

بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِیْمِ .

# Nb Tip Etching and CrO<sub>2</sub> Thin Films on Sapphire

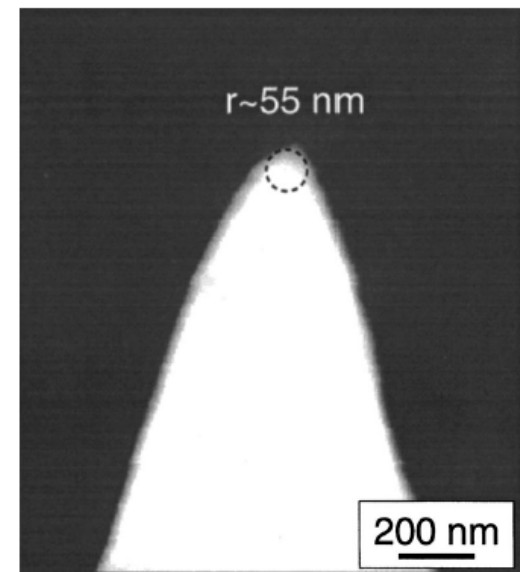
Muhammad Shahbaz Anwar

Group Meeting 17-12-2007

# Nb Tip Etching

Diameter of Nb wire: 0.3mm  
Solution: HCl 25%  
Counter Electrode: Graphite Block  
Whole process was completed in three steps,

- 1) 30 volts ac was applied between Nb wire and counter electrode, was decreased to 17V with a rate of 0.16 V/min.  
(Bubbling and Sparkling was observed about the Nb wire immersed into solution)
- 2) The voltage was maintained at 17V for 40min.  
(weak bubbling and sparking was observed at the end of the immersed Nb wire)
- 3) Voltage was decreased to 2V within few seconds and kept there until the current reduced to zero.  
(the colour of the tip front was silver like)

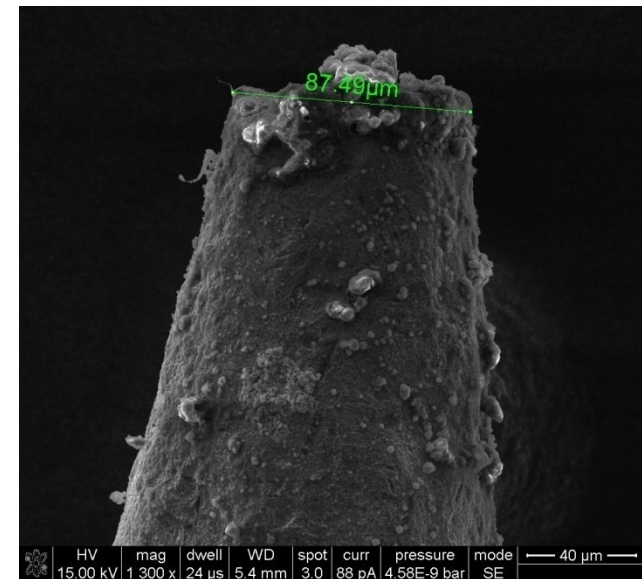


# Tip Etching

Diameter of Nb wire: 0.25mm  
Solution; HCl 37%  
Starting Voltage; 20V  
Counter Electrode: Graphite block

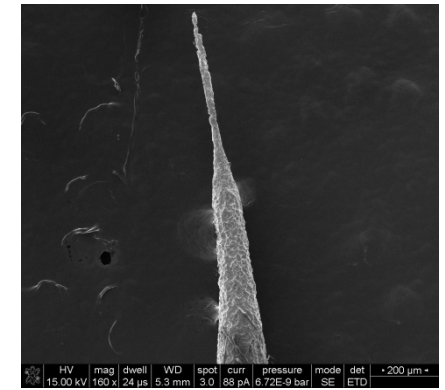
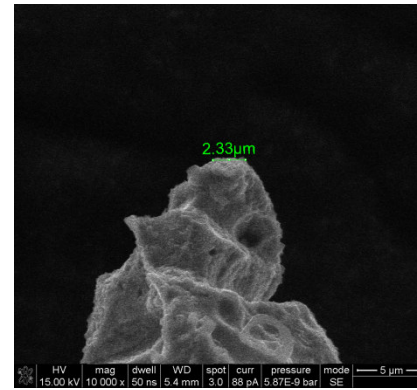
Due to high concentrated solution Nb wire  
was etched very fast

