only the STT effect on vortex dynamics was focused on. Although the effect of Oersted fields induced by flowing currents on vortex dynamics is significant, as evidenced by recent experiments [7], this effect has not been considered so far.

In this work, we investigated the effects of the Oersted field and STT of out-of-plane dc currents applied to the vortex states of nanodots. It was found that the vortex eigenfrequency ω_0 varies linearly with the Oersted field strength induced by the out-of-plane dc current. The vortex chirality, represented by the rotation sense of the in-plane curling magnetization of a vortex state, is also a parameter that determines the vortex egienfrequency shift. For the same (opposite) chirality as that of the Oersted field, the eigenfrequency increases (decreases) with increasing field strength. The results originate from the Zeeman energy contribution of the Oersted field to the potential energy for a shifted vortex. The result is consistent with the fact that the ω_0 is determined by the stiffness coefficient κ of the potential energy, as $\omega_0 = \kappa/|G|$, with the gyrovector constant G [8]. Moreover, the vortex core switching, its critical velocity, reversal mechanism have been investigated, which are consistent with results obtained from in-plane oscillating field and current driven vortex excitations reported in our previous papers [2-4]. The present results reveal that the Oersted field as well as STT of spin-polarized currents are essential factors in determining vortex gyrotropic motions and vortex core switching.

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