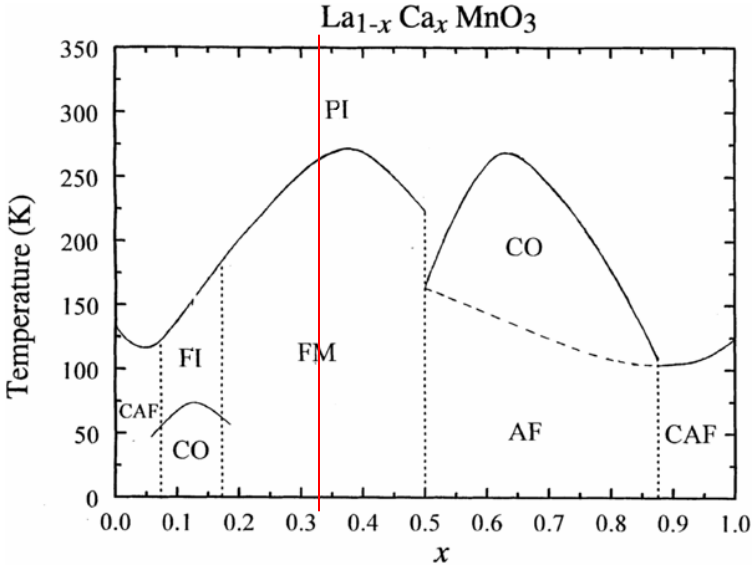
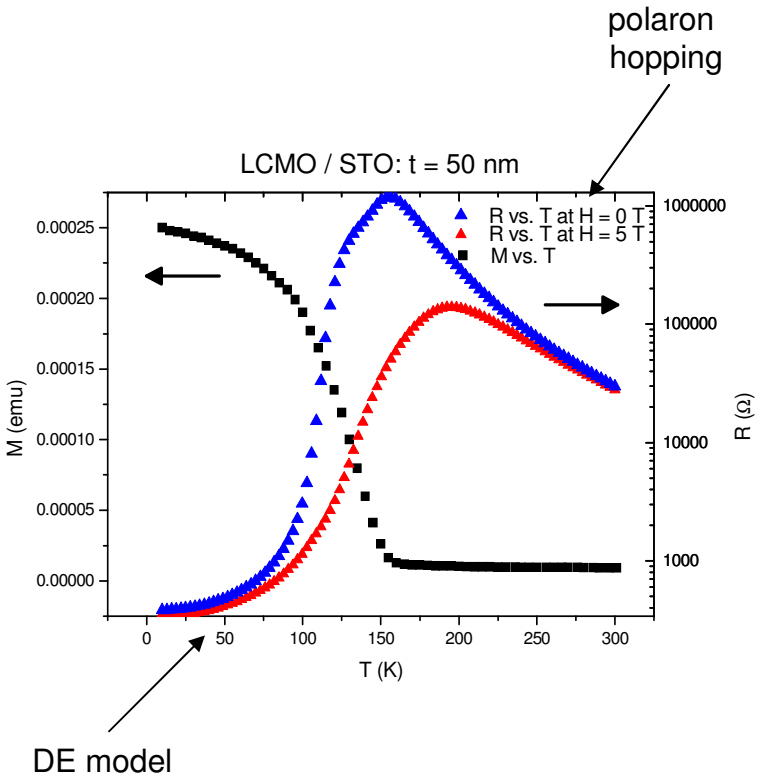
Microstructured LCMO: Electroresistance effects

Christianne: groupmeeting 01-10-07

(APL **91** 062101 (2007))

