Simultaneous observation of anti-damping and inverse spin Hall effect in $La_{0.67}Sr_{0.33}MnO_3$/Pt bilayer system

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Figure S1 shows the X-ray diffraction peaks of the sample S1. All diffraction peaks are corresponding to (001) plane of LSMO. Since LSMO and $SrTiO_3$ (STO) peaks lies on the similar diffraction angle due to well-matched lattice parameters, it is difficult to differentiate them from the x-ray diffraction pattern. We did not observe any other diffraction peaks corresponding to different orientation of planes. Therefore, we concluded that our LSMO thin films are epitaxial grown perpendicular to (001) plane of STO substrate.

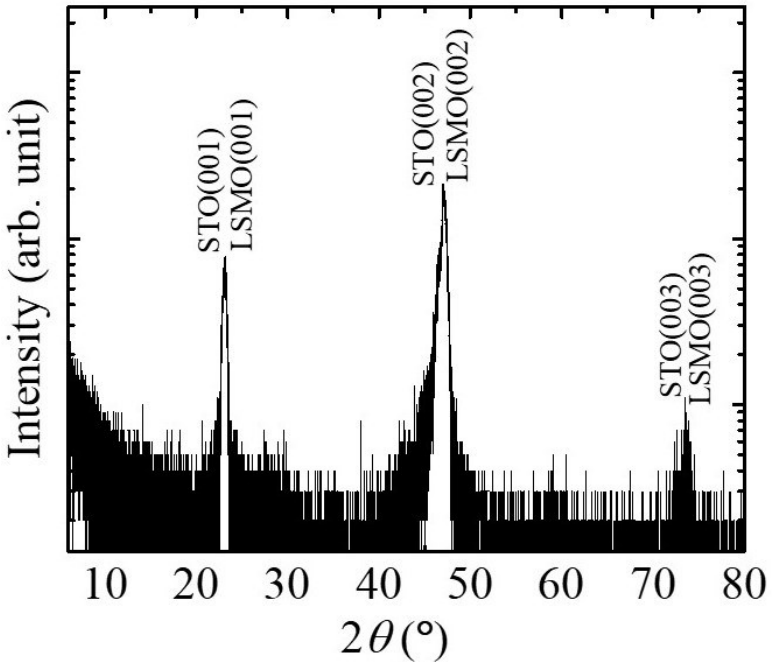

Fig. S1. X-ray diffraction pattern measured in θ-2θ geometry of LSMO thin film (sample S1) deposited on STO (001) substrate by using oxygen plasma assisted molecular beam epitaxy (OMBE).

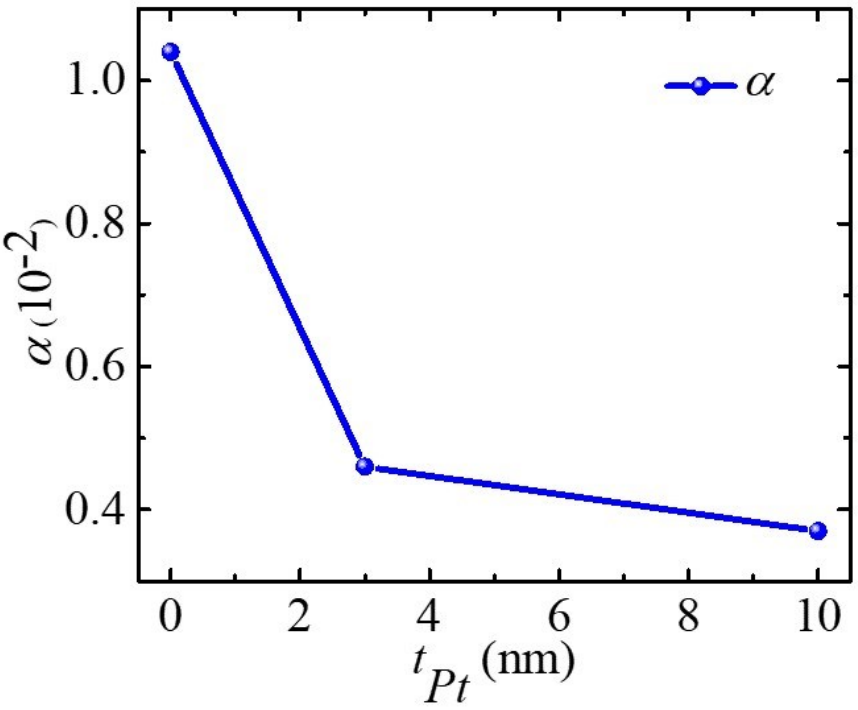

Fig. S2. α dependency on t_{Pt}. With increase in $t_{Pt,}$ α decreases.

Figure S2 shows that with increase in t_{Pt}, α decreases.

