



中国科学技术大学微纳研究与制造中心
USTC Center for Micro- and Nanoscale Research and Fabrication

2016 Summer Demonstration

-Electrodes Fabrication by EBL

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2016.7



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Outline

- Goals
- Materials
- Procedures
- Techniques
- Other issues
- F&Q

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Goals

- Present a **whole process** of electrodes fabrication
- Combine **Theory** and **Experiment**
 - Classroom instruction
 - Cleanroom demonstration
- Explain **key roles** in fabrication
- What we can do & what is our **limits**

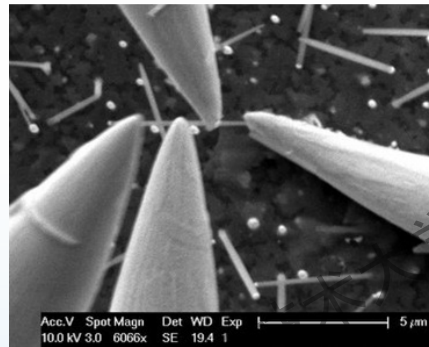


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How to measure electrical properties of nanomaterials?

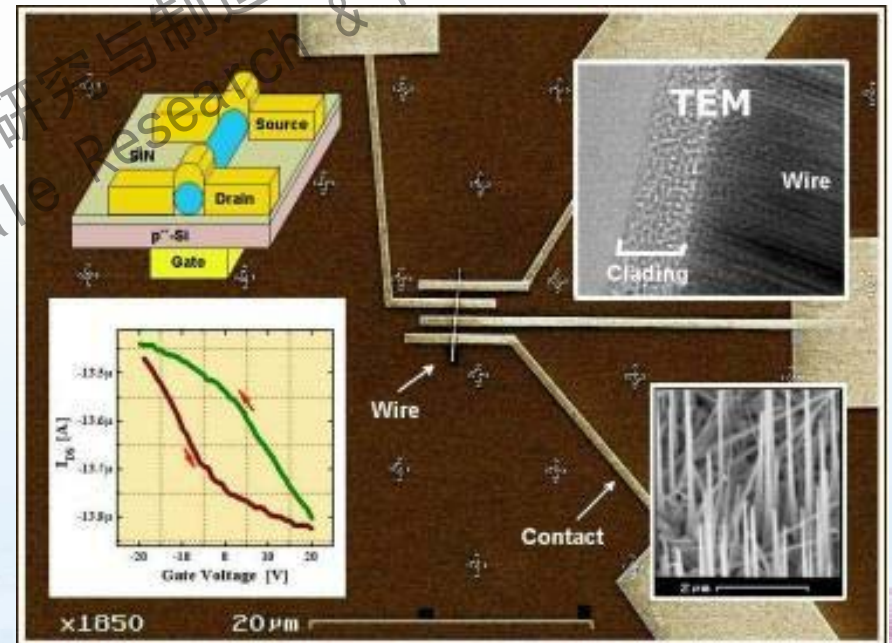
Nanomanipulator

XYZ Nanopositioners



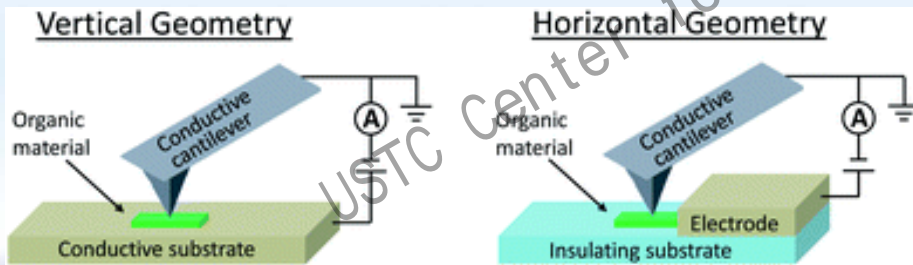
<http://www.azonano.com/article.aspx?ArticleID=3166>