Tip # 001

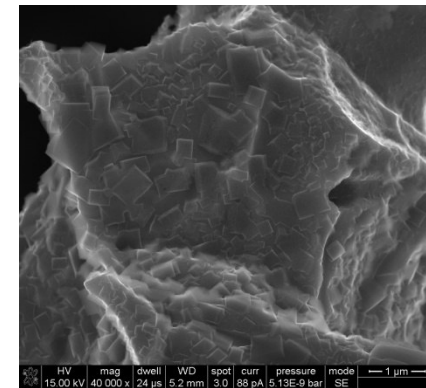


Solution: HCl 25%  
Starting Voltage 25V

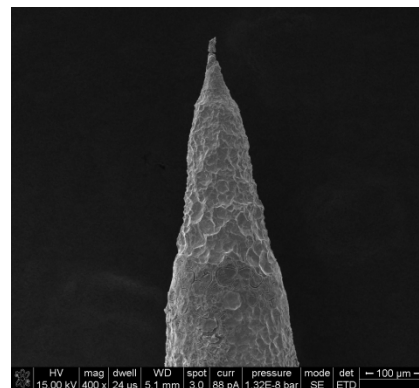
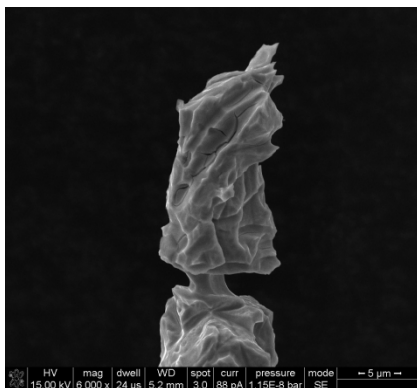
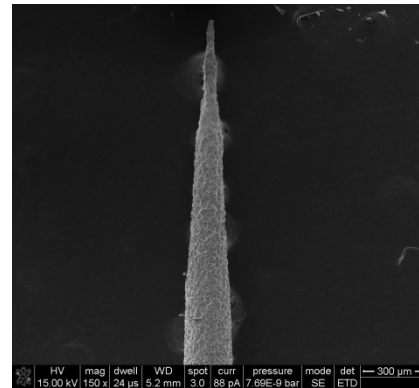
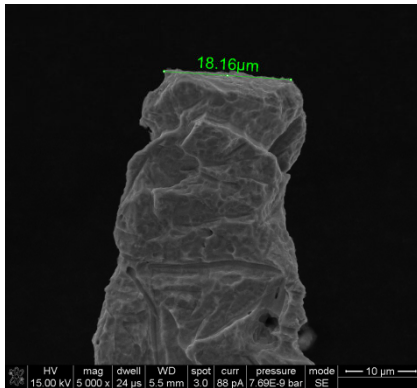
- 1) Voltage was reduced, 25 to 17V with rate of 1V/min
- 2) Kept at 17V for 10min
- 3) Voltage was reduced to 3V with in few seconds and kept there until current reduced to zero



Tip # 003



Tip # 004



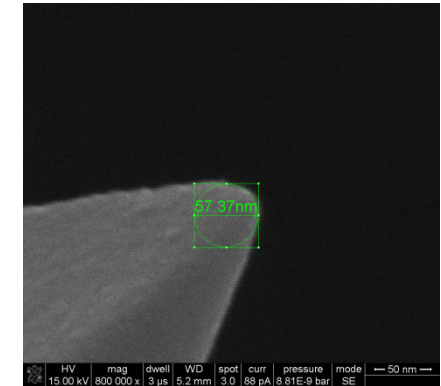
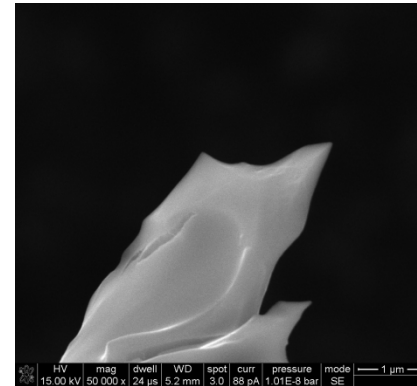
Tip # 005

Solution: HCl 25%  
Starting Voltage 30V  
At 17V a sharp sparkling was started which stopped within 2min and current was reduced to zero

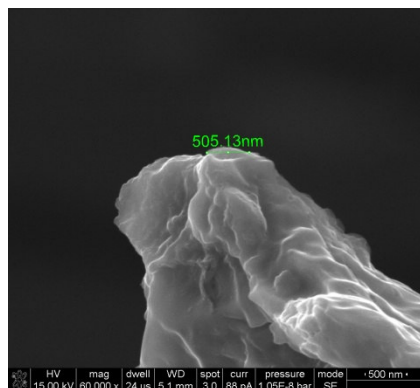
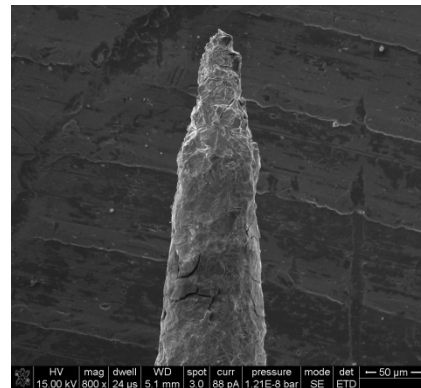
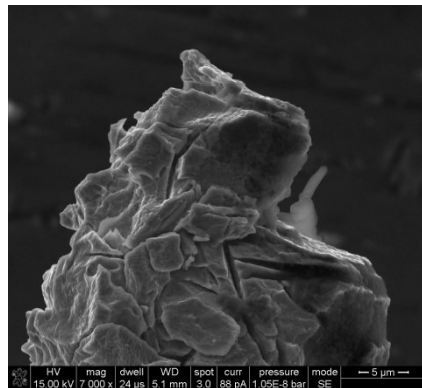
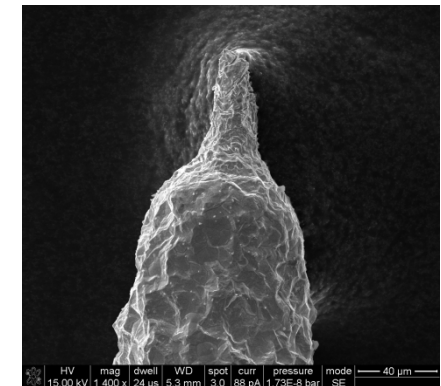
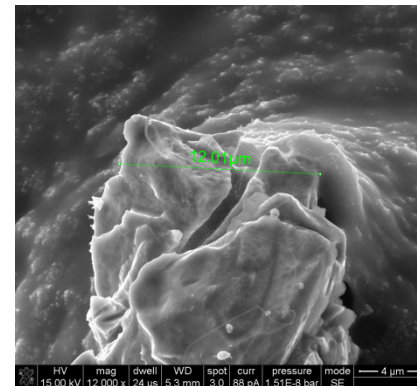
To etch tip#006,

- 1) voltage was dropped to 5V from 17V to reduce the sparking
- 2) After current reduced to zero about half of mm immersed again into solution at 5V
- 3) Kept there until the current reduced to zero

