Two Dimensional Electron Gases at Oxide Interfaces

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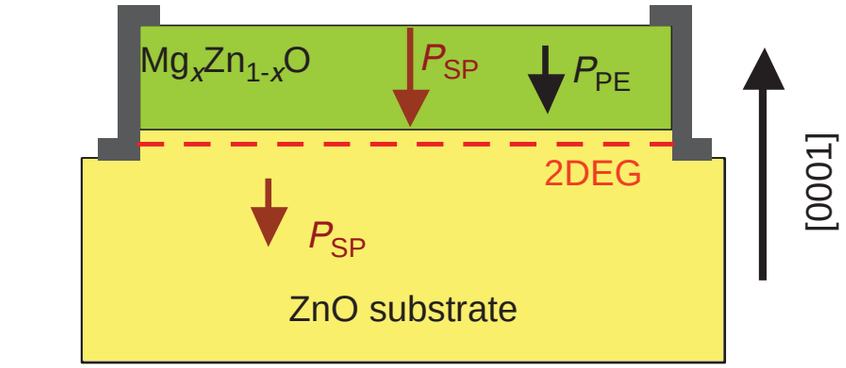
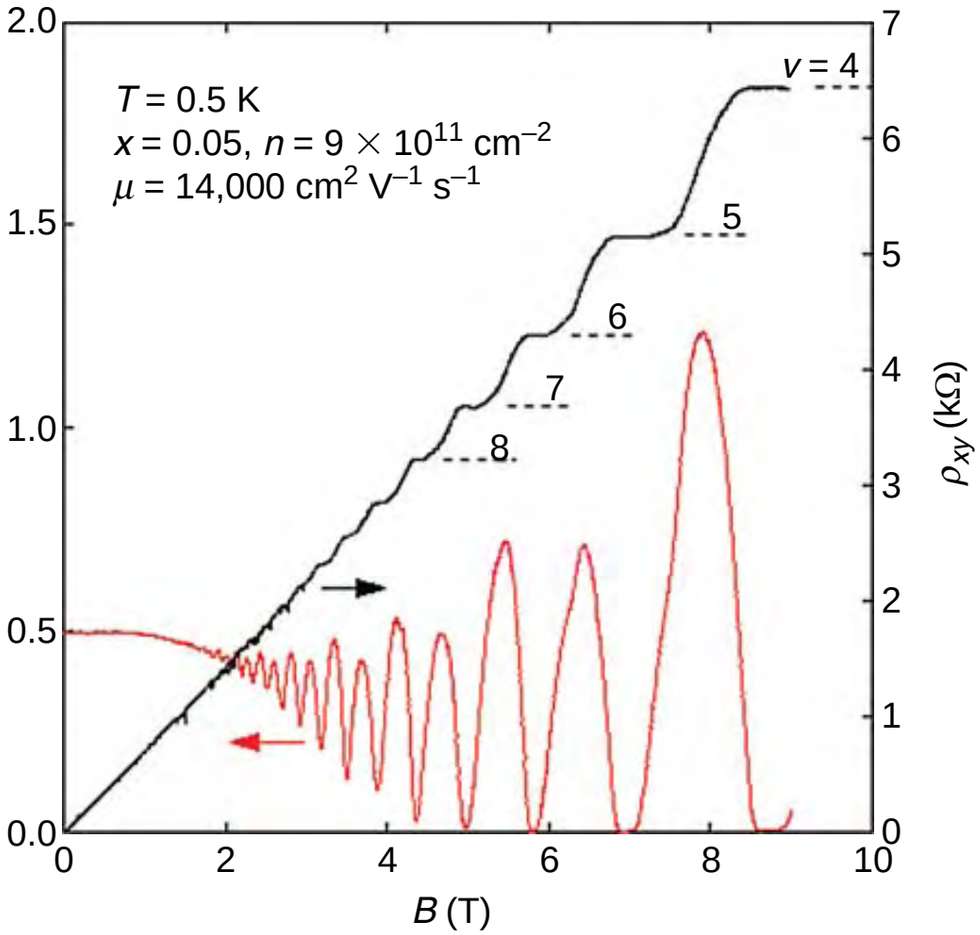
DFG: SFB 484, EC: Nanoxide

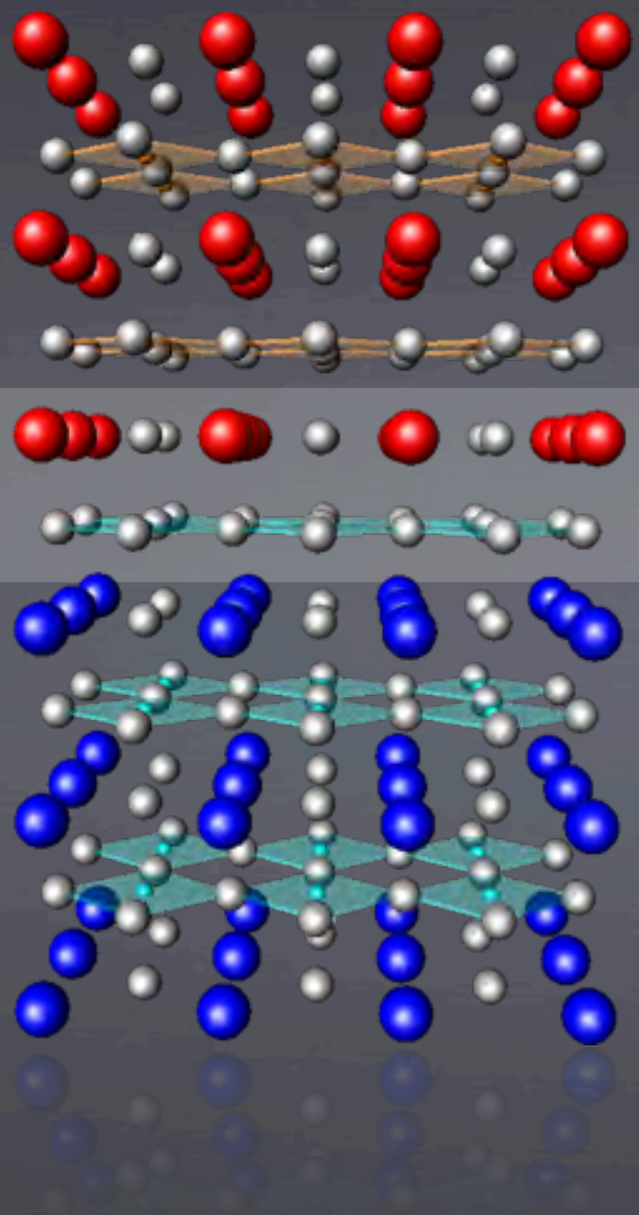
2-DEGs Can Be Realized in Oxides





A. Tsukazaki *et al.*, Science (2007)

The *n*-type $LaAlO_3$ / $SrTiO_3$ Interface



$LaAlO_3$

band-insulator

$LaTiO_3$

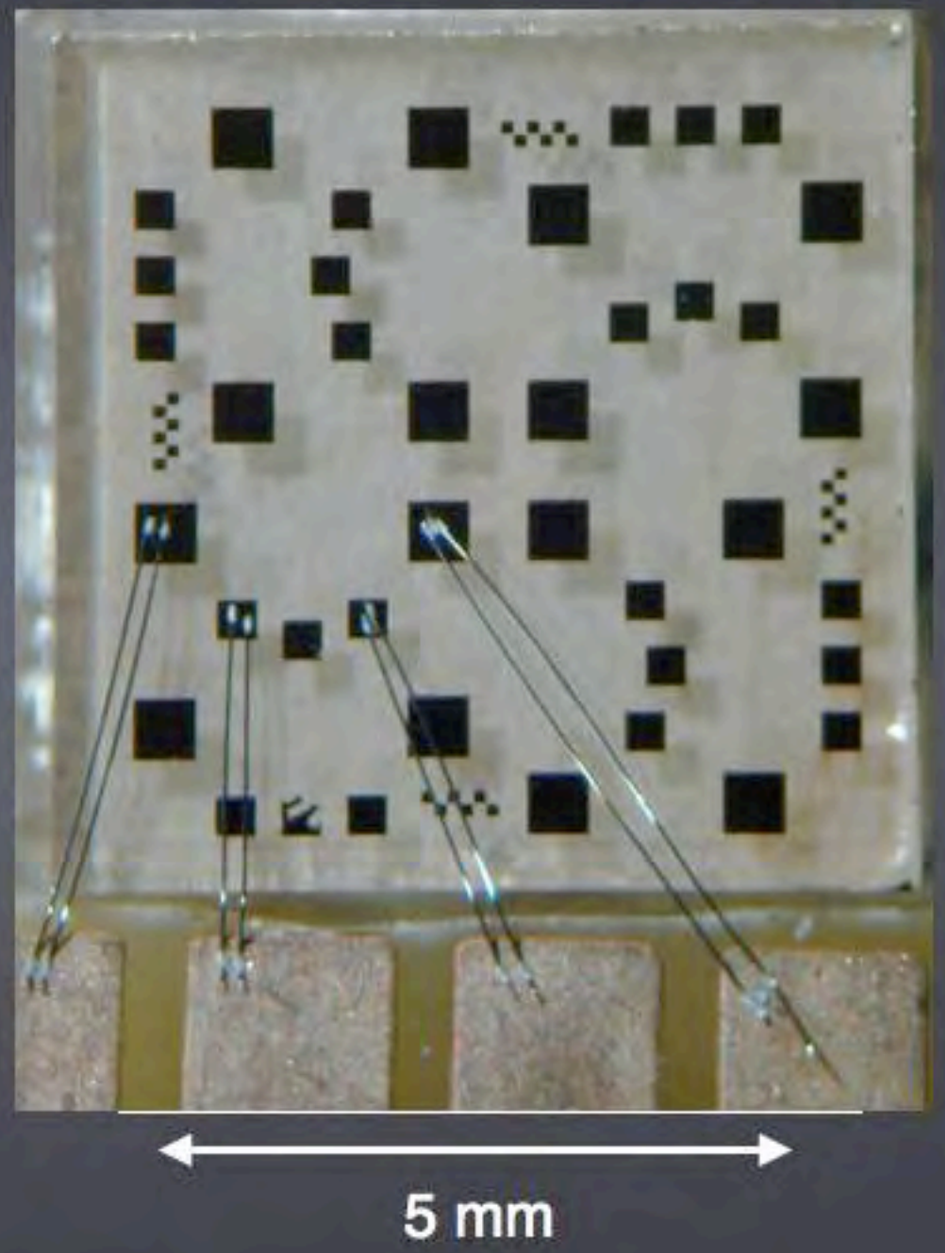
$SrTiO_3$

band-insulator, quantum-paraelectric

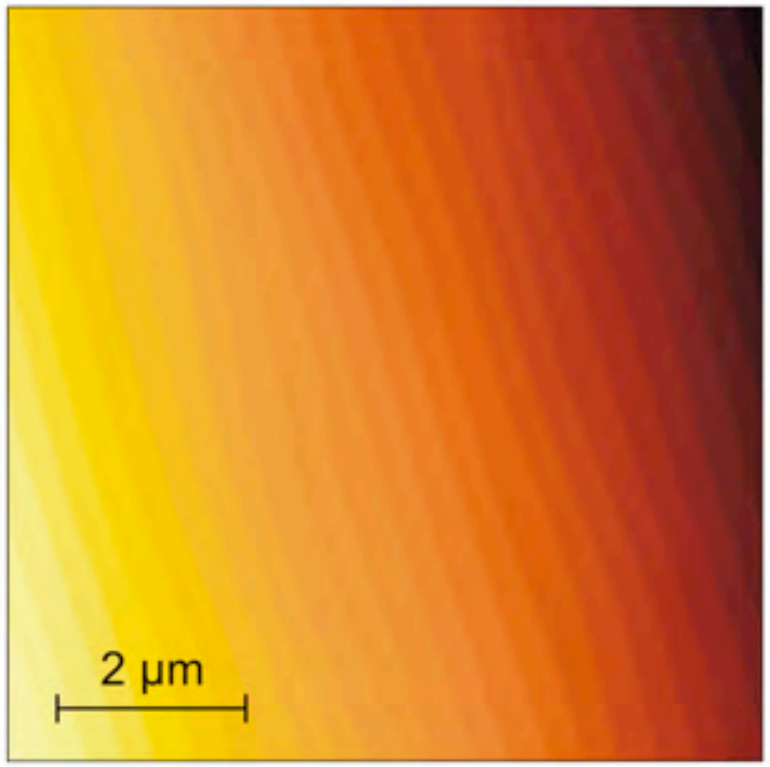
A. Ohtomo, H. Hwang, Nature **427**, 423 (2004)