single nanowire field effect transistor



<http://www.ee.bgu.ac.il/~shalish/electronics.html>

C-AFM measurement geometries



J. Mater. Chem. C, 2014, 2, 3118-3128

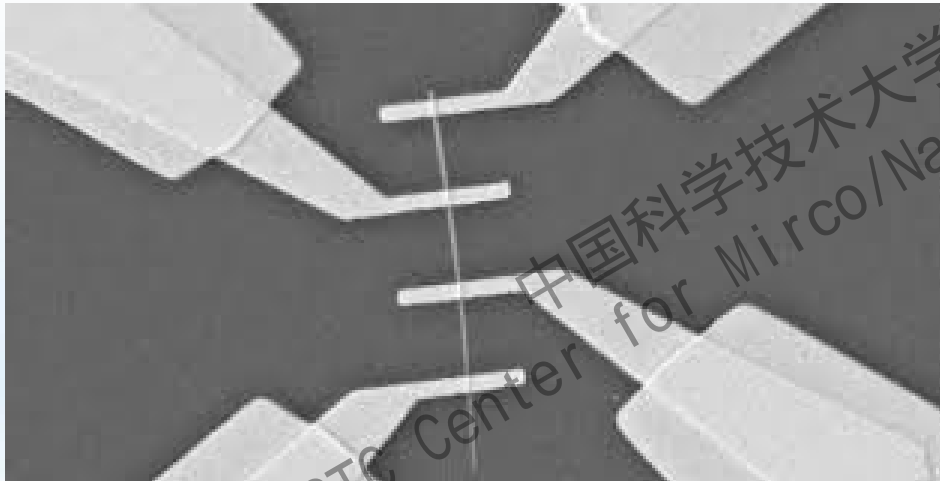


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Nanomaterials Electrical Characterization by electrodes

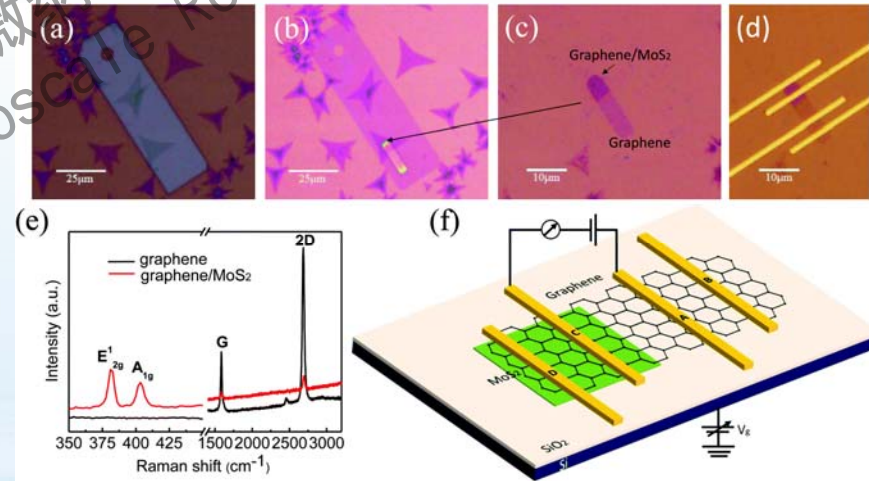
Nanowire

Diameter: ~100nm
Length: >10 μ m



Nanodisk

Thickness ~10nm
Length ~5 μ m



<http://www.swansea.ac.uk/engineering/nanohealth/researchareas/newsensorsdevices/>

