RAPME 2014
VCU Research with Nanomagnets and Nanowires

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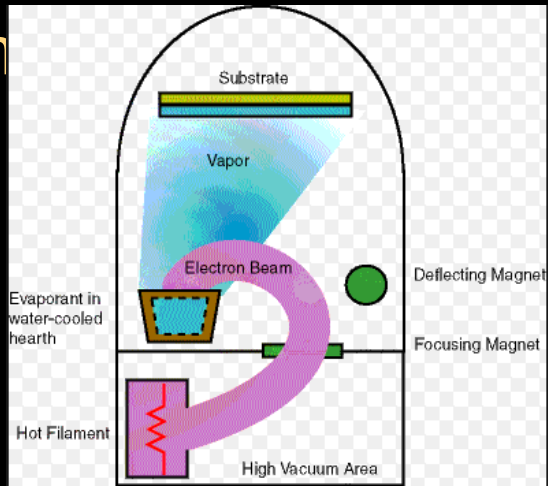
Top-Down Approach

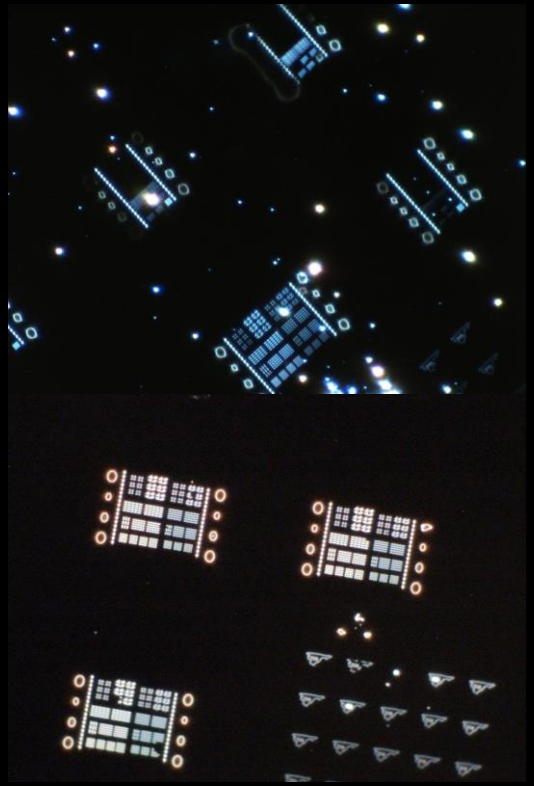
- Fabrication
- CAD designs - Computer-aided designs
- PMMA on the silicon wafer
- Electron beam lithography - electrons are bombarded on the silicon wafer to create the designs. Electrons pierce through the PMMA layer.

Electron-Beam Deposition

- 5nm of titanium and 10nm of cobalt.
- The material is heated in a high vacuum area.
- Then the electron beam is focused with magnet and curved with a deflecting magnet.
- The electron beam are vaporized in the water-cooled hearth, and then it is deposited on the substrate.
- Lift off in acetone and then sonication