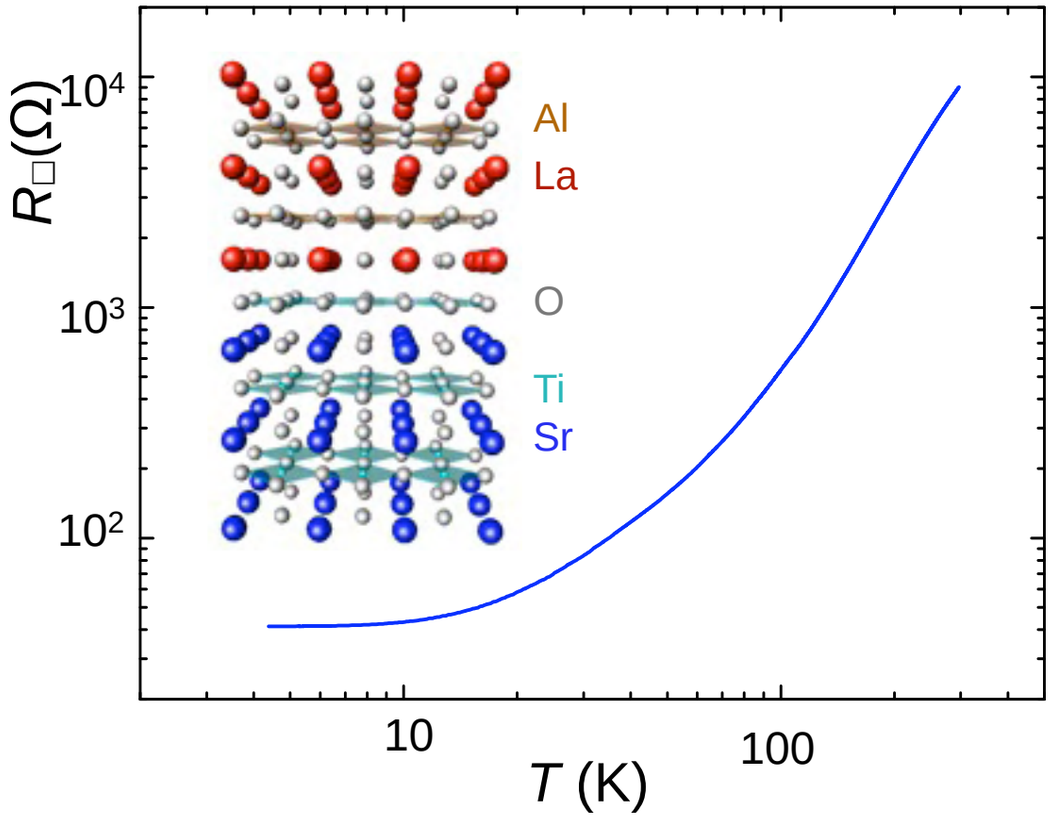
Sample Configuration

Contacts via ion-etching and Au-sputtering



8 unit cells $LaAlO_3$ on $SrTiO_3$



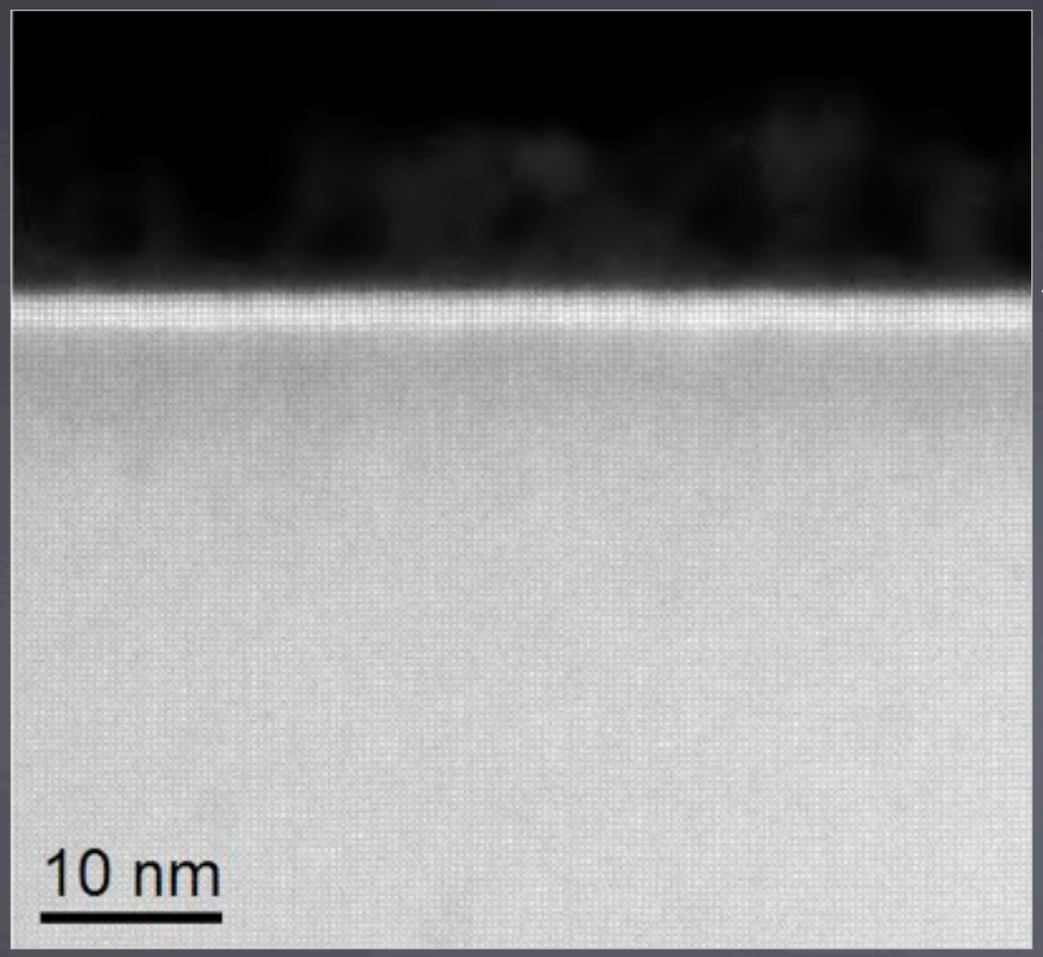


	$\sigma_s\ (\Omega/\square)^{-1}$	$n_S\ (cm^{-2})$	$\mu\ (cm^2/Vs)$
300 K	5×10^{-5}	$2\text{-}4\times10^{13}$	7
4.2 K	5×10^{-3}	$2\text{-}4\times10^{13}$	700

STEM: Cross Section

HAADF

LAADF



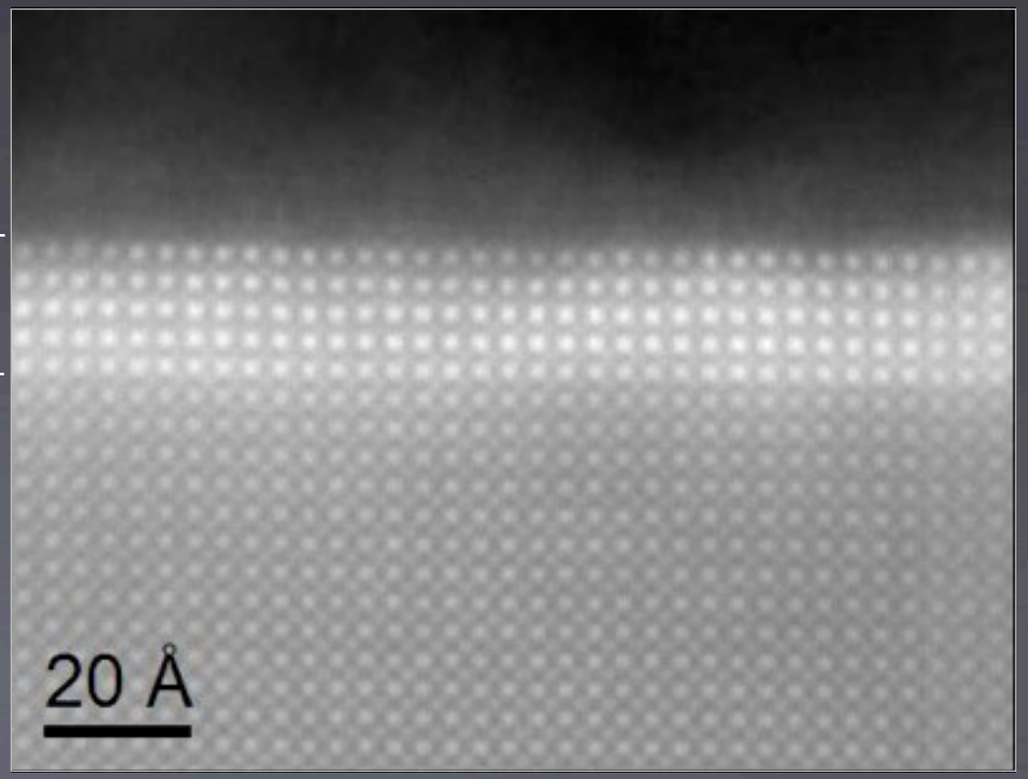
5 uc

$LaAlO_3$

[001]

