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Impedance Behavior in Co/Cu/Co/NiFe Pseudo Spin Valve with Annealing Treatment

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Spintronics, which may contains a spin/magnetic tunneling junction (S/MTJ) or a pseudo spin valve (PSV) [1], has been widely expected to play a central role in the future generation of spin technology such as nonvolatile memory, pick-up heads and magnetic sensors, etc.. In this study we extend our previous work [2] to report on the frequency response features of the Magneto impedance (MI) behavior of PSV which anneals at varied temperature from room temperature (R_T) to 200°C. The magneto impedance (MI) behavior of Ta/NOL/Co/Cu/Co/NiFe/substrate pseudo spin valve (PSV) was investigated at RTin the frequency ranged from 100 Hz to 40 MHz. Magneto impedance, $MI = M|Z|e^{i\theta} = MR + iMX$ in which $MX = MX_L - MX_C$, of the PSV originates mainly from the inductance and capacitance of the device . It may also contain small amount of the parasitic inductance and capacitance from the wire. For a metallic multilayer such as PSV, usually X_L dominates and X_C negligible. At fixed frequency, the AC behavior in the PSVis very interesting to get MR and MX loop, and MR loop is reversal to MX. Thus, a typical GMR effect leads to a MRloop behavior, while the magneto impedance of the PSV leads to a MX loop behavior. The MX curve is negative at low frequency. It turns positive at the frequency $f \geq 476$ kHz, indicative of the resonance frequency of the circuit. The MX ratio showed a transition region to change sign across zero. For instance, MX ratio changed from 1793 % at 476kHz to -1523 % at 477 kHz respectively. With raising annealing temperatures, the capacitance effects of PSV decrease due to the increasing of oxide thickness. It means that the impedance measurement have allowed us to investigate oxide behavior with different annealing temperature of the PSV. The magneto impedance effect of PSV has been the first time investigated. It is found that the PSV can be regarded as a combination of resistances, inductances and capacitances, and equivalent circuit theory can be used to analysis the AC behavior of this system. The |MX| ratio is more than 1800 % at resonance frequency (f_r)= 476 kHz. This suggests strongly that PSV is potentially a very sensitive frequency sensor.

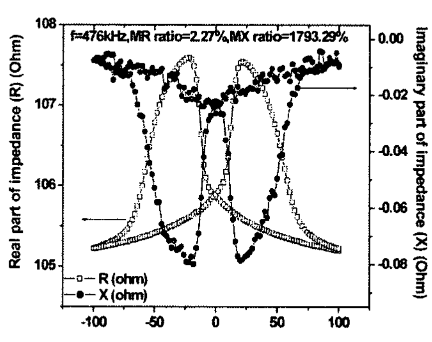

Fig. 1. At resonance frequency (476 kHz), the shape of MR loop is reversed to that of MX.

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Switching Field Control of Spin Valve Sensors Using Magnetic Field Wave

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The structure of magnetoresistive sensors with excitation field line (EFL) is widely applied for magnetic random access memory [1] and magnetically coupled isolator [2] as a low field application. In this study, spin valve (SPV) sensors having excitation field line [3] are fabricated by photolithography process and the behaviors of switching field are investigated depending on the amplitude of the current into the EFL. Fig. 1(a) shows a microphotograph of the specimen which has two EFLs above the sensor. The width of EFLs is 10 μm andthe gap between the EFL and the SPV sensor is 1.2 μm. Alternate current (AC) of 10 KHz is applied to the EFL and the magnetic field wave is generated around the line, about 0.2 Oe/mA at the position of the sensor. As shown in Fig. 1(b), the switching field reduction of about 20 Oe is observed and the switching is more sensitive to the magnetic field when the peak current is 200 mA. Switching field shift is also available by controlling the offset of the current. In addition, Fig. 1(c) shows power spectral density (PSD) of the sensor output signal at the frequency domain when the AC of 10 KHz is applied into the EFL. The peak at 10 KHz (operating frequency) is far from the 1/f noise [4] region due to the modulated magnetic field [5] at the position of the sensor and the noise reduction effects can be expected. If the EFL is patterned under SPV sensors with small switching field (≤ 20 Oe), this structure can be applied highly sensitive and low noise magnetic field sensor.

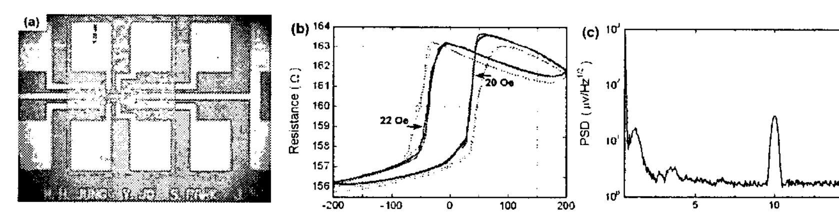

Fig. 1. (a) Microphotograph of the spin valve sensors with excitation field lines, (b) R-H curves of the sensor with(solid line) and without (dotted line) alternative current, (c) Power spectral density (PSD)of the sensor output signal when the AC of 10 KHz is applied.

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