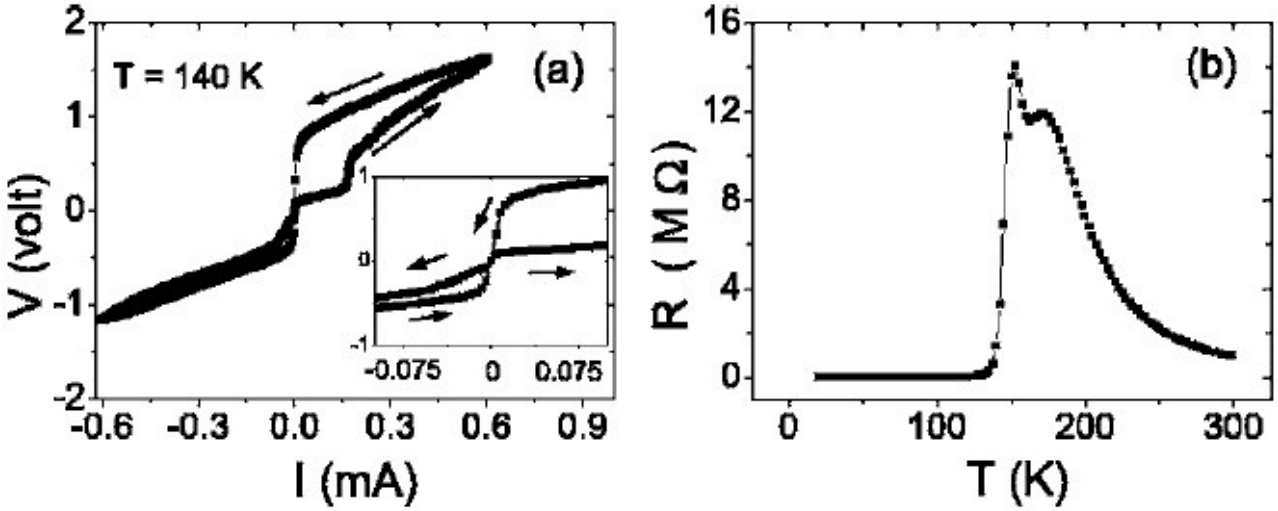
Manganites





- Manganites have a metal-insulator transition at T_C
- Inhomogeneous state → phase separation → percolative conductance leads to nonlinear IV-curves.

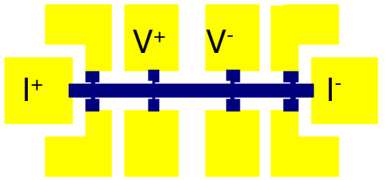
LCMO

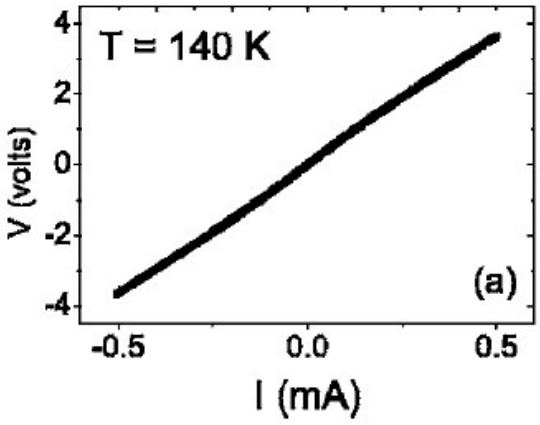


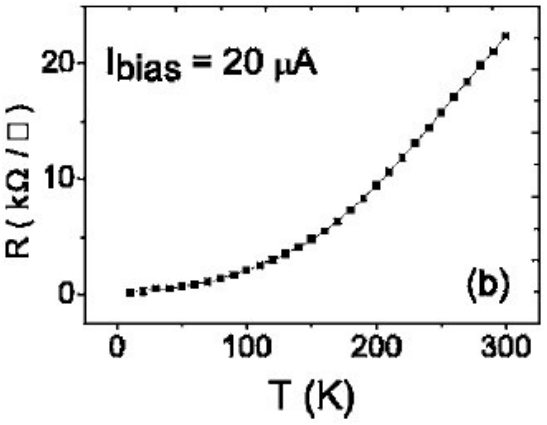
- 4pt. IV curves, size: t = 8 nm, w = 5 μm
- asymmetry, nonlinearity and hysteresis!
- partly probing the bridge but current leakage

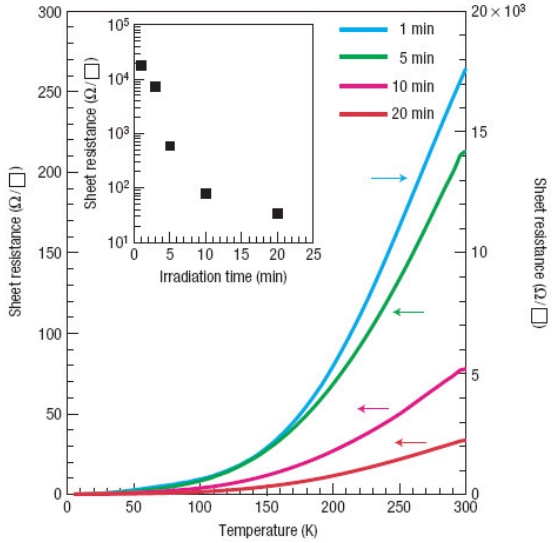
STO

- 4pt. IV curves 30 sec etched (350 V; 10 mA) STO, size: 2.6 x 1.5 mm^2
- conducting STO, resistance comparable to the bridge







