Supplementary Information for
Enhanced Anomalous Hall Effect of Pt on an Antiferromagnetic Insulator with Fully Compensated Surface

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The field dependence and the temperature dependence of Hall resistance R_H and anomalous Hall resistance R_{AHE} of Pt/YIG and Pt/LSMO are compared side by side in Fig. S1. The sign reversal around 50 K for the anomalous Hall resistance R_{AHE} of the 10 nm Pt/YIG heterostructure is clearly seen in Fig. S1 (b), while R_{AHE} of the 2 nm Pt/3UC LSMO remains negative at all measured temperatures in Fig. S1 (d). The R_{AHE} value of the 10 nm Pt/YIG at 300 K is one order of magnitude smaller than the ordinary Hall resistance R_{OHE}. Without the subtraction of R_{OHE}, the contribution of R_{AHE} at 300 K is almost invisible in Fig. S1 (a). In stark contrast, the R_{AHE} value of the 2 nm Pt/3UC LSMO at 300K is almost 3 times larger than the R_{OHE} value as shown in Fig. S1 (c) and (d).

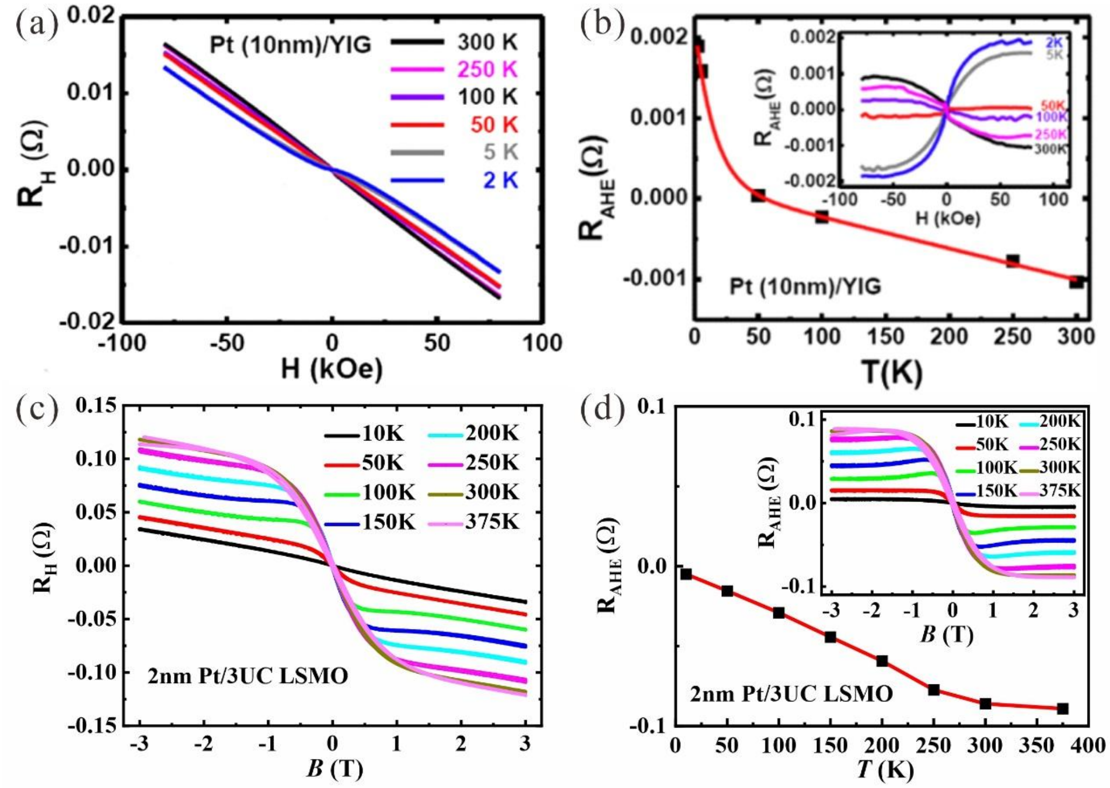

Fig. S1 (a) Field dependence of Hall resistance R_H at different temperatures for 10 nm Pt/YIG (copied from Ref. [1]). (b) The anomalous Hall resistance R_{AHE} as a function of the temperature for 10 nm Pt/YIG (copied from Ref. [1]). The inset shows R_{AHE} as a function of magnetic field. (c) Field dependence of R_H at different temperatures for

2 nm Pt/3UC LSMO. (d) R_{AHE} as a function of the temperature for 2 nm Pt/3UC LSMO. The inset shows R_{AHE} as a function of magnetic field.