Tip # 005



Tip # 006



Tip # 008

Solution: HCl 20%

Starting Voltage: 30V

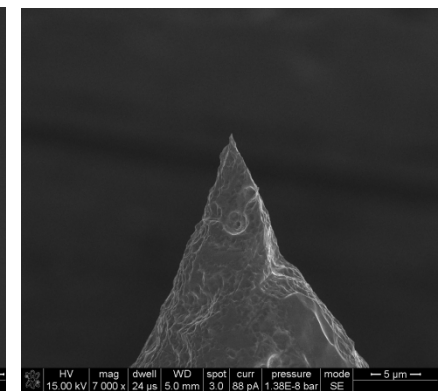
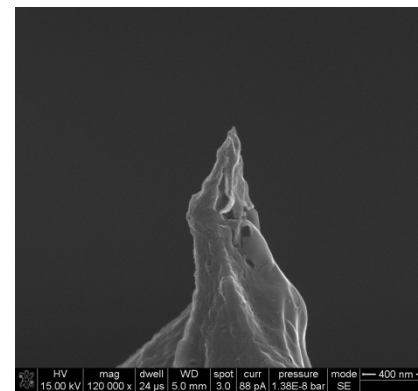
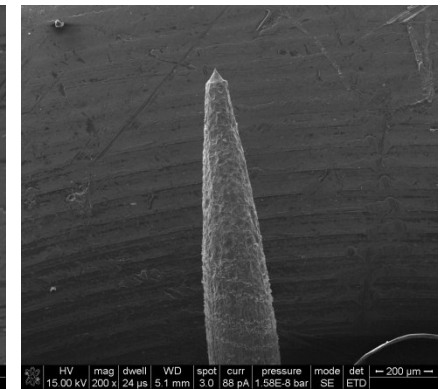
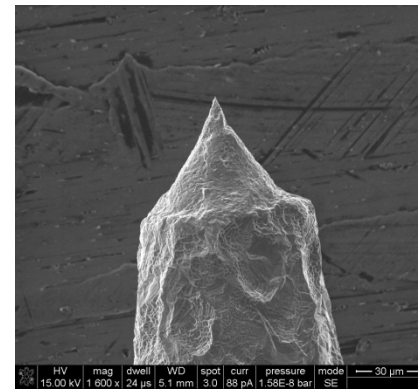
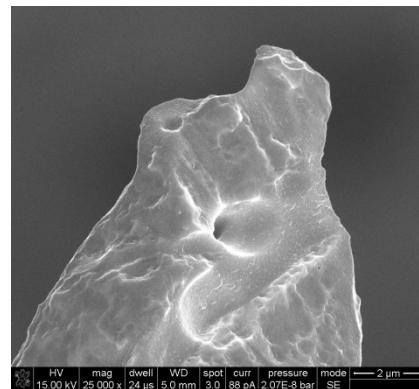
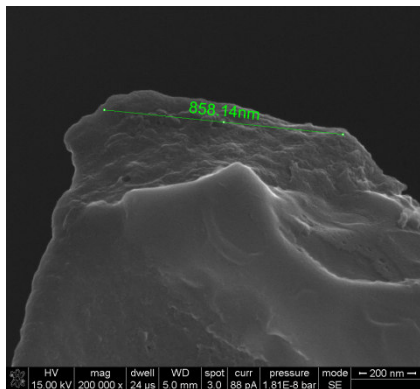
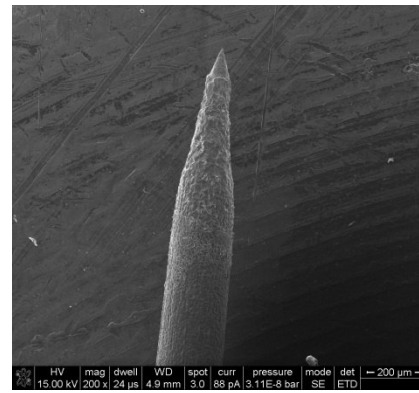
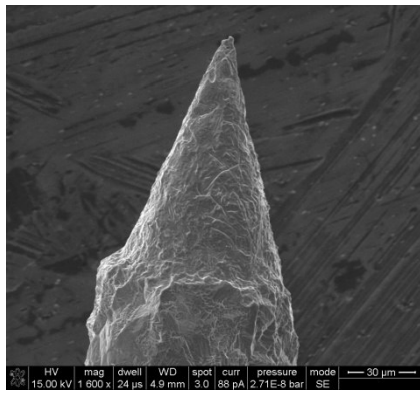
Rate of etching was very slow, no sharp sparking was produced



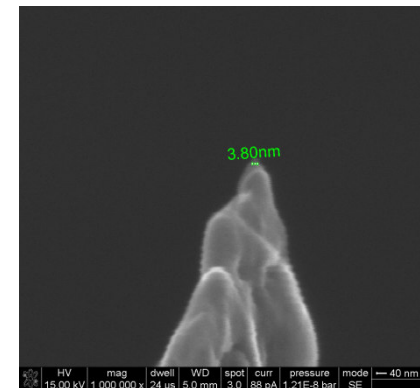
Solution: HCl 25% **Tip# 010**

Starting Voltage: 30V

- 1) It kept at 30V for 5min
- 2) Voltage reduced to 17V with rate of 1V/min
- 3) Voltage was reduced to 5V within few second at the start of sharp sparking.
- 4) It was kept at 5V voltage until current reduced to zero
- 5) Tip was immersed again into solution until current again reduced to zero

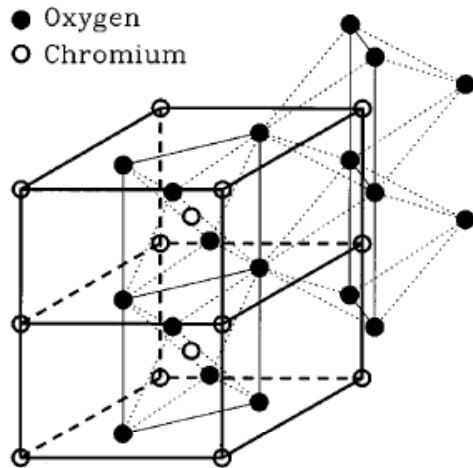


Tip#011



# Introduction to CrO<sub>2</sub>

CrO<sub>2</sub> is a half metallic ferromagnetic with  $T_c \approx 395\text{K}$ . It has tetragonal rutile structure with lattice parameters  $a=0.4422\text{nm}$  and  $c=0.2917\text{nm}$ , like TiO<sub>2</sub> with  $a=0.4952\text{nm}$  and  $c=0.2959\text{nm}$