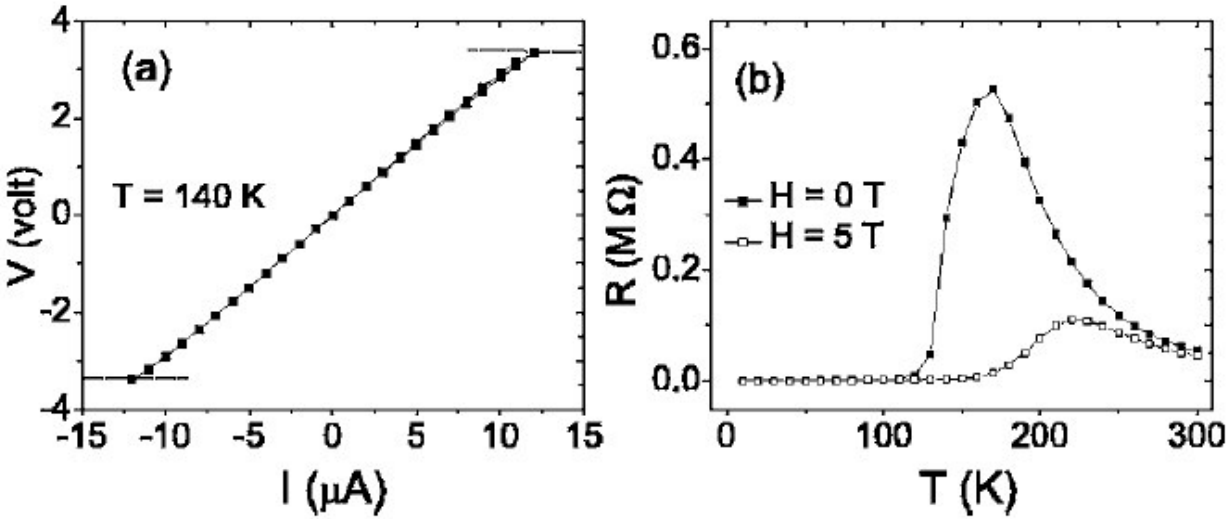


Kan et al. Nat. Mater. **4** (2005):

- sheet resistance Ar-etched STO (300 V)
- 1 min (light blue line) comparable to our sheet resistance

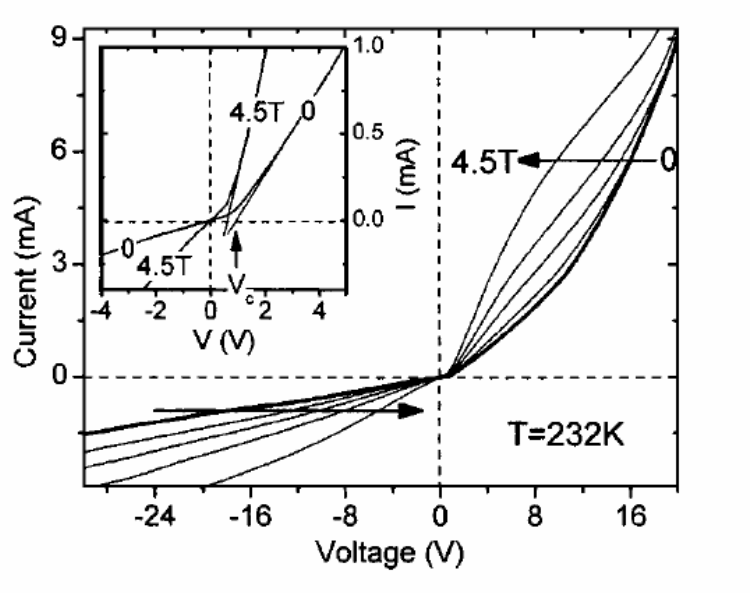
Solution: short O_2 plasma etch restores insulating state of STO

LCMO (treated)



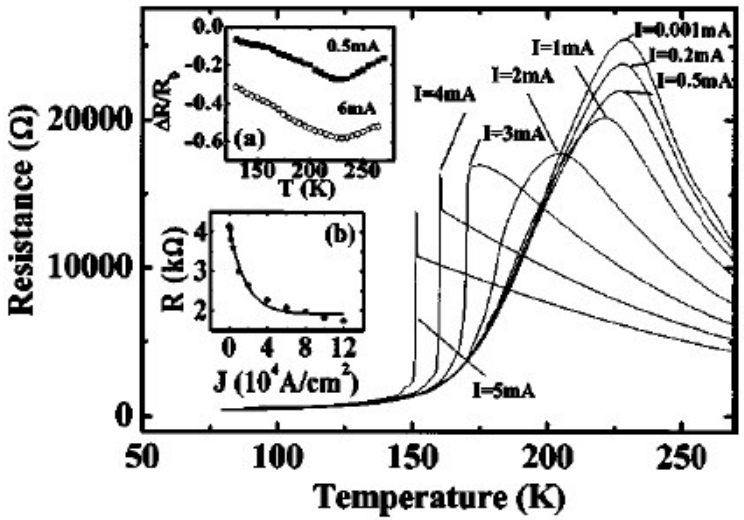
- 4pt. IV curves, size: t = 8 nm, w = 5 μm
- linear + symmetrical IV curves for T = 10 – 300 K
- no Electroresistance for J : 2.5 10^5 A/m^2 -1.5 10^9 A/m^2

