中国科学技术大学
University of Science and Technology of China

Surface Impact on Oxide Interface

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Chen Zhenlan
Pei Yuxiang
Wang Tianyi

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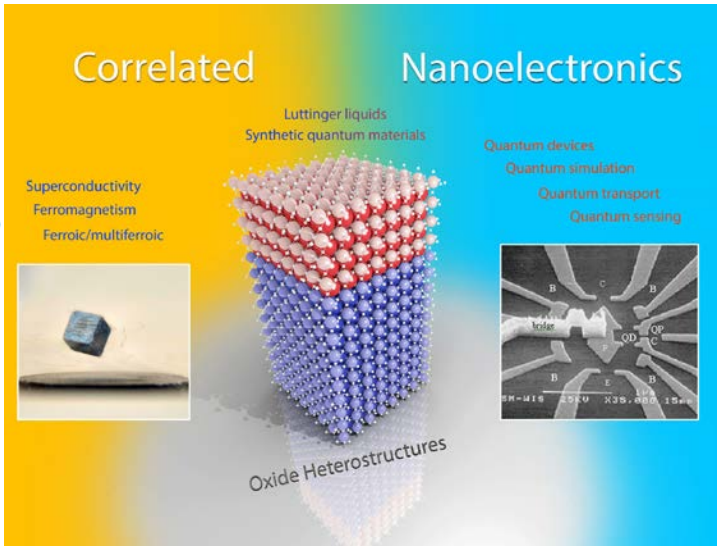
Background

- Correlated oxide interfaces



A high-mobility electron gas at the $LaAlO_3/SrTiO_3$ heterointerface

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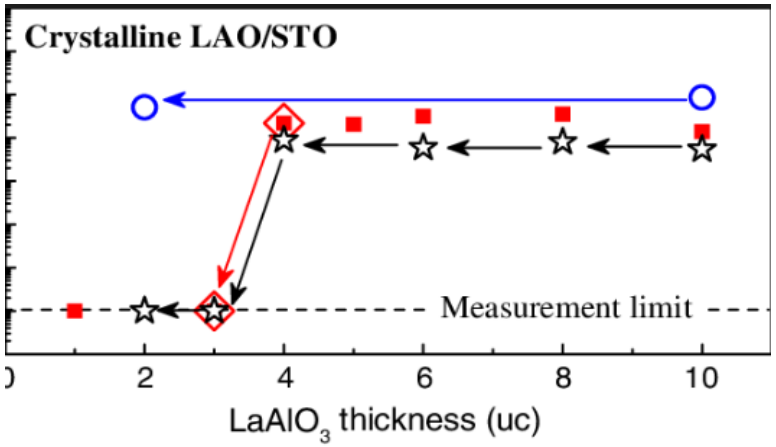
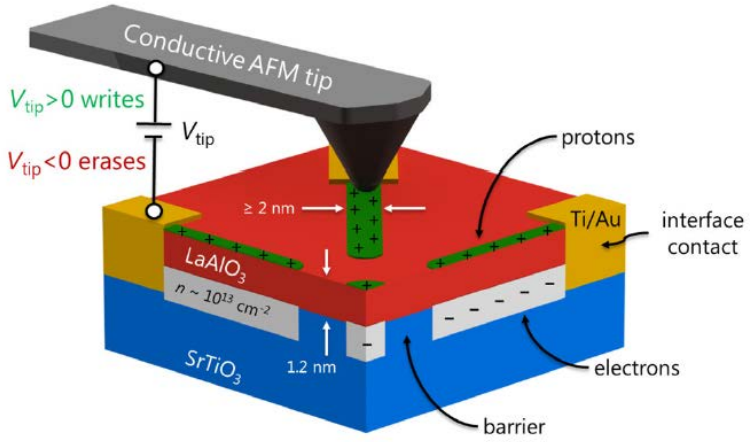
[2]*Institute for Materials Research, Tohoku University, Sendai, 980-8577, Japan*
[3]*Japan Science and Technology Agency, Kawaguchi, 332-0012, Japan*
[4]*Department of Advanced Materials Science, University of Tokyo, Kashiwa, Chiba, 277-8651, Japan*

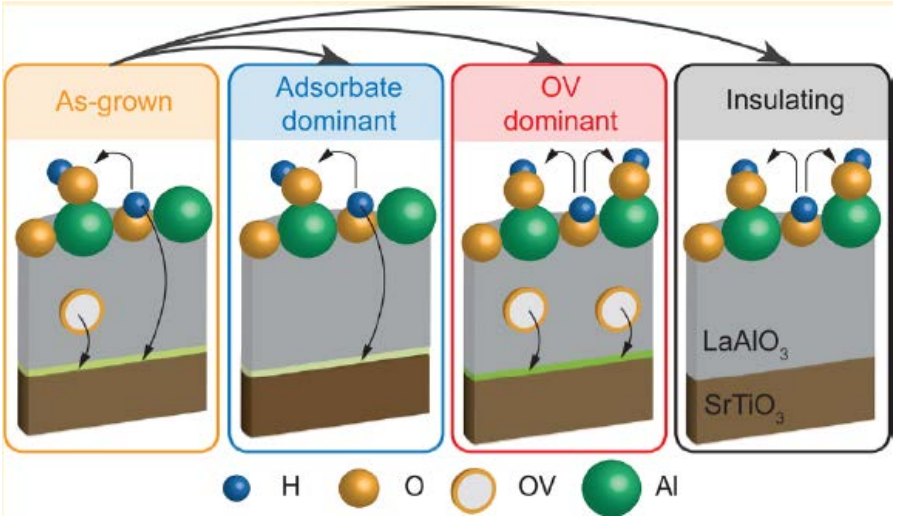


Background

- Tuning the 2DEG at the interface
- Apply strain
- Oxygen plasma exposure
- Biased AFM probe