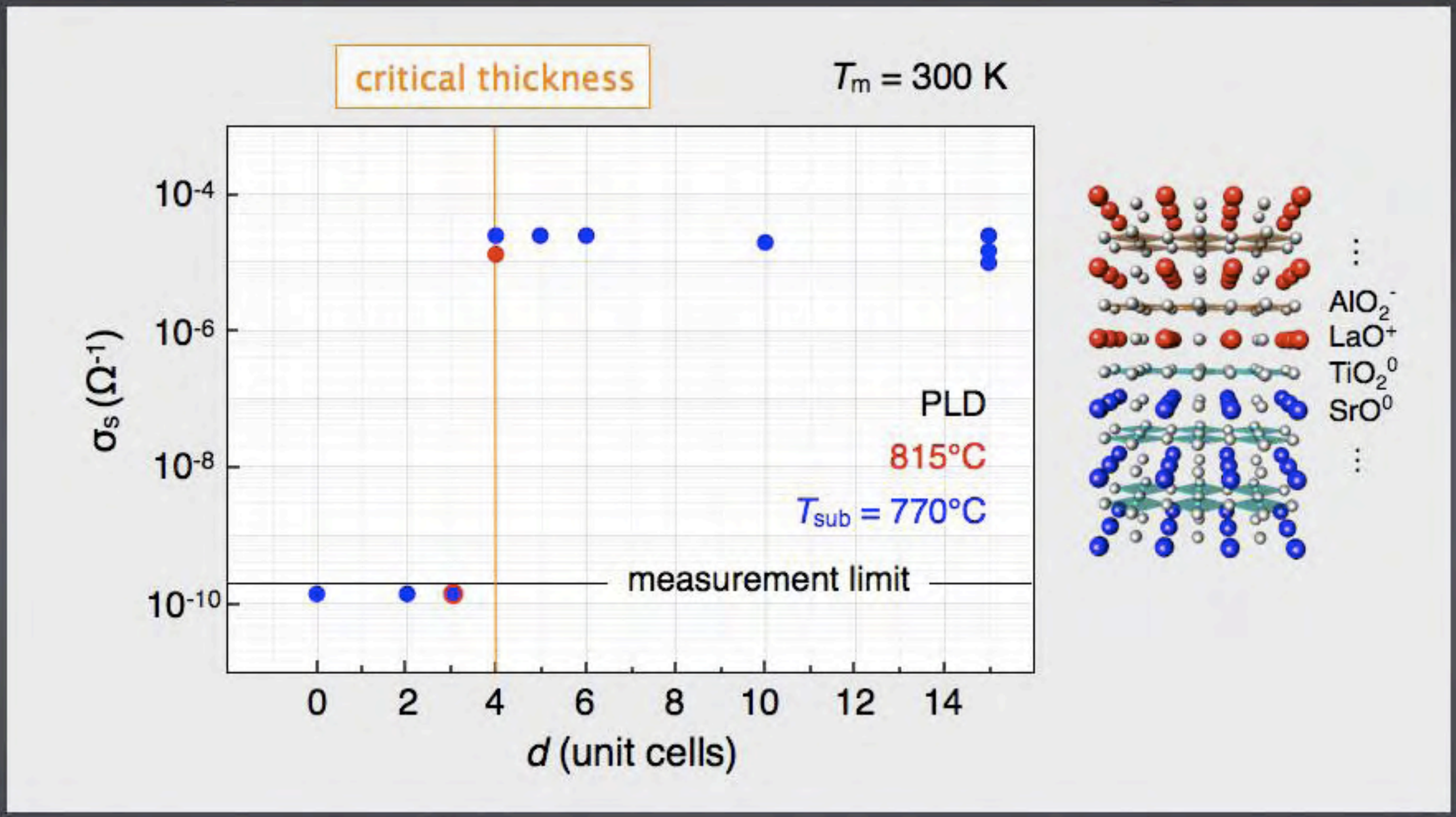
$SrTiO_3$

Substrate



L. Fitting-Kourkoutis, D.A. Muller (Cornell)

Interface Conductivity *vs* Number of $LaAlO_3$ Unit Cells



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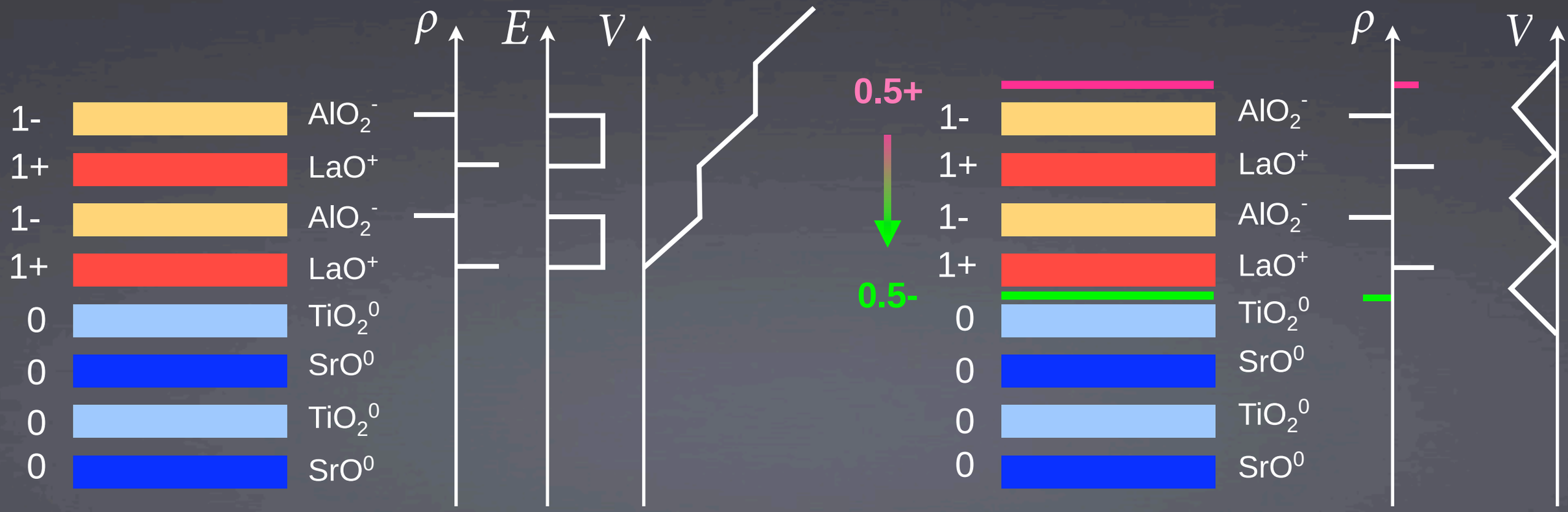
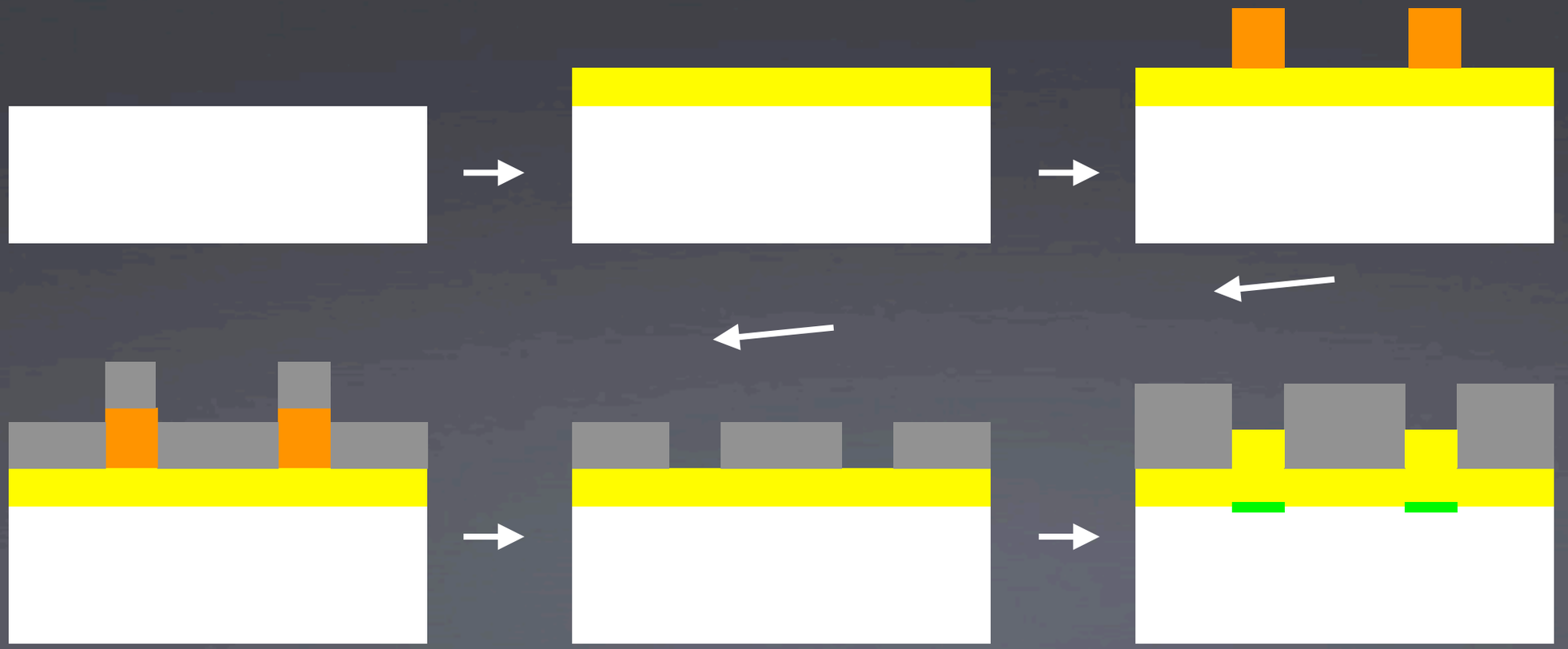
S. Thiel *et al.*, Science **313**, 1942 (2006)

The Polar Catastrophe is another Possible Source of Charge Carriers



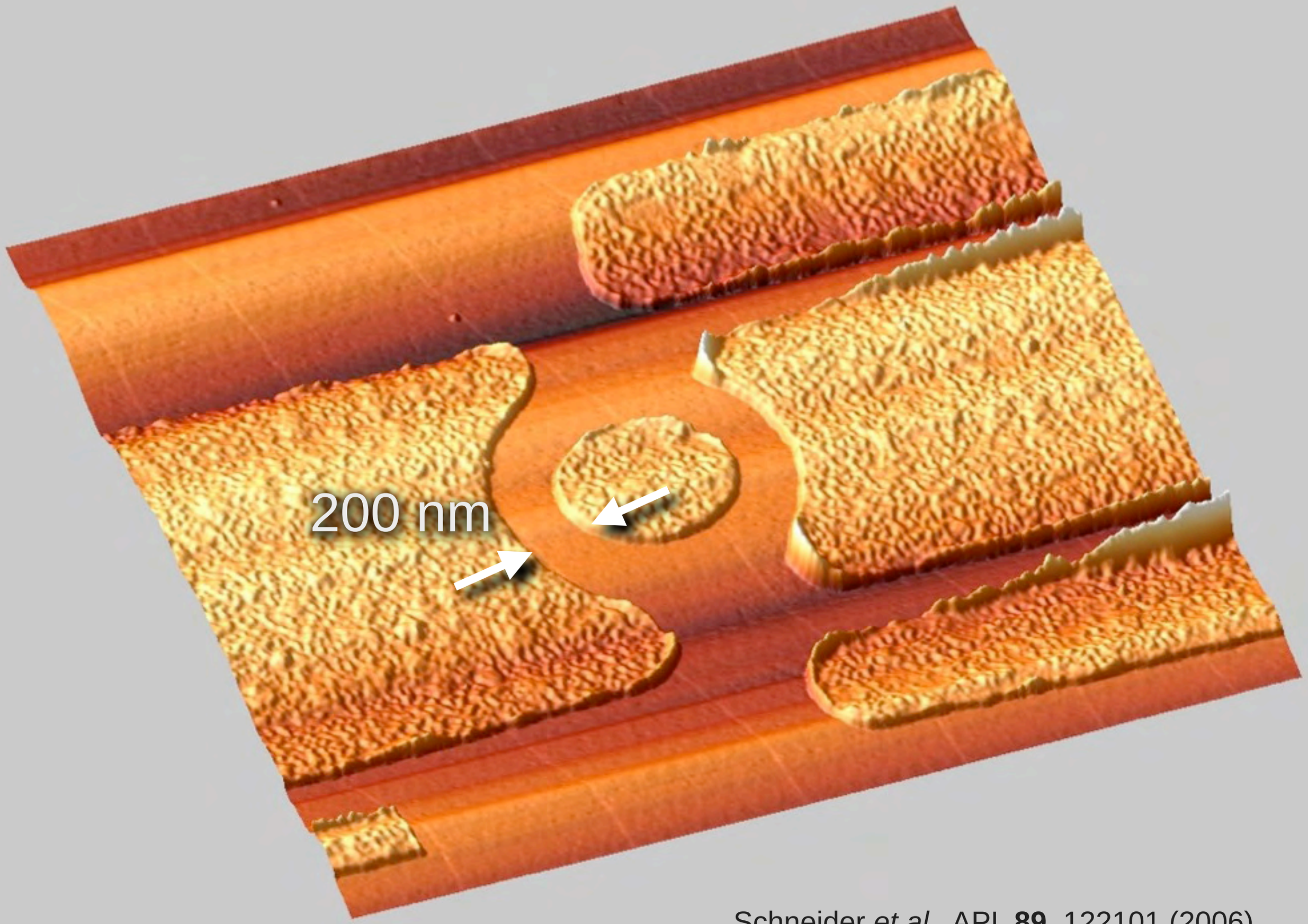
N. Nakagawa *et al.*, Nature Materials (2006)