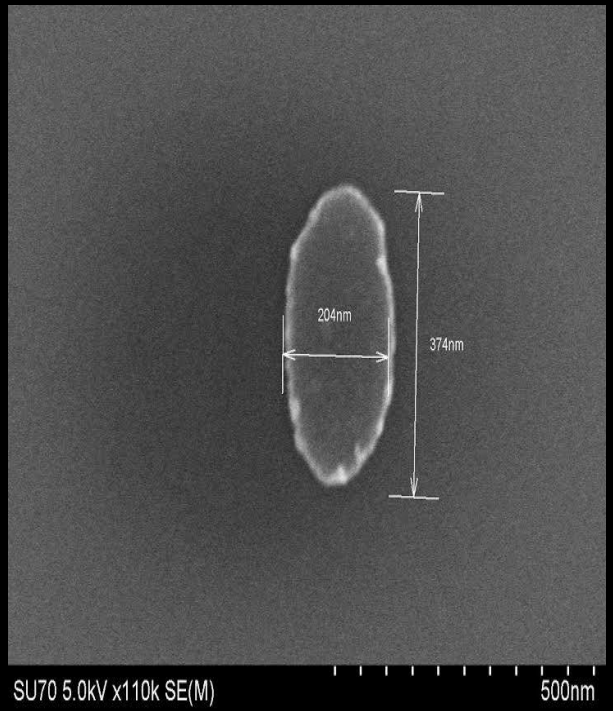


Microscopic Images - Optical Microscope



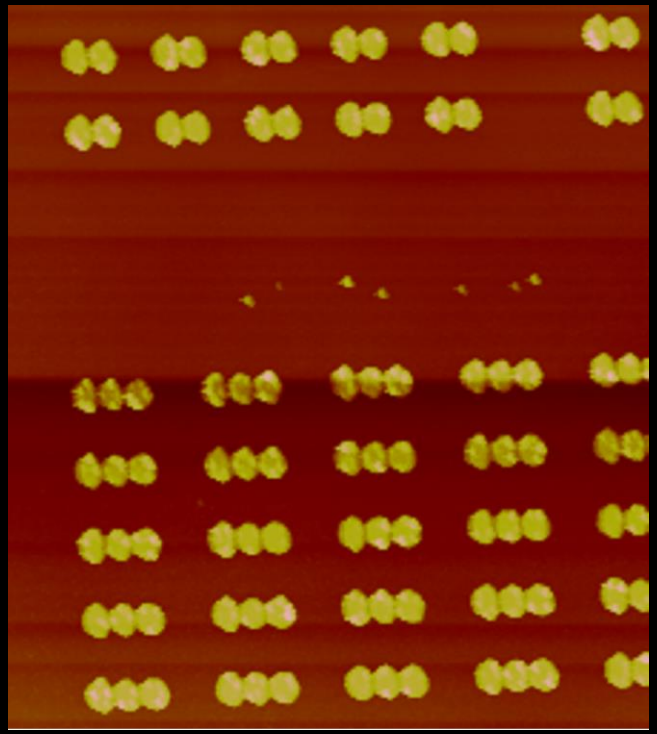
- Magnets
- Markers
- Dust Particles
- Dark Field Image
- Electron-beam lithography
- Electron-beam deposition

Microscopic Images - SEM



- Scanning Electron Microscope
- width - 204 nm
  Height - 374 nm

Microscopic Images - AFM



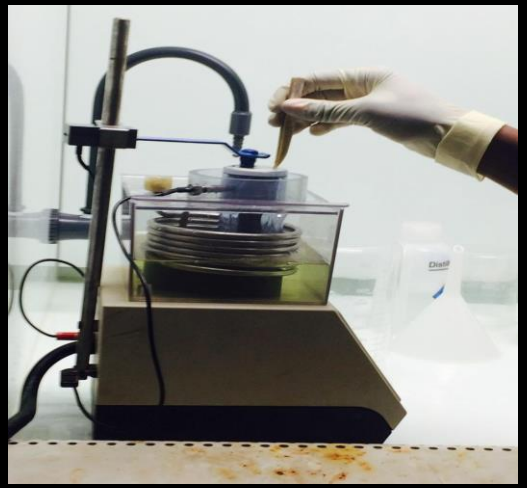
- Atomic Force Microscope
- Used to find 3D images.