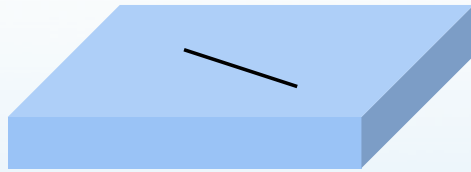
Nanoscale, 2015, 7, 11611-11619



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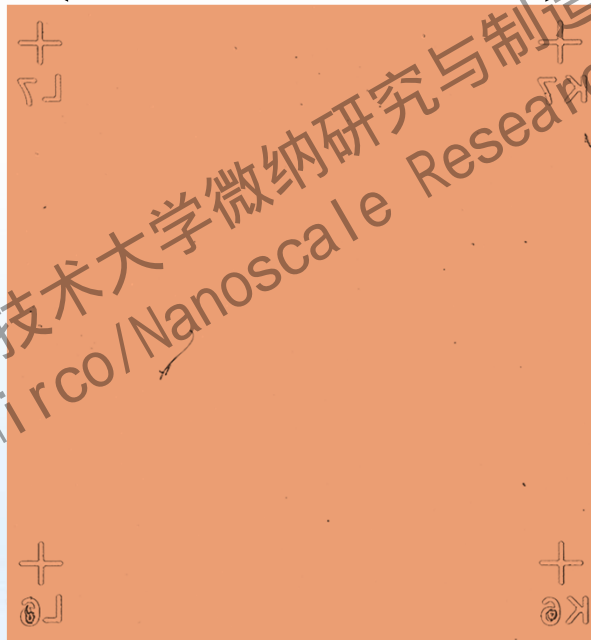
Electrodes Fabrication Procedures

1. Sample Dispersion&Location



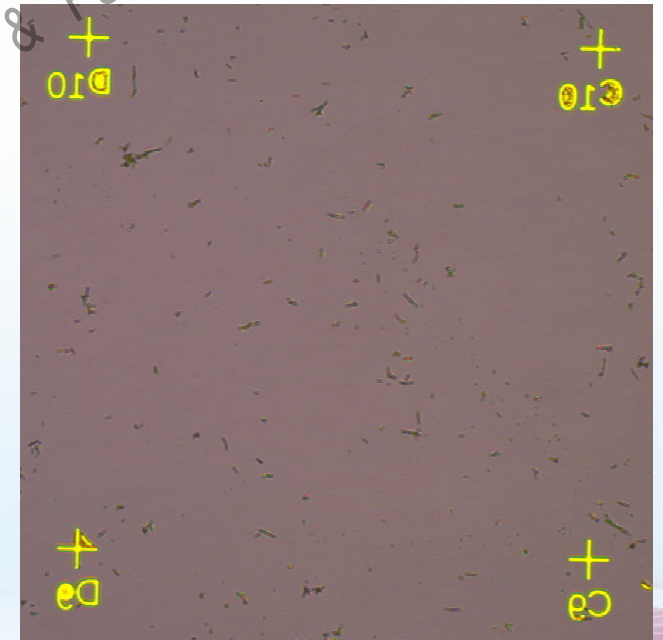
10mmX10mm

500 μ m



Good

1-2 samples in area



Bad

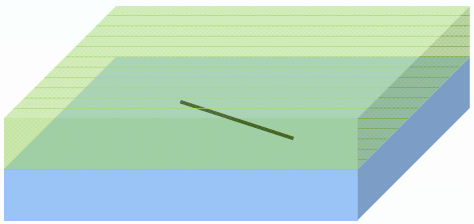
Too many samples in area



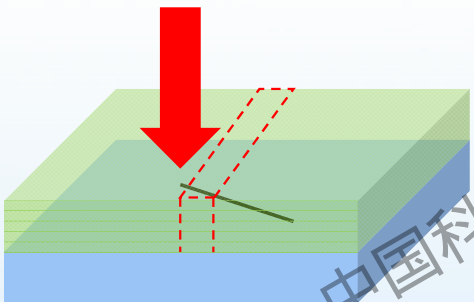
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2. E-beam lithography

