SUPPORTING INFORMATION:

Spin to charge conversion in chemically deposited epitaxial $La_{0.9}MnO_3$ thin films capped with Pt

Compositional analysis of the LMO/Pt interface:

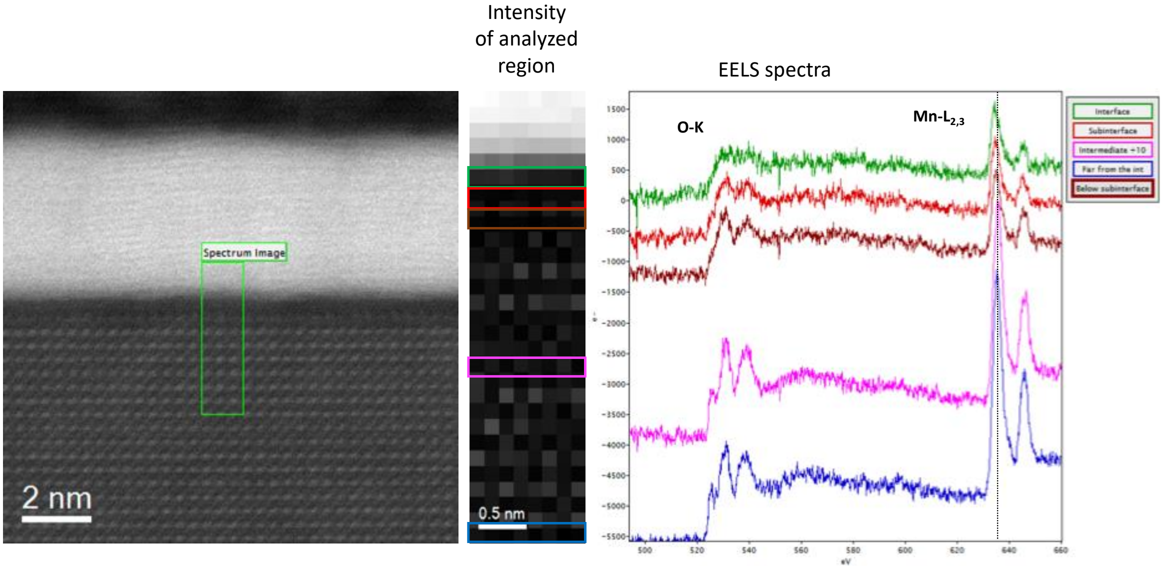

Figure S1: *Analysis of the raw ELNES structure showing the intensity of analyzed region in the middle and the EELS spectra on the right.*

EELS spectra show a **blueshift** of the Mn-$L_{2,3}$ edge (shift towards higher energies) when moving from the LMO/Pt interface towards the substrate, with an energy difference of ~0.8 eV. This suggests a lower valence of Mn, i.e. a **more reduced** phase at the interface. O-K edge does not present strong modifications besides the suppression of the pre-peak at ~525 eV.