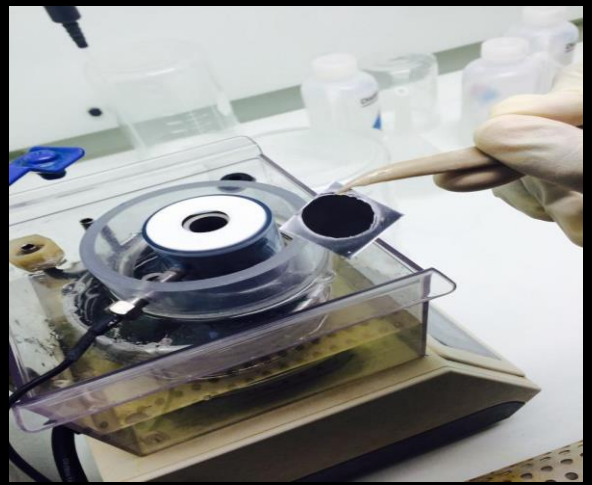
Bottom-Up Approach

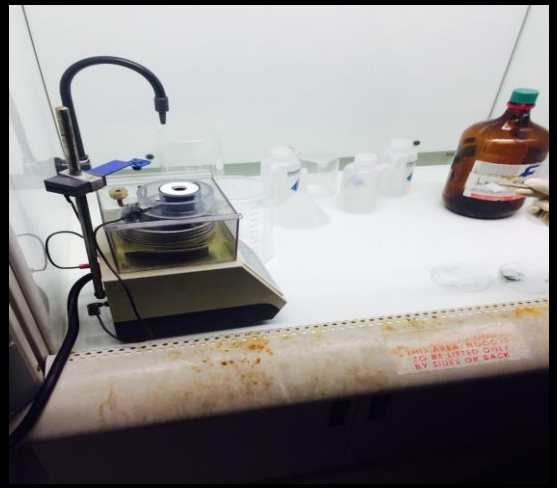
- Describes how molecules interact with each other forming a type of disorder
- Steps taken:
  - electropolishing
  - anodization
  - etching / characterization
  - metal deposition
  - EDAX, VSM, SEM

