Study on the Effect of Pt Resistivity on SOTs in Pt/Co/AlOx Trilayer Structure

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1. 서 론

Since the discovery, spin-orbit torque has been receiving a great deal of attention due to its possible applications in non-volatile spin-orbit torque magnetic random access memory (SOT-MRAM) as well as in reprogrammable magnetic switch which can be integrated in spin logic devices [1]. In heavy metal/ferromagnet/oxide structures, in-plane current generates spin accumulation at the HM/FM interfaces with spin Hall effect (SHE) and/or interfacial spin-orbit coupling (ISOC), which gives rise to a spin-orbit torque arising from the spin orbit coupling to the FM layer. As of today, there are several reports on the contribution of the ISOC, which was controlled by inserting Cu layer at the HM/FM interface or by oxygen manipulation [2]. On the other hand, there is only a handful of study on the modulation of the SHE, which is considered to be determined when the materials are chosen.

In this work, we report a systematic study on an effect of the underlayer Pt resistivity on the spin-orbit torque in Pt/Co/AlOx structure, the well-studied structure that has a strong PMA, by means of Pt deposition pressure manipulation. Our harmonic lock-in measurement results and the current induced magnetization switching results both demonstrate that the SHE contribution to the SOT can be improved by the increase of the Pt resistivity.

2. 실험방법과 결과

The thickness of the Pt layer between Ta underlayer and Co layer was carefully controlled in order to obtain 5 nm thickness with thickness deviations of less than 2% for the entire set of samples using X-ray reflectivity (XRR) analysis. Based on the XRR data, the deposition rates for the Pt layer were obtained and Ta(3)/Pt(5)/Co(0.8)/AlOx(1.8) layers (numbers in nanometers) were deposited on Si/SiO_2 substrates by magnetron sputtering with Pt deposition pressures of 3, 10, 20, 30, 40, 50mTorr accordingly. Here, only the Pt deposition pressures were varied and all the other layers were deposited at 3mTorr.

All samples were patterned into $5\mu m$-width hall cross bar using photolithography and ion milling. The SOTs were measured using harmonic lock-in technique with polar angle of 4° with in-plane fields applied parallel (DLT) and perpendicular (FLT) to the current flow direction. Finally, the current-induced magnetization switching characteristics were studied by applying longitudinal current pulses with fixed magnetic field along the current flow direction.

In this study, the resistivity of the Pt was tuned up to around 60% with control of the deposition condition. As can be seen in the harmonic signals, the slope of the second harmonic signal increased as the Pt deposition pressure increased. This increase in the slope of the harmonic signals suggest that the effective fields which reflect SOT also increased with increase in Pt resistivities. Moreover, the current-induced magnetization switching results show decreased critical current with increased Pt deposition pressures which show good agreement with the harmonic lock-in measurements.

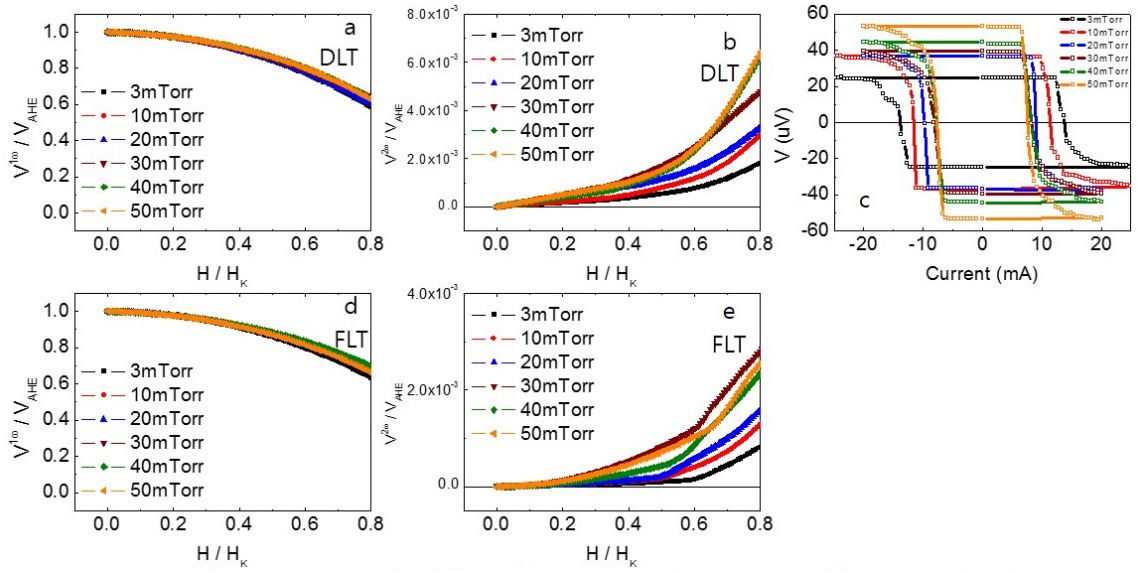

Fig. a, b, d, e, Harmonic signals for DLT and FLT measured at 2mA for different Pt deposition pressures normalized by V_{AHE} **c,** Current-induced magnetization switching for different Pt deposition pressures with external longitudinal field of 100Oe.

3. 결 론

We have studied the effect of Pt resistivity on the spin-orbit torque in Pt/Co/AlOx structure by controlling Pt deposition pressures from 3 to 50mTorr. Increase in the slope of the second harmonic signal was observed with increase in the Pt deposition pressures. Moreover, switching results show decrease in switching current with increase in Pt deposition pressures both of which suggest the increase of SOT with increase of Pt resistivities.

4. 참고문헌

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[2] Qiu, X. *et al.* Spin-orbit-torque engineering via oxygen manipulation. *Nature Nanotechnology* **10**, 333-338 (2015).