Electroresistance

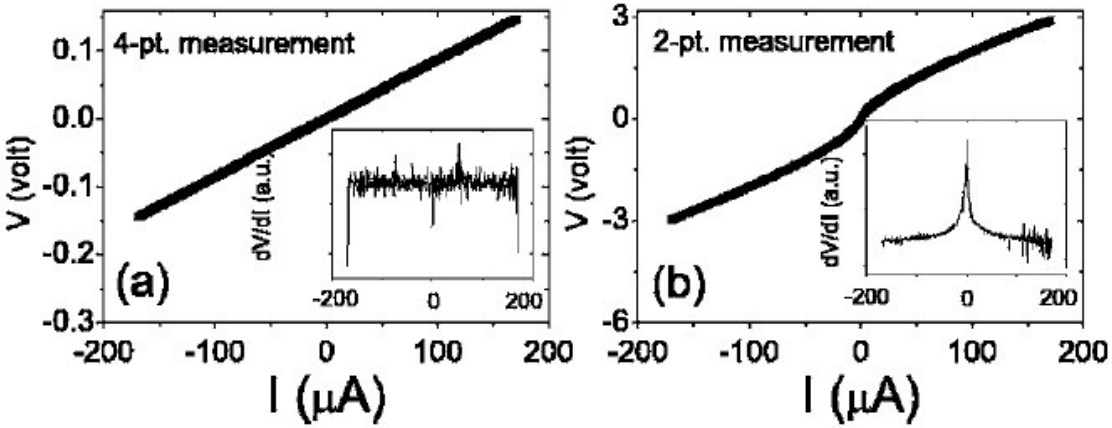


Sun et al. APL **86** (2005):
- 2pt. IV curves, size: t = 120 nm, w = 200 µm
- current processing → J = 1.6 10^9 A/m^2
- Electroresistance + contact resistance

Zhao et al. APL **86** (2005):
- 4pt. R vs. T size: t = 100 nm, w = 50 µm
- strongly decreasing R as function of I
  → J = 2 10^5 A/m^2 -1.2 10^9 A/m^2
- Electroresistance (T_p no shift) + heating (T_p shift to lower T)
- others report T_p shift to higher T like MR

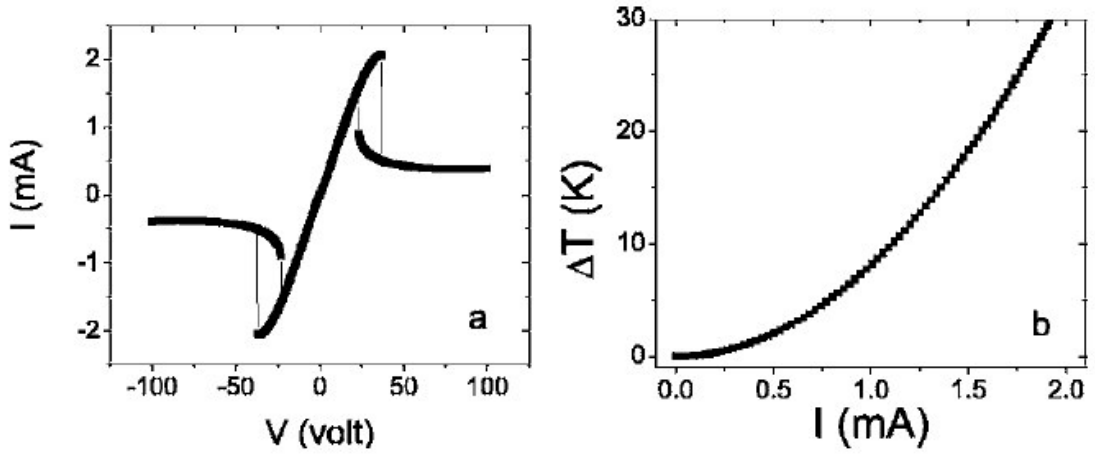


Our samples: very homogeneous even on micrometer scale ?!



- IV curves 2 pt. vs. 4 pt. at 10 K
- dV/dI (inset) shows clear nonlinearity of the 2pt. IV due to large contact resistance

- VI curve (2 pt.) at 50 K shows resistance switching, Joule heating?
- estimation indicates that Joule heating is significant



