First Attempt to Use Conductive AFM for chemical nanocharacterizing

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X-tip Workshop, Grenoble Nov. 2005

The aim of presentation

- The scanning capacity microscopy (SCM) method fills one of the workpackages of the X-tip project. It needs testing and demonstration samples.
- The aim of this presentation is to show the first results of laboratory experiments with conductive atomic force microscopy (cond-AFM), which hopfully helps to choose and characterize such kind of samples.

The samples we can prepare and use

•Firstly, we obtained a conductive AFM option for our SPM, which has a testing sample for the SCM.

•Secondly, we have technique for preparation thin and ultrathin metal oxide layers using atomic layer deposition method: Al_2O_3, TiO_2, ZrO_2, HfO_2, SnO_2, Cr_2O_3.

We can vary film growth conditions, precursors and substrates, which all may vary the crystallinity, morphology and composition (residual compounds) of the film material.

•Thirdly, we can grow nanocrystalline metal films on different substrates using thermal evaporation: Ag, Au, Pt.

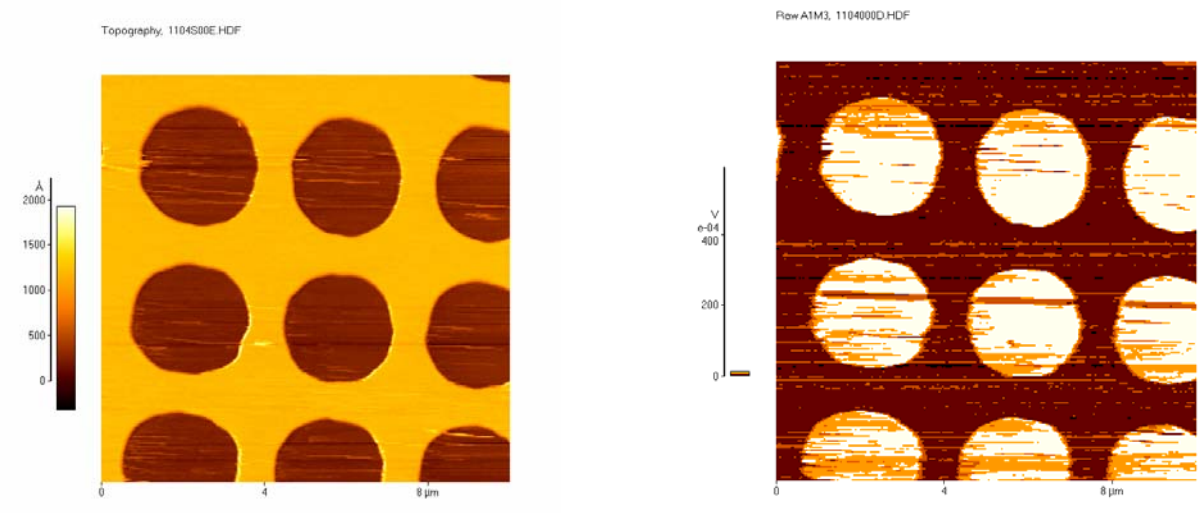
•Fourthly, we can prepare thin films of conductive polymer on metal substrate using electrochemical deposition and direct the structure of the film through deposition parameters.

Cond-AFM results: equipment

We used multifunctional AFM AutoProbe CPII (Veeco) upgraded for cond-AFM, measuring currents from 1pA to 10 mA with tip/sample potential ±10 V, and used Pt/Ir coated probes (SCM-PIC, Veeco).