Patterning the Electron Gas



- interface is not exposed to environment
- surface remains unexposed
- compatible with standard lithography techniques

Schneider *et al.*, APL **89**, 122101 (2006)



Schneider *et al.*, APL **89**, 122101 (2006)

Mapping the spatial distribution of charge carriers in $LaAlO_3/SrTiO_3$ heterostructures

M. BASLETIC*, J.-L. MAURICE, C. CARRÉTÉRO, G. HERRANZ*†, O. COPIE, M. BIBES, É. JACQUET, K. BOUZEHOUANE, S. FUSIL AND A. BARTHÉLÉMY†

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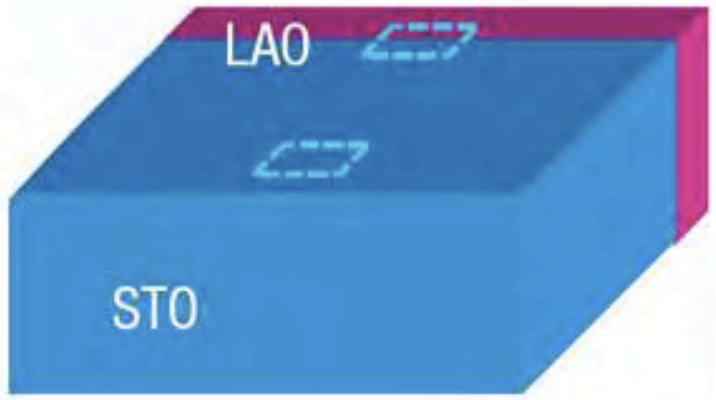

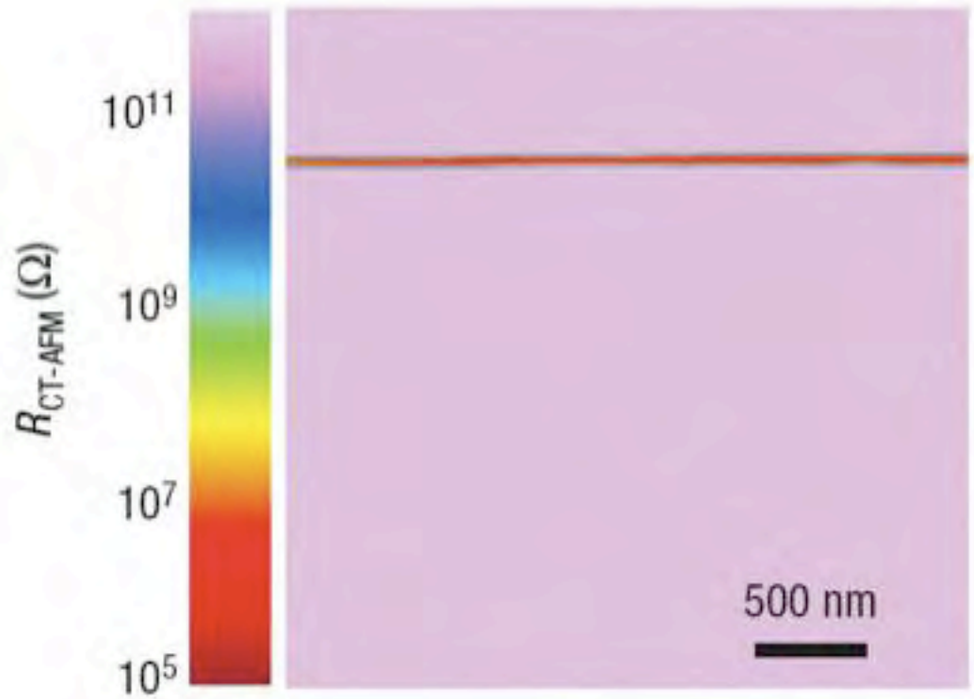

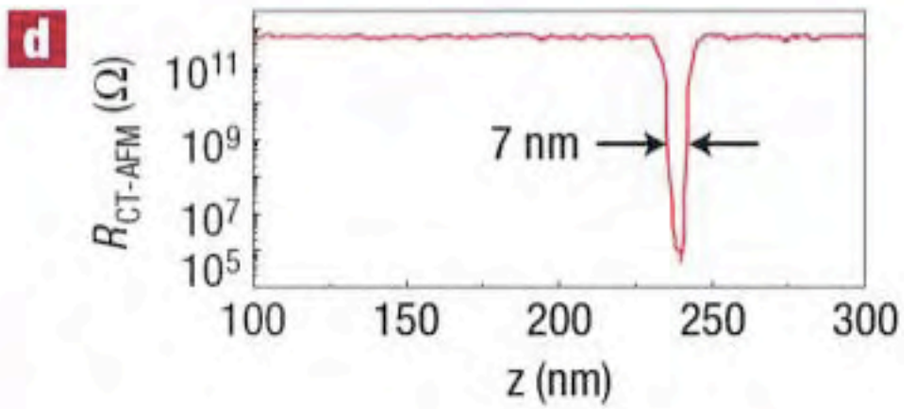

Profiling the interface electron gas of $LaAlO_3/SrTiO_3$ heterostructures by hard X-ray photoelectron spectroscopy

M. Sing,[1] G. Berner,[1] K. Goß,[1] A. Müller,[1] A. Ruff,[1] A. Wetscherek,[1] S. Thiel,[2] J. Mannhart,[2] S. A. Pauli,[3] C. W. Schneider,[3] P. R. Willmott,[3] M. Gorgoi,[4] F. Schäfers,[4] and R. Claessen[1]

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[2] *Institute of Physics, Universität Augsburg, Electronic Correlations and Magnetism, Experimentalphysik VI, Universitätsstrasse 1, D-86135 Augsburg, Germany*
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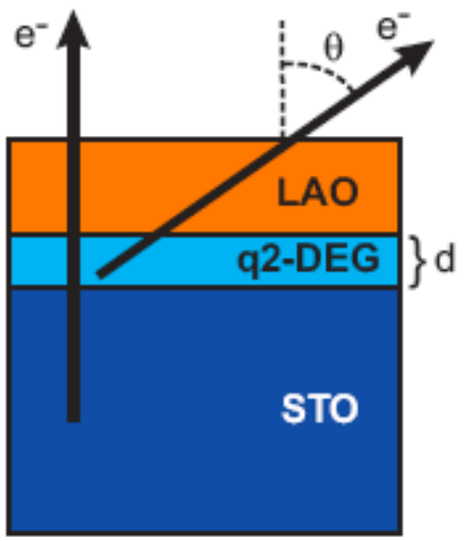
[4] *Berliner Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung m.b.H., Albert-Einstein-Str. 15, D-12489 Berlin, Germany*



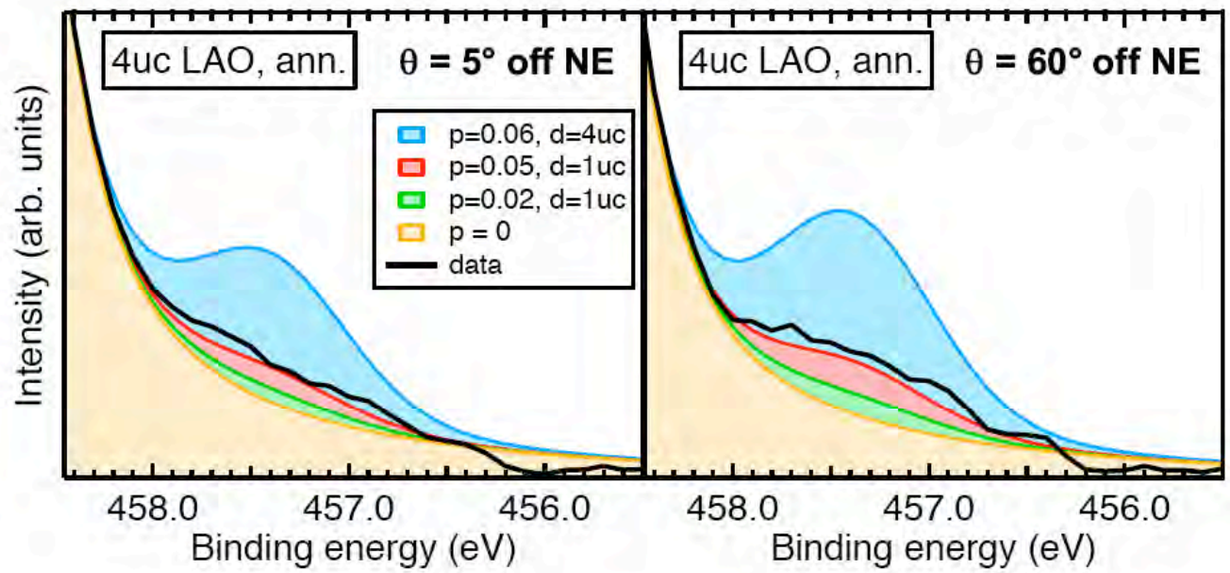
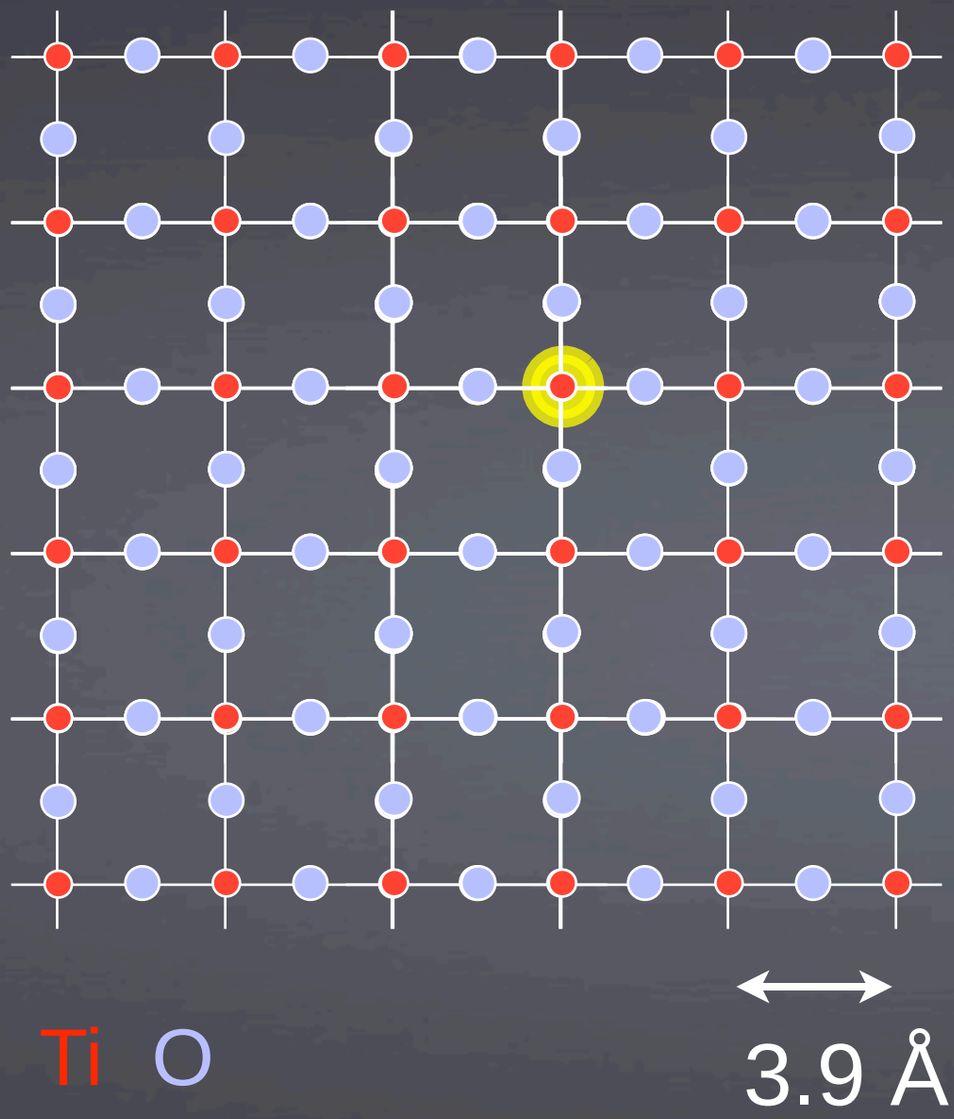