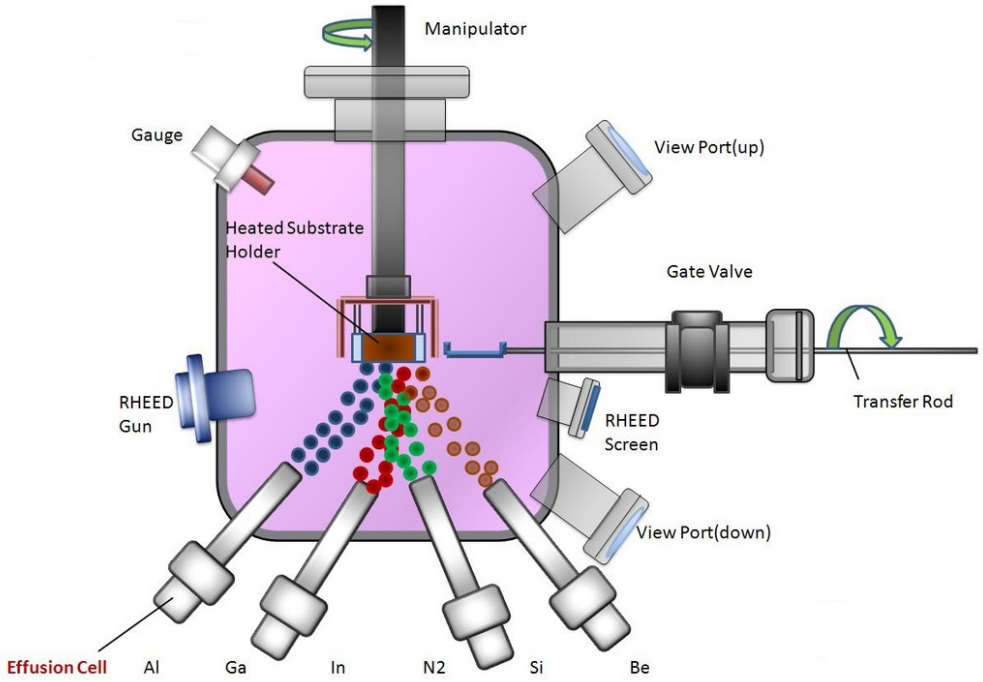
Surface environment?