Conclusions

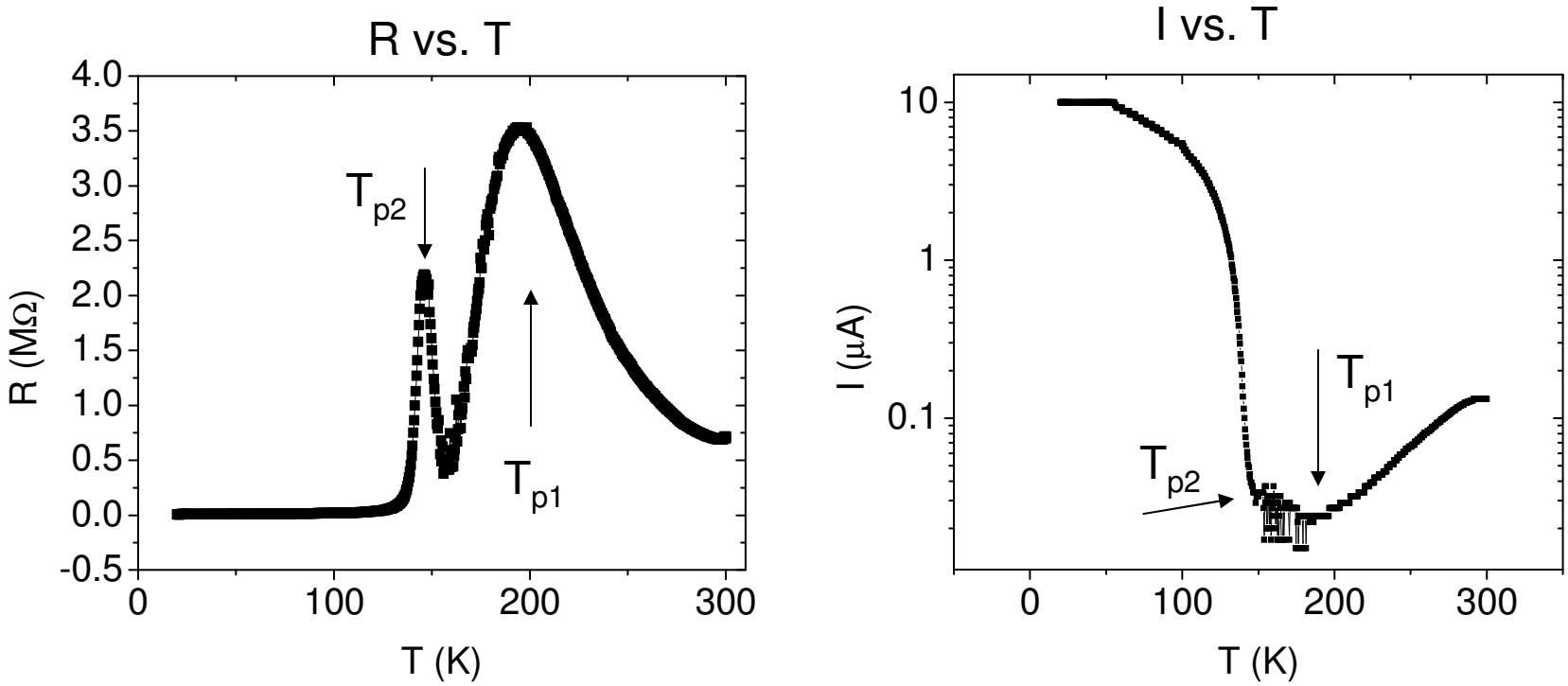
- No electroresistance is observed in our (treated) LCMO microbridges.

- Peculiarities in IVs are caused by:
  - conducting STO
  - large contact resistance
  - Joule heating