Electropolishing

- Making the surface smooth

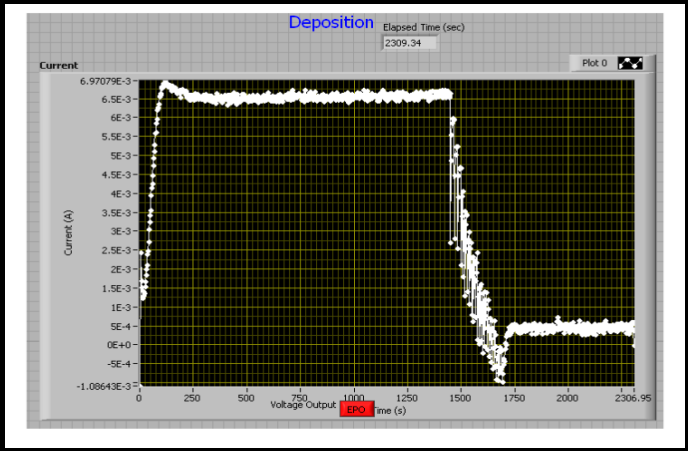






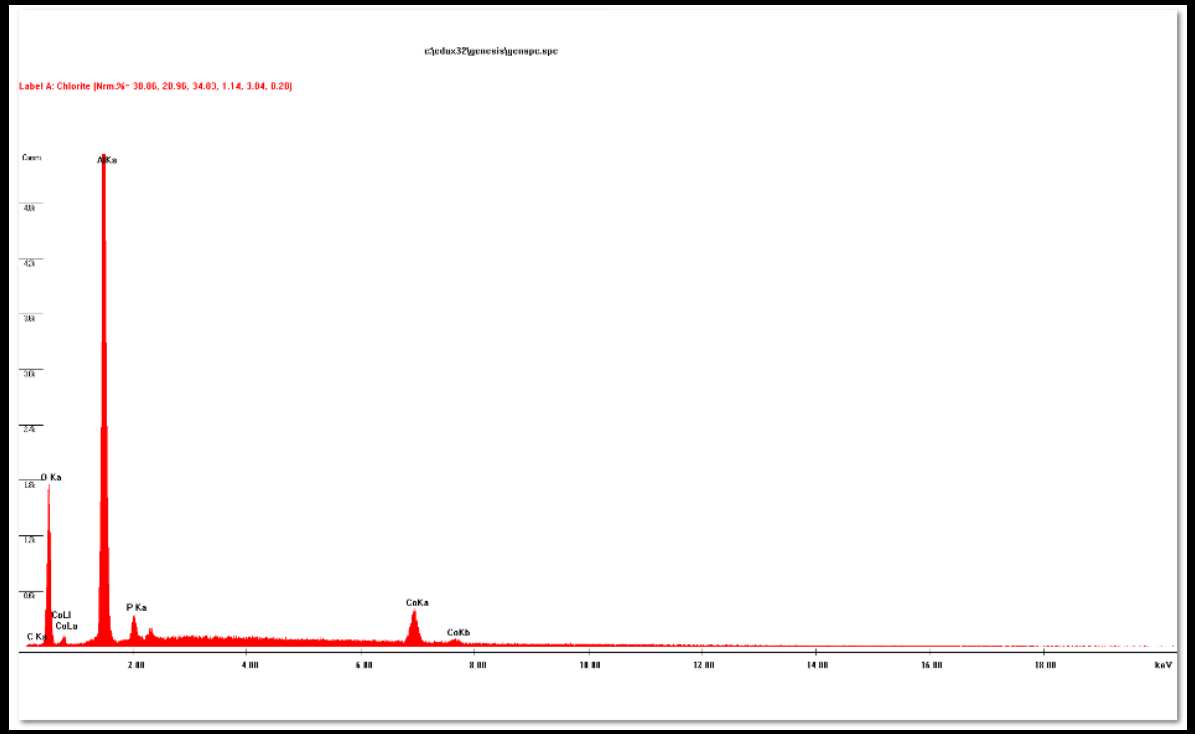
Anodization

- Consists of two types of deposition - AC and DC
- Four different samples used



EDAX

- Graph

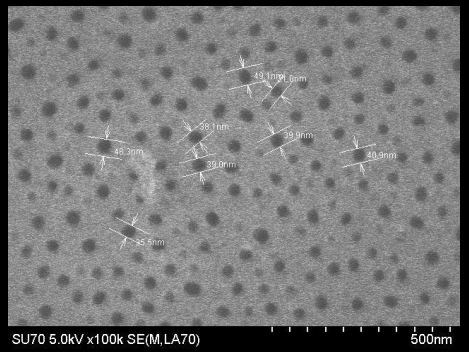

c:\edax32\genesis\genspc.spc
Label A: Chlorite (Nrm.%= 30.86, 20.96, 34.03, 1.14, 3.04, 0.20)
AlKa
O Ka
CoLl
CoLa
C Ka
P Ka
CoKa
CoKb
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
keV

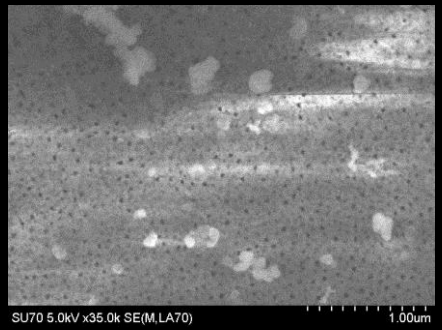
Characterization

Characterization consists of SEM imaging (normal imaging, etching rate, pores, multistep, top view, and clouds) and also VSM imaging (the existence of magnetic movement).