For comparison with standard sample to our results we have deposited one sample S4 with structure Si/$Co_{40}Fe_{40}B_{20}$ (5nm)/Pt (3nm) by DC sputtering. Figure S3 shows the ISHE data for the sample S4. We have separated V_{sym} and V_{asym} contribution from the data using equation (4). For calculation of θ_{SHA} we have performed angle dependent ISHE measurements as shown in Figure S4. Value of θ_{SHA} for this sample calculated to 0.022 which match well with other previously reported values for Pt.

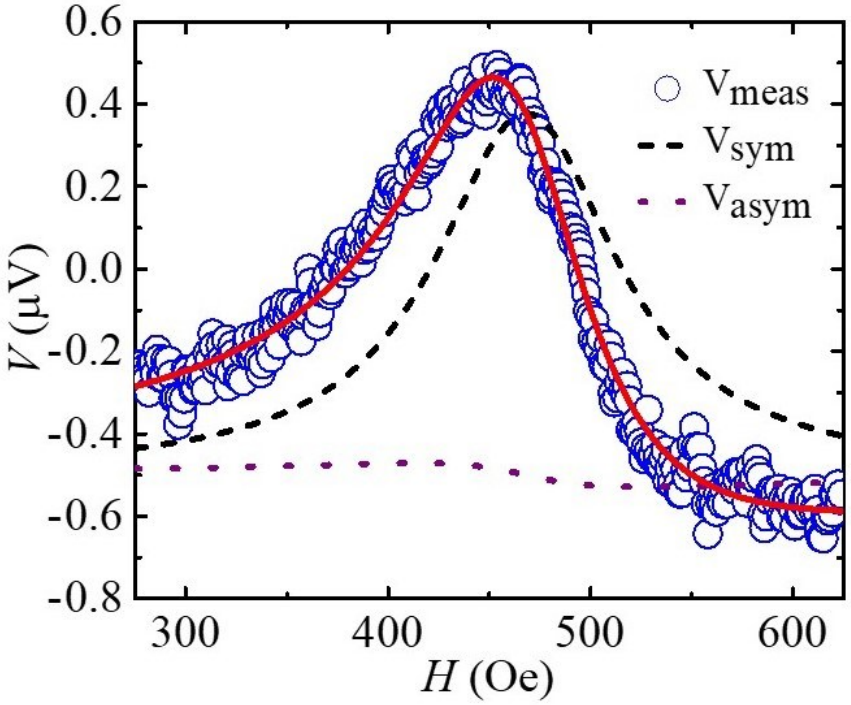

Fig. S3 ISHE voltage for samples Si/$Co_{40}Fe_{40}B_{20}$ (5nm)/Pt (3nm). Open circles (in blue) is the measured ISHE voltage and solid line (in red) represents the best fit of the data fitted by equation (4). Dash (in black) and dot (purple) lines represent the V_{sym} and V_{asym} components, respectively, evaluated by fitting to equation (4).

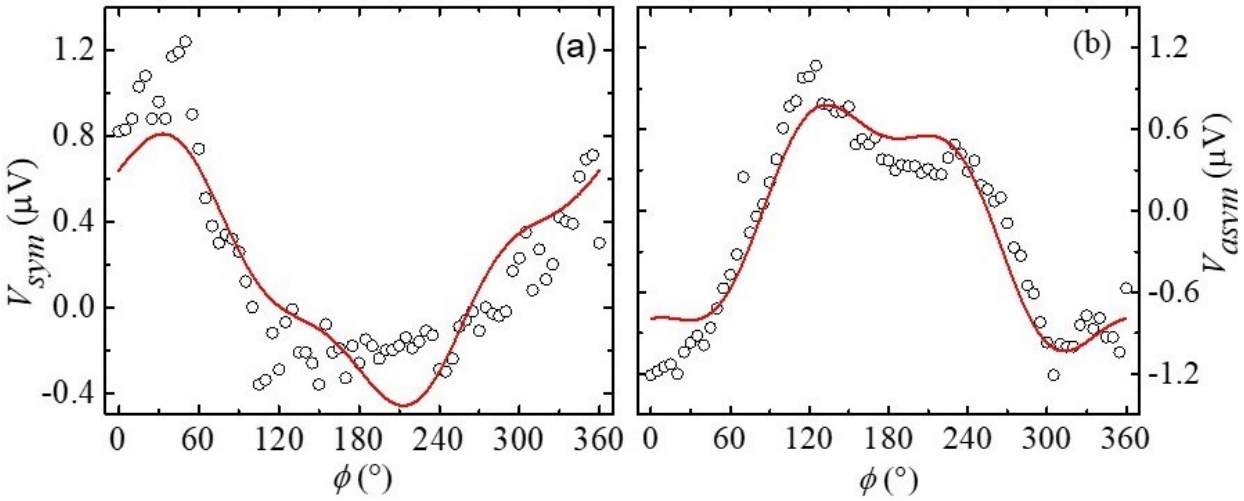

Fig. S4 (a) and (b) Angle dependent V_{sym} and V_{asym} for Si/$Co_{40}Fe_{40}B_{20}$ (5nm)/Pt (3nm) sample. Figure (a) and (b) were fitted by using equation (5) and equation (6) respectively.