Recent results

bridge: 1 x 20 μm^2 ; t = 10 nm
Au contacts

bridge $\perp$ steps; measured in PPMS during cooling

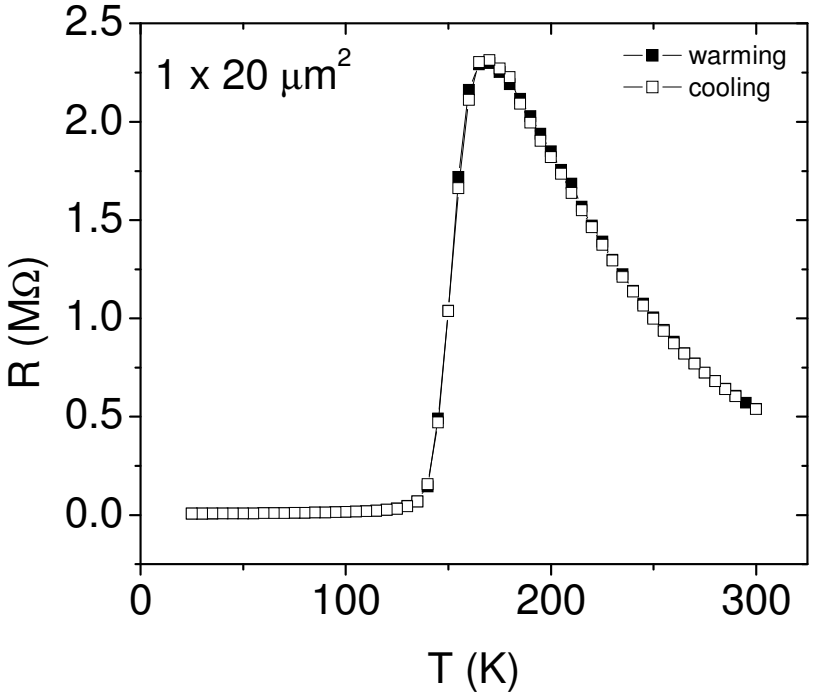


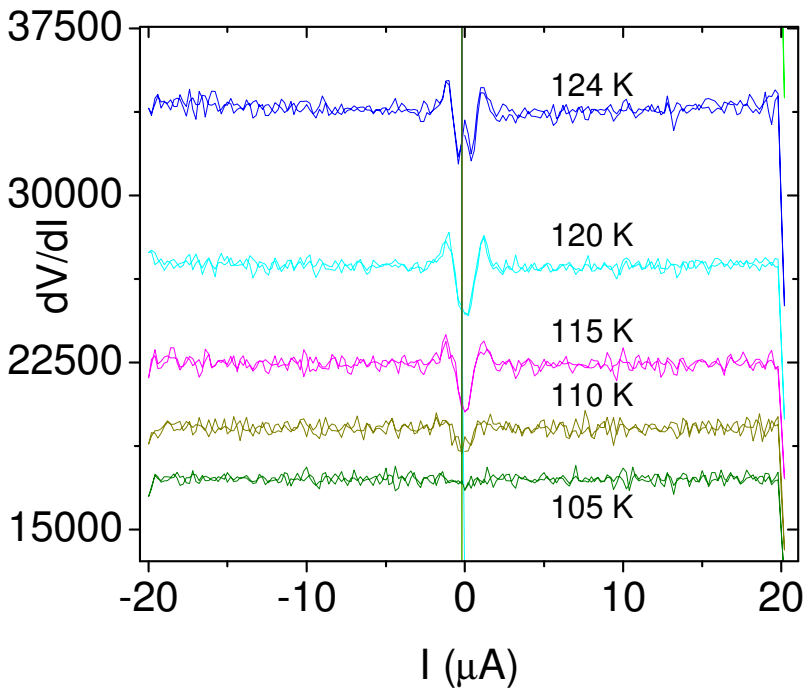
T_{p1} ~ 190 K; T_{p2} ~ 145 K

Recent results

bridge: 1 x 20 μm^2 ; t = 10 nm
Au contacts

bridge ⊥ steps; R vs. T from IV curve; I = 0.6 μA





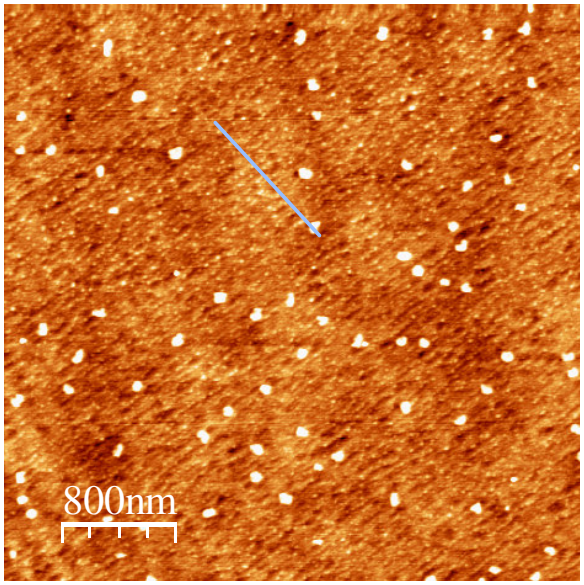
T_p ~ 170 K

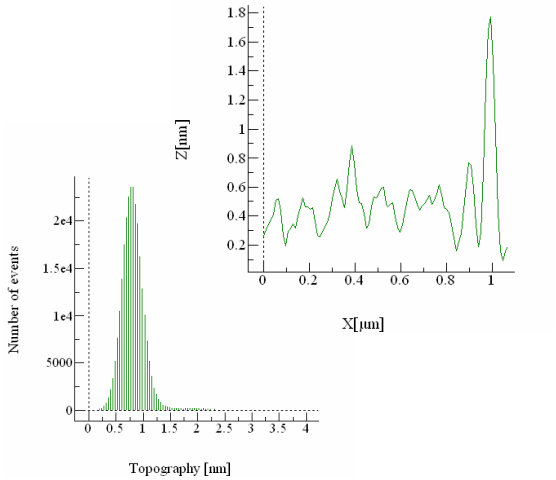