Cond-AFM results: testing sample

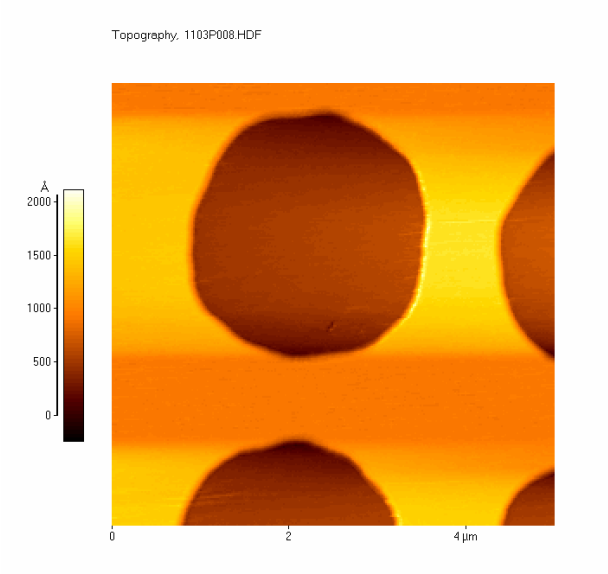
SCM testing sample of Veeco

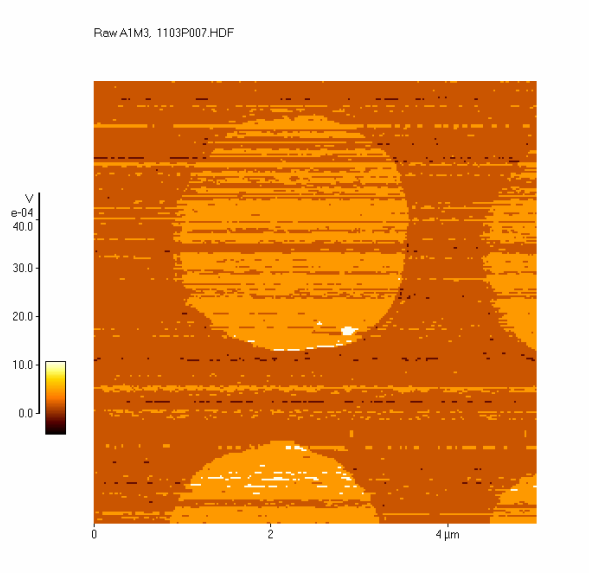


Really we are measuring potential on 10 MΩ resistor and are using amplification of from 10^4 to 10^9 for low noise mode and from 10^5 to 10^{10} for high voltage mode.

. . . Cond-AFM results: testing sample

…more

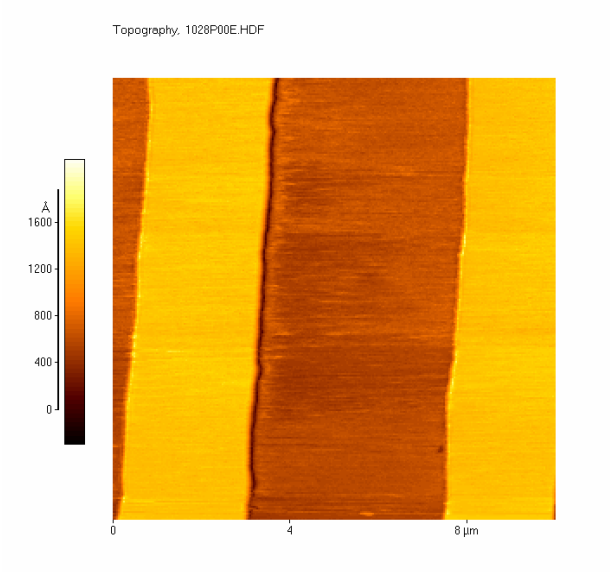


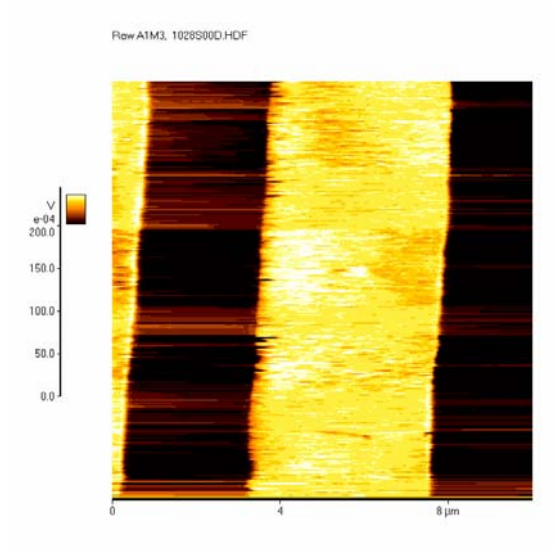


Note the noise level!

