Supporting Information for:

Why In_2O_3 Can Make 0.7 nm Atomic Layer Thin Transistors?

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1. TLM Measurements on Thick ALD In_2O_3

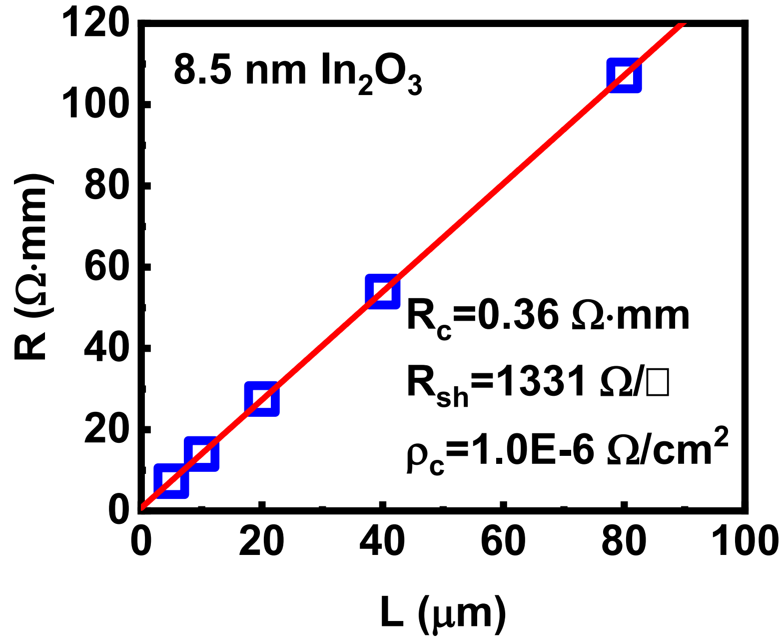

Figure S1. TLM measurement of 8.5 nm In_2O_3 on 90 nm SiO_2/Si substrate with 80 nm Ni contacts, exhibiting R_C of 0.36 Ω · mm, R_{sh} of 1333 Ω/□ and ρ_c of 1.0×10^{-6} Ω/cm^2.