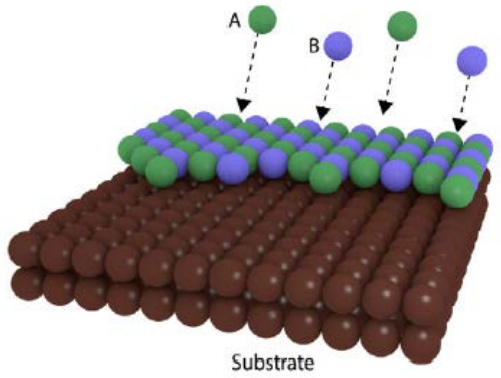




Measurement Preparation

- Sample preparation

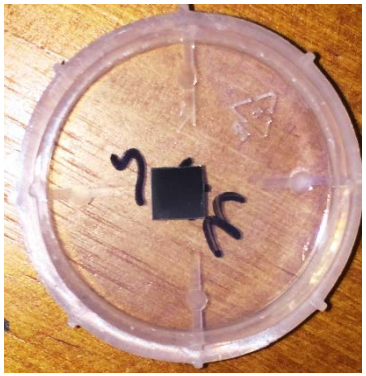




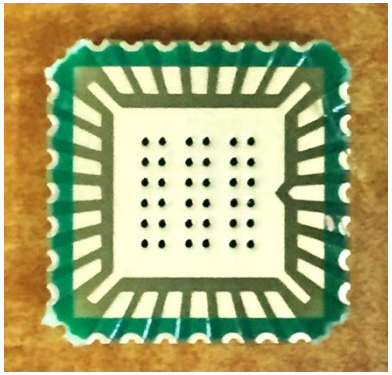
Molecular Beam Epitaxy（MBE）

Measurement Preparation

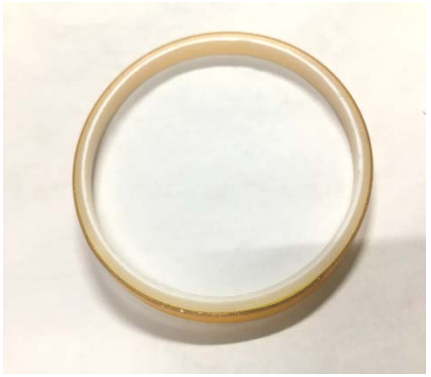
- Sample Assemble



LAO/STO Sample

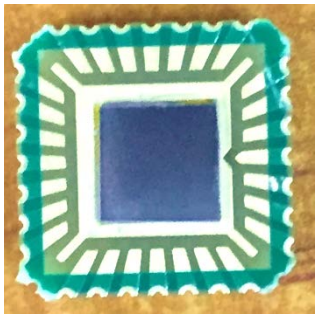


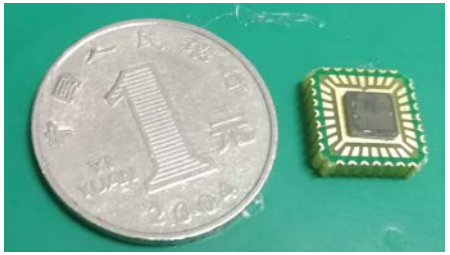
Self-made Chip



Double Side Tape

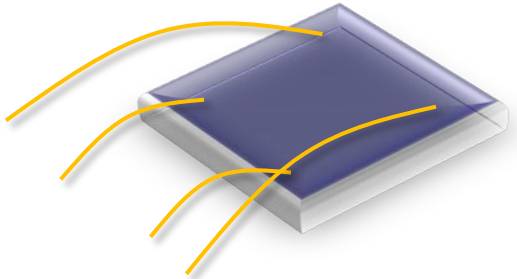
Assemble



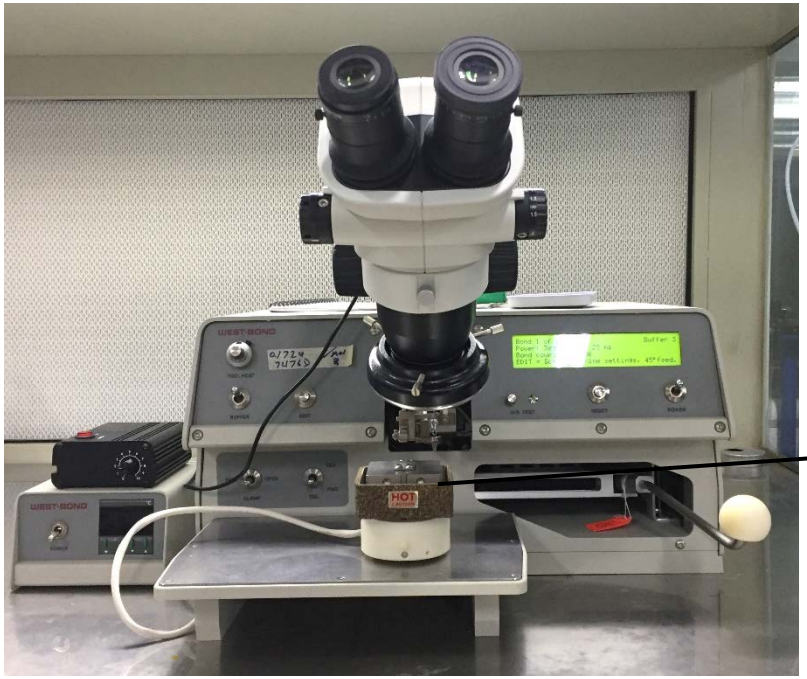


Measurement Preparation

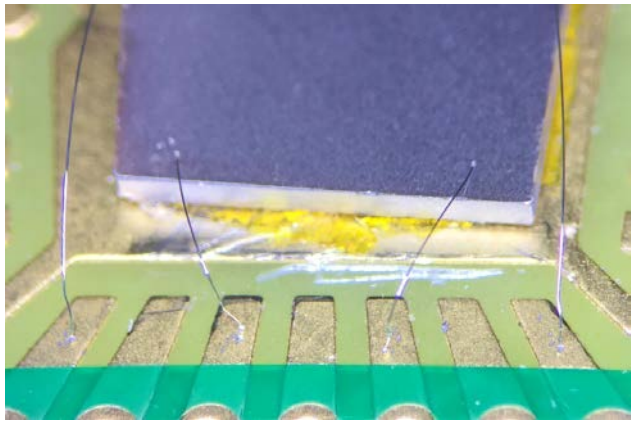
- Wire Bonding



Sketch



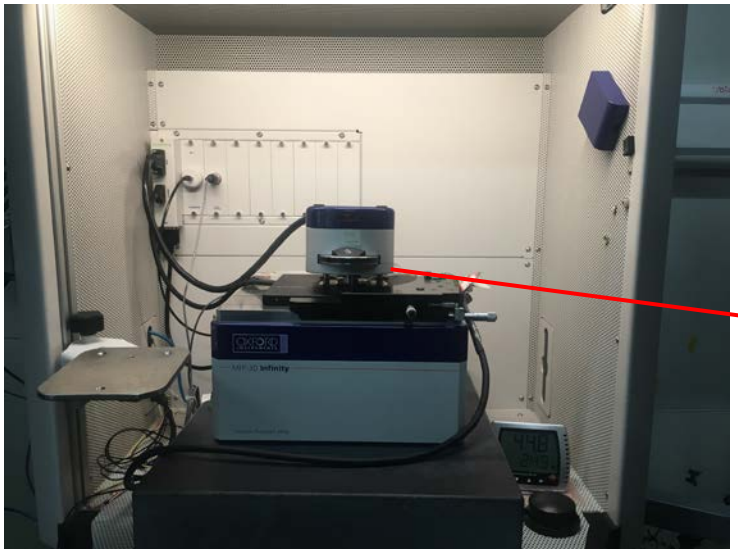
West Bond Lead Joint Machine



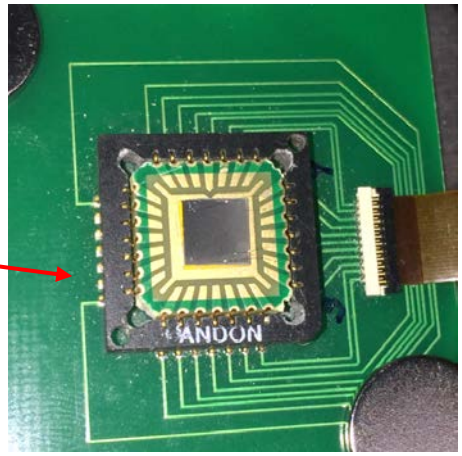
Measurement Preparation

- Measure instrument