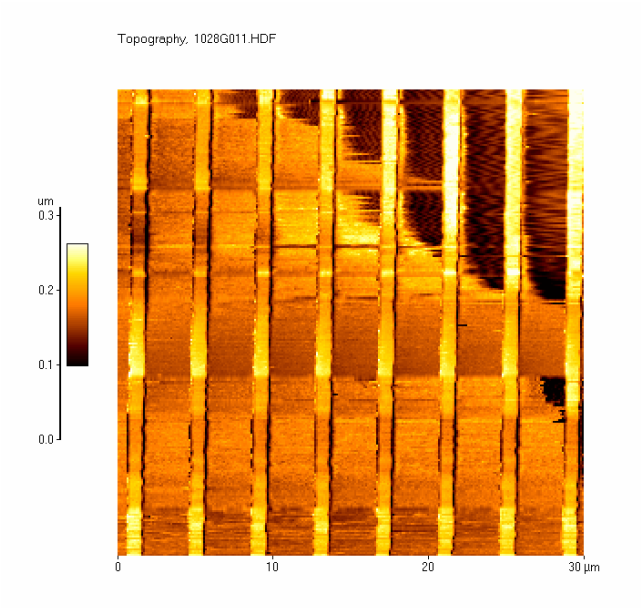
. . . Cond-AFM results: testing sample

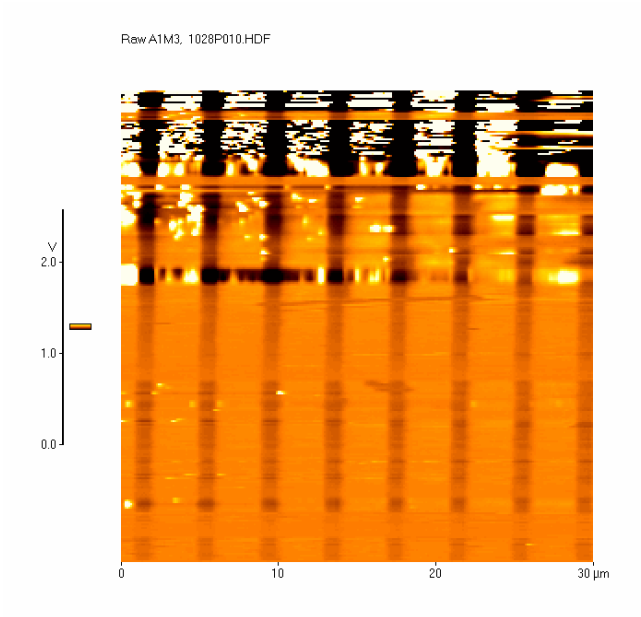
…more



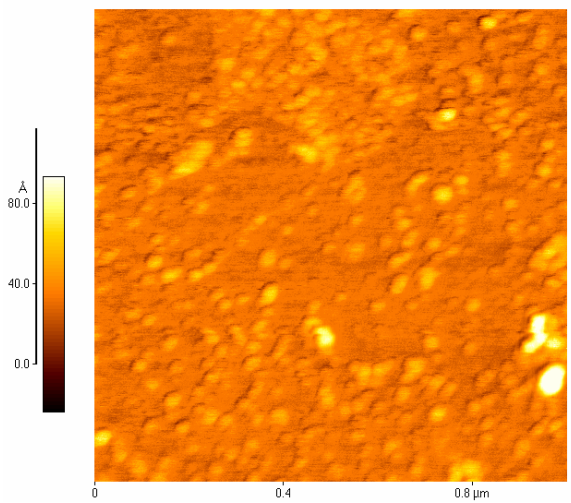


. . . Cond-AFM results: testing sample





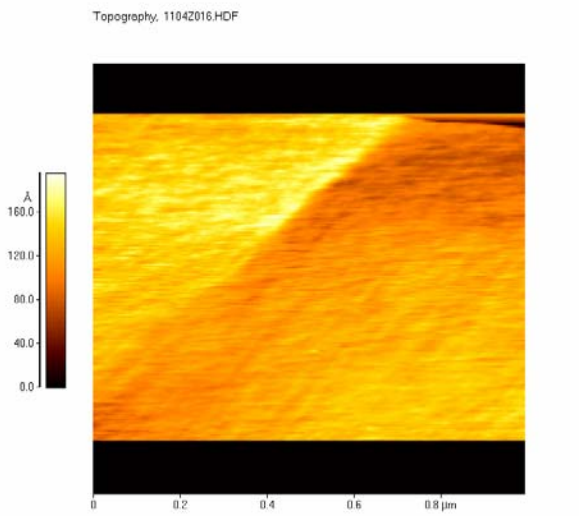
Cond-AFM results: HfO_2/Si sample

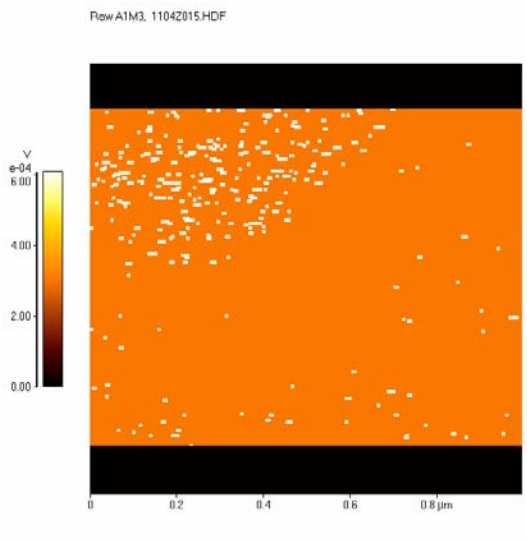