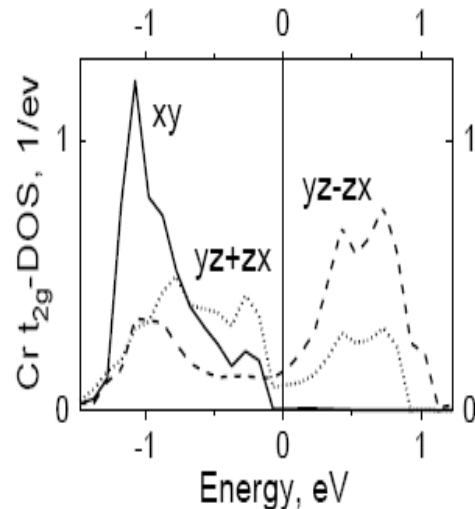
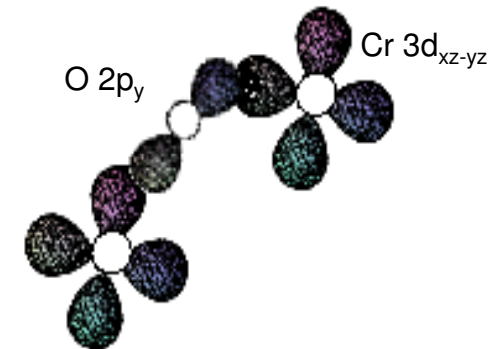
a axis mismatch

- b/w CrO<sub>2</sub> and TiO<sub>2</sub> = -3.7%
- b/w CrO<sub>2</sub> and Al<sub>2</sub>O<sub>3</sub> = -7.1%

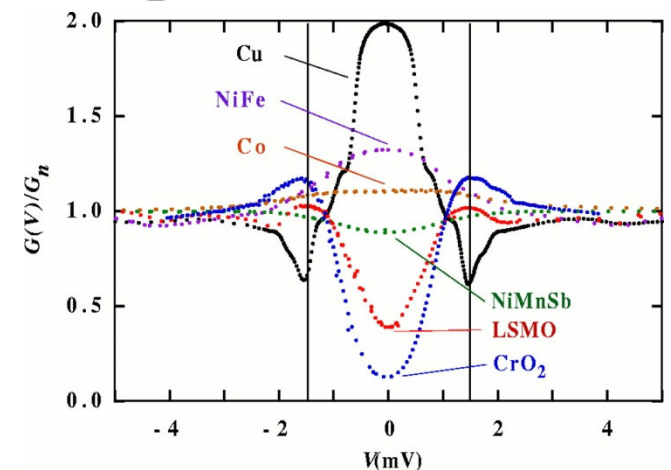
Cr<sub>2</sub>O<sub>3</sub> is an antiferromagnetic with  $T_N \approx 307\text{K}$ . It has hexagonal structure like Al<sub>2</sub>O<sub>3</sub> with lattice parameters  $a=0.4951\text{nm}$  and  $c=1.3566\text{nm}$

a axis mismatch

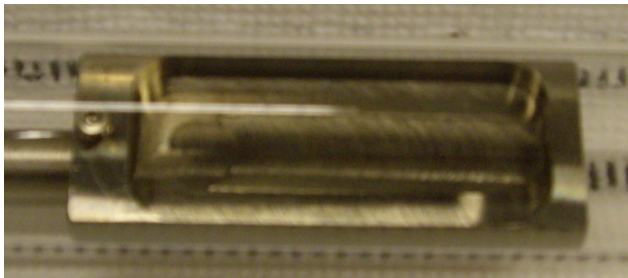
- b/w Cr<sub>2</sub>O<sub>3</sub> and Al<sub>2</sub>O<sub>3</sub> = 4%
- b/w CrO<sub>2</sub> and Cr<sub>2</sub>O<sub>3</sub> = -10.7%



CrO<sub>2</sub> exhibits self doped double exchange, which is responsible for half metallic behavior. It has observed theoretically and experimentally that CrO<sub>2</sub> has 100% spin polarization



# Deposition Setup



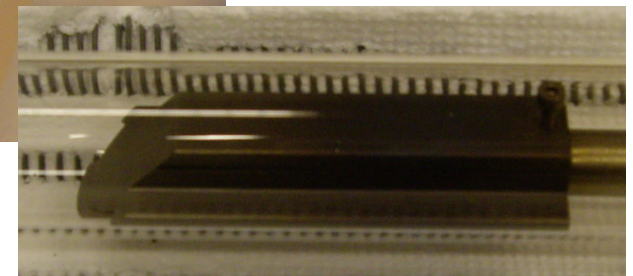
Precursor Boat



Furnace  
(250°C)