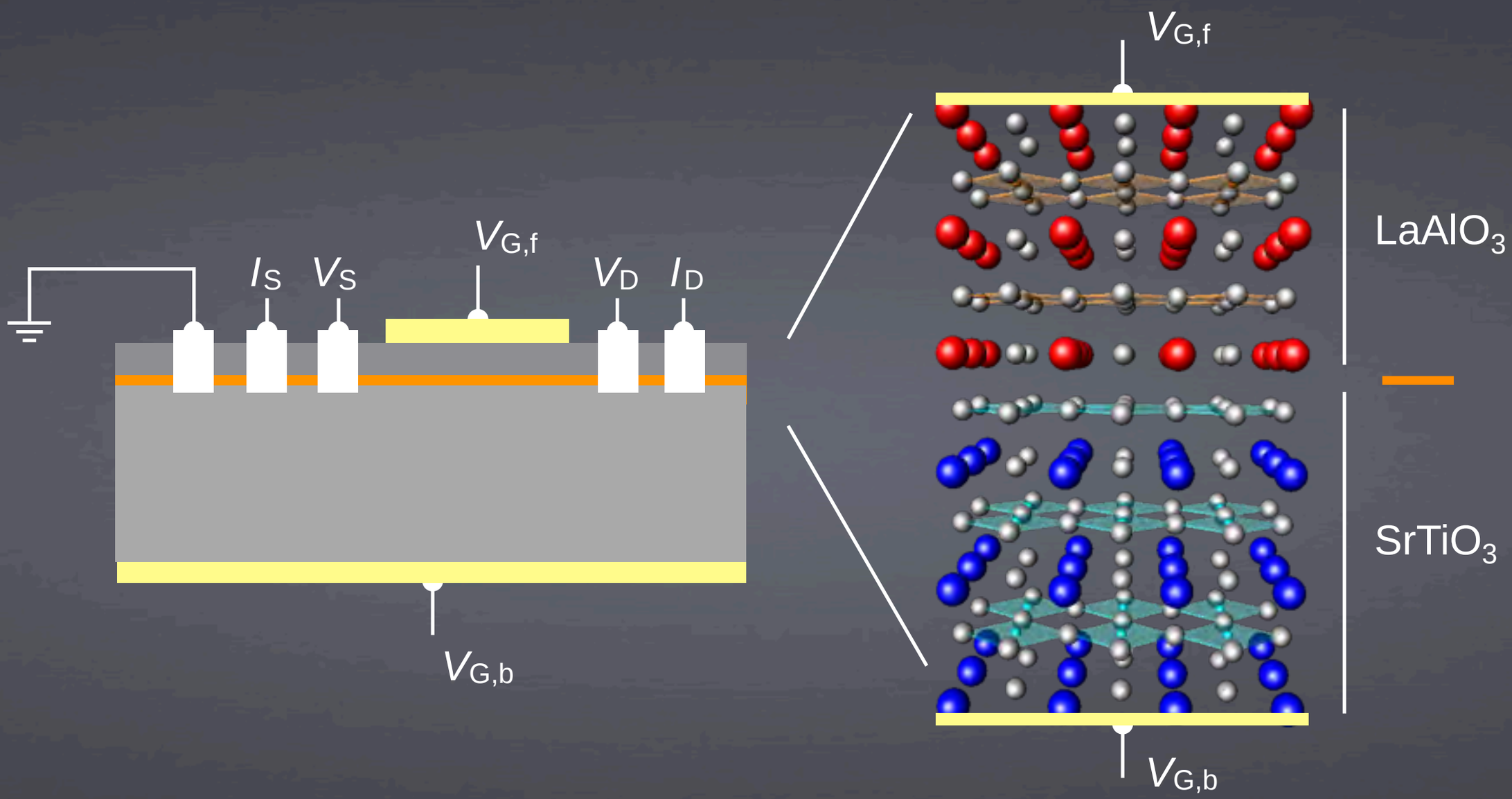
FIG. 4: (Color online) Comparison between experimental data and simulated spectra of the Ti $^{3+}$ spectral weight for the annealed 4 uc sample.

Low Carrier Density at the Interfaces ~2-4×10^{13}/cm^2

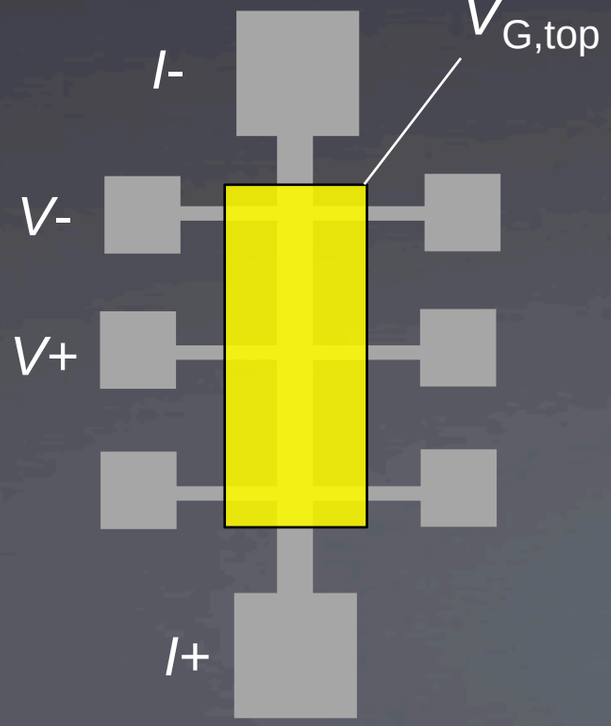


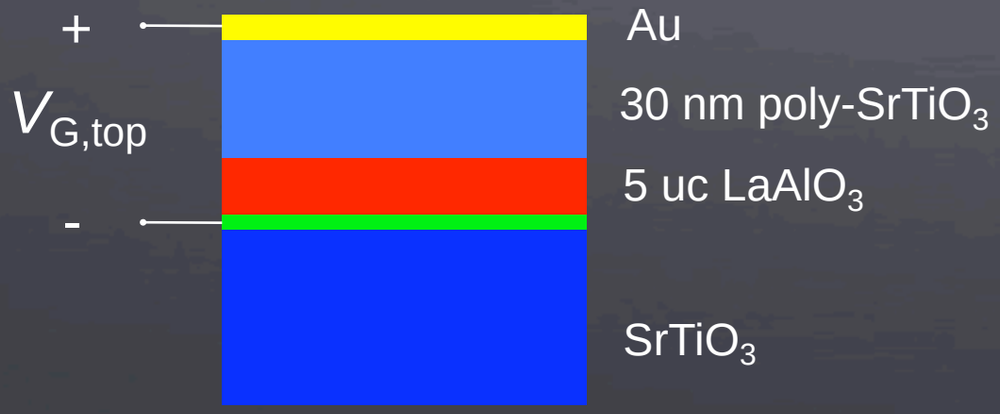
TiO_2-plane

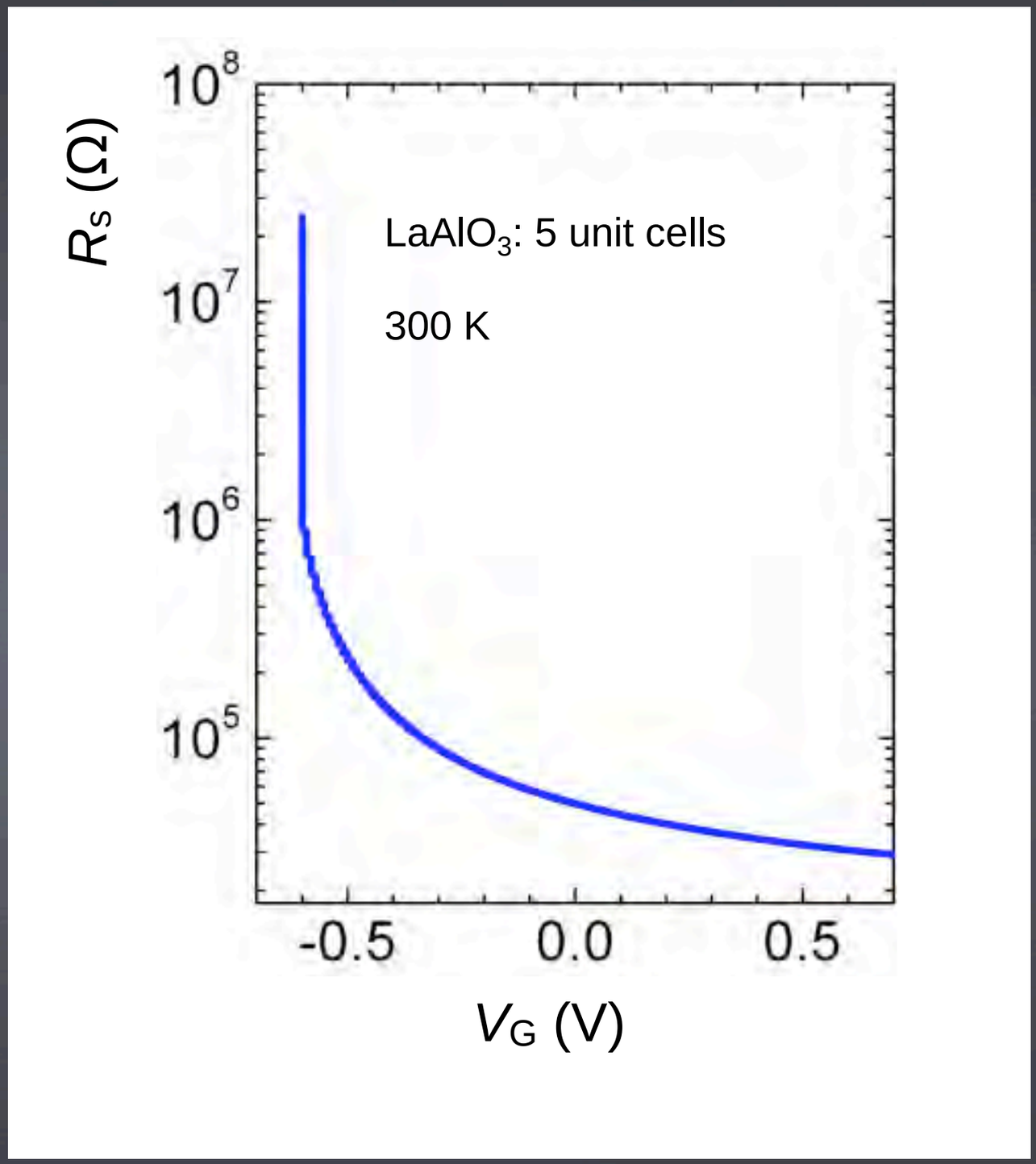
Gate-Field Induced Phase Transition to 2-DEG?