NI PXI 1033 DAQ card



Oxford MFP-3D Infinity AFM

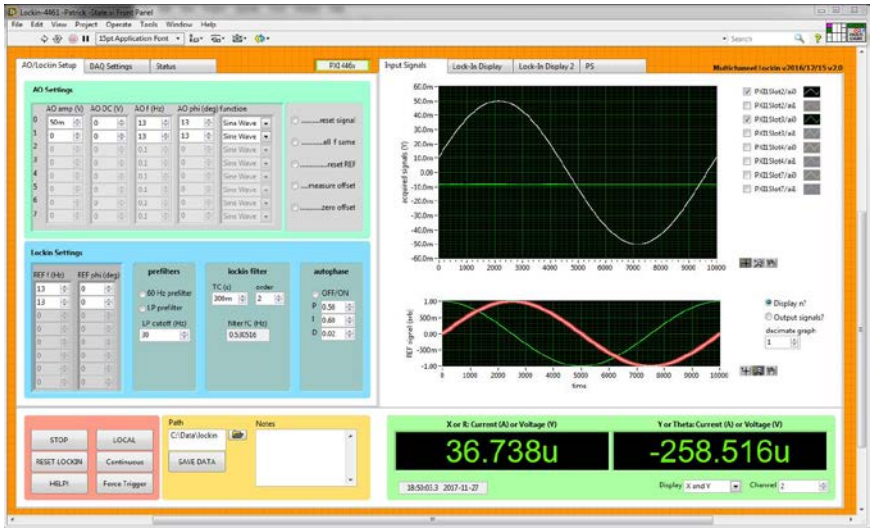


Sample Holder

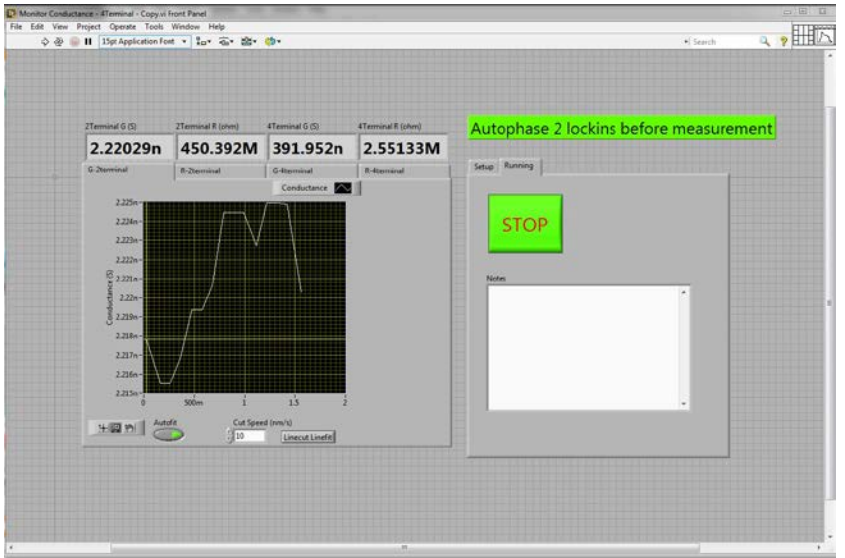
Measurement Preparation

University of Science and Technology of China

- Measure Program



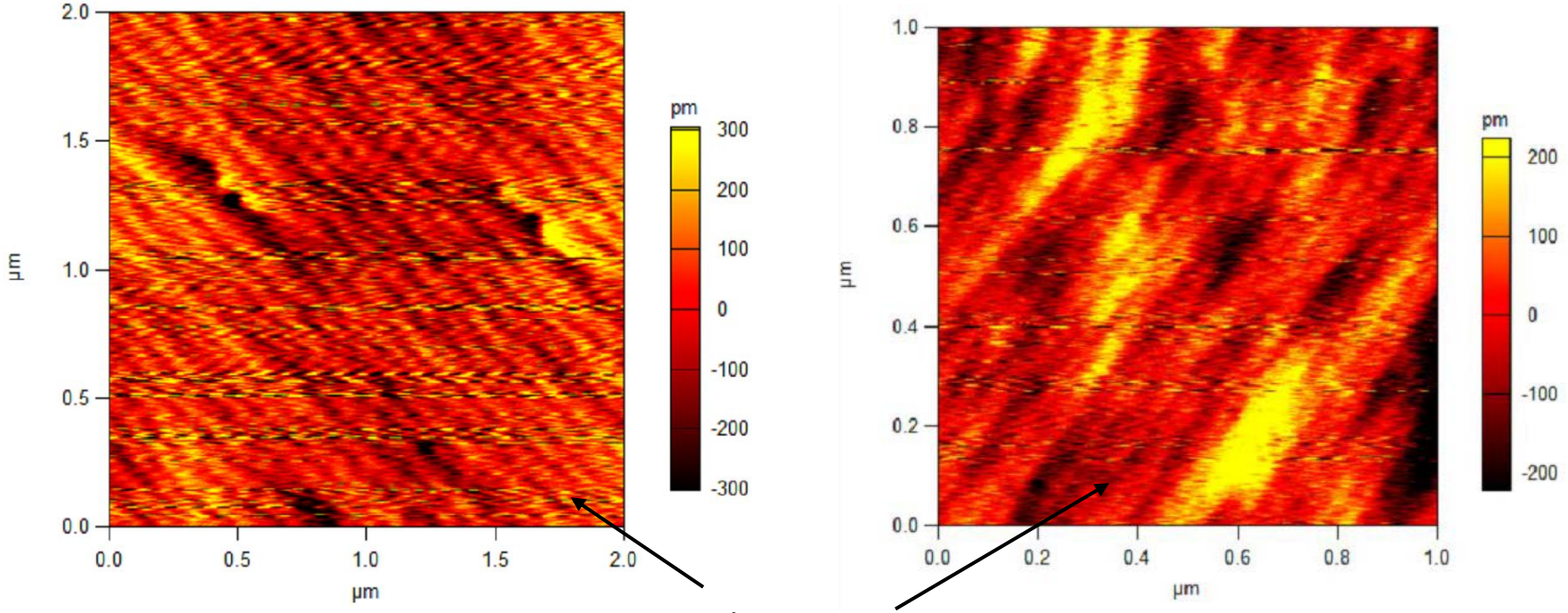
Lock-in Amplifier



Monitor Conductance

Results

- Surface AFM Image

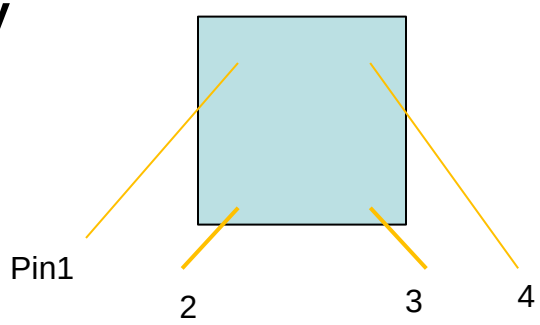


3uc LAO/STO

8uc LAO/STO

Results

- Initial Interface Conductivity

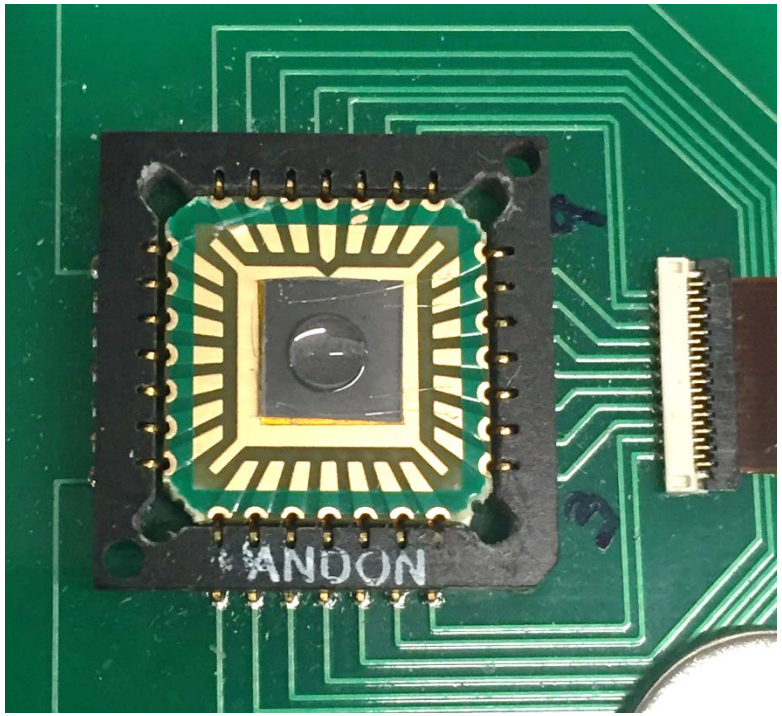


Sample Character			Interface conductivity		
3uc LAO/STO	Insulating	5mm*5mm	4.8 nS	(208 MΩ)	(Pin 2-3)
5uc LAO/STO	conductive	5mm*5mm	217.9 uS	(4.59kΩ)	(Pin 2-3)
8uc LAO/STO	conductive	5mm*5mm	13.1 uS	(76 kΩ)	(Pin 2-3)
STO Substrate	Insulating	5mm*5mm	4.2 nS	(238 MΩ)	(Pin 2-3)