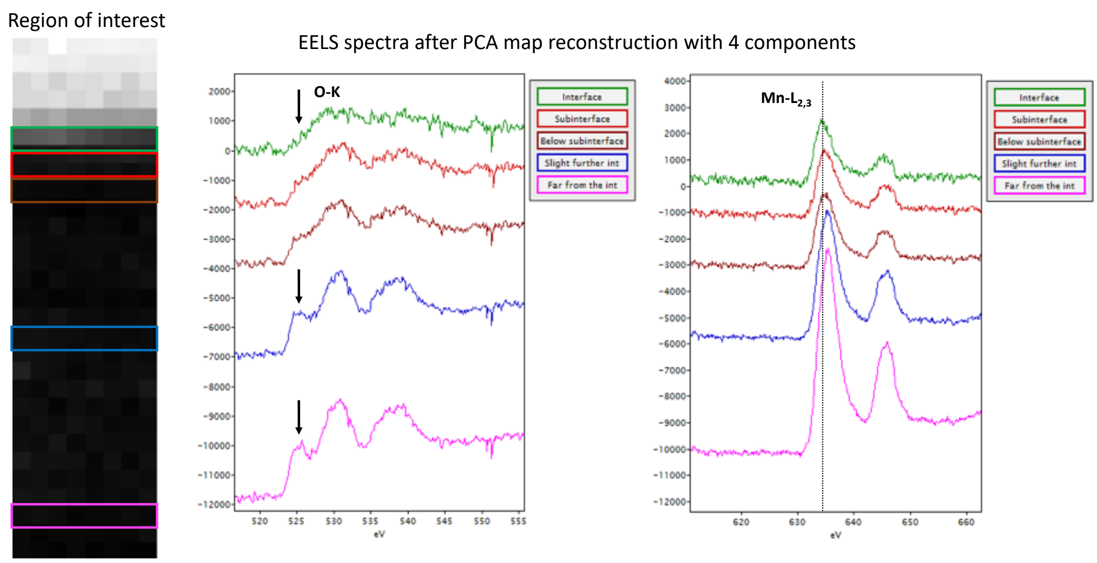

Figure S2: *Statistical analysis of the signal. Principal Components Analysis for denoising.*

After a careful analysis, with denoising and reconstruction, the Mn-$L_{2,3}$ edge still presents the shift towards higher energies and O-K edge makes evident the appearance of a pre-peak when moving far from LMO/Pt the interface.

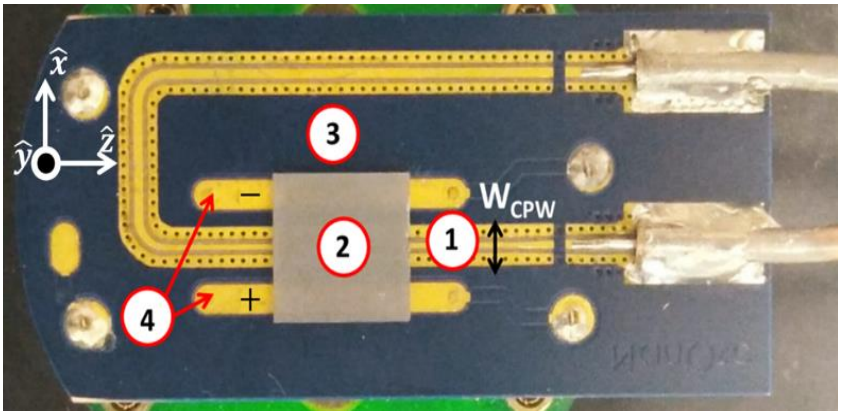

Figure S3. *Top view photograph of the actual measurement system. The numbers correspond to the following parts: (1) CPW with a total width W_{CPW} = 1.4 mm (including the RF signal active line in the middle and the two ground lines on both sides). (2) The sample placed upside down on top of the CPW with a total width of 5 mm. (3) Insulating layer. (4) Contact pads with bumps raised 20 µm above the insulating layer for making electrical contact with the sample by means of Au contacts. Finally, Kapton tape is used to fix and tighten the sample onto the CPW (not shown). This sample holder is the "CPW PPMS IP ISHE" model produced by NanOsc Instruments (http://www.nanosc.se/wave-guides.html).*

As mentioned in the main text, in order to try to clarify what could be the temperature dependence of V_{ISHE} we have analyzed the expected dependence of the different magnitudes that appear in the V_{ISHE} equation. According to the analysis of Azevedo et al.[1] and after some algebra, V_{ISHE} can be written as:[2,3]

$$V_{ISHE} = QR\lambda\theta_{SH} tanh\left(\frac{t_{Pt}}{2\lambda}\right) p\Delta \mathrm{H}^{-2} \mathrm{g}_{\mathrm{eff}}^{\uparrow\downarrow} \quad (1)$$

The ellipticity p-factor may be expressed in terms of H_{res} and M_{eff} as:[3]

$$p = \frac{2\pi f_{res}(H_{res}+4\pi M_{eff})}{\gamma(2H_{res}+4\pi M_{eff})^2} \quad (2)$$

