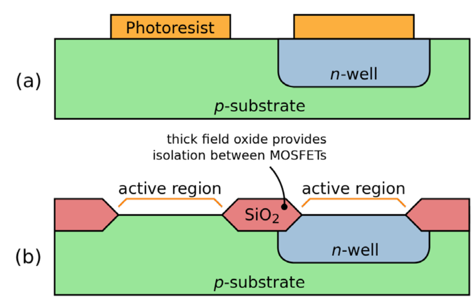
Student Guide

Nanofabrication Tools: Etching and Tin Films

Safety
You must wear safety glasses at all times. Be careful not to get any chemical in your eyes or mouth. Wear safety gloves and apron if available. Wash hands immediately after using chemicals

Introduction: Nanotechnology is the science of the very small – atoms and molecules. Scientists and engineers are creating new materials and devices by using unique properties of nanoscale materials. The quest for ever-more-powerful computers and communications devices has ignited interest in nanotechnology. Nanotechnology holds the key to future devices not only in computer industry but also in the medical field using robotic surgical tools and serum analyzers.

Nanofabrication manufacturing involves making devices at the smallest dimensions. While it was first used in the semiconductor industry, the technologies are now used for a wide variety of applications. Creating a microprocessor, or any other kind of integrated circuit, requires photolithography, which is process of creating patterns on a piece of semi-conducting material, such as silicon, using light. Photolithography is a multi-step process and a complex integrated circuit on a silicon wafer can take up to a month to create.



Example of steps used in semiconductor manufacturing steps. https://commons.wikimedia.org/wiki/File:MOSFET_Manufacture_-_2_-_define_active_regions.svg

The following activities will allow you to experience some of the processes used in nanofabrication including thin film layer deposition (electroplating) and etching. You will be experimenting with variables that may or may not affect the deposition of thin films.

Pre-Lab: You teacher may ask you to watch a video or read about the fabrication processes used in semiconductor manufacturing. In class, you will discuss the process and review the vocabulary terms associated in the processes.

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Directions for the Activities:

Day1 Electroplating

1. Prep a quarter using fine steel wool to remove any oxides or dirt. Use gloves to avoid any more finger prints.
2. Using a sharpie, mask off some area/pattern that you don't want to be electroplated. Make sure to completely cover the areas of interest with sharpie ink.
3. Put 50 mL of $CuSO_4$ solution in the beaker.
4. Attach the penny or the copper piece to one of the alligator clip.
5. Attach the quarter to another alligator clip
6. Attach the penny to +ve end of 3V battery pack. This is the anode.
7. Connect the quarter to the cathode (-ve end of the battery)
8. Immerse penny and quarter in solution for 1 minute.
9. Remove quarter and change clip position for even plating.
10. Immerse coin again and repeating for total of 3 minutes.
11. Remove quarter and rinse well with water.
12. Remove sharpie/mask using rubbing alcohol.
13. Bring to shine by light rubbing with fine steel wool.

Day 2 PCB Pattern:

1. Prep the PCB Board using fine steel wool bring to a shine.
2. Draw a pattern on the shiny copper side using a sharpie, making sure to completely cover the area.
3. Pour 10 mL of the etch solution $CuSO_4$ in a petri-dish.
4. Place the PCB in the etch solution with pattern side completely covered with the etch solution. Place it face down for complete coverage.
5. Check on the board frequently by picking it up out of solution using forceps.
6. Once completely etched away, completely rinse the board with water.
7. Remove sharpie marks using rubbing alcohol.
8. Bring to shine by light rubbing with fine steel wool.

Day 3 Etch Time:

1. Label clean slides on one end depending on the experimental design.
2. Punch 3 holes in aluminum foil tape and place the three discs on each slide.
3. Place all the slides in the staining jar and pour $CuCl_2$ solution.
4. Start timer and remove the slides at appropriate times.
5. Place these slides in another staining jar containing water.
6. Shake the slides slightly to remove any copper buildup.
7. Using forceps, pull the slides out and place on a clean paper towel.
8. Clean the foil discs using q-tips while applying very light pressure.
9. Using the Dino-lite microscope to measure the size and number of pits in three areas of each foil disc. Find the average.
10. Plot a graph using pore size as a function of time.
11. Find the regression for the line. You would need this for the next activity.

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Day 4 Design Challenge:

1. Using the information from last three activities design a process to get three areas of different pore sizes on a 1 inch round foil disc.
2. Get your design checked by the teacher.
3. Make measurements and take pictures of your foil disc showing three areas of different pore sizes.
4. Include pictures in your lab report.

Record your Observations:

Day 1: Take a picture of your electroplated quarter and include with the lab report. Explain how you achieved your pattern on the quarter.

Day 2: Take a picture of your etched PCB board and include with the lab report. Explain how you achieved your pattern on the quarter.

Day 3: Record your etch time data in the table below or your lab notebook. Create a scatterplot with pore size as a function of time and find a best fit regression line for your data. You will use this graph for next part of your lab. Explain your results.

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Table: Etch time and pore size relationship

Time (minutes)	Pore size (μm)			
	Replicate 1	**Replicate 2**	**Replicate 3**	**Average**
1.0				
2.0				
3.0				
4.0				
5.0				

Day 4 Design Challenge: How did you prepare the membranes so that they had three distinct areas? Include pictures in your report. Discuss the steps used in your challenge and the results. How would you improve on your process?

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Draw Conclusions:

1. Did your quarter electroplating activity result in what your expected?

2. Did the etching in activity 2 result in a pattern that you expected?

3. For activity 3, discuss how your etched pores and shapes either differed or were similar on the three discs. How did etch time effect the pores and shapes? What technologies do thin films stand to revolutionize?

4. Which electrode served as the cathode in the electrolysis chamber?

5. Which electrode served as the anode in the electrolysis chamber?

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