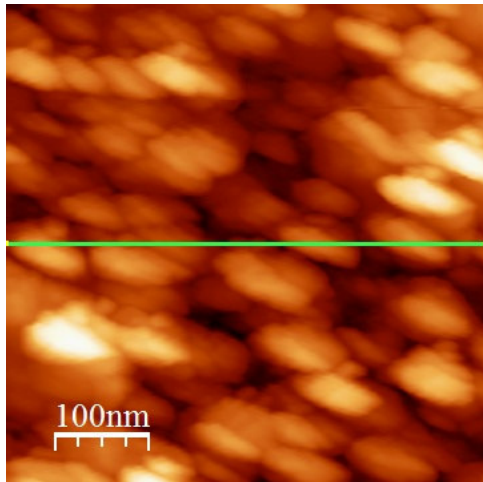
Substrate Holder

Borosilicate Glass  
Tube

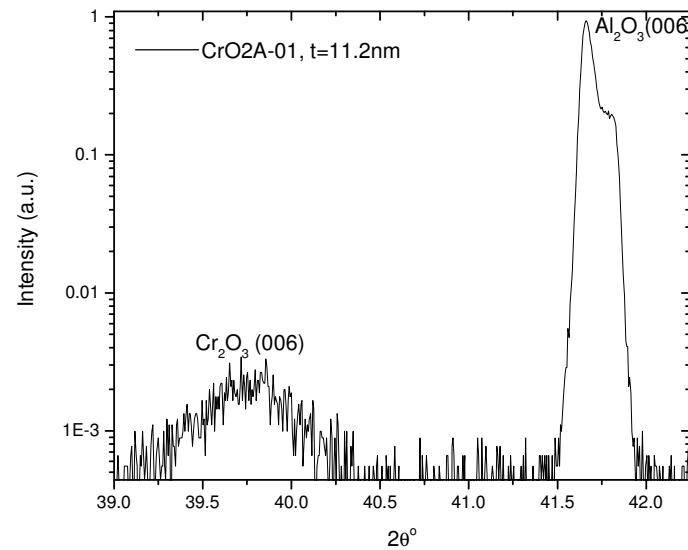
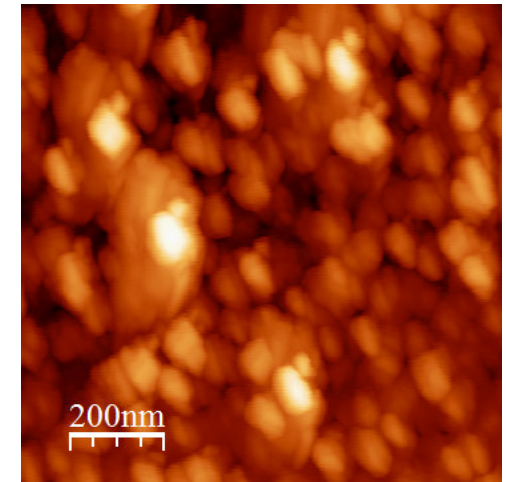




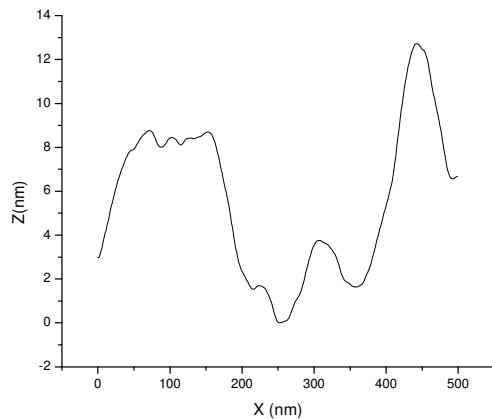
# AFM and XRD analysis



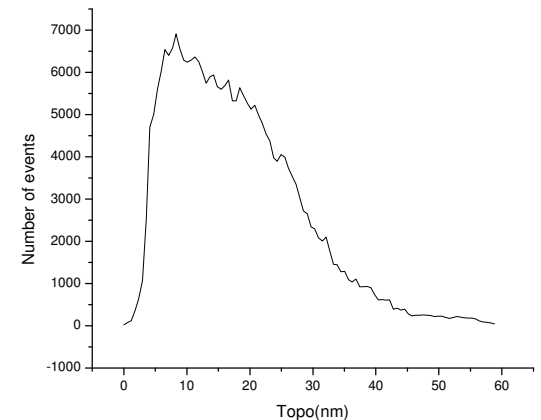
CrO<sub>2</sub>A-01  
Precursor Temp. 260 °C  
Substrate Temp. 400 °C  
O<sub>2</sub> flow 100sccm  
Deposition Time: 30min

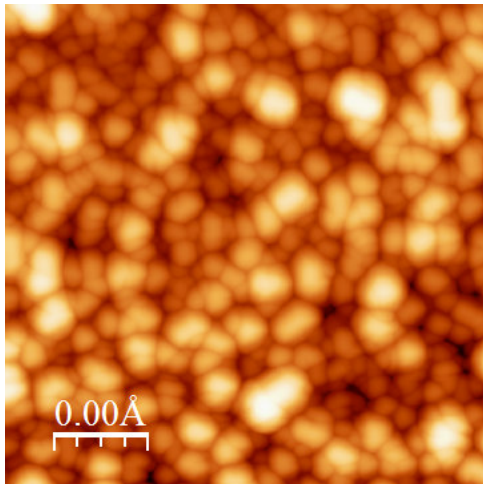


RMS Roughness = 10.1747nm  
Average Height = 18.1997nm

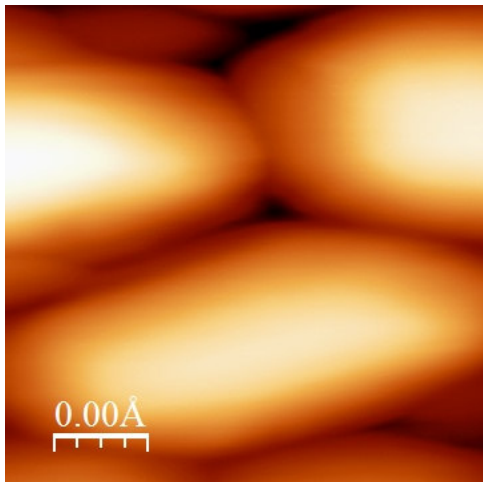
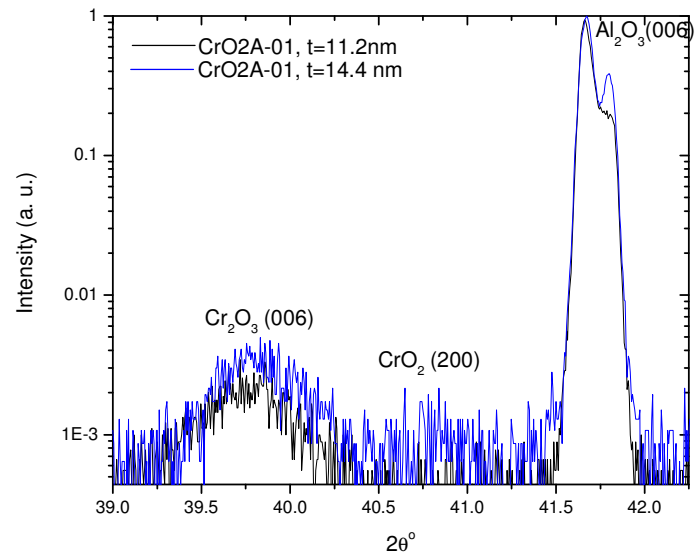
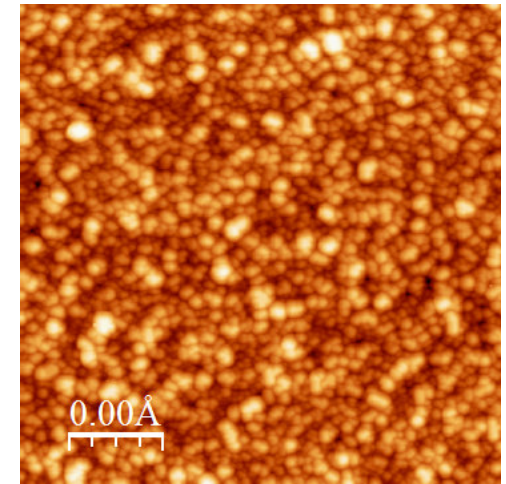