Zero current feature 110 K to 140 K

L477 1.0 deg STO

4 x 4 μm

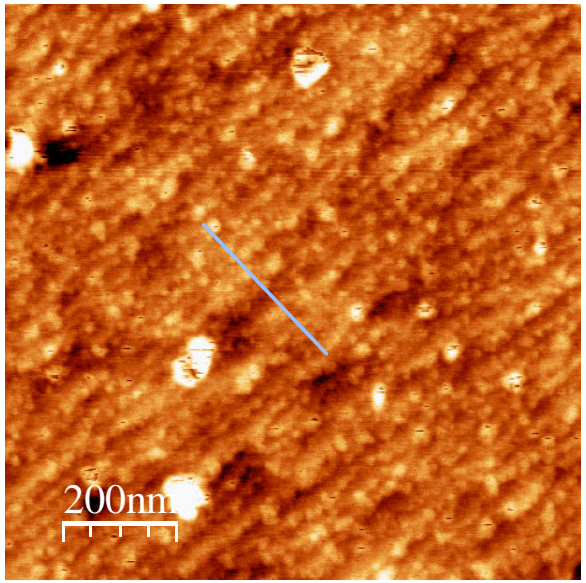
rms roughness: 0.24 nm

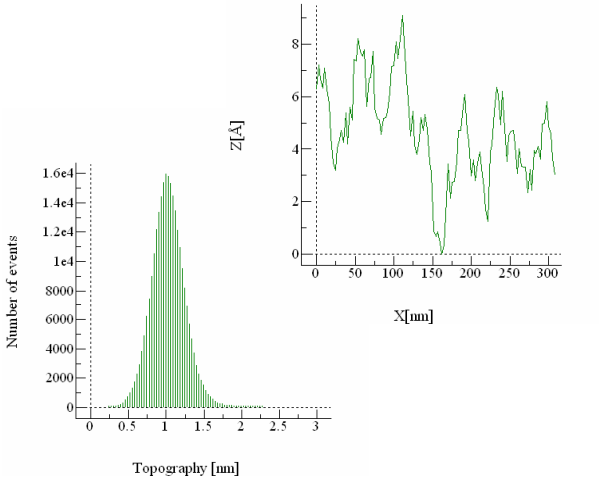




1 x 1 μm

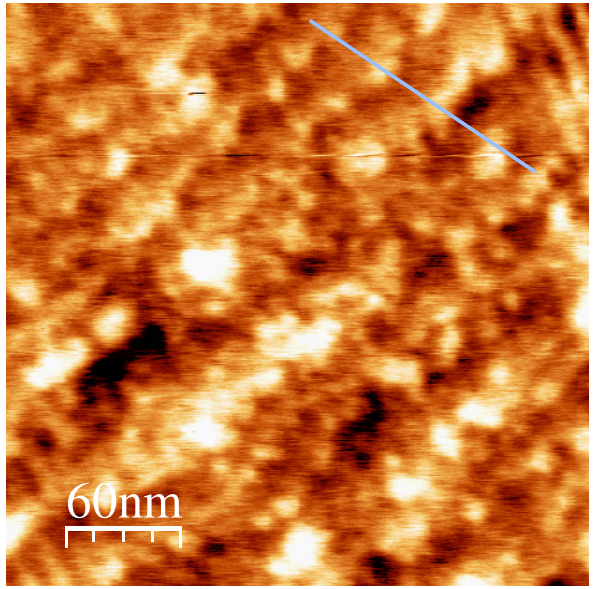
rms roughness: 0.25 nm

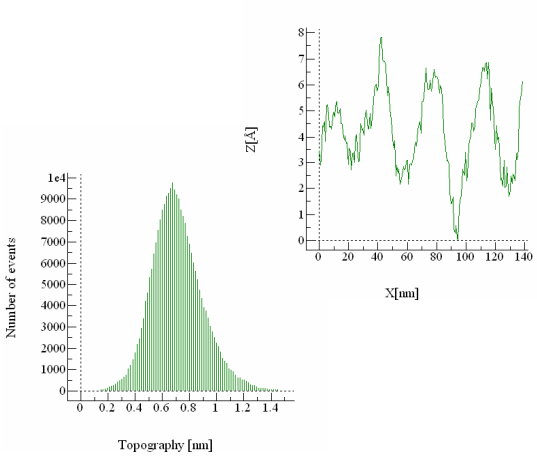




300 x 300 nm

rms roughness: 0.187 nm

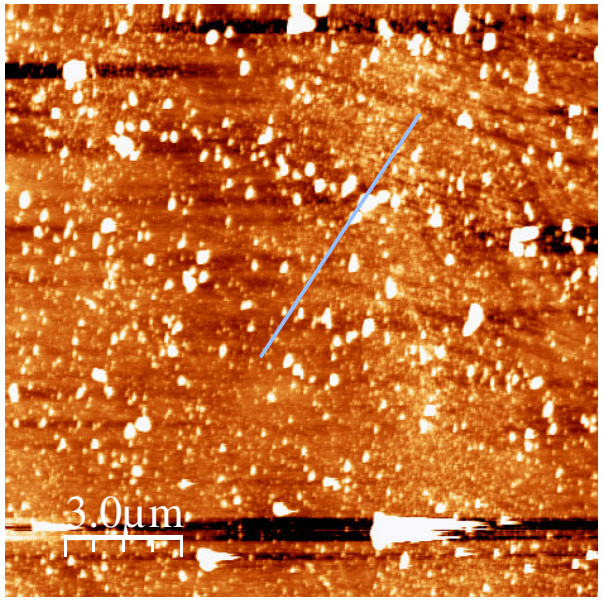




Flat STO for STM L478