HfO_2 ultrathin amorphous film (~ 2 nm) prepared with ALD at 300ºC, using $HfCl_4$ and H_2O precursors and 4 growth cycles. The film is probably noncontinuous (island like).

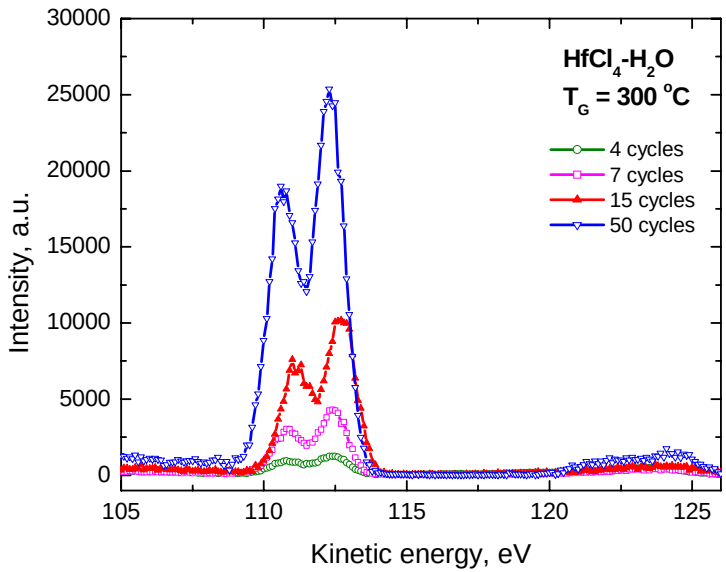
…Cond-AFM results: HfO_2/Si sample

The very first results of cond-AFM on oxide film. Data obtained with a Pt-Ir coated cantilever.



