Hall data and two-band conduction

The conduction of the $LaAlO_3/SrTiO_3$ sample that is deposited at 10^{-6} mbar is completely dominated by oxygen vacancies, with a carrier density n_{ox} of the order of 10^{17} cm^{-2}, as can be directly obtained from the Hall data of Supplementary Figure 1. The mobility of these carriers increases at low temperatures to about 10^4 cm^{2}V^{-1}s^{-1}. With this many oxygen vacancies there is no need for a polar discontinuity at the interface [1,2]. The number of oxygen vacancies can be reduced by depositing the samples at higher oxygen deposition pressures. When n_{ox} drops well below half an electron per unit cell (of the order of 10^{14} cm^{-2}), the polar discontinuity is sustained and interface induced carriers n_{int} will contribute to conduction. When two contributions to conduction (index 1 and 2) are taken into account, the equations for sheet- and Hall resistance are generally written as

$$R_H = \frac{n_1\mu_1^2 + n_2\mu_2^2}{e\left(n_1\mu_1 + n_2\mu_2\right)^2},$$
$$R_S = e\left(n_1\mu_1 + n_2\mu_2\right)^{-1}$$

The Hall and sheet resistance data of all our samples can be fitted with this two-band model [3], where the bands 1 and 2 are likely to be identified as arising from the oxygen vacancies and the interface respectively.

For the 1.0 and 2.5×10^{-3} mbar samples, the sheet resistance is found to be determined by the interface induced carriers ($n_{int}\mu_{int}$ being larger than $n_{ox}\mu_{ox}$) despite the fact that μ_{ox} is much larger than μ_{int} (the latter being of the order of 1 cm^{2}V^{-1}s^{-1}), which is of relevance to the interpretation of the magnetoresistance data of this manuscript.

However, in the nominator of the expression for R_H, the squared mobility enters, making the oxygen vacancies important in the interpretation of R_H. It is found that n_{ox} at high temperatures is about 10^{11} cm^{-2}, and that this density is strongly reduced at low temperatures. This gapping of the carriers is expected since the impurity band becomes so narrow (few carriers) that it no longer intersects the Fermi level [4]. The low temperature carrier freeze-out of n_{ox} gives rise to the observed upturn in $1/eR_H$ in Supplementary Figure 1.

Concluding, in the samples deposited at relatively high oxygen pressure, the sheet resistance is determined by the interface induced carriers. The influence of a small amount of oxygen vacancies only becomes apparent in the measured Hall resistance. Additionally, for two contributing conduction bands, a small positive contribution to magnetoresistance is to be expected.

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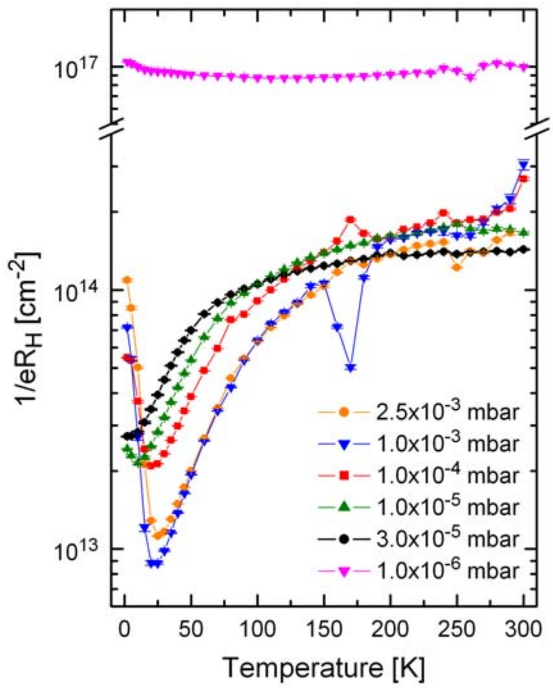

Supplementary Figure 1 | Hall coefficient. Temperature dependence of the inverse Hall resistance of *n*-type $SrTiO_3$-$LaAlO_3$ conducting interfaces, grown at various partial oxygen deposition pressures.