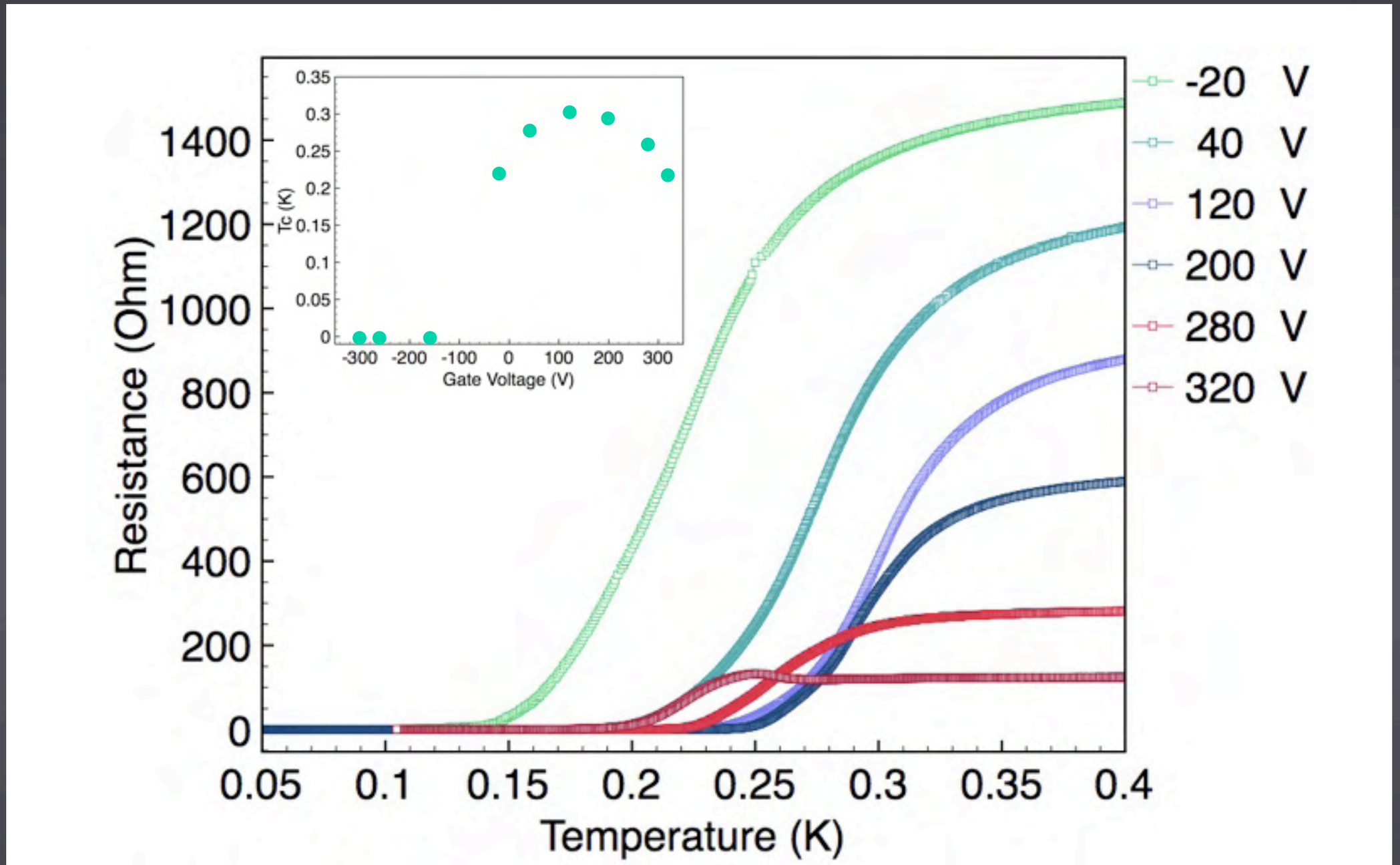
Field Effect Experiments - Top Gate





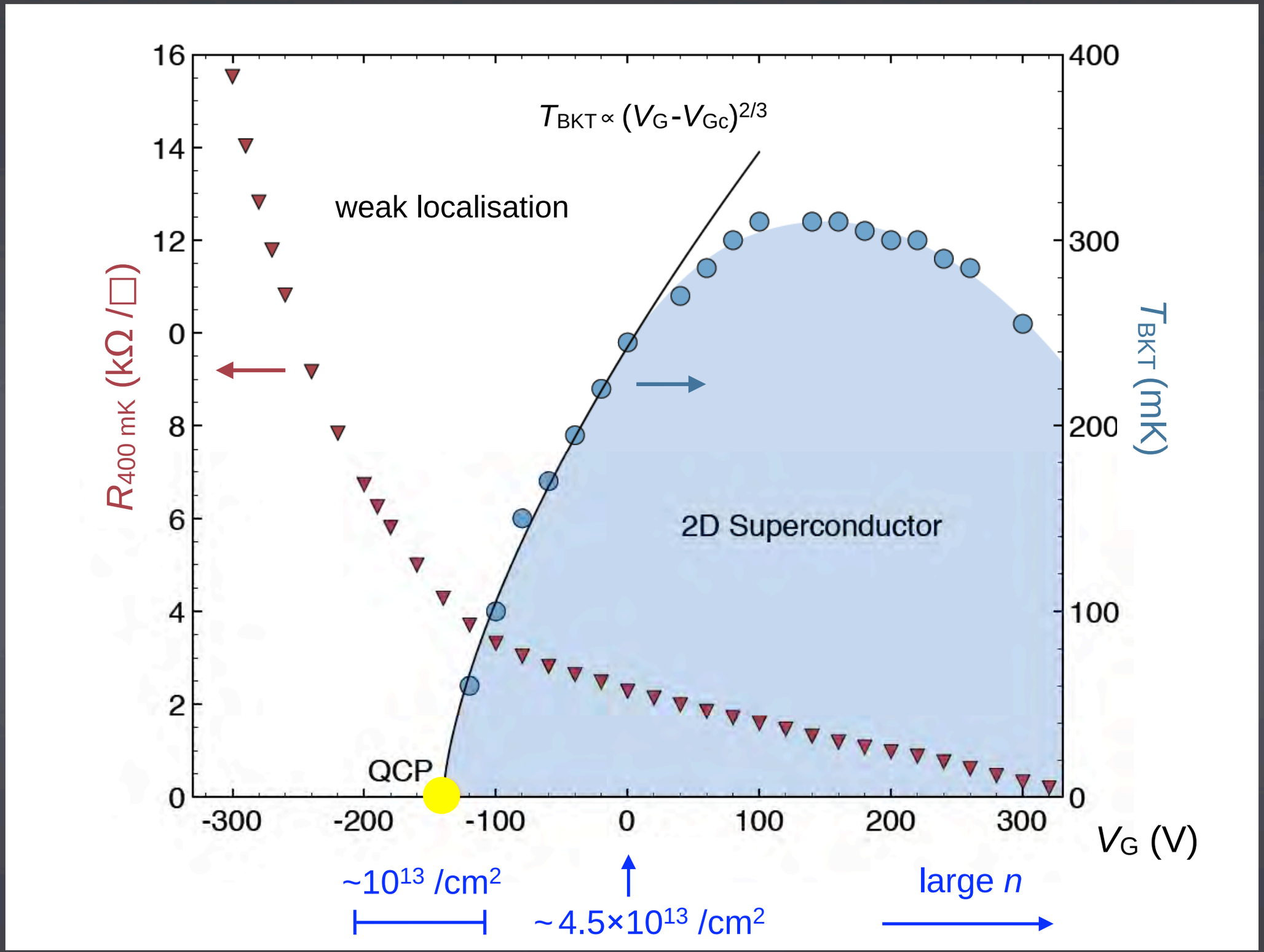


Field Effect Tuning of the Interface Properties



A.D. Caviglia *et al.*, nature 2008

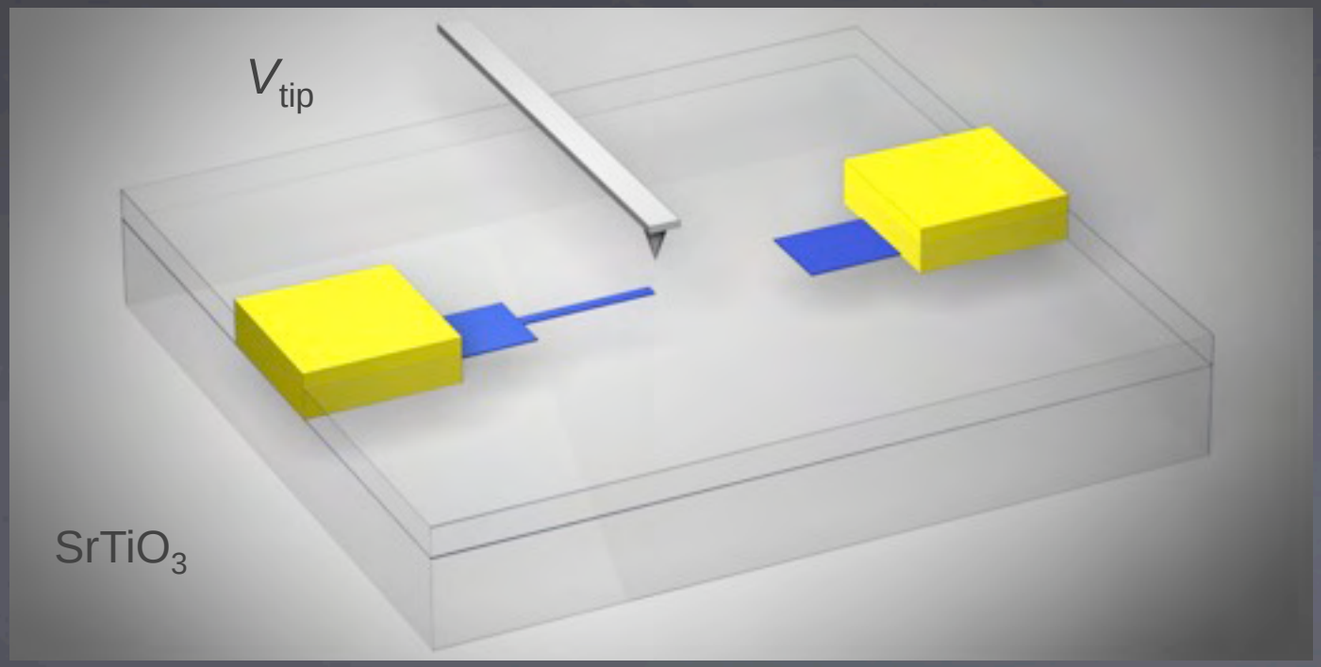
Measured Phase Diagram of the $LaAlO_3/SrTiO_3$ Interface