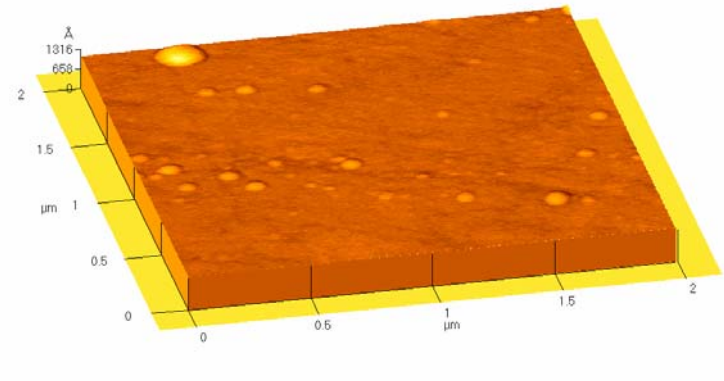


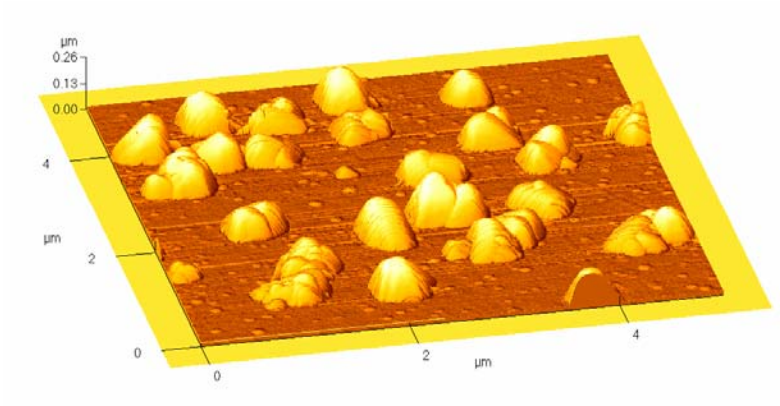
SPEM results: HfO_2/Si sample

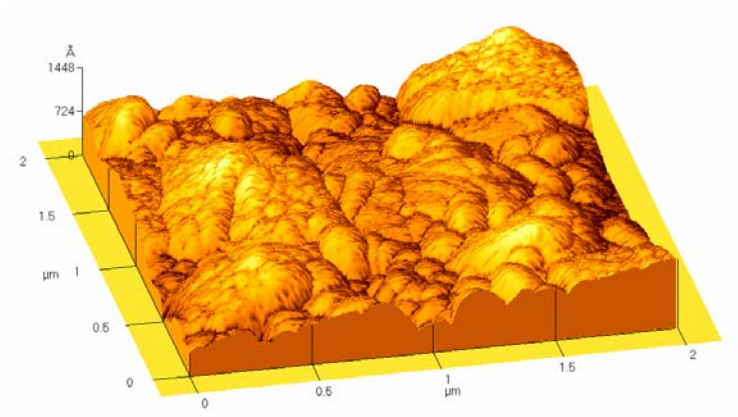


SPEM, BL-31 of MAX-lab, Lund

Discussions: TiO_2 films







AFM images of TiO_2 thin films deposited on GaAs in (a) 100 and (b) 300 and (c) 3000 cycles.

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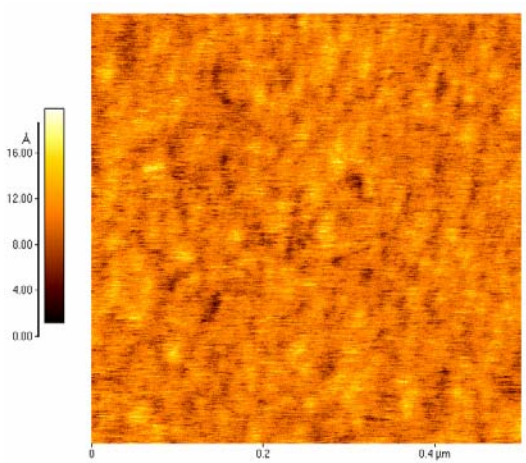
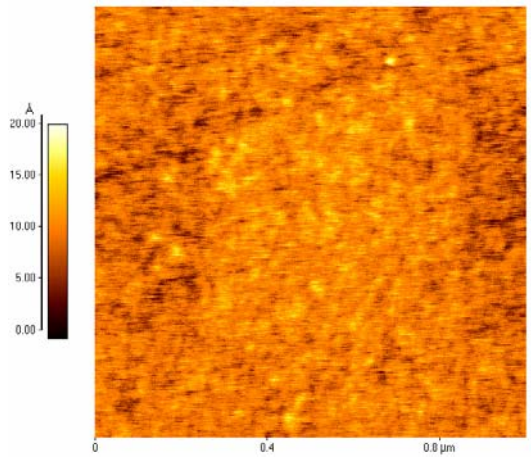
Discussions: Pre-treated ($HF+H_2O$) Si-substrate

0.5x0.5 µm;
1.8 nm;