15 x 15 µm

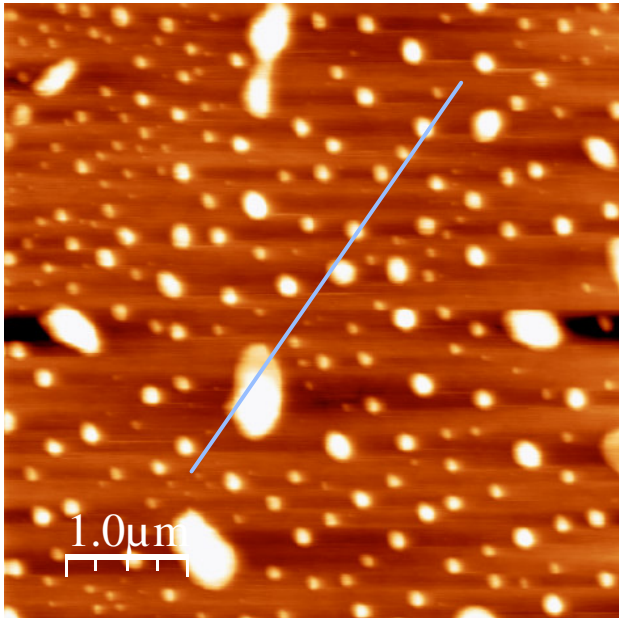
rms roughness: 2.01 nm

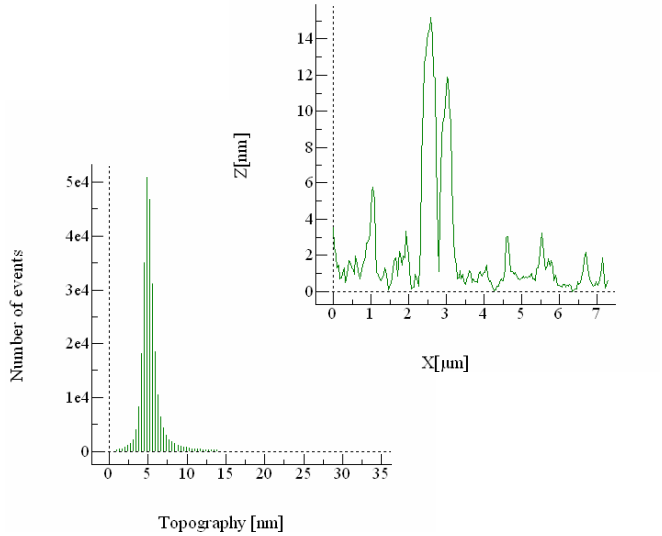


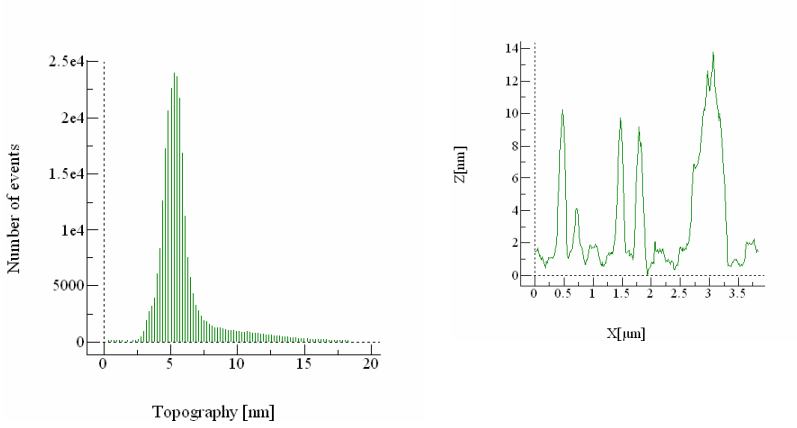
Clean IPA, ethanol, acetone ultrasound + cotton tip

5 x 5 µm

rms roughness: 2.38 nm



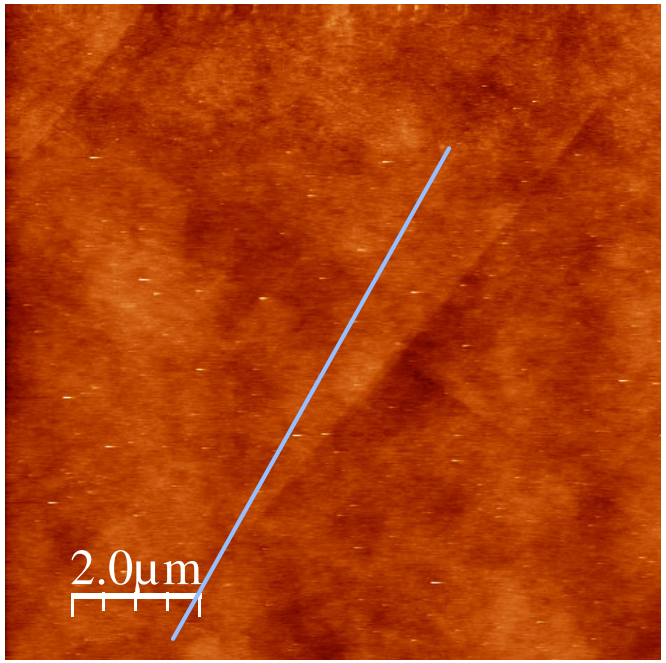




Flat STO for STM L478 CLEAN!!

15 x 15 µm

rms roughness: 0.238 nm



Ethanol +
lens paper!

1.5 x 1.5 µm

rms roughness: 0.196 nm