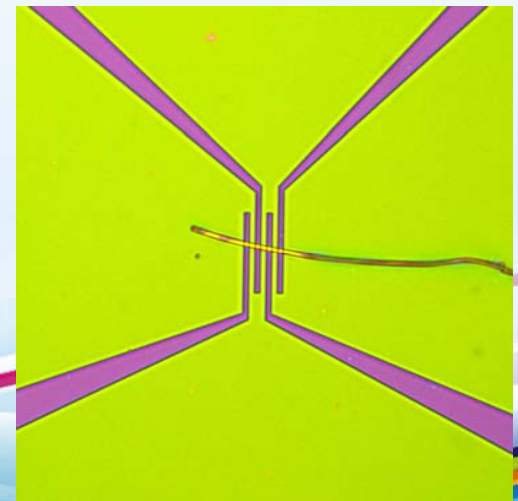
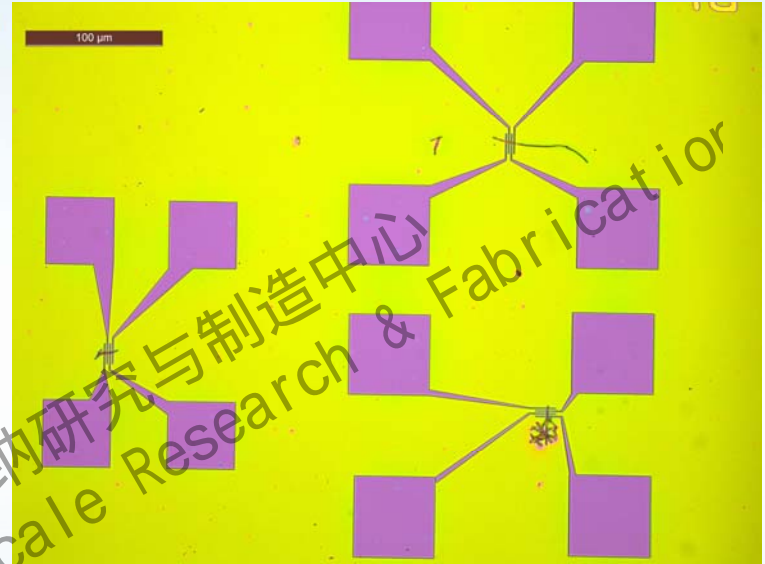
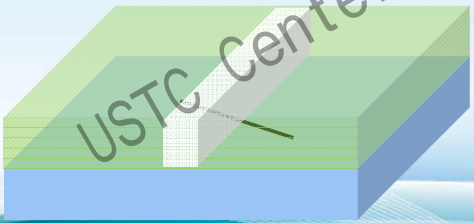
Resist



Exposure



Develop

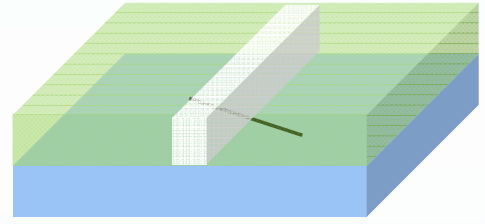




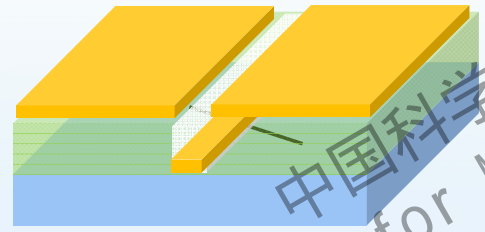
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3. Metal Deposition&Lift-off