RMS=0.17 nm



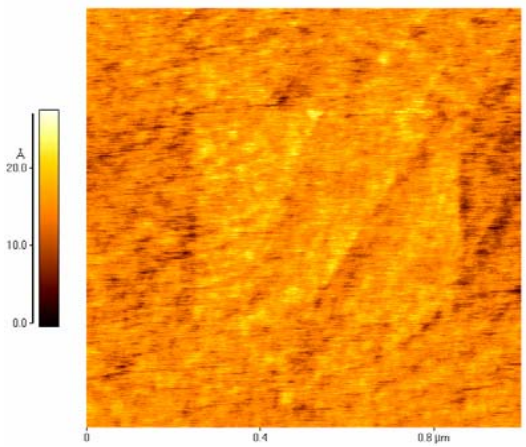


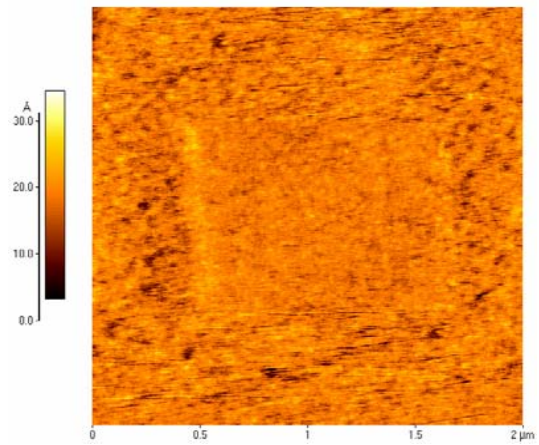
1x1 µm; 2.1 nm

RMS=0.2 nm

1x1 µm; 2.7 nm

RMS=0.24 nm





2x2 µm; 3.2 nm

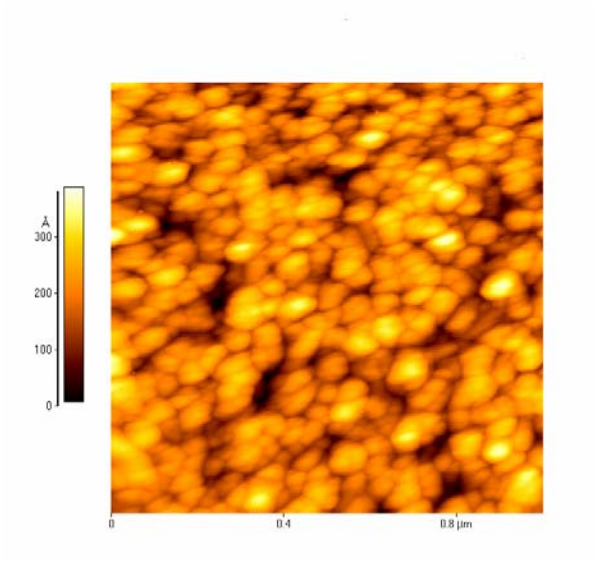
RMS=0.26 nm

after 0.5 h

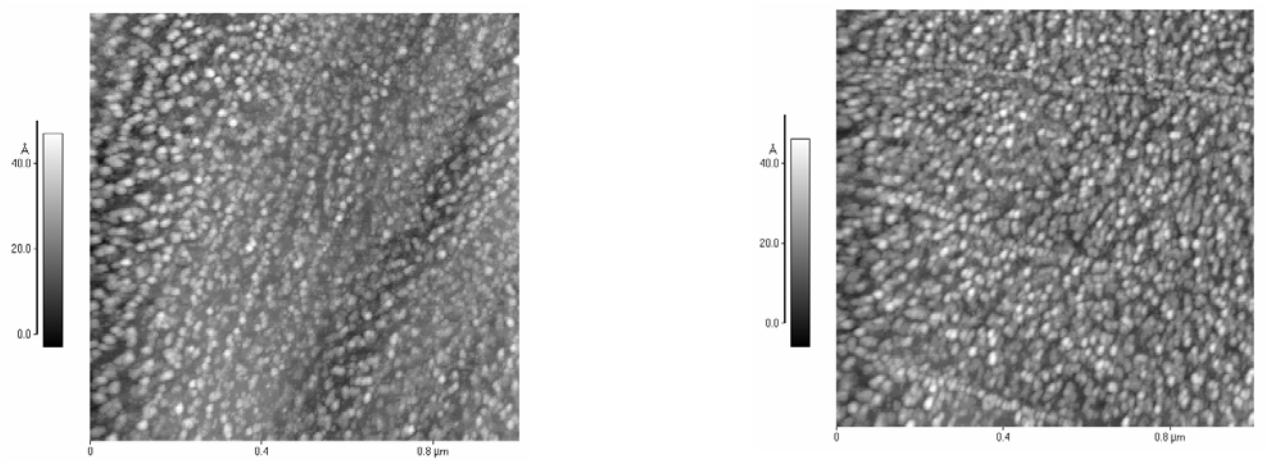
after 1.5 h; new place

Cond-AFM Results: SnO_2/Si sample

SnO_2 ultrathin amorphous film (~ 10 nm) prepared with ALD at 300ºC, using $SnCl_4$ and H_2O_2 precursors and 300 growth cycles. The film is nanostructured).



Sample preparation



Metal (Ag) ultrathin film on HOPG, ~0.3nm (left) and ~0.5 nm(right).