Supporting Information

Two-Dimensional Electron Gases at LaAlO$_3$/SrTiO$_3$ Nanostructured Heterointerfaces with a Buffering Layer for Oxide-based Electronics

Hong Yan, Zhaoting Zhang, Cong Bi, Shuanhu Wang, Ming Li, Lixia Ren, Changle Chen, Kexin Jin*

Shaanxi Key Laboratory of Condensed Matter Structures and Properties, School of Science, Northwestern Polytechnical University, Xi’an 710072, China

* Author to whom correspondence should be addressed; e-mail: jinkx@nwpu.edu.cn
Figure S1. XRR image of the samples LAO and LSAT deposited for 1h on STO substrates.

Figure S2. Temperature dependence of sheet resistance for the LAO/STO with different LAO film thickness.
Figure S3. Time evolution of the resistance at LAO(0.4 nm)/LSAT(0.4 nm)/STO heterointerfaces under light illumination at different temperatures.

Figure S4. Time evolution of the resistance at LAO(0.8 nm)/LSAT(0.4 nm)/STO heterointerfaces under light illumination (a) at \( T < 100 \) K and (b) at \( T > 100 \) K.
**Figure S5.** Time evolution of the resistance at LAO(1.6 nm)/LSAT(0.4 nm)/STO heterointerfaces under light illumination at different temperatures.

**Figure S6.** Time evolution of the resistance at LAO(3.2 nm)/LSAT(0.4 nm)/STO heterointerfaces under light illumination at different temperatures.
**Figure S7.** Time evolution of the resistance at LAO(6.4 nm)/LSAT(0.4 nm)/STO heterointerfaces under light illumination at different temperatures.

**Figure S8.** Time evolution of the resistance at LAO(3.2 nm)/LSAT(0.8 nm)/STO heterointerfaces under light illumination at different temperatures.
**Figure S9.** Temperature dependence of resistance of 1.2 nm LAO/STO heterointerface before and after light illumination in dark.

**Figure S10.** Temperature dependence of carrier density and carrier mobility for the (1.6, 0.4) sample.
Figure S11. Photoinduced percentage change (a) $\Delta R_p$ and (b) $\Delta R_s$ in resistance as a function of temperature at LAO/STO heterointerface, $\Delta R_p = (R_d - R_p)/R_d$, $\Delta R_s = (R_d - R_b)/R_d$.

Figure S12. Comparison of the relaxation time constant ($\tau$) of (a) $(m, 0.4)$, (b) $(3.2, n)$, and $(m, 0)$ samples. $\tau$ is calculated by a stretched exponential of the form $R \propto \exp\left[-\frac{T}{\tau}\right]$ with $0 \leq \beta \leq 1$. 