Thickness measured by XRD = 11.2nm  
Roughness = 2.4nm

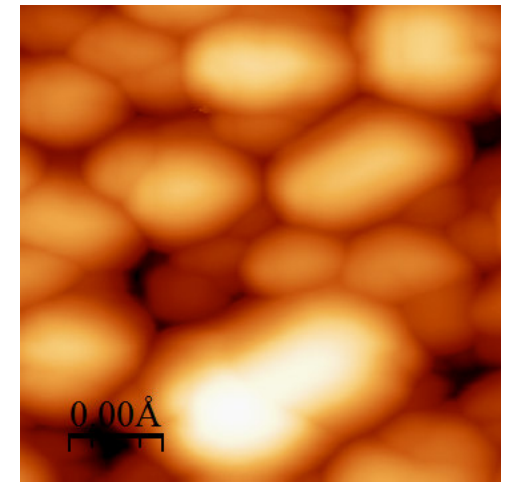


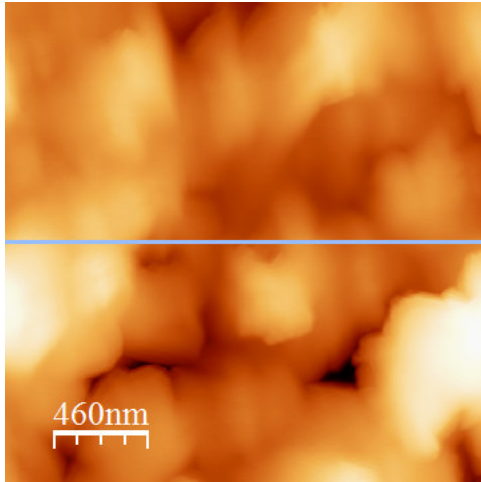


CrO<sub>2</sub>A-03  
Precursor Temp. 260 °C  
Substrate Temp. 390 °C  
O<sub>2</sub> flow 100sccm  
Deposition time: 60min

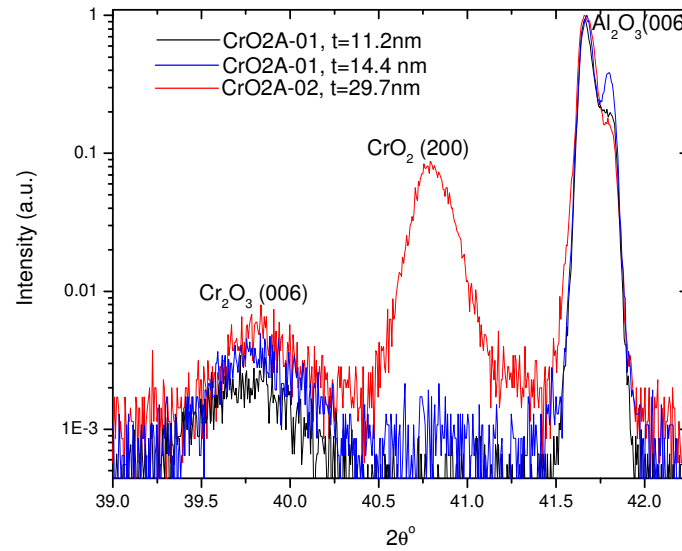
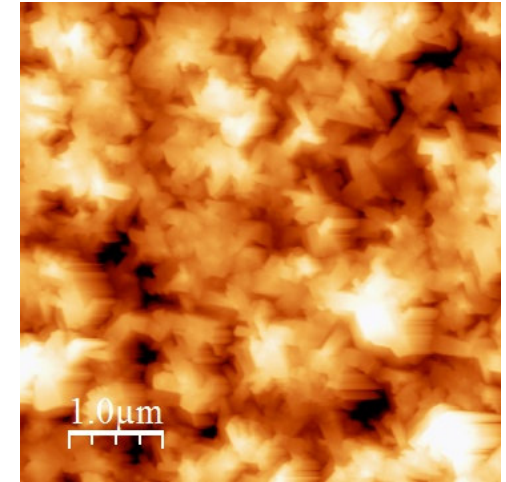