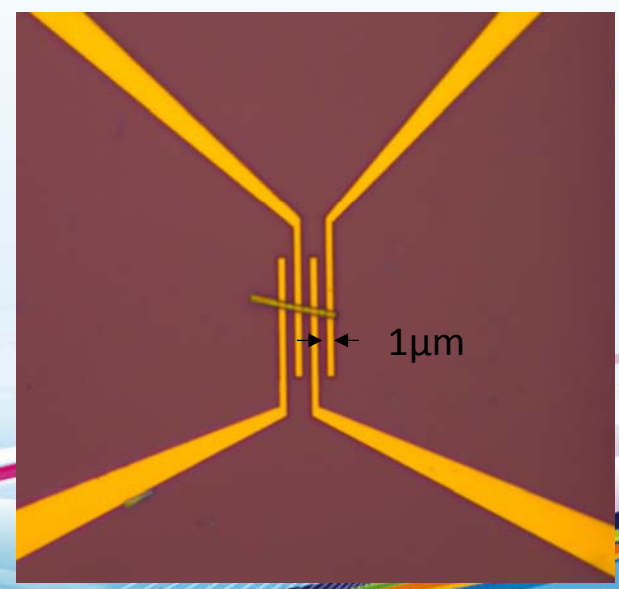
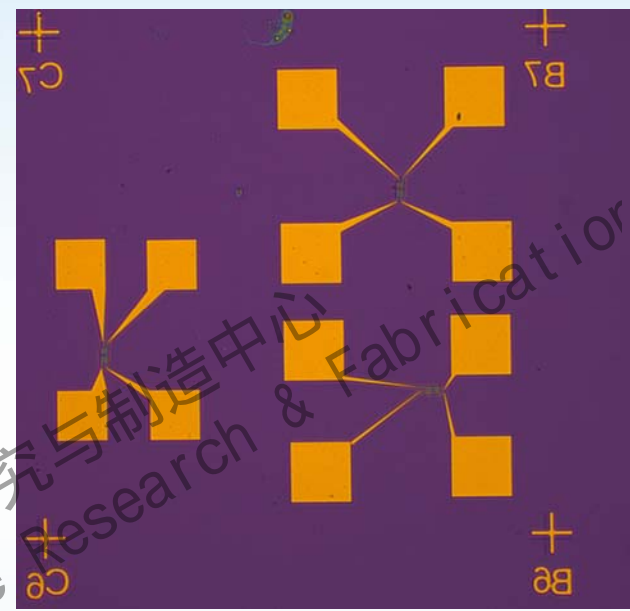
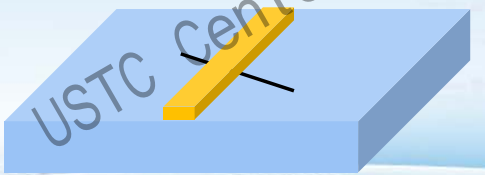
Clean
(optional)



PVD



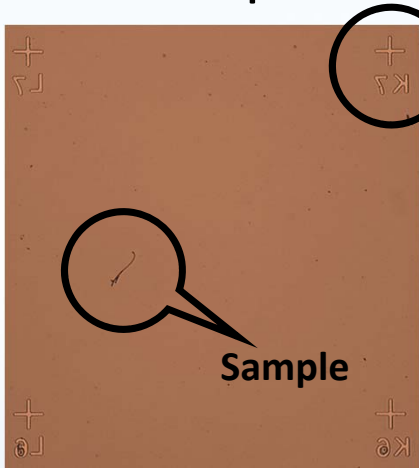
Lift-off





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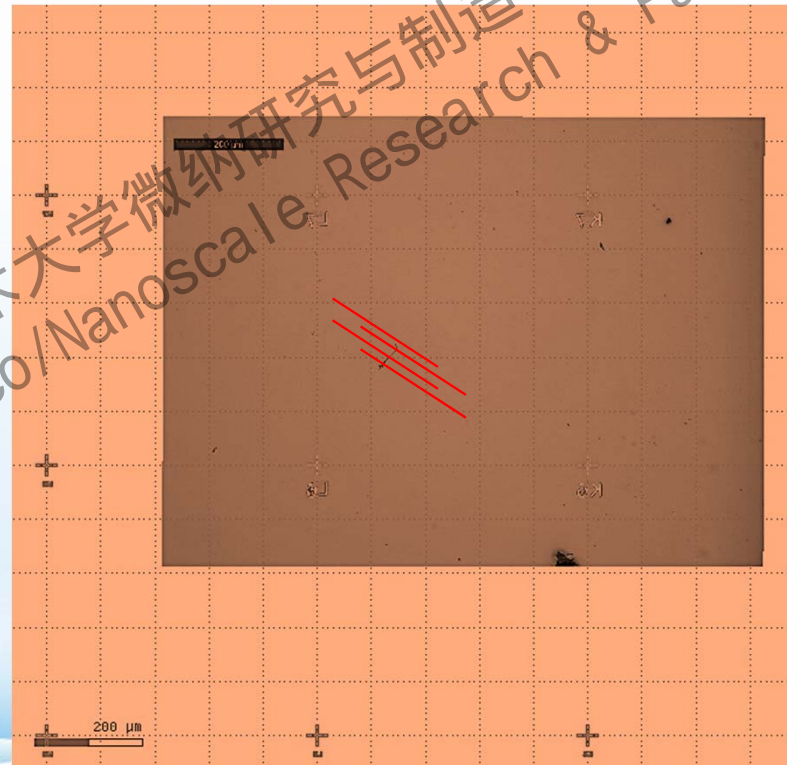
Sample Location