The diffusion of Mn into the Pt at the Pt/LSMO interface is important, but the diffusion of Mn itself can't yield sizable AHE. As reported by Ning An *et al.* [2], the $Mn_{1-x}Pt_x$ epitaxial films can show large AHE, but only at the composition of Mn_3Pt, which is known as a noncollinear antiferromagnet in $L1_2$ structure. It is deposited under the optimized sputtering power of Mn target to make sure the right Mn_3Pt stoichiometry and annealed at 600 ℃ to make sure the right $L1_2$ structure. These critical conditions don't fit in our case, where the Mn impurities in the Pt are diluted. To know the role of the interdiffusion of Mn, we measured the Hall resistivity of 2 nm $Pt_{100}Mn_1/SrTiO_3(001)$. As shown in the Fig. S2 (a), AHE is almost unvisitable. It proves that only the diluted Mn impurities in Pt at the interface are not sufficient to exhibit AHE, and it needs the help of underlying LSMO through the exchange interaction.

In addition, we have measured the Hall resistivity of 2 nm Pt/2 nm Mn/$SrTiO_3$(001). As shown in the Fig. S2 (b), although T_N of bulk Mn is 95 K, AHE clearly appears at 100K and gets significantly enhanced at 300 K. Since both Mn and Pt layers are conducting, the contribution of AHE from Mn layer and Pt layer are mixed. However, by comparing the magnitude of ρ_{AHE} of 2 nm Pt/2 nm Mn sample (1.5×10^{-1} μΩ·cm) and 2nm Pt/3 UC LSMO sample (1.8×10^{-2} μΩ·cm) at 300K, we can conclude AHE is mainly from the Mn layer due to the short-range order above T_N.

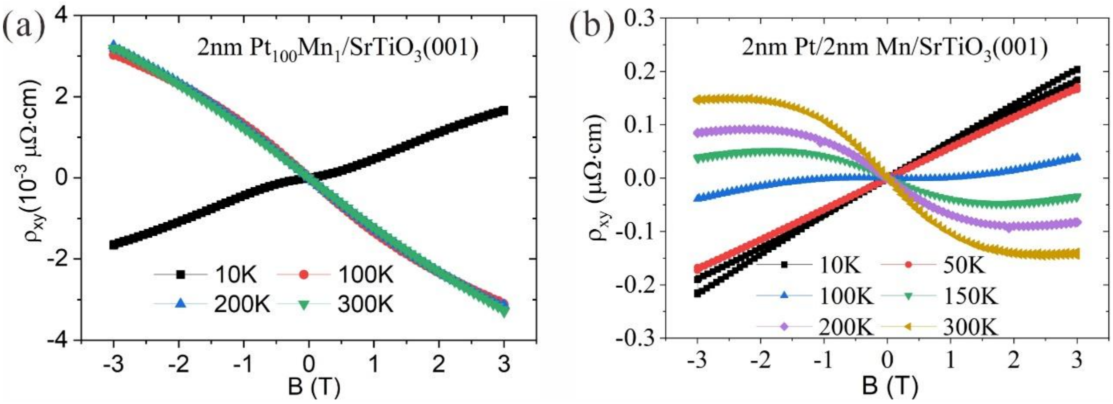

Fig. S2 (a) Field dependence of Hall resistivity at different temperatures for 2 nm $Pt_{100}Mn_1/SrTiO_3(001)$. (b) Field dependence of Hall resistivity at different temperatures for 2 nm Pt/2 nm Mn/$SrTiO_3$(001).

Reference

[1] S.Y. Huang, X. Fan, D. Qu, Y.P. Chen, W.G. Wang, J. Wu, T.Y. Chen, J. Q. Xiao, and C.L. Chien, Physical Review Letters 109, 107204 (2012).

[2] N. An, M. Tang, S. Hu, H.L. Yang, W.J. Fan, S.M. Zhou, and X.P. Qiu, Sci. China-Phys. Mech. Astron. 63, 297511 (2020).