Name: ____________________________Date: ________________Class: _________________

Student Worksheet

Part 1: Wet Etching

Safety

Wear safety glasses while using the etching solutions: vinegar, lemon juice, and Coca-Cola®, for they all contain dilute amounts of acid and will burn if splashed into the eye. Scissors can be a cutting hazard, so use caution.

Introduction

In this lab, you will discover how scientists sculpt tiny electrical components that are used in an iPod or cell phone! You will do a *wet etching process* (also called "*acid etching*"), which is often used to make very tiny parts (integrated circuits containing transistors) used in a computer. Computers, cell phones, and iPods would not work without this process, so let's get started, and you can submit your resume to Intel later. Because of micro and nanotechnology the parts are getting smaller and smaller with transistors measuring between 20 and 50 nanometers, or billionths of a meter. This small size allows for millions of transistors to be in a single electronic device. But how do they make such small things? This lesson will help you learn about one of the methods called wet etching.

Materials per group

- safety glass (one per student)
- 25 in. electrical tape
- 25 in. clear tape
- 25 in. masking tape
- 9 Alka-Seltzer® tablets
- 9 antacid tablets
- 9 art plaster molds
- pair of scissors
- metric ruler
- 9 index cards
- pen
- 9 Petri dishes, with 3 compartments in each Petri dish
- 3 beakers, 100 ml each
- 50 ml vinegar
- 50 ml lemon juice
- 50 ml Coca-Cola®
- 3 pipettes
- pair of tweezers
- 10× magnifying lens
- clock

Make a Prediction:

1. Which of the three masks (types of tape) will adhere the best to all substrates?

I think the clear tape will make the most suitable masking material.

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2. Which of the three etching solutions (vinegar, lemon juice, or Coca-cola®) will etch the most material away?

*I think the vinegar will remove the most material.*_________

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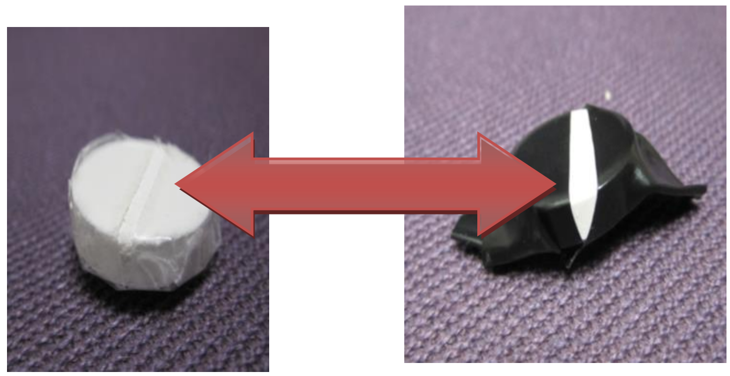
3. Which of the three substrates (Alka-Seltzer®, antacid tablet, art plaster) will be the best material to work with? The best material will:
    - produce the deepest channel
    - make the smoothest surface
    - be the easiest to handle
    - not be fragile

    *I think the antacid tablet will make the most suitable substrate material to use with the given etching solutions.*______________

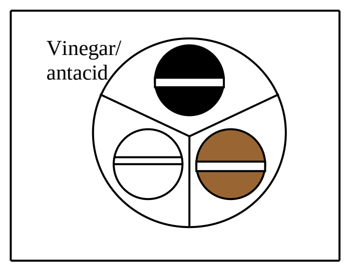
Procedure

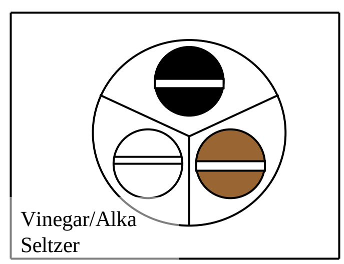


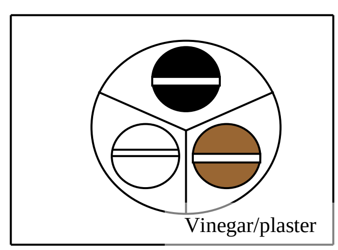
1. Tape 3 antacid tablets with electrical tape, so that there is a 4 mm gap in the middle as shown to the right.
2. Tape 3 antacid tablets with clear Scotch tape and 3 antacid tablets with tan masking tape, in the same manner as you did in step 1.
3. Repeat steps 1–2, but this time tape the Alka-Seltzer® tablets.
4. Repeat steps 1–2, but this time tape the plaster molds. You should now have a total of 27 substrates (tablets) to test.
5. Outline a Petri dish on each index card.
6. Label one index card: *vinegar/antacid.* Set the Petri dish on top of the

    circle, and put the 3 taped (electrical, masking, clear tape) antacid

    tablets in each compartment of the Petri dish.
7. Label one index card: *vinegar/Alka-Seltzer®*. Set the Petri dish on top of the circle, and put the 3 taped (electrical, masking, clear tape) Alka-Seltzer® tablets in each compartment of the Petri dish.
8. Label one index card: *vinegar/plaster*. Set the Petri dish on top of the circle, and put the 3 taped (electrical, masking, Scotch® tape) plaster molds in each compartment of the Petri dish.