Thickness measured by XRD = 14.4nm  
Roughness = 2.6nm

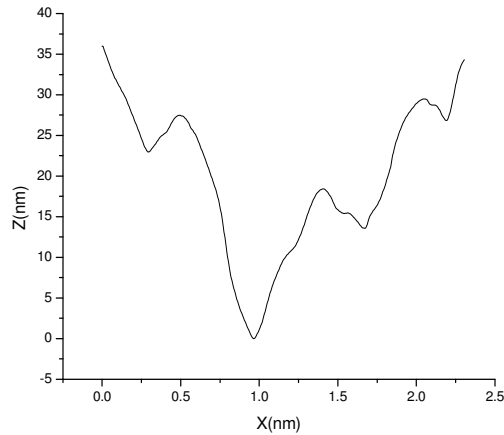




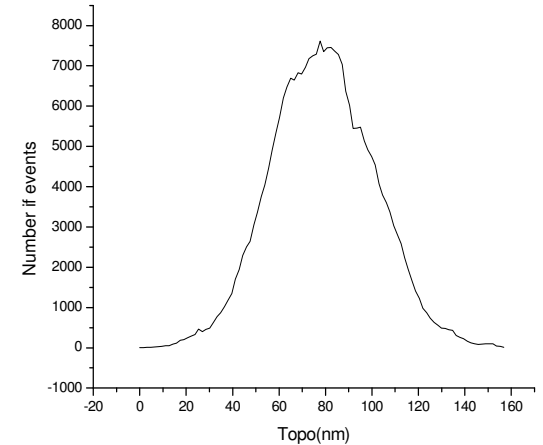
CrO<sub>2</sub>A-02  
 Precursor Temp. 260 °C  
 Substrate Temp. 390 °C  
 O<sub>2</sub> flow 100sccm  
 Deposition Time: 150min

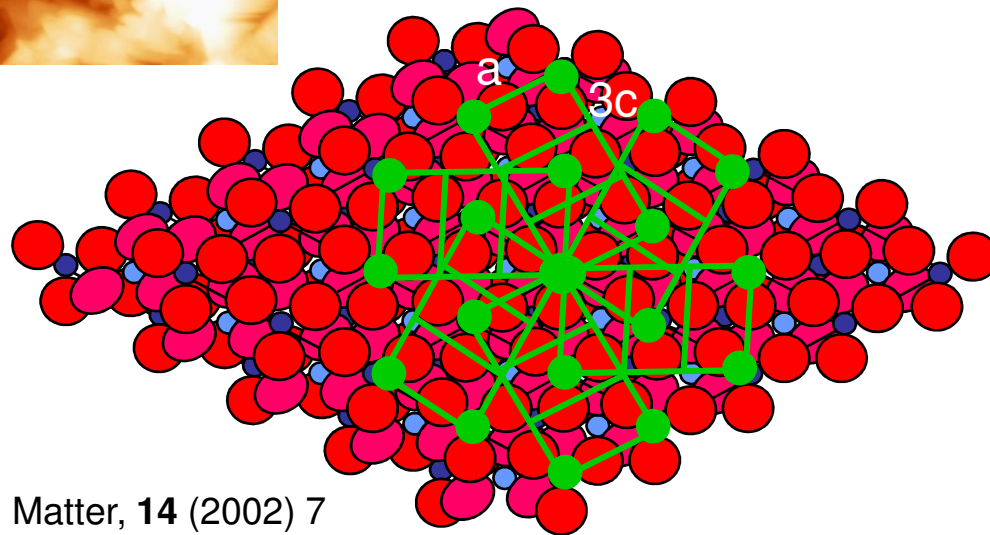
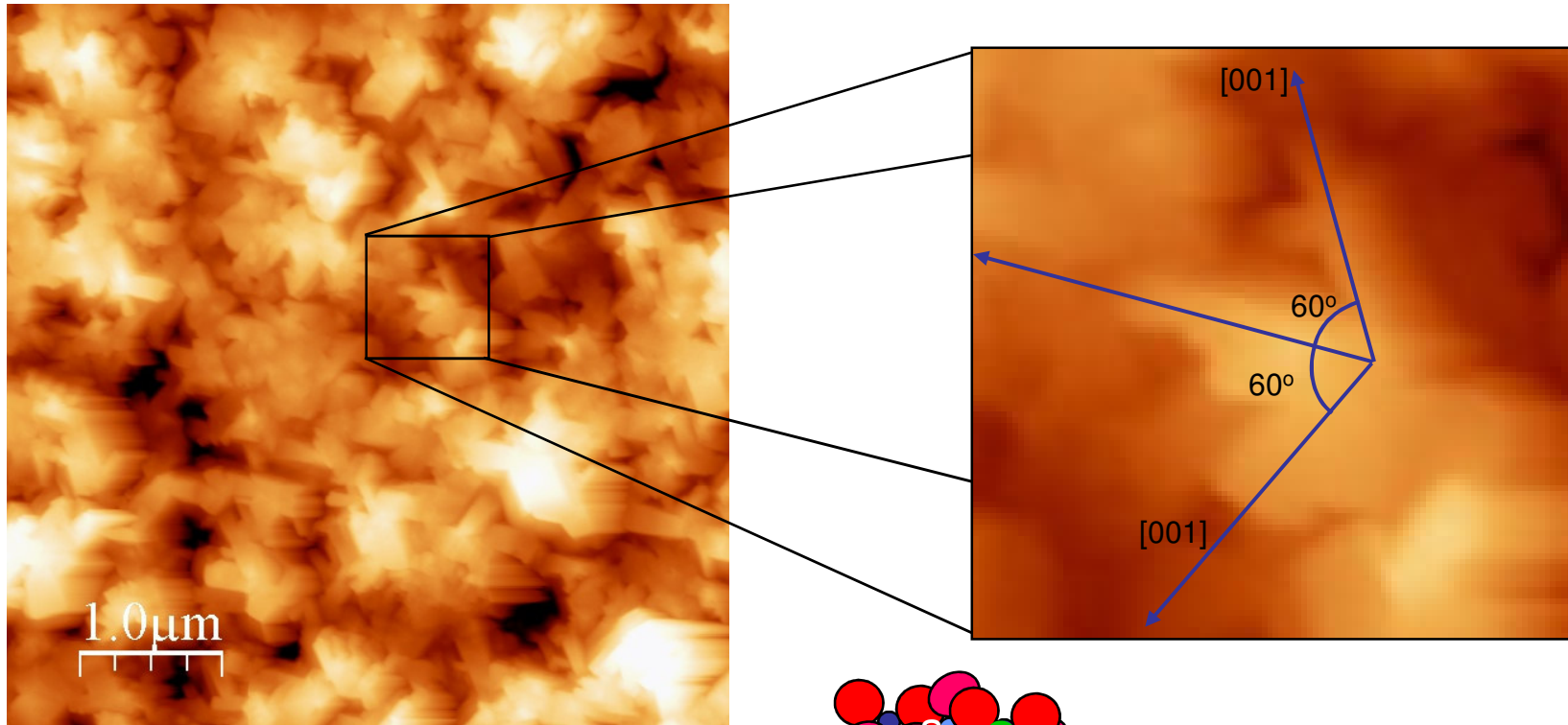