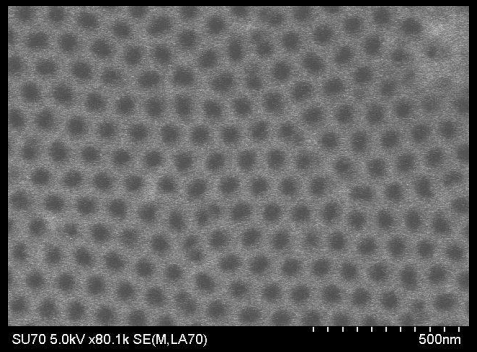
Characterization: SEM Imaging

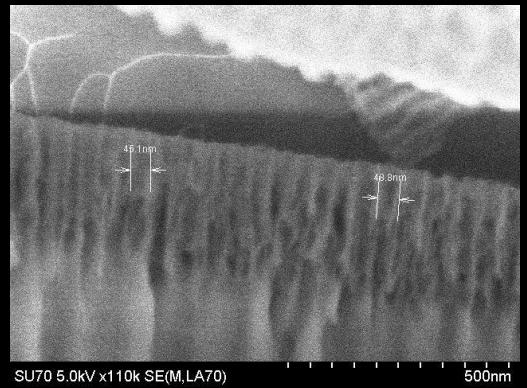
sample 1





sample 4

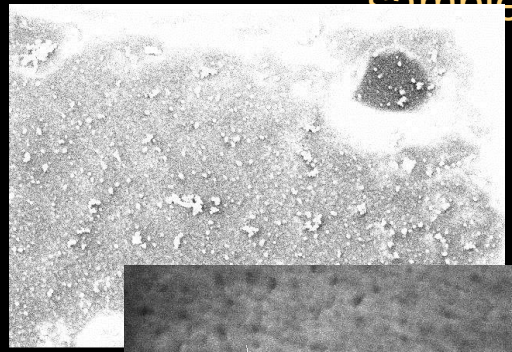


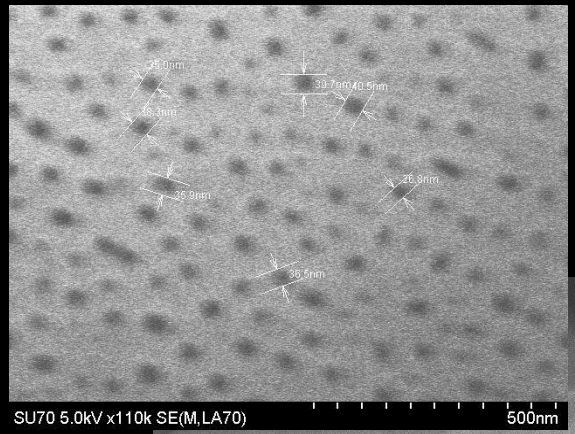


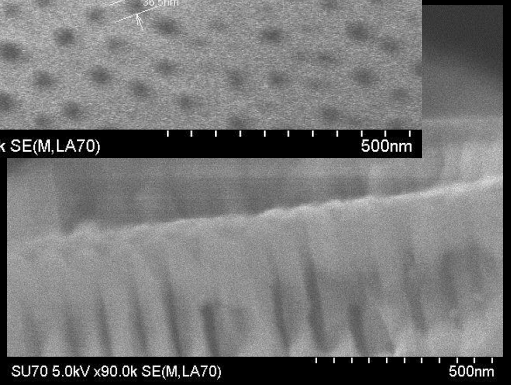
Characterization: SEM Imaging

sample 2

sample 3



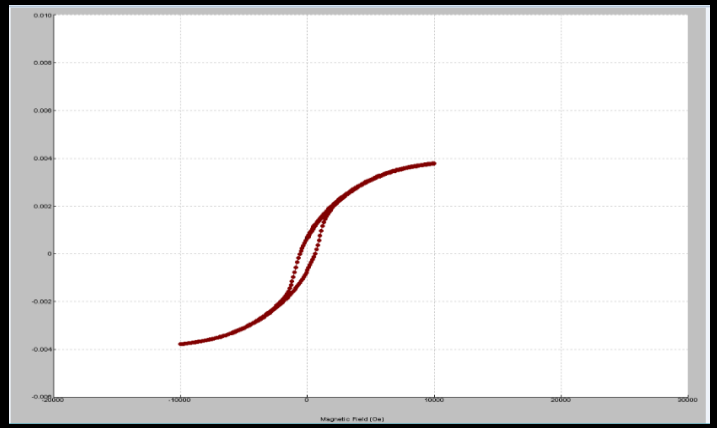




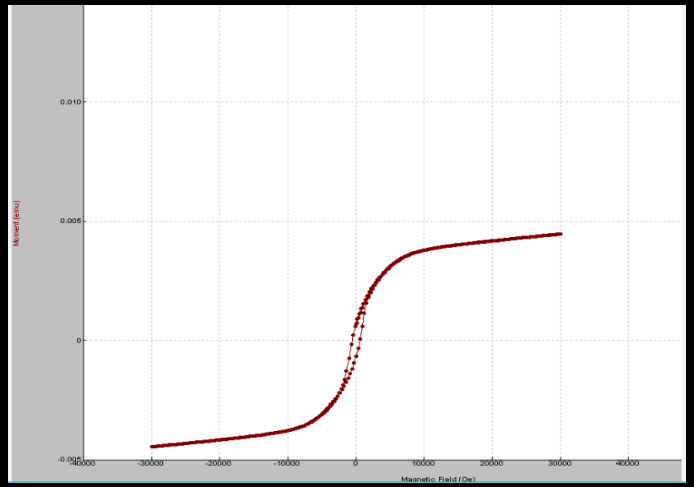
Characterization: VSM Imaging

- Hysteresis Loop with 4 different tests

zero to 10K to -10K to 10K



test for 30K (three times as fast)