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9. Repeat steps 6–8, but this time substitute the word *lemon juice* or the word *vinegar*.
10. Repeat steps 6–8, but this time substitute the word *Coca-Cola*® for the word *vinegar*.
11. Use a pipette to drop the vinegar on the exposed surface of each tablet. How do you know whether a reaction is taking place? How do you know whether the reaction is fast or slow? Write your observations in the table on the next page.
12. Add enough vinegar to completely submerge the exposed surface of all tablets and let them set for 10 minutes.
13. Repeat steps 11–12 with the petri dishes labeled lemon. This time use an unused pipette with lemon juice.
14. Repeat steps 11-12 with the petric dishes laves Coca-Cola®. This time use an unused pipette with Coca-Cola®.
15. Use tweezers to remove all tablets from the Petri dishes and let them dry on a paper towel.
16. Observe the condition of the masks to see how well they stuck to the substrate. Write your observations in the table.
17. Observe each tablet with a magnifying lens. Answer the questions in the table.

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Record Your Observations:

	a. How well did these acids react with the substrate? b. How well did these acids etch the substrate for the ***best*** channel?		
	Vinegar	**Lemon juice**	**Coca-Cola®**
Plaster	*No bubbles; no changes.* *No visible etching noted.*	*Gas bubbles were small but insignificant.* *Yellow stain left behind.* *No visible etching noted.*	*Gas bubbles were a little larger and numerous.* *Brown stain left behind.* *No visible etching on the surface.*
Antacid	*Gas formation was noted on surface of substrate; the bubbles stuck to each other and built up until they disappeared into the air.* *Etching was deep with undercutting below mask; channel was well-defined.*	*Gas formation was the strongest; more bubbles formed than with the other etching solutions.* *Etching was deep with undercutting below mask; channel formed was deeper than with the coca-cola and vinegar.*	*Gas formation was very high; gas bubbles were large and numerous, but the bubbles did not appear to be working on the substrate.* *Did not create a deep channel.*
Alka-Seltzer®	*Gas formation was explosive on surface and reaction was fast based on the amount of bubbles formed.* *The liquid diffused into the substrate making it "crumble" when handled.* *Undercutting was very noticeable.* *Tablet completely dissolved after being submerged for 3–5 min.*	*Gas formation was the strongest; more bubbles formed than with the other etching solutions.* *Etching was deep with undercutting below the mask.* *Tablet completely dissolved after being submerged for 3–5 min.*	*Gas formation was very high and the tablet began to dissolve the longer it sat in the etching solution.* *Did create a deep channel.* *The liquid "ate into the substrate more" the longer it was submerged.* *Tablet completely dissolved after being submerged for 3–5 min.*

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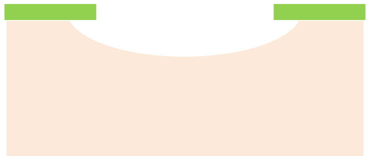
	Did the mask (tape) adhere well to the substrate?		
	Black electrical tape	**Clear Scotch® tape**	**Masking tape**
Plaster	*Did adhere well.*	*Tape sealed well, kept liquid from diffusing into the substrate.*	*The tape did adhere well.*
Antacid	*Tape sealed well to start off with; but liquid went under the tape.*	*Tape sealed well, kept liquid from diffusing into the substrate.*	*The tape did not adhere as well as the other two.*
Alka-Seltzer®	*Tape sealed well to start off with, but liquid went under the tape.*	*Tape sealed well, kept liquid from diffusing into the substrate.*	*The tape did not adhere well.*

Analyze the Results

1. Why did bubbles form on the exposed surface of the substrate?

   The acid contained in the etching solution chemically reacted with the substrate forming the gas at the surface.

2. Draw what the channel looked like in the space below. Label all parts: substrate, undercutting and mask.



The green block is the mask.
The peach is the substrate.
The undercutting is the section missing directly below the mask.

3. Did this channel undergo an *isotropic etch* or an *anisotropic etch*? Justify your answer.

   The etched shape looks more like an isotropic etch because the undercutting is about the same depth as the channel.

4. Why do you think this shape was formed?

   The action of the etching solution and the formation of the gas bubbles etched the material as it penetrated the surface of the substrate.

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Draw Conclusions

5. Did the type of etching solution determine the amount of gas forming on the surface?
   The results indicated that the amount of gas was higher on the lemon juice, which led me to believe that the type of etching solution will determine the amount of gas formed.

6. Which of the masking materials performed best? Justify your answer.
   The best masking material is the clear tape. The clear tape made the best-etched channel on the substrates tested indicating it is the best masking material for the materials provided.

7. What was the best substrate to make a channel? Explain.
   Although the Alka-Seltzer tablet formed a deeper channel, it became very fragile and easily fell apart. Therefore, we determined that the antacid tablet is the best substrate, for it forms deep, smooth channels and does not fall apart.

8. Why would the etching process be considered nanotechnology? The etching occurs at the atomic and molecular level – removing molecules and atoms of the three materials being etched. This is at the nanoscale.

9. Why would engineers want to make integrated circuits that have transistors in the nanoscale?
   By making them smaller, they could put more transistors on a chip which would allow for the ICs to perform more functions at faster times.

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