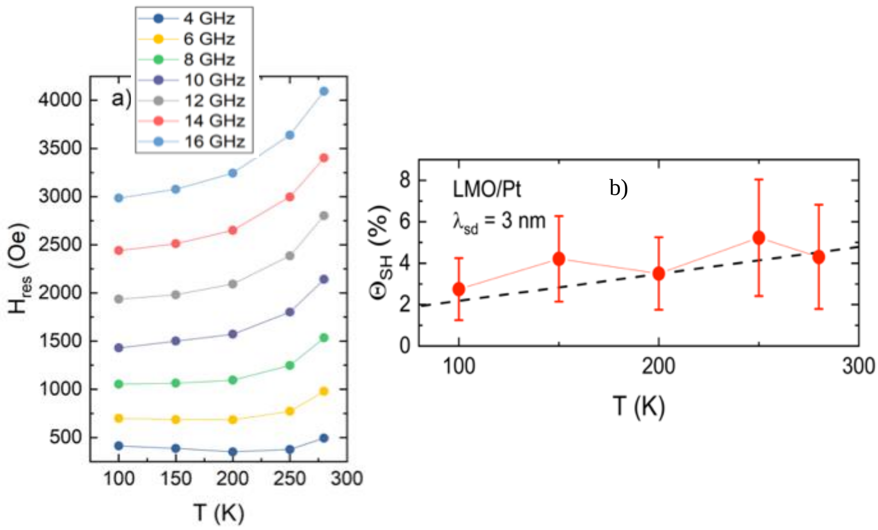

Figure S4: *a) Temperature dependence of the resonant field, H_{res}, for different frequencies. b) Temperature dependence of the spin Hall angle.*

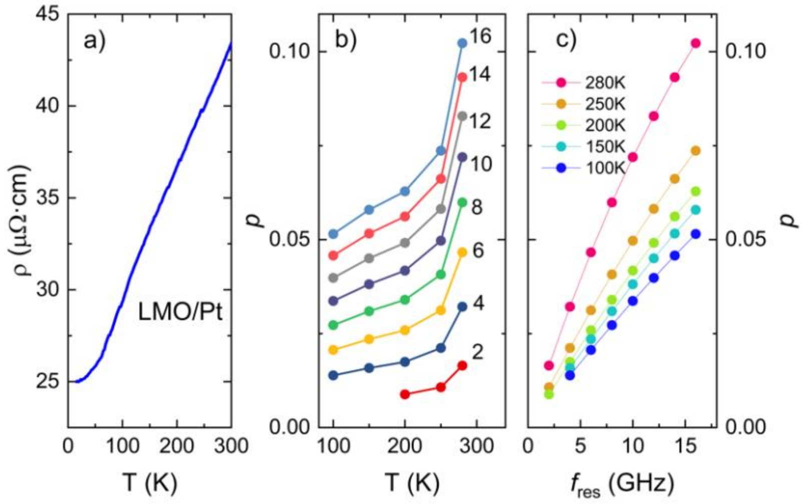

Figure S5: *Resistivity of the LMO/Pt system measured as a function of temperature (a), and ellipticity p- factor as a function of temperature for each frequency (b) and as a function of the resonance frequency for each temperature (c). The numbers in (b) correspond to the resonance frequency in GHz. The p-factor has been calculated according to Eq. [2].*