Marker

Sample

Klayout



Errors ~ 100nm

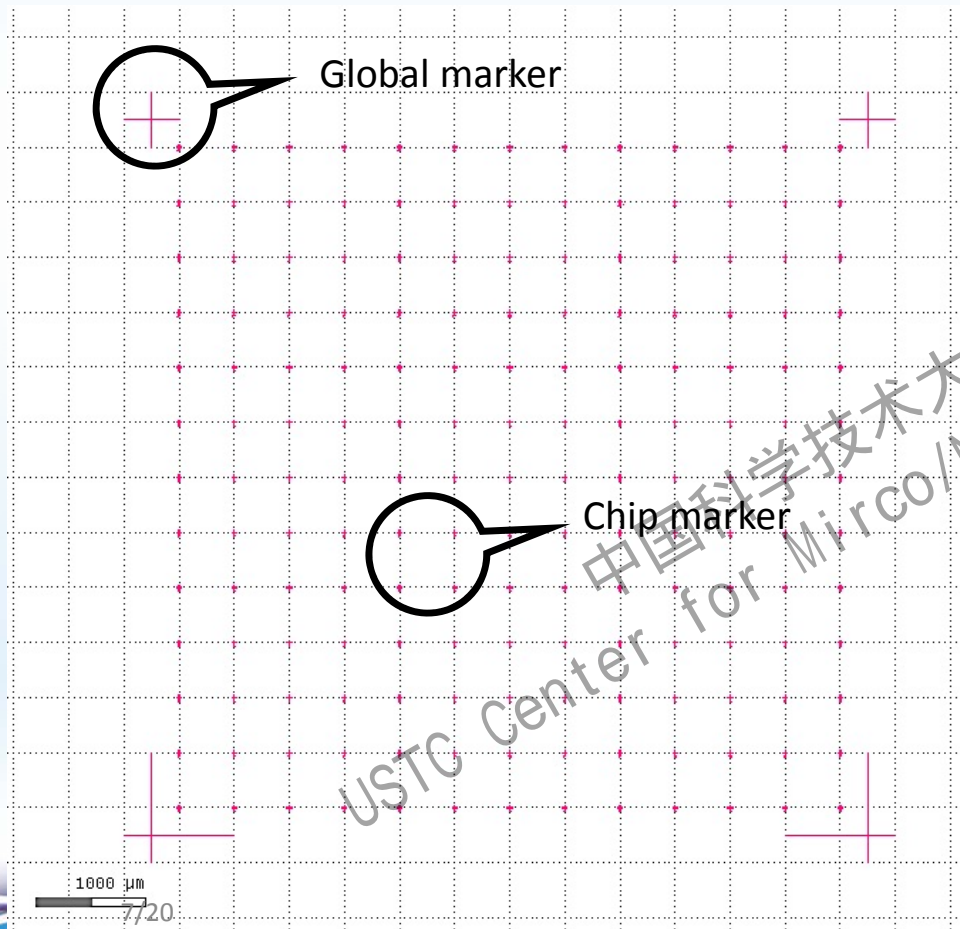
- Picture resolution
- Marker detection

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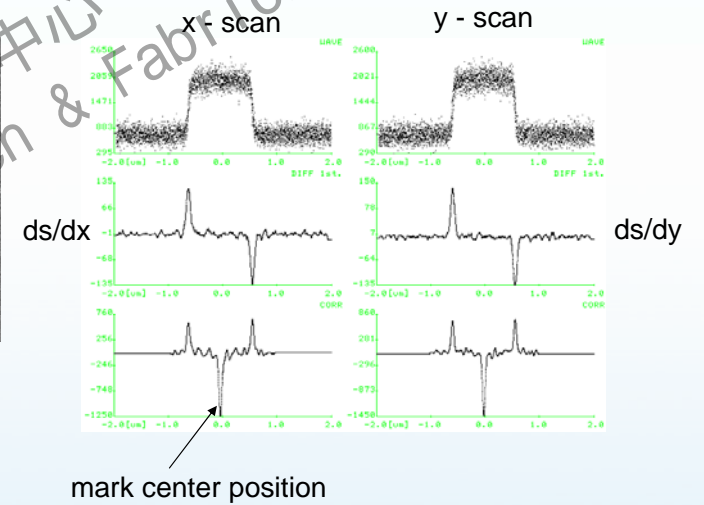
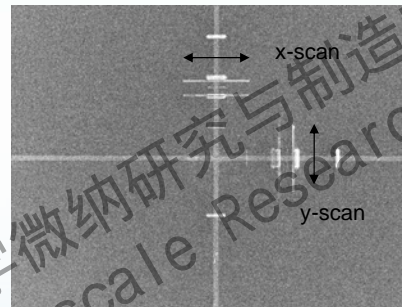


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E-beam lithography



Mark Detection

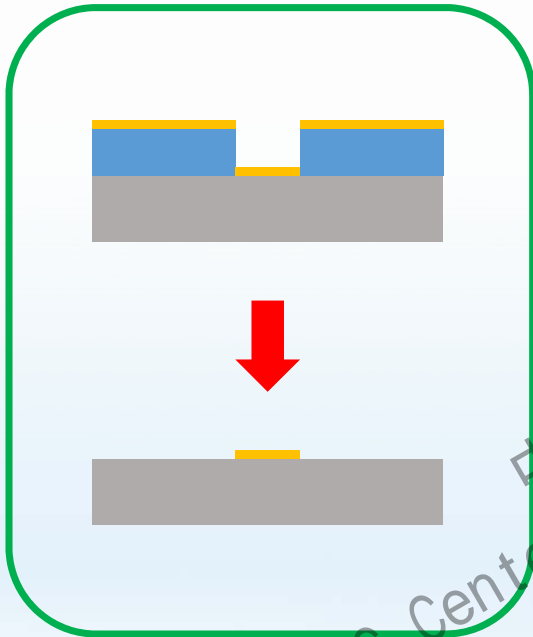


Errors (50nm~1μm)

- Global marker or Both?
- Auto or Manual Mark detection



Lift-off



Lift-off process

Immersion in Acetone solution (NMP, Remove PG)

Immersion time differs from different metal deposition methods

- Sputter over 8 hours
- Evaporation 1-10 mins

Resist profile have great impact on results



Normally Resist thickness is 10 times larger than the metal thickness

Single line and grating have different critical dimensions (CD) in lift-off.
The single line have smaller CD than grating.

- Single line 50nm
- Grating 200nm

Metal deposition can affect the metal line aspect ratio.