PS: without special statement ,we only use pin 2-3 in later measurement

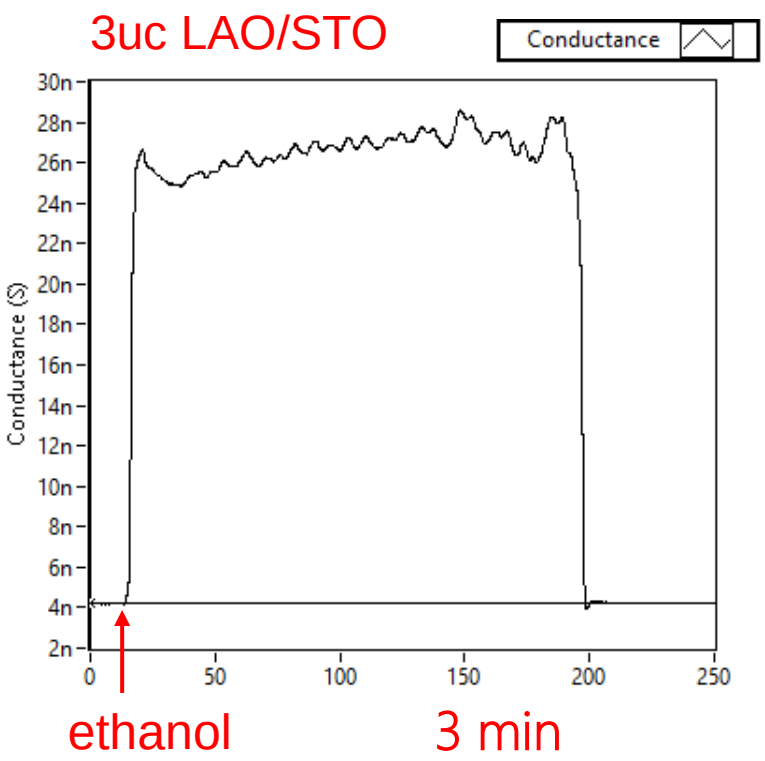
Results

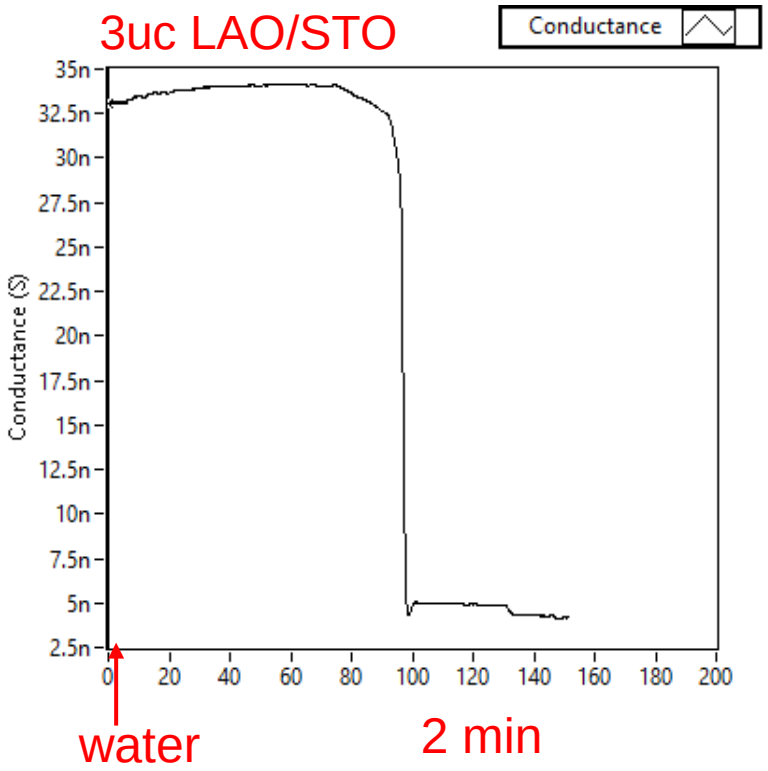
- Surface Treatment (Drip Directly)



Results

- Surface Treatment: on STO Substrate





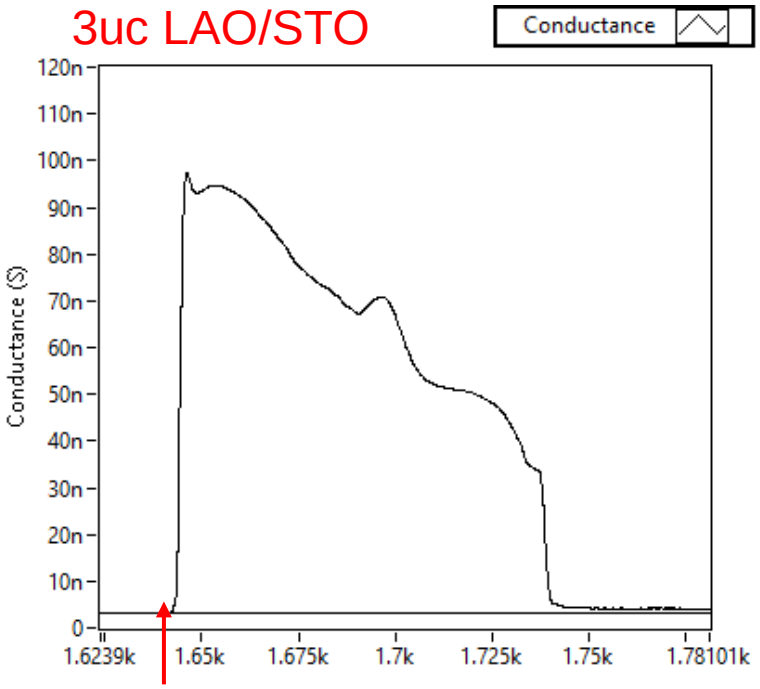
Conductance Jump (about 30nS) decrease quickly after liquid evaporation

Exclude the impact of solvent's conductance.

Results

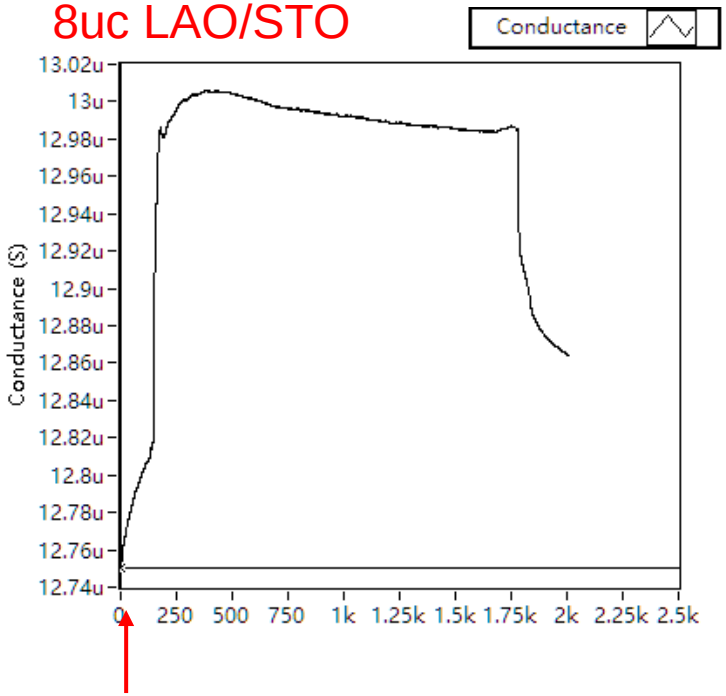
- Surface Treatment： Drip on LAO/STO Surface

3uc LAO/STO



ethanol 2 min

8uc LAO/STO



water 30min

Larger Conductance Jump (100~300 nS) decrease after liquid evaporation

Have impact on the interface.