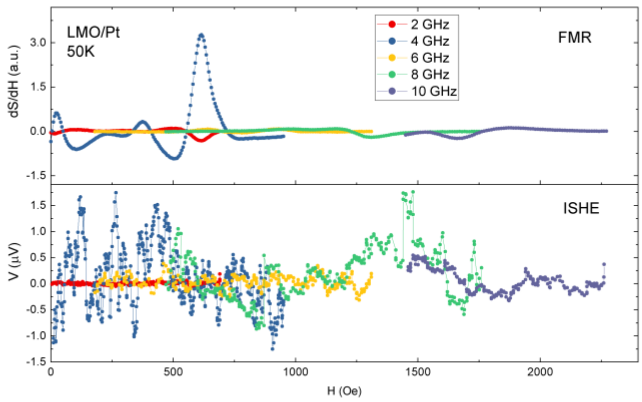

Figure S6: *FMR spectra and voltage signals measured at 50K.*

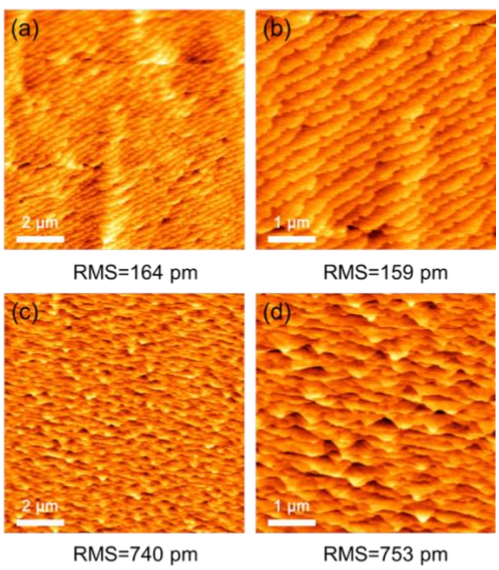

Figure S7: *Atomic force microscopy surface topography images ($10 \times 10\ \mu m^2$, and $5 \times 5\ \mu m^2$) of representative $La_{0.92}MnO_3$ thin film samples on top of STO substrates with different thicknesses.*

Films thermally treated in conventional annealing conditions, 2 °C/min heating ramp, dwell time 60 min at 990 °C with an oxygen flow of 0.1 l/min. (a) and (b) 10 nm thick film; (c) and (d) 23 nm thick film.

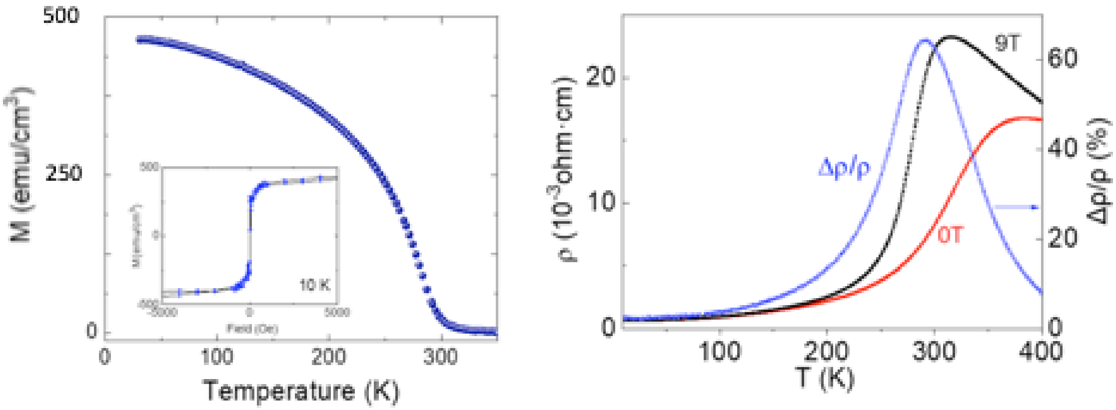

Figure S8: *(a) Temperature dependence of the magnetization measured at 5 KOe (field-cooled) for a LMO film of 10 nm thick. Inset shows a typical hysteresis loop obtained at 10K. (b) Temperature dependence of the electrical conductivity at H = 0 (red curve) and H = 9 T (black curve). Magnetoresistance defined as $\Delta\rho(H)/\rho = (\rho(H) - \rho(0))/\rho(0)$ is also presented (blue curve).*

[1] A. Azevedo et al. Phys. Rev. B 83, 144402 (2011)
[2] B. Sahoo et al. Advanced Quantum Technologies 4, 2000146 (2021).
[3] V.A. Atsarkin et al. J. of Exp. and The. Physics 130, 228 (2020); Journal of Physics D: Applied Physics 51, 245002 (2018).