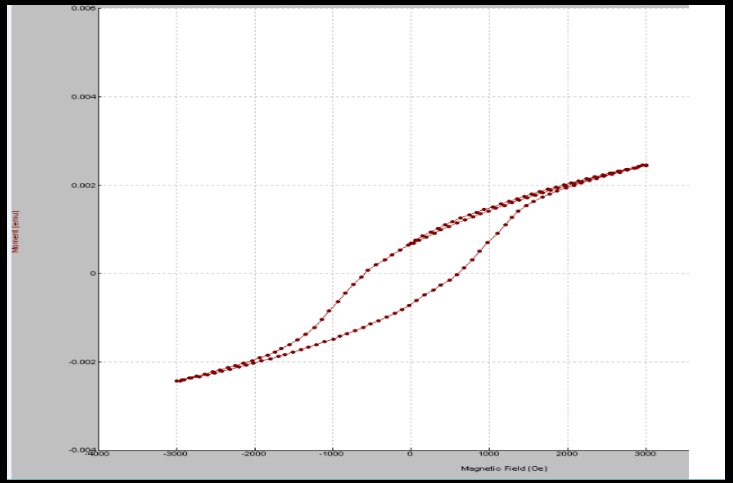


Characterization: VSM Imaging

samples cont:

0 to 3K to -3K to 3K

test w/o sample



Nanowires and the Physics Behind It

Main Purpose and Objective: To position the nanowires in specific regions and test the mechanical properties.

The Process:

1. Develop a wafter through the fabrication process and use Electron Beam Lithography (EBL) as an addition in the process.

Nanowires Physics Cont.

2. Conduct dielectrophoresis (control the position of nanowires with the use of a function generator) as part of a nanowire solution. In result, you should get nanowires that bridge the electrodes.
3. Conduct SEM or Scanning Electron Microscopy to locate points of where the nanowires are present.

Nanowires Physics Cont.

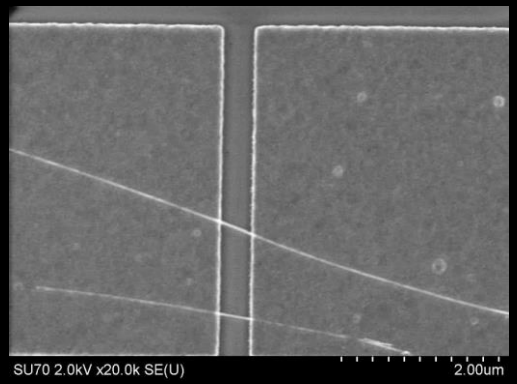
4. Once the locations of the nanowires are found, conduct AFM or Atomic Force Microscopy.
5. Finally, conduct different steps of Lithiation to find and test the strength of nanowires also known as Young’s Modulus.

Nanowires Physics Cont.

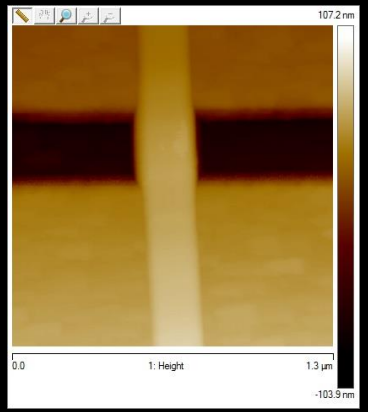
Note: There are different nanowire experiments with different parameters as well.

Depends primarily on the experimenter and what materials he/she decides to use.

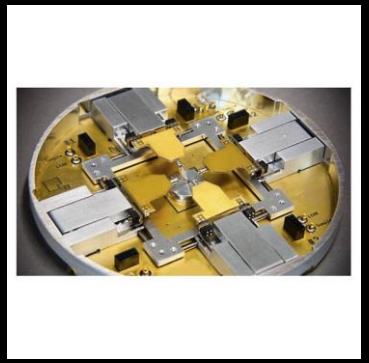
Nanowires Physics Cont.



SEM Image of Nanowires



AFM Image



Manipulator Robot we used to get measurements of our sample chip in the SEM.

Reflection- Arindam Gupta

- Got hands on experience with things I never thought I would be able to do.
- Learned a lot of new things and how to apply my Chemistry skills when working on these experiments.
- Made great connections with all 3 Phd students: Mamun, Iftekhar, and Naveen.

Reflection- Harini Mody

- Increased my knowledge of chemical and physical properties of magnets.
- Got practical experience with nanoscale.
- Had a blast working with all the members.

Reflection- Myah Massenburg