RMS Roughness = 22.0224nm  
 Average Hight = 79.6733nm



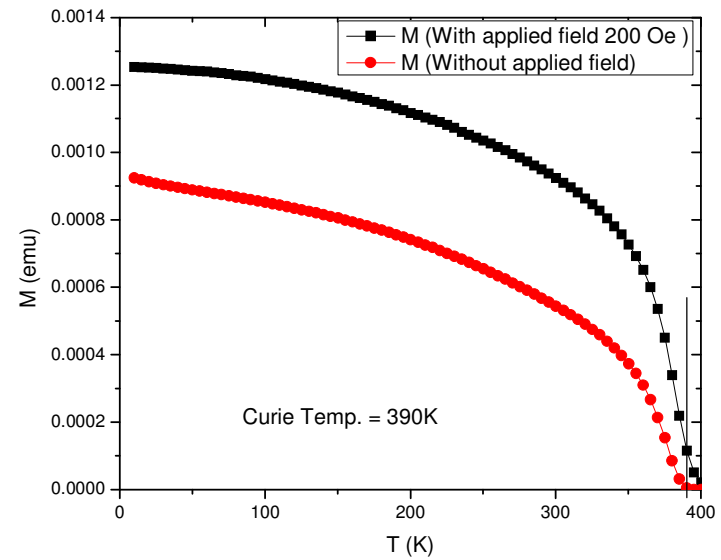
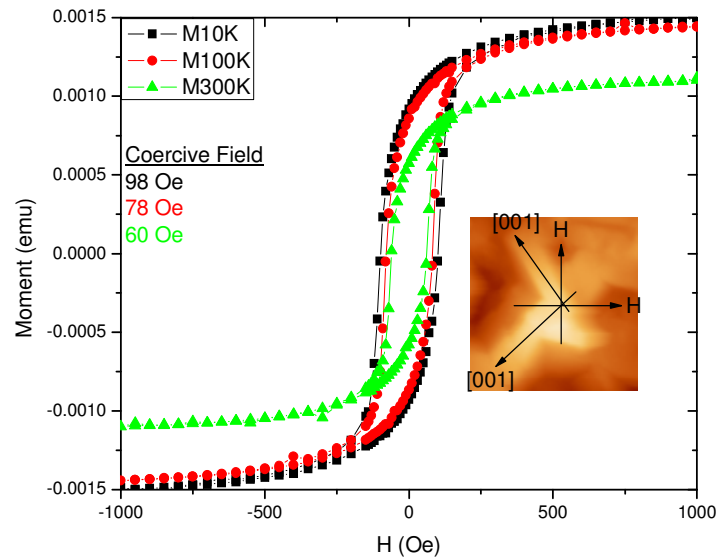
Thickness measured by XRD  
 CrO2 thickness = 14.8nm,  
 Roughnes = 4.6nm  
 Cr2O3 thickness = 14.9nm  
 Roughness = 4.4nm



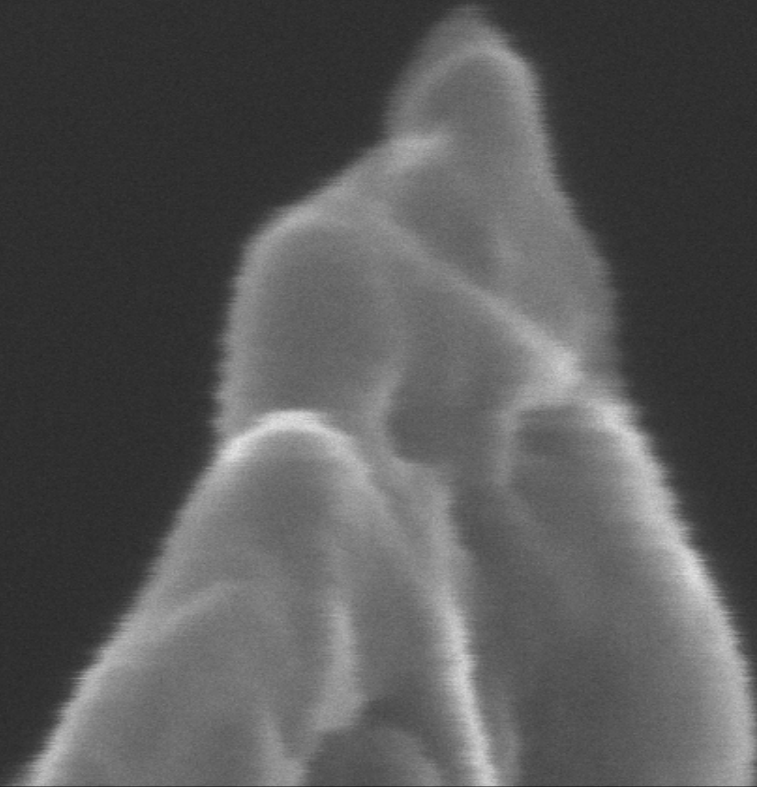




# SQUID Measurements



**Happy Eid Mubarik  
and  
Merry Christmas to all in Advance**



	HV	mag	dwell	WD	spot	curr	pressure	mode	← 40 nm →
	15.00 kV	1 000 000 x	24 $\mu$ s	5.0 mm	3.0	88 pA	1.21E-8 bar	SE	