Results

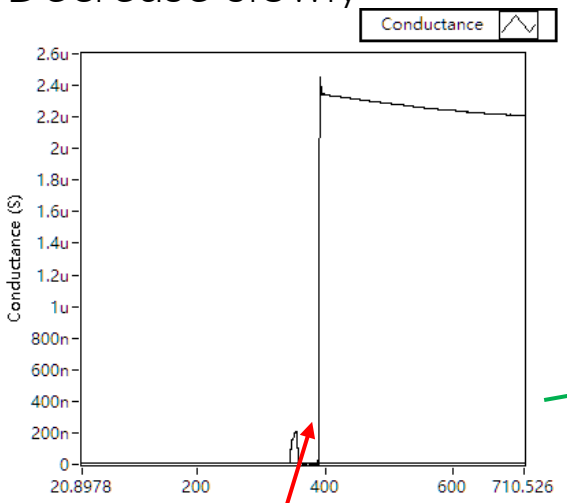
- Surface Treatment： N_2 gun blow after dripping

Surface adsorption process(SAP)

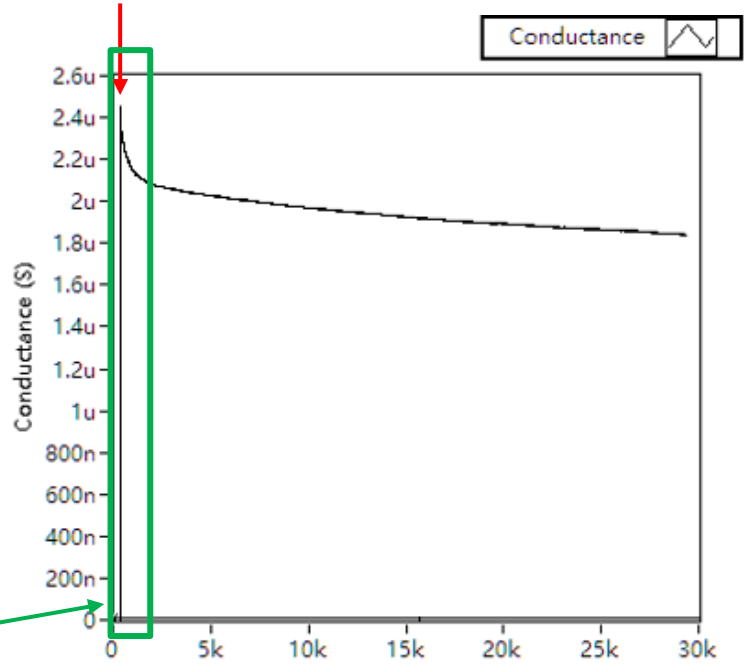
Conductance before SAP： 4.8 nS

Giant Conductance Jump : to 2.4uS

Decrease slowly



Water SAP

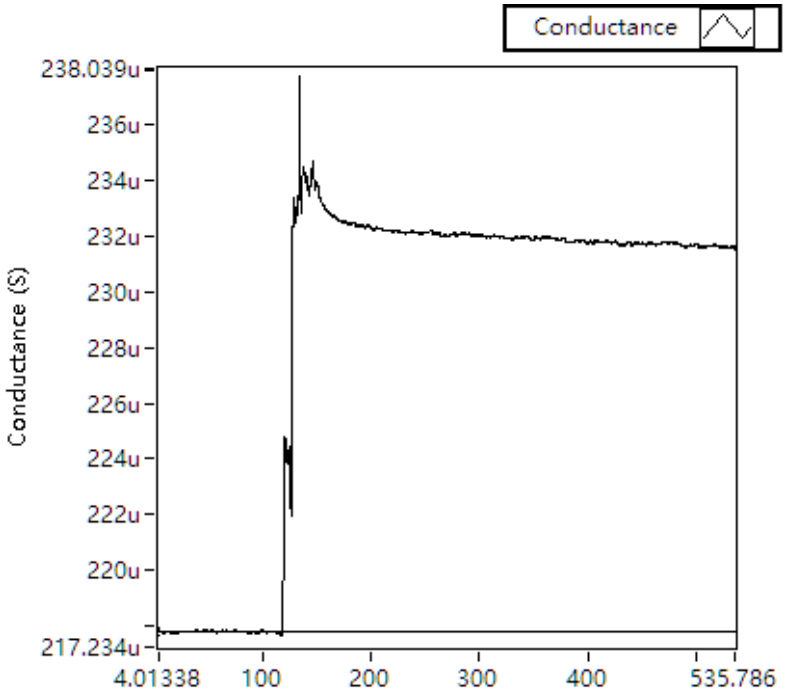


3uc LAO/STO 8.5h

SAP is a better method.