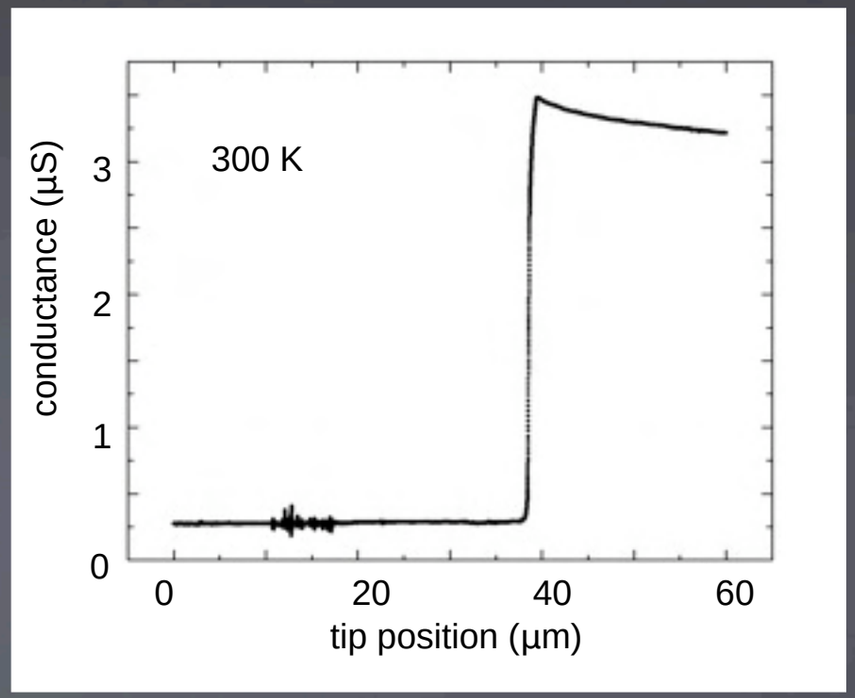


A.D. Caviglia *et al.*, nature 2008

Electric Field Lithography

- induce insulator-metal transition locally





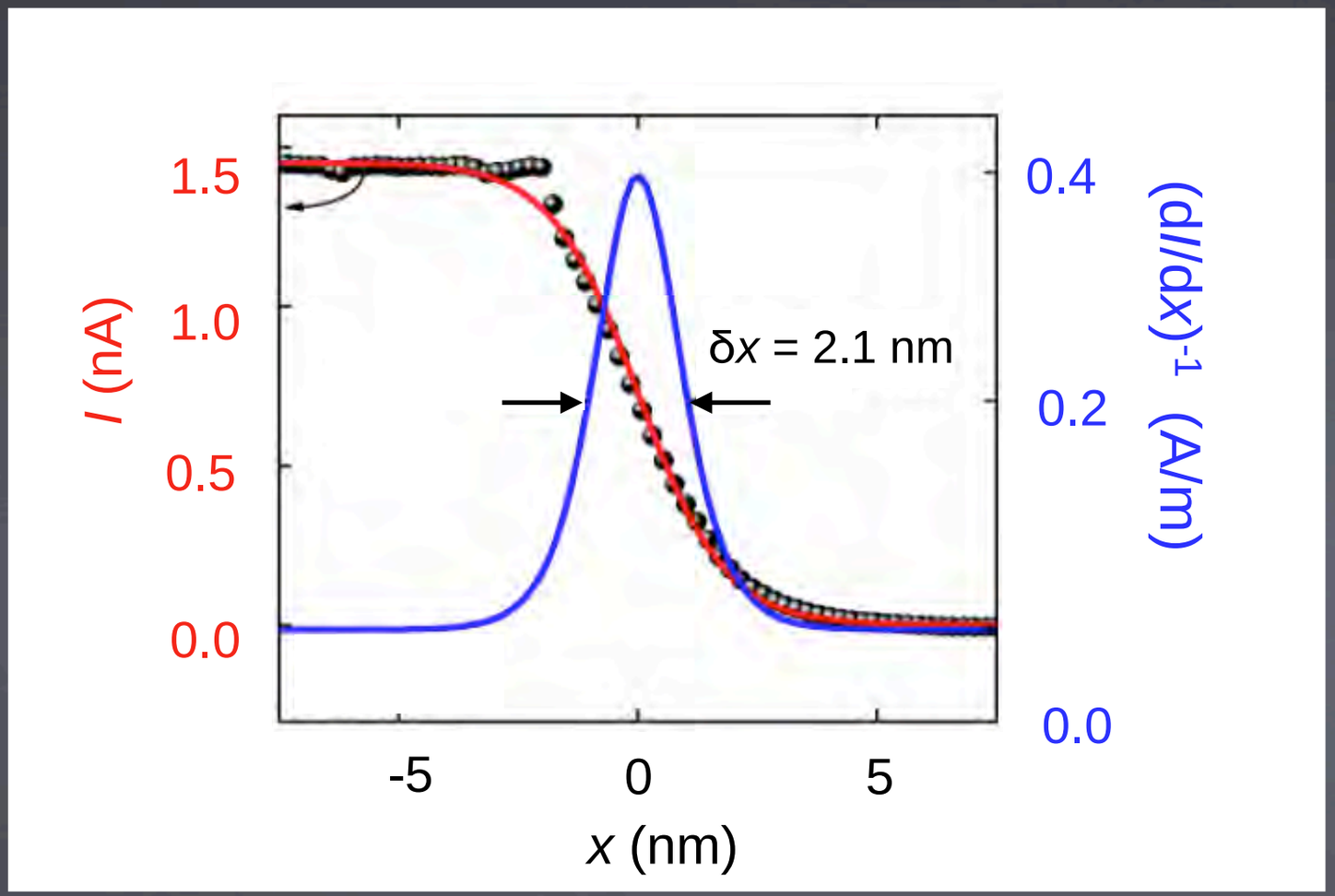
Nanowires

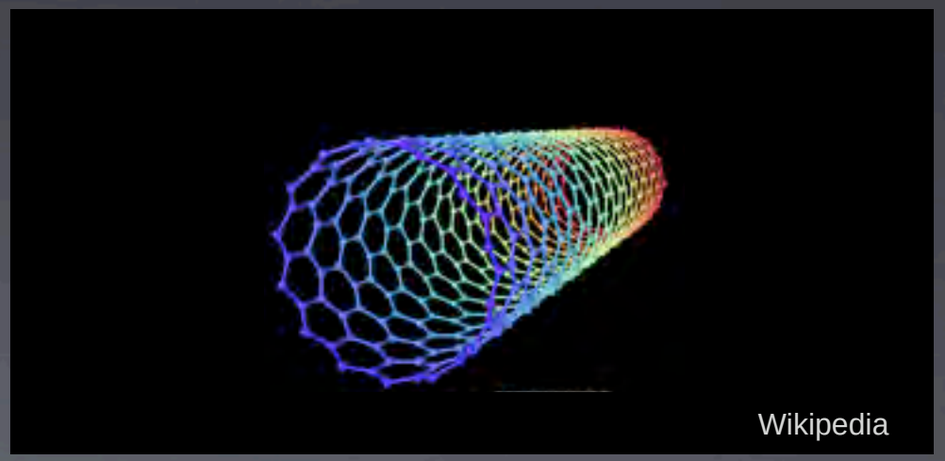
- can be written and erased repeatedly
- are stable at 300 K for > 24 h (but not always)