- Sputter Low AR (<0.5)
- Evaporation High AR (>1)



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Other issues

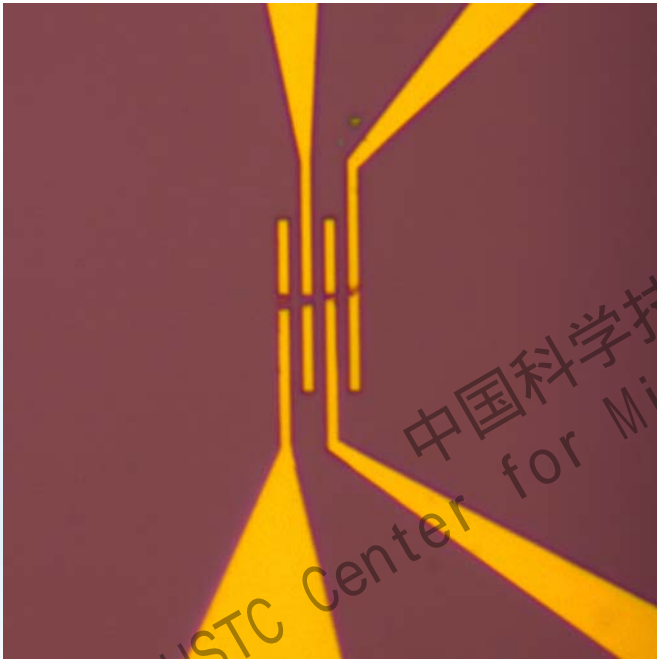
➤ Cleaning! Cleaning! Cleaning!

- Before coating resist may prevent electrodes stripped off.
- Before depositing metal may help to get good electrical contact.
- To remove the residual resist you can chose RIE with O₃ or RIE with Ar.
- After lift-off, to get good results samples need to be cleaned by some means.



F&Q

1. Why my nanowire is missing?



Reason

Metal thickness is not high enough to hold the nanowire

Solution

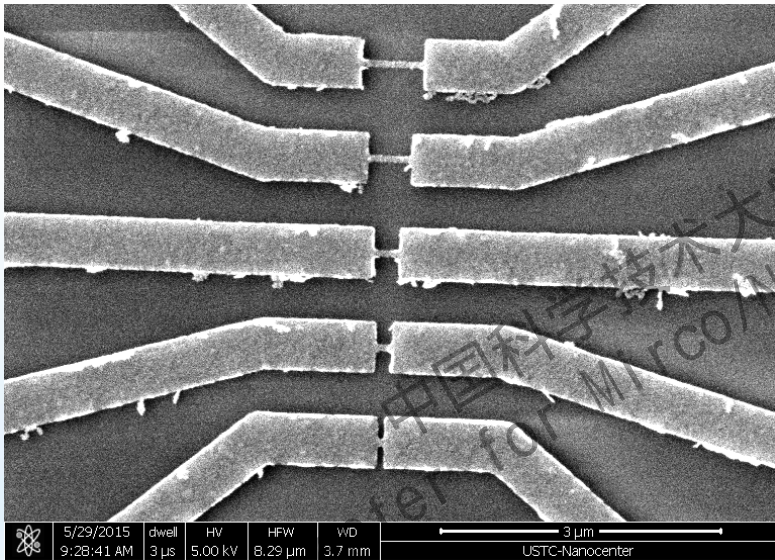
Increase the metal thickness.

For sputter the thickness is half the nanowire height. For evaporate the thickness should be the same height



F&Q

2. Why electrodes edge are not clear?



Reason

Metal deposited on the side wall of resist.

Solution

Increase thickness of the resist

Using bilayer resist profile

lift-off in Ultrasonic



F&Q

3. Can lift-off twice help getting a better results?



Reason

Lift-off without enough time.

Solution

Ultrasonic in Di H₂O with high power hopefully can remove them



F&Q

4. Why my devices have bad electrical contact?
 - ✓ Please check if you have clean your samples well.
 - ✓ Please check if you have enough metal thickness (>30nm).
 - ✓ Give a high current to improve the contact.
5. After expose I find electrodes misplaced on the nanowires?
 - ✓ Please check if you have the right design?
 - ✓ Please check if the EBL exposure file is correct?
 - ✓ Please check if pattern exposed in same working condition?



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Thanks for listening
Do you have any questions?

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