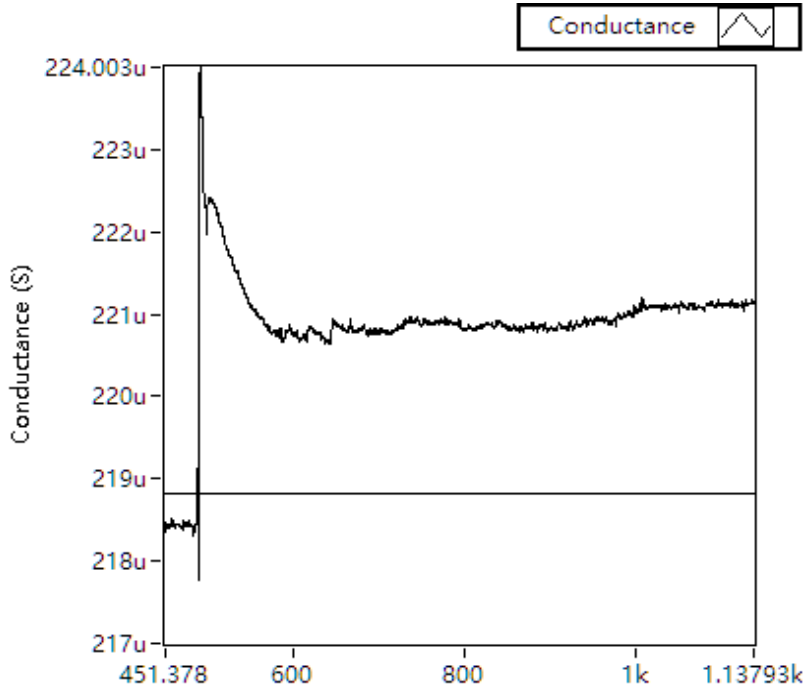
Results

- Surface Treatment: SAP



Water 5uc LAO/STO

217.2uS to 232uS

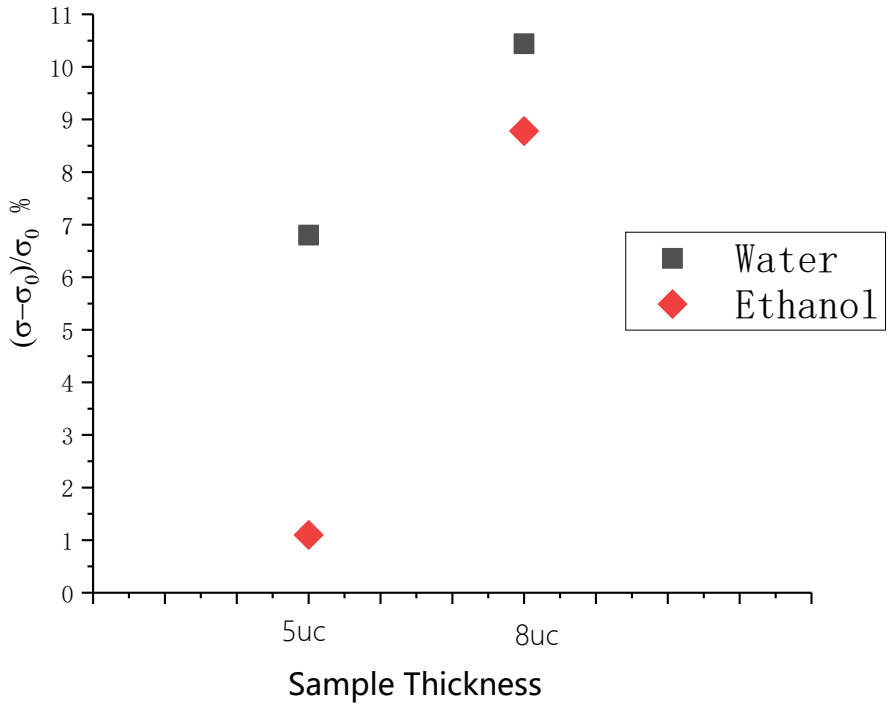


Ethanol 5uc LAO/STO

218.5uS to 221uS

Results

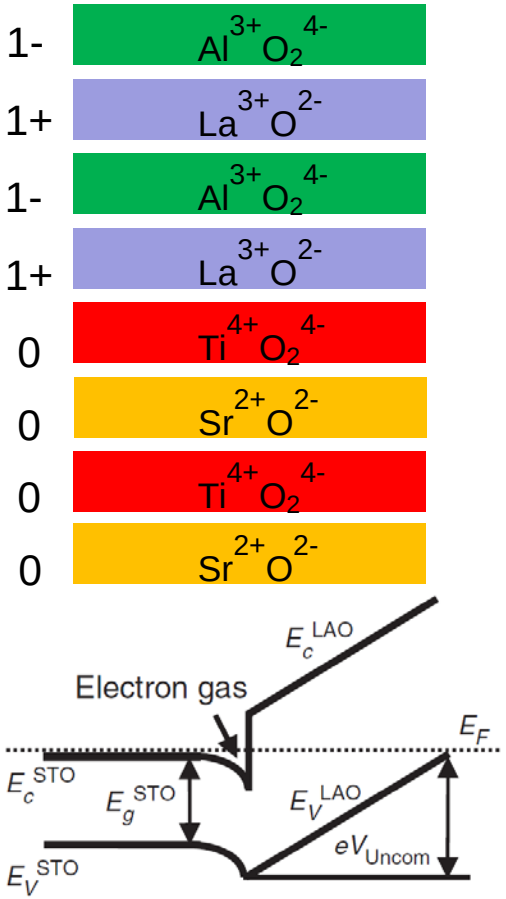
- Surface Treatment: SAP

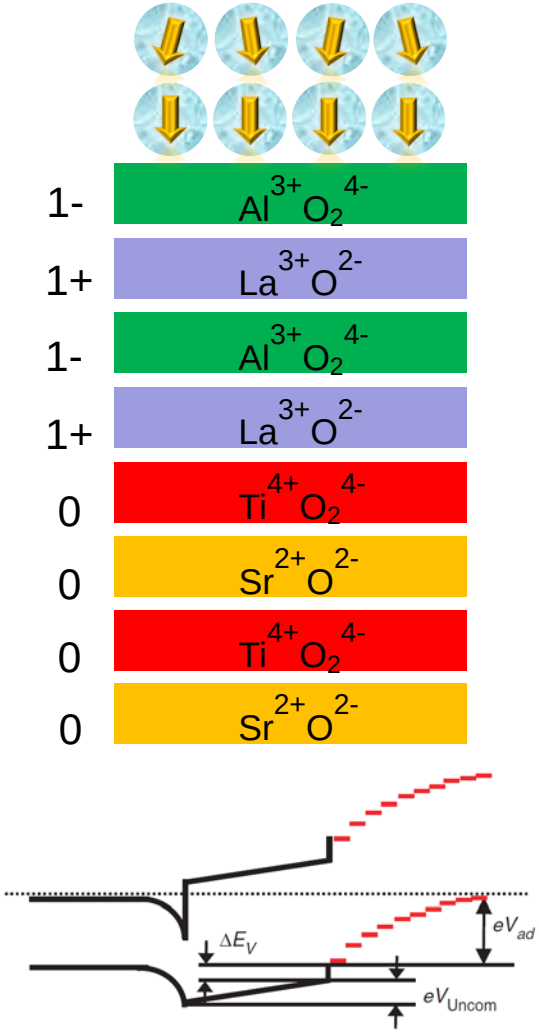


Conductance change by SAP
Different solvent on different thickness samples

Discussion

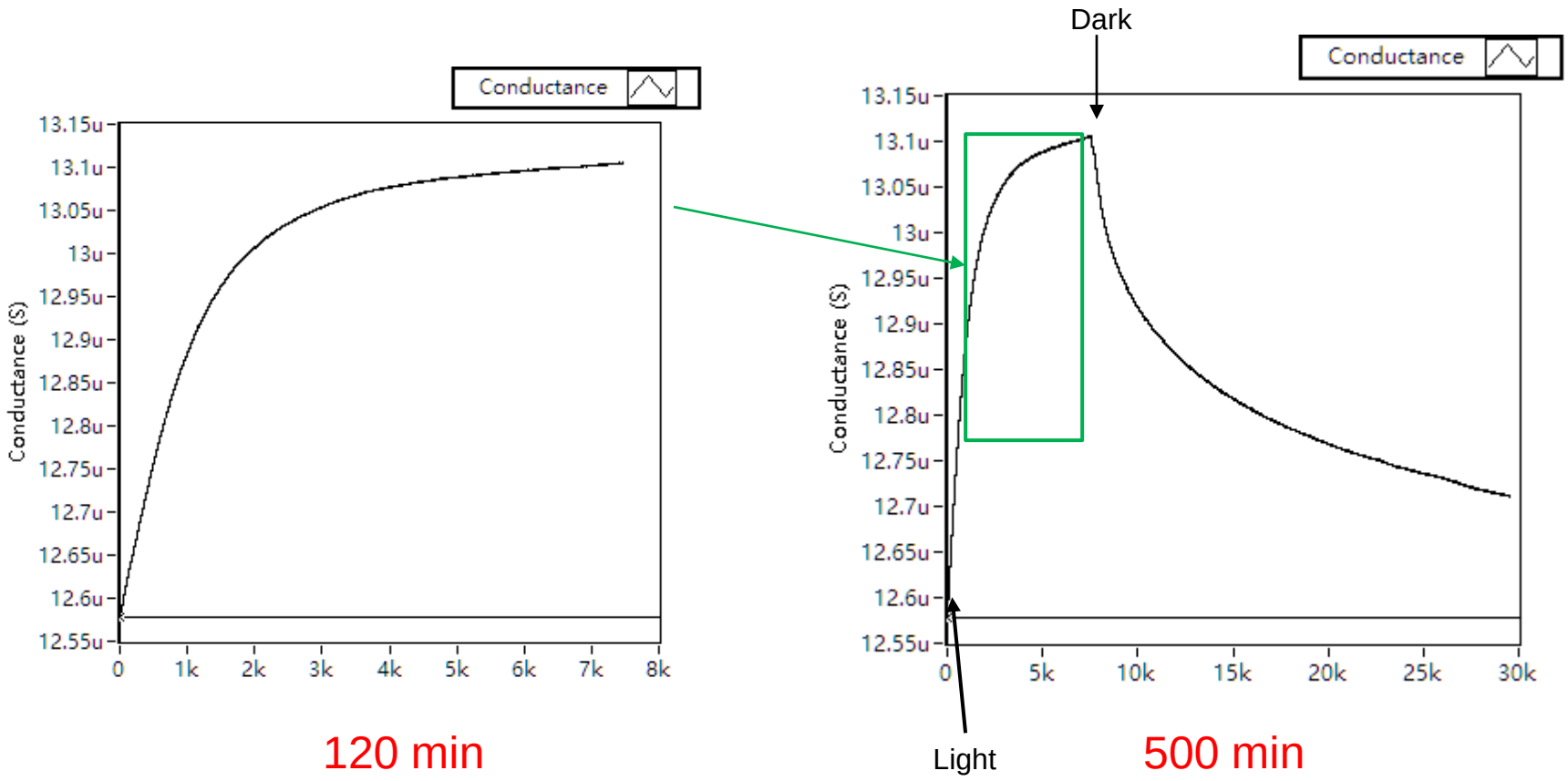
- Electronic Reconstruction Mechanism





Results

- Surface Treatment :Light Stimulate



120 min

500 min

8uc LAO/STO

Results

- Surface Treatment：Annealing

Put 8uc Sample into a quartz vessel

Anneal at 350℃, 0.01MPa oxygen

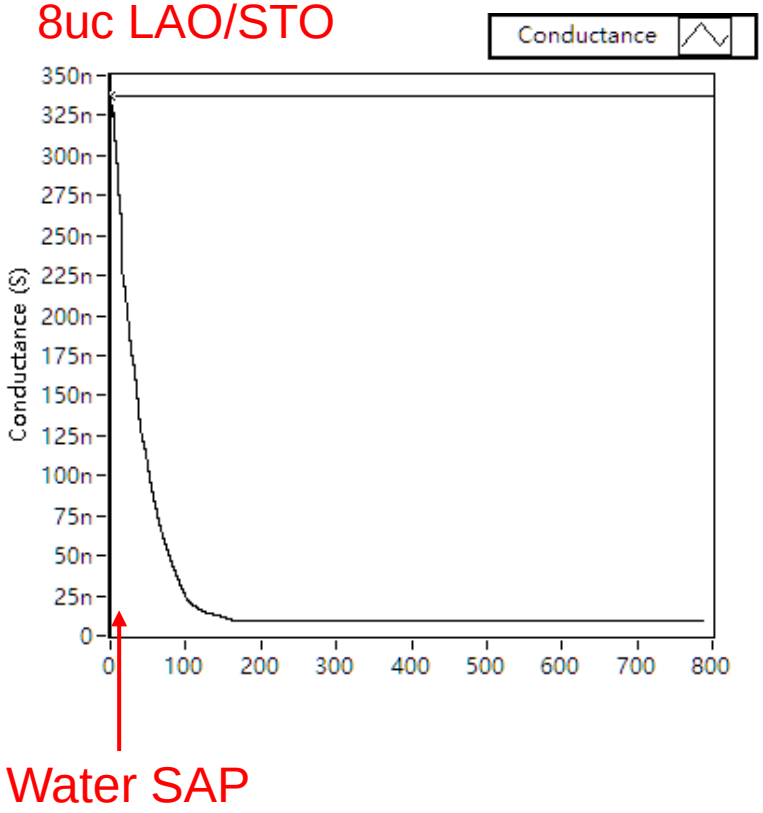
Annealing furnace

Conductance switch: 12uS → 11.8nS

OV contribute much.

Results

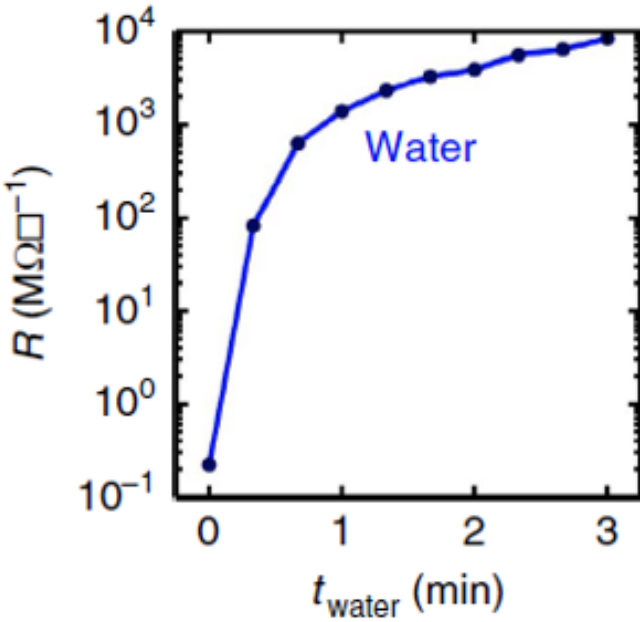
- Surface Treatment: on Sample after Annealing



Large Jump from 11.8nS to 330nS
but decrease quickly

Discussion

- OV contribution



Giant conductivity switching of LaAlO3/SrTiO3 heterointerfaces governed by surface protonation
Keith A. Brown et.al

Future plan

- More solvents with different polarity
- Light of different wavelengths
- Solutions to find the impact of ions
- Difference between PLD and MBE samples
- Decay time
- …

Thanks!

Acknowledgements:
Experimental work at Chenglab is supported by Mengke Ha, Qing Xiao and Prof. Cheng

References

1. Control of electronic conduction at an oxide heterointerface using surface polar adsorbates Yanwu Xie et.al

2. Giant conductivity switching of LaAlO3/SrTiO3 heterointerfaces governed by surface protonation Keith A. Brown et.al

3. Tailoring LaAlO3/SrTiO3 Interface Metallicity by Oxygen Surface Adsorbates Weitao Dai et.al

4. “Water-cycle” mechanism for writing and erasing nanostructures at the LaAlO3/SrTiO3 interface Feng Bi et.al

Results

- Polar catastrophe

  Does not explain 2DEL formation in (110) LAO/STO samples, which have no polar discontinuity