C. Cen *et al.*, Nature Materials **7**, 298 (2008)

Electric Field Lithography

- induce insulator-metal transition locally





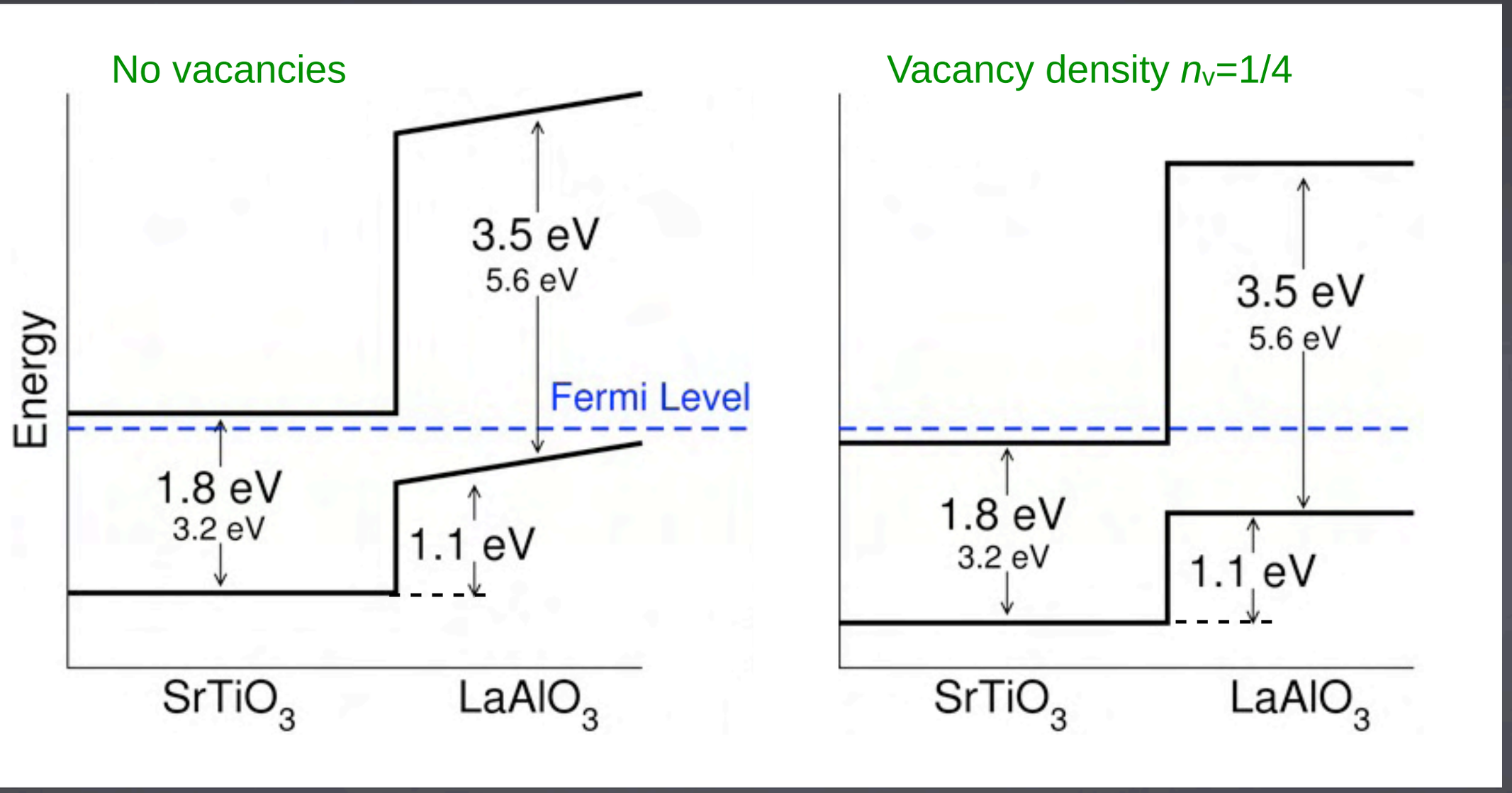
written wires with nanotube diameter

Nanowires

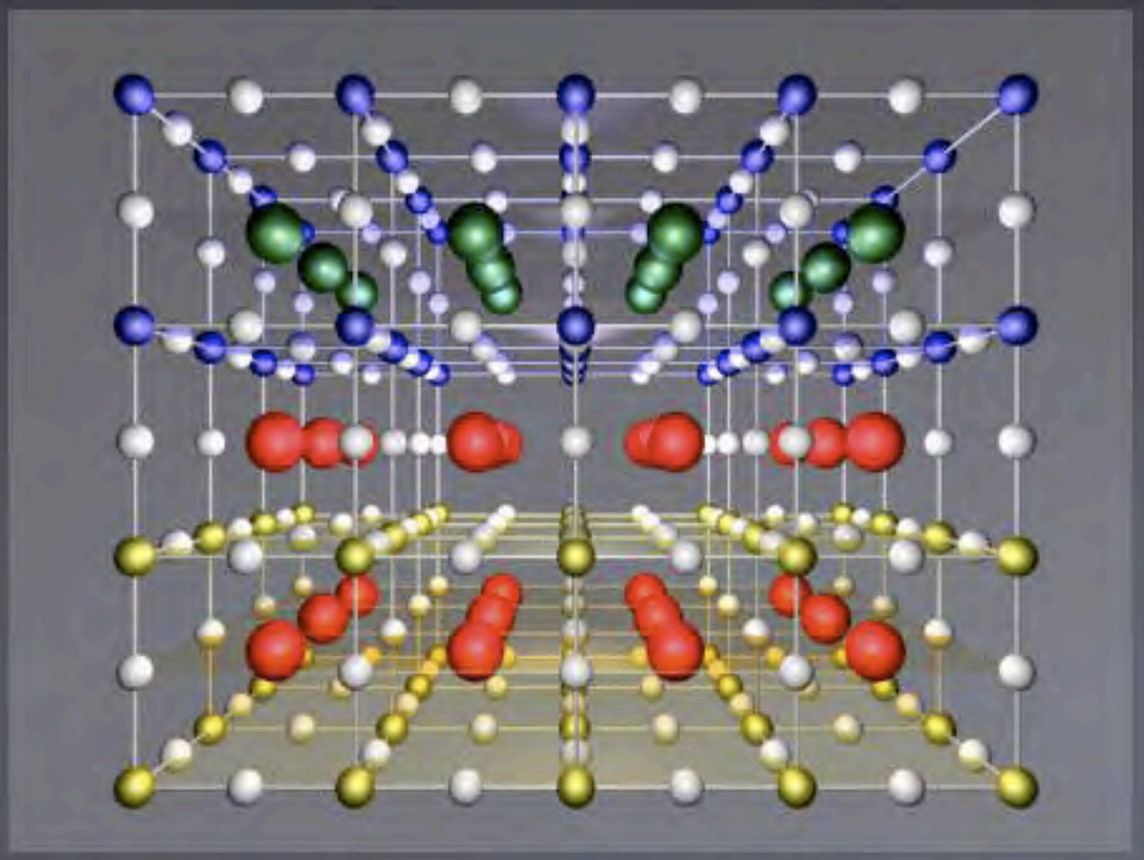
- can be written and erased repeatedly
- are stable at 300 K for > 24 h (but not always)

C. Cen *et al.*, Nature Materials **7**, 298 (2008)

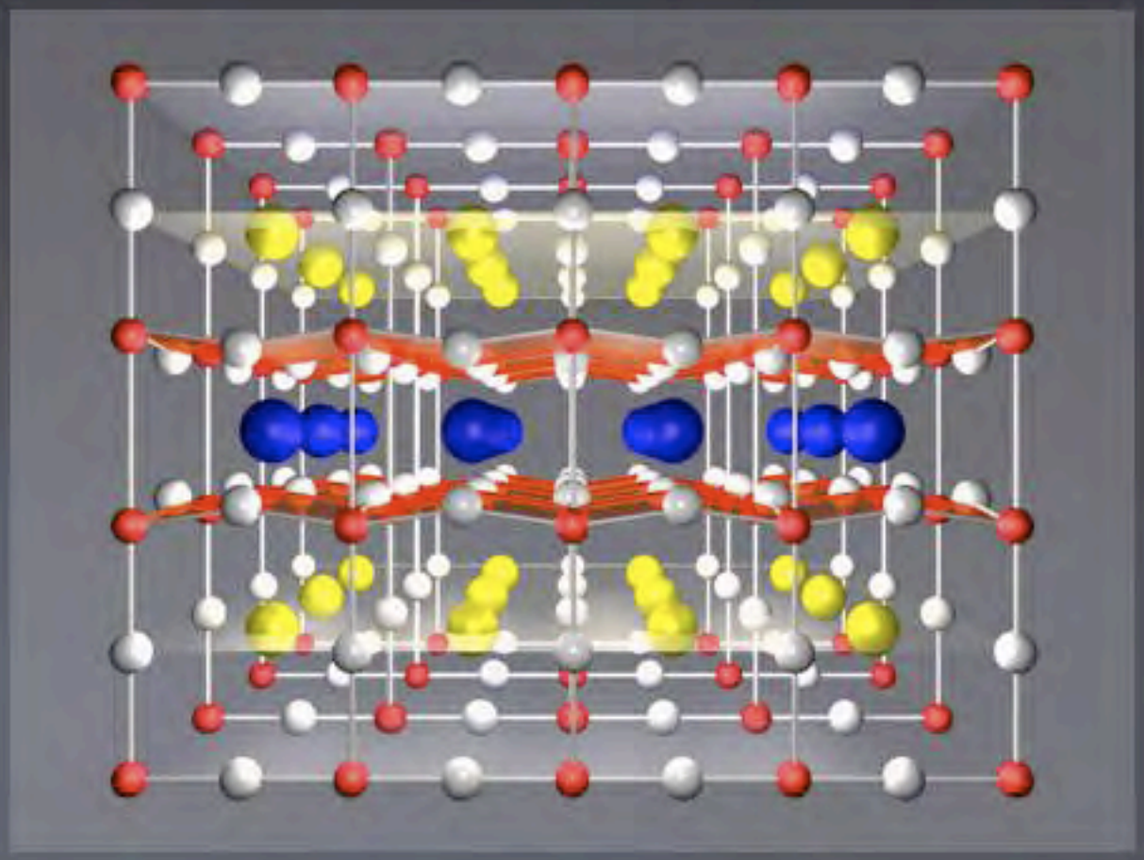
Possible Writing Mechanism



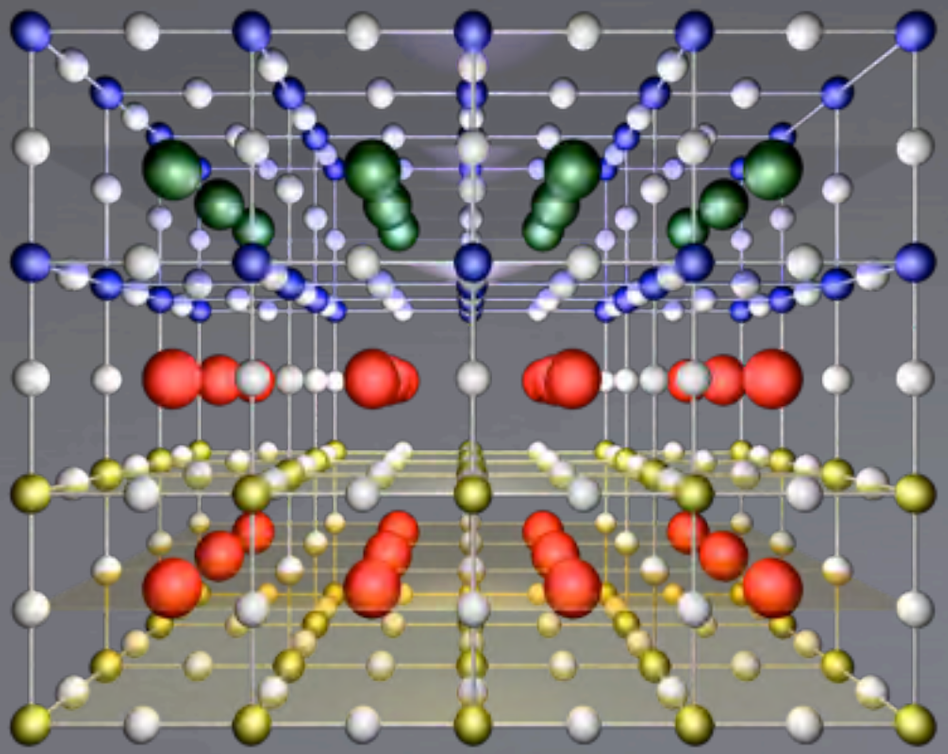
C. Cen *et al.,* Science in press



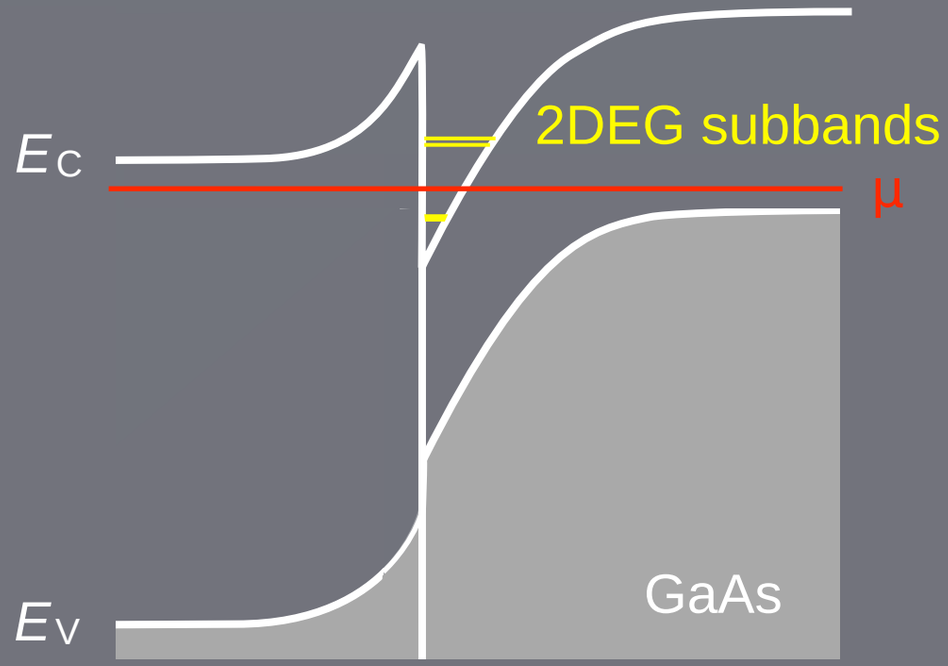
$LaAlO_3/SrTiO_3$



$YBa_2Cu_3O_7$



$LaAlO_3/SrTiO_3$



(AlGa)As/GaAs Heterostructure