Electron Beam Lithography

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Lithography

Source

Mask

Pattern

“Photo”
Electron Beam Lithography (EBL)

Source

Mask

Pattern

Pattern with electron beam

Develop with the developer

Deposition of metal layer

Lift-off with acetone
Applications of EBL

“Size Dependent Transport and Thermoelectric Properties of Individual Polycrystalline Bismuth Nanowires”

False color SEM image of EBL pattern:
- Heater (red and white)
- Inner electrodes for temperature (dark blue)
- Outer electrodes for 4 point probe (light blue)
Process Layout

Schematic

Overview

Pre-processing

EBL

Post-processing

Detailed Parameters

Wafer

Resist

Spin Coat

Design

SEM

NPGS

Develop

Deposit

Metal

Liftoff

- Type
- Preparation
- Chemistry
- Volume
- Resist type
- Time
- Baking conditions
- Hot Keys for DesignCAD LT 2000
- Importing files
- Aperture
- Operating voltage
- Spot size
- Working distance
- Optimize imaging
- SEM magnification calibration
- Beam current
- Simulate write time
- Mode confirmed
- Test for dose
- Developer chemistry
- Time Temp.
- - Target Type
- - Sputtering current
- - Time
- - Ultrasonic Condition
- Time

It takes patience!!
The EM Core can provide these supplies for your EBL:
- Undoped silicon wafers
- 950K PMMA A10 resist (10 wt% solids loading)
- Anisole thinner solution to obtain dilutions

~ 200 nm (A4) resist is then baked for 15 minutes at 180°C.
~ 50 nm (A2) resist has also been experimented with

Patterns are designed in DesignCAD (.dc2 file)
Patterning Setup

Best microscope resolution = Best patterning resolution

Faraday Cup for measuring the beam current

Scratch for height adjustment
Patterning

First test run: No height adjustment

After adding scratch for height adjustment
1.3 nC/cm
26 µsec

0.25 nC/cm
5 µsec

1 nC/cm
21 µsec

Array hexagons 480 nm separated by 100 nm!

Next: Test resolution limit of our system.
Remaining Issues

Resolution Test: This completed using 30 kV accelerating voltage on ~200 nm thick resist and a developer at room temperature.

Potential Solutions:
• Reducing aspect ratio
• Developing temperature
• Undercutting method
“Fundamentals of Electron Beam Exposure and Development”
Mohammad Ali Mohammad,
_Nanofabrication Techniques and Principles_ 2012. Ch 2. pg 16, 21
Found to work better for 50 nm resist
Lift-Off

Solution!!
50 nm Resist Experiments

Resolution Pattern: Lines descending from 1 micron to 10 nm. This pattern was formed using an undercutting method with 10kV as the accelerating voltage.

Hexagon Pattern: This was patterned using the undercutting method and cold developer.
Conclusions and Future Directions

• Provide uncertainty analysis for customers

• Develop proficiency in positive resist patterning with 200 nm and 50 nm resist films

• Explore negative resist patterning

• Explore patterning onto nonconductive (glass)
Questions?