2. The Impact of TNL Alignments

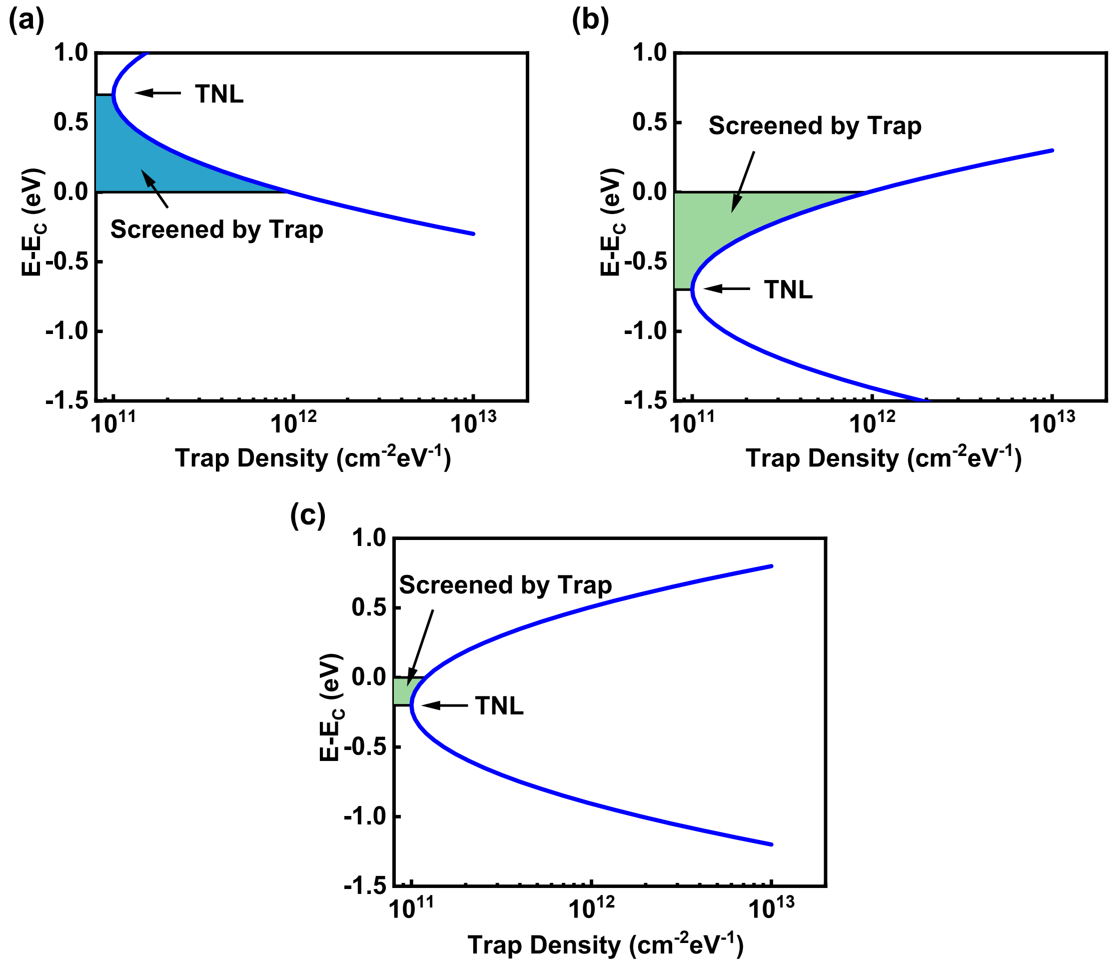

Figure S2. Energy level with respect to E_C *versus* trap density for In_2O_3 with different TNL locations at (a) TNL far above E_C, (b) TNL deeply below E_C and (c) TNL near E_C.

3. Infinity Quantum Well Model on TNL Alignments

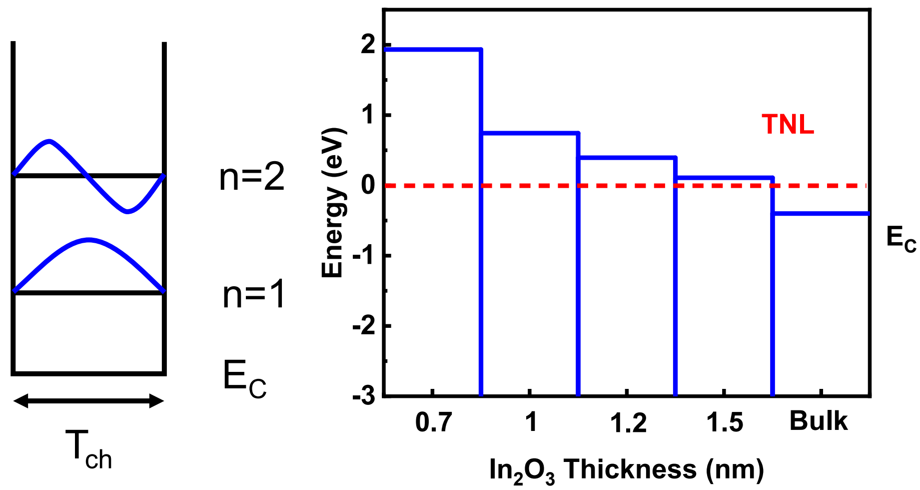

Figure S3. Conduction band minimum of In_2O_3 at different thicknesses from 0.7 nm to bulk. TNL alignments are modulated by the thickness of In_2O_3 due to quantum confinement.

In In_2O_3 transistor structure as shown in Fig 1(a), the semiconducting In_2O_3 is sandwiched by insulating Al_2O_3 and air, so that electron transport in In_2O_3 behaves like 2D electron gas in an infinity quantum well, as also shown in Fig. S3. Considering the ground state energy in an infinity quantum well, the change of E_C by quantum confinement can be written as $\Delta E_C = \frac{\pi^2 \hbar^2}{2m^*} \frac{1}{T_{ch}^2}$. The effective mass (m*) of electron in In_2O_3 is about $0.33m_e$, where m_e is electron rest mass.[1,2] Thus, thickness-dependent ΔE_C with respect to TNL can be calculated, as shown in Fig. S3. Since TNL is the intrinsic property of the material so that it is independent on the channel thickness. As can be seen, this simple model shows TNL moves deeper inside bandgap while decreasing the T_{ch}, resulting in the reduction of carrier density and positive V_T shift, which agrees well with the experimental data and DFT calculation.

REFERENCES

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(2) Preissler, N.; Bierwagen, O.; Ramu, A. T.; Speck, J. S. Electrical Transport, Electrothermal Transport, and Effective Electron Mass in Single-Crystalline In_2O_3 Films. *Phys. Rev. B